Journal of Innovation & Knowledge 15 (2026) 100997

Contents lists available at ScienceDirect

Journal of Innovation & Knowledge

journal homepage: www.elsevier.com/locate/jik

Transformation of the Economic Sustainability Management System of Russian Industrial Companies Utilizing Blockchain Technologies and Knowledge Management Mechanisms

Mikhail Vladimirovich Khachaturyan, Evgeniia Valeryenva Klicheva

Department of Strategic and Innovative Development, Faculty "Higher School of Management," Financial University under the Government of the Russian Federation, Moscow, Russia

A R T I C L E I N F O

JEL Codes:
Q01 Q56 D83 O14

Keywords:
economic sustainability of the organization
knowledge management
implementation of blockchain technologies
supply chain transparency
modeling of structural equations

A B S T R A C T

The escalating dynamism and complexity of the conditions of national and international competition compel organizations across all sectors of Russian industry to enhance the economic stability of their operations through continuous improvements in their products and business processes. In these circumstances, knowledge and the presence of high-quality management mechanisms within a company's organizational structure become pivotal tools for ensuring long-term and sustainable development. Among the most relevant mechanisms for addressing the challenges of improving an organization's economic sustainability within the realm of management science and practice are the effective implementation of blockchain technologies and the augmentation of supply chain transparency through the development and implementation of solutions in the domain of organizational and production knowledge management. In this context, based on the application of the resource-oriented approach and technology adoption model, the authors of this study endeavor to identify and emphasize the empirical relationships between these mechanisms within the framework of addressing the problem of ensuring Russian industrial companies' efficiency. The novelty of this study lies in the fact that the characteristics of applying these factors of management systems' digitalization in the studied sector of the economy, exemplified by Russia, remain poorly explored both at the national and international levels. The empirical data that served as the foundation for this study were gathered through interviews with 293 respondents, comprising senior, middle, and junior managers of companies operating within the processing sectors of the Russian industry. Structural equations with partial least squares method (PLS-SEM) were employed to analyze the empirical data obtained. Empirical analysis has demonstrated a substantial impact on the adoption of blockchain technologies through the expansion of the range of organizational and production knowledge-management mechanisms. In turn, the introduction of blockchain technologies has a notable positive impact on enhancing supply chain transparency. A key finding of the study, based on empirical data analysis of Russian industrial companies, confirms a management science statement: the comprehensive introduction and expansion of blockchain technologies and mechanisms for managing organizational and production knowledge have a noticeable positive impact on addressing challenges to business economic sustainability. Furthermore, the analysis of the mediation effect revealed a consistent mediating role of blockchain technology introduction and increased supply chain transparency on the formation of a sustainable relationship between organizational and production knowledge management mechanisms and problem-solving for economic sustainability. This study expands the scope of research on the interconnection and mutual influence of organizational and production knowledge-management mechanisms, blockchain technology introduction, and increased supply chain transparency. Additionally, it provides valuable insights for top managers of manufacturing industry companies and politicians, highlighting the role of these mechanisms in addressing economic stability challenges faced by industrial companies in Russia.

Introduction

The rapid pace of technological advancement and digital adoption presents new opportunities for businesses across various economic sectors, intensifying global competition for resources and significantly shortening product life cycles and organisational life cycles. Conversely, the accelerated pace of scientific and technological progress creates an increased need for the development and implementation of novel management methods and mechanisms, fundamentally altering the logic of organisational management structures (Hafeez et al., 2025;

https://doi.org/10.1016/j.jik.2026.100997
Received 7 April 2025; Accepted 23 February 2026
Available online 2 March 2026

Shahzad et al., 2025a; Haq et al., 2024). Kim and Shin (2019) posited that the widespread adoption of blockchain technologies will fundamentally transform both the operational logic of corporate management systems and supply chains across all economic sectors.

Blockchains are defined as 'cryptography-based decentralised and distributed systems consisting of an ongoing list of digital records that are shared within a peer-to-peer network' (Mahula et al., 2025). Blockchains were introduced in 2008, with Bitcoin representing the first decentralised peer-to-peer form of digital currency. However, the underlying concept of a 'cryptographically secured chain of blocks for storing information' had already appeared in the academic literature of the 1990s, particularly in the work of Haber and Stornetta (1991). Haber and Stornetta's (1991) research on document time-stamping and data structures can be traced to the immutable property of blockchain, as later highlighted by Nakamoto in his white paper (Nakamoto, 2008; Kayani & Hasan, 2024).

Blockchains have four distinctive features—decentralisation, transparency, immutability, and programmability—that have transformative effects on organisations.

First, blockchain operates as a decentralised ledger that is free from the control of central institutions, in which each participant within the network maintains an identical copy of the ledger.

Second, the intrinsic characteristic of decentralisation fosters a transparent and widely shared data source, thereby enabling an unprecedented level of openness and accessibility (Shahzad et al., 2024a).

Third, blockchain employs a mechanism in which transaction data are encrypted and organised into blocks. These blocks are then securely linked together, forming an unalterable and chronological transaction trail, hence the nomenclature 'blockchain' (Zhang et al., 2024). This immutability lies at the core of blockchain's integrity and reliability.

Fourth, blockchain technology incorporates 'smart contracts', which are self-executing agreements between trading partners and include programmable capabilities. Smart contracts enable registered peers within the network to validate transactions autonomously and anonymously (Tan et al., 2025). Moreover, they play a pivotal role in determining whether a new block can be appended to the blockchain in the correct chronological order, thereby enhancing the system's efficiency and trustworthiness (Mahula et al., 2025).

Initially adopted as a technological tool for improving business processes, blockchains have evolved beyond being merely efficiency- and productivity-enhancing technologies. Contemporary blockchain solutions, such as smart contracts and decentralised autonomous organisations (DAOs), increasingly position blockchains as a platform for inter-firm cooperation and collaboration.

The current trajectory of the digital economy supports the assertion that the introduction of blockchain technology not only augments supply chain transparency but also contributes to the achievement of organisational economic sustainability. The adoption of blockchain technologies facilitates closer integration among supply chain participants, catalysing qualitative transformations in management systems that enhance the economic viability of business activities (Munir et al., 2022; Cagigas et al., 2023).

Another pertinent aspect that warrants attention is the development of green supply chain operations. In this context, the implementation of blockchain technologies can also support the establishment of environmentally friendly supply chains (Yousaf, 2021).

In contrast, in today's environment, organisations' management systems focus on achieving the objectives of supply chain digital transformation as a crucial aspect of ensuring the sustainability of their operations while pursuing three primary objectives: economic, environmental, and social (Sizan et al., 2025; Zkik et al., 2024). Moreover, a predominant area of research in management science is sustainable development; this encompasses not only the Sustainable Development Goals designated by the United Nations but also the development of environmental legislation, the introduction of environmentally friendly technologies, and the assessment of the effectiveness of regulatory interventions in the formation and development of initiatives aimed at creating flexible supply chains (Geng et al., 2021; Jin et al., 2022).

Under contemporary conditions, a substantial factor in ensuring the sustainability of an organisation's operations is the knowledge economy. In this regard, adopting blockchain technologies as the foundation of knowledge management solutions within an organisation is becoming an increasingly pivotal factor in ensuring economic sustainability in both the manufacturing and service divisions of industrial enterprises (Shahzad et al., 2024a). Furthermore, blockchain solutions in the domain of knowledge management are emerging as an important operational tool for evaluating organisations' competitiveness (Irfan et al., 2020). Another factor contributing to the integration of blockchain technologies into organisations' knowledge management systems is the imperative to establish mechanisms for collecting, disseminating, and utilising information, which has become a determining factor in achieving business efficiency objectives (Haq et al., 2024).

In the context of accelerating digital transformation, the owners and top management of prominent organisations such as Tesla, Nike, Gazprom, Yandex, Sberbank, Matsushita, Unilever, and others increasingly emphasise the utilisation of knowledge that organisations can acquire through stakeholders implementing blockchain technologies, as well as through other environmental factors, to develop and implement development strategies. This approach aims to enhance environmental responsibility and sustainable development (Sizan et al., 2025; Zkik et al., 2024).

The growing complexity and dynamism of organisational environments have heightened the need for effective knowledge management systems to facilitate decision-making, innovation, and the efficient use of resources within organisations. Knowledge management involves capturing, distributing, and effectively using organisational knowledge (Sartori et al., 2021). However, traditional knowledge management systems often face challenges in ensuring data security, preventing unauthorised access, and promoting transparency and accountability in the exchange of knowledge. The advent of blockchain technology, characterised by its decentralised, immutable, and secure features, presents an opportunity to address these limitations by providing a more robust and transparent framework for managing organisational knowledge (Alhasan & Hamdan, 2023).

Blockchain is a distributed ledger technology that enables the recording of transactions in a secure, transparent, and tamper-resistant manner. In organisational knowledge management, blockchain can offer several advantages, such as providing a transparent and auditable history of knowledge transactions and ownership (Philsoophian et al., 2022). The use of smart contracts on the blockchain can also automate various processes within knowledge management systems, ensuring that knowledge is shared in accordance with predefined rules and protocols while reducing human error and bias (Haq et al., 2024). Moreover, blockchain's decentralised nature eliminates the need for a central authority, thereby enhancing users' privacy and control over their knowledge contributions.

In recent years, the application of blockchain to knowledge management systems has attracted significant attention. Organisations are exploring blockchain's potential to transform the ways in which knowledge is stored, accessed, and shared within and across organisations (Haq et al., 2024). One of the key benefits of integrating blockchain into knowledge management systems lies in its ability to enhance trust among stakeholders by providing a secure and immutable record of knowledge transactions. This form of cooperation can foster a collaborative environment in which employees are more willing to share valuable insights, knowing that their intellectual contributions are securely documented (Asa & Zosu, 2023). Furthermore, blockchain can ensure that knowledge is accessible only to authorised individuals, thereby minimising the risk of data breaches and information leaks.

However, despite its potential, integrating blockchain into knowledge management systems presents several challenges. Issues such as

scalability, the energy consumption of blockchain networks, and the complexity of implementing blockchain within existing organisational frameworks require careful consideration (Haq et al., 2024).

Smart contracts enable automation within the management systems of industrial companies by executing predefined business logic automatically. They can be used for knowledge validation, knowledge approval workflows, rights management, and related processes (Sizan et al., 2025). For example, smart contracts may validate new knowledge contributions, ensuring that only high-quality and relevant information is shared (Zkik et al., 2024). Such automation reduces administrative burdens, enhances operational efficiency, and ensures compliance with organisational policies (Daidai & Tamnine, 2023).

Blockchain consensus mechanisms, such as Proof of Work (PoW), Proof of Stake (PoS), and Practical Byzantine Fault Tolerance (PBFT), are vital for ensuring trust and security in decentralised management systems used by industrial companies, with each model offering distinct trade-offs in terms of security, scalability, and energy efficiency (Daidai & Tamnine, 2023). Governance within blockchain-based management systems is also critical, as it requires transparent structures to facilitate fair decision-making, which may be complicated by decentralisation (Tripathi et al., 2023). In addition, the linear structure of blockchain data can slow knowledge retrieval, prompting the adoption of hybrid models such as off-chain storage, in which only metadata or cryptographic hashes are stored on-chain, thereby improving security and retrieval efficiency (Haq et al., 2024).

The authors selected this research topic based on the observation that, despite a substantial number of publications addressing the implementation of blockchain technologies in knowledge management systems to enhance supply chain transparency and achieve economic sustainability objectives, practical experience in addressing these challenges in developing countries remains limited. Although several empirical studies have been conducted in recent years, the experience of implementing such initiatives in Russia has not been adequately reflected in existing research.

In this context, this study aims to analyse the characteristics of the impact of integrating digital solutions in the domain of knowledge management and blockchain technologies on achieving objectives related to economic sustainability and organisational development within Russian industry. The selection of this research topic is justified by the fact that these issues remain poorly studied, while Russian industry has accumulated substantial practical experience in their implementation. The authors believe that this experience is of considerable interest to international researchers and government officials involved in designing measures to stimulate organisational development in this area.

The objective of this study is to examine the characteristics of the development and implementation of mechanisms for integrating digital solutions into the field of knowledge management, specifically blockchain technologies, within the management systems of Russian industrial companies. These mechanisms are considered primary drivers for achieving economic sustainability objectives. A distinctive feature of this paper lies in the fact that, over the past decade, Russia has accumulated substantial experience in utilising innovative digital solutions based on blockchain technologies. These solutions have been applied in transforming industrial management systems, enhancing supply chain transparency, and addressing challenges associated with achieving sustainable development goals. At the same time, it should be acknowledged that both the accumulated empirical data on the development and implementation of such projects and the analysis of their effectiveness remain insufficiently explored in international management research.

The examination of the identified research issues within the framework of this study expands the theoretical and practical foundations in several directions. First, the proposed theoretical model allows for the evaluation of the impact of developing and implementing knowledge management mechanisms and solutions on the adoption of blockchain technologies within organisational management systems. This, in turn, supports the achievement of organisational goals related to sustainable economic growth and development. Second, this study contributes to the existing body of knowledge by expanding research on economic growth and industrial development through the introduction of blockchain technologies and the enhancement of supply chain transparency. The characteristics, directions, and practical applications of these technologies, particularly in Russia, remain insufficiently studied.

Furthermore, the selection of the research object is driven by the absence of comprehensive studies examining the Russian experience of digitalising knowledge management processes and introducing blockchain technologies to ensure organisational economic stability in the international context. Despite its novelty, this experience may be of interest to international researchers, practitioners, and representatives of government bodies engaged in analysing these issues and developing practical solutions.

The selection of Russian industrial enterprises as the subject of this research is justified by the recognition that, in the context of the transition to a digital economy, despite the dominance of non-production sectors in both developed and developing economies, industry retains substantial potential to serve as a foundational area for achieving sustainable rates of economic growth and development.

This study will be valuable for senior managers and government officials involved in the development and implementation of blockchain technologies in business processes. The findings can be used to improve knowledge management mechanisms and tools, thereby enhancing the long-term sustainability, productivity, and transparency of supply chains.

The paper is structured as follows. The second section presents a comprehensive review of the relevant scientific and practical literature. This is followed by a detailed discussion of the methodology, results, and conclusions. The final section identifies promising areas for future research.

Review of literature and development of hypotheses

Literature review

Knowledge Management and Blockchain Adoption

Blockchain solutions for production and management are based on distributed ledger technology (DLT). This technology was first described in the scientific literature in the work of Satoshi Nakamoto, which was dedicated to the world's first cryptocurrency, Bitcoin (Nakamoto, 2008). The publication of this work generated widespread scientific interest in blockchain technologies beyond the cryptocurrency sphere, leading to a rapid expansion of academic research. To date, a substantial and well-developed body of literature exists that examines both the theoretical and practical aspects of blockchain technology development and implementation across various sectors of the modern economic system (Haq et al., 2024; Shahzad et al., 2024a; Zhang et al., 2024).

Based on an analysis of existing publications in management science on blockchain technology development, many researchers have identified several key directions for its development and implementation within modern management systems (Daidai and Tamnine, 2023). The authors of this study consider the most significant areas to include managerial, production, and organisational barriers that hinder the implementation of blockchain technologies in organisations of all ownership forms; issues related to ensuring the confidentiality of know-how and the protection of trade secrets during organisational transformation and the subsequent implementation of blockchain-based business processes; socio-economic factors associated with the need for radical transformation of business processes; the retraining and reskilling of organisational personnel and managers; the need to establish a shared understanding among owners and top management of the essence and significance of blockchain technology for the successful transformation of production processes and management systems; the

development of innovative mechanisms to account for the interests and influence of organisational stakeholders during the transformation of production and management systems based on blockchain technologies; and the identification of promising areas and applications of blockchain technology.

Initially, the development of blockchain technologies occurred primarily within small and medium-sized high-technology enterprises, owing to their greater administrative and managerial flexibility. However, only in recent years have large corporations recognised the potential and importance of blockchain technologies in improving the quality and adaptability of business processes. This recognition has led to the increasing adoption of blockchain technologies across a wider range of business domains and industries (Alhasan & Hamdan, 2023; Asa & Zosu, 2023; Daidai & Tamnine, 2023). It is important to note that, within management science, the focus of research on blockchain technologies has gradually shifted from emphasising their technical and design characteristics (Tripathi et al., 2023) to analysing how these technologies transform value creation processes for organisations, both from the perspective of owners and consumers (Abbas & Myeong, 2024).

Contemporary management research encompasses a broad range of blockchain applications, including well-established areas such as cross-border transfers and settlements, data collection, processing, analysis, and storage, wealth analysis, and supply chain management (Abbas & Myeong, 2024; Li et al., 2023). In addition, innovative and emerging research directions include the development and utilisation of renewable energy sources, decentralised business process management (Yan et al., 2024), the construction of integrated predictive analytics systems based on blockchain technologies and artificial intelligence, and digital transformation solutions in the financial sector (Daidai & Tamnine, 2023; Shahzad et al., 2024a; Ejairu et al., 2022). Despite this diversity of research themes, the most extensively studied areas of blockchain technology continue to relate to its relevance and effectiveness in supply chain management (Shahzad et al., 2024a), logistics, and finance (Daidai & Tamnine, 2023; Kayani and Hasan, 2024).

In recent years, the Russian corporate sector has achieved a relatively high level of development in information technology infrastructure, enabling the introduction of innovative digital solutions within supply chains. Nevertheless, manufacturing companies continue to face challenges in adapting to the digital transformation of supply chains, which requires increased flexibility and adaptability (Irfan et al., 2020). Russian companies are no exception to these challenges. In this context, the implementation of blockchain technologies can contribute to enhancing supply chain transparencysation, strengthening organisational integration, and improving overall economic sustainability.

Modern management science posits that the integration of knowledge management mechanisms and blockchain technologies in both theory and practice can be achieved as follows. An industrial organisation establishes an advanced monitoring system within the context of its primary production processes. This system ensures the execution of tasks related to monitoring equipment condition and determining maintenance requirements. A comprehensive set of information concerning the condition of equipment and its performance levels is transmitted in real time to the organisation's management information system database through nodes and solutions based on blockchain technologies. By implementing these nodes and blockchain-based solutions, the organisation employs advanced methods for integrating organisational data and verifying its accuracy.

The core of this approach lies in the rapid transfer of knowledge characterising the functionality and efficiency of equipment utilisation, which directly affects production processes. This knowledge can then be promptly stored in a blockchain-based database, ensuring accessibility for all authorised users within the organisation's blockchain network. Within this network, information can be made simultaneously available to all relevant stakeholders. At the same time, following completion of the information-receiving algorithm, the receiving and control blocks are updated, and the entire dataset is transferred to storage. Corresponding datasets are periodically entered into the blockchain network. Once each subsequent data block is encrypted, new or additional information becomes accessible to users (Shahzad et al., 2024a). The knowledge acquired through the organisation's information system, based on the described scheme of data acquisition and recording, is then transferred to authorised users for subsequent utilisation and the development of management decisions. As a result, the potential for generating competitive advantages is enhanced. The integration of this blockchain-based scheme for data collection, aggregation, and knowledge generation provides the necessary level of transparency and stability in modern information systems. This integration highlights the importance of knowledge management systems within organisational structures for their collective use and dissemination both internally and within the external environment (Daidai & Tamnine, 2023).

Some researchers have identified a certain degree of negative impact of knowledge management mechanisms and related decisions on organisational effectiveness. However, while highlighting and analysing these negative effects, such researchers also acknowledge that the presence of effective management systems addressing associated risks and threats stimulates investment in the research and development of knowledge management mechanisms and solutions. Such investment is regarded as essential for the generation and implementation of new ideas and technologies (Sartori et al., 2021).

One potential application of blockchain technology lies in the field of knowledge management, as advanced technologies play a significant role in this domain, particularly in the context of globalisation and the information age. In this environment, organisations operate amid vast volumes of data, making it challenging to identify and acquire the most relevant information required for optimal performance. For knowledge to circulate effectively, its flows must be properly structured and efficiently managed (Pinto, 2020). Accordingly, technologies such as blockchain can enhance efficiency and improve information flows within organisations.

In addition, knowledge management faces challenges related to power dynamics and trust, security in the creation and transfer of knowledge, and motivation for knowledge sharing (Daidai & Tamnine, 2023; Philsoophian et al., 2022). Given that blockchain enables features such as trust, transparency, and immutability within databases, it has the potential to address these challenges and contribute to the improvement of knowledge management practices.

By mitigating or eliminating challenges encountered in knowledge management, such as those outlined above, organisations can also improve other organisational aspects, including organisational sustainability. Despite the growing consensus regarding the importance of organisational sustainability, many organisations continue to face difficulties arising from the absence of a comprehensive management structure that adequately meets, balances, and integrates the three dimensions of sustainability—economic, environmental, and social—commonly referred to as the Triple Bottom Line.

In addition, several studies examining obstacles to the adoption of blockchain technology in other business domains have been considered. Rejeb et al. (2021) conducted a bibliometric review of the literature on blockchain adoption in logistics and supply chain management and identified a range of challenges, including trust-related issues, concerns regarding data transparency and immutability, operational difficulties, lack of regulatory support, limited stakeholder awareness, system complexity, shortages of skilled specialists, and issues related to scalability and processing speed. Similarly, Naseem et al. (2023) and Bajar et al. (2024) examined the implementation of blockchain technology in reverse logistics. Naseem et al. (2023) focused on the e-commerce sector and ranked implementation barriers using the fuzzy Analytic Hierarchy Process (AHP), whereas Bajar et al. (2024) concentrated on the automobile industry and analysed interrelationships among barriers using the DEMATEL method.

Blockchain technology, initially introduced as the underlying infrastructure for cryptocurrencies such as Bitcoin, has evolved into a

transformative tool with a wide range of applications across various sectors, including knowledge management (Nakamoto, 2008). Blockchain is a decentralised and distributed ledger that records transactions across a network of computers in a secure and transparent manner. Its key characteristics—immutability, transparency, and cryptographic security—make it particularly suitable for enhancing the security and efficiency of knowledge management systems (Philsoophian et al., 2022). Blockchain's immutability ensures that once data are recorded, they cannot be altered or tampered with, thereby providing a reliable audit trail (Tripathi et al., 2023). This feature is especially important for maintaining the integrity of sensitive information within knowledge management systems, where data authenticity and traceability are paramount. For example, in healthcare systems, blockchain can be used to securely store patient records, ensuring that medical histories remain accurate and tamper-proof (Zhang et al., 2024).

Moreover, blockchain's decentralised architecture eliminates the need for intermediaries and central authorities, reducing the risk of single points of failure and enhancing data resilience. This decentralisation improves data security in knowledge management by minimising vulnerabilities to cyberattacks and unauthorised access (Philsoophian et al., 2022). Organisations can utilise blockchain to implement secure access controls and data-sharing protocols, thereby protecting intellectual property and confidential business information. In addition, blockchain transparency allows all network participants to access transaction records, fostering trust and accountability. This feature is particularly valuable in areas such as supply chain management, where stakeholders require real-time access to reliable information on product origins and logistics (Abbas & Myeong, 2024). By integrating blockchain into knowledge management systems, organisations can enhance transparency in data-sharing processes while maintaining privacy and confidentiality (Philsoophian et al., 2022).

The security of knowledge management systems is further reinforced by blockchain's use of cryptographic algorithms to protect data transactions and communications. Cryptographic techniques ensure that only authorised parties can access and decrypt sensitive information, thereby mitigating risks associated with data breaches and cyber threats (Philsoophian et al., 2022). For instance, blockchain-based smart contracts can automate and enforce data access permissions according to predefined rules, reducing human error and strengthening data security measures (Daidai & Tamnine, 2023). The integration of blockchain technology into knowledge management systems also creates opportunities for innovation and efficiency. Smart contracts—self-executing agreements with predefined terms encoded in software—enable the automated verification and execution of transactions within decentralised networks. In the context of knowledge management, smart contracts can streamline processes such as intellectual property rights management and licensing, reducing administrative burdens and improving operational efficiency (Li et al., 2023).

Furthermore, blockchain facilitates enhanced collaboration and data sharing among multiple stakeholders while preserving data integrity and ownership rights. By leveraging blockchain technologies, organisations can establish trusted networks for sharing research outputs, academic publications, and proprietary knowledge assets. This collaborative approach supports innovation and accelerates knowledge dissemination across global networks, benefiting sectors such as academia, healthcare, and finance (Gupta et al., 2024).

The scalability of blockchain technology enables knowledge management systems to accommodate growing volumes of data and transactions without compromising performance or security. Innovations such as sharding and off-chain solutions allow blockchain networks to handle increased throughput while maintaining consensus and data integrity (Philsoophian et al., 2022). This scalability is particularly important for large-scale applications in knowledge-intensive industries, where real-time data processing and analysis are critical for effective decision-making (Asa & Zosu, 2023). Blockchain technology therefore holds considerable promise for transforming knowledge management by enhancing security, transparency, and efficiency (Li et al., 2023). By leveraging blockchain's decentralised architecture, cryptographic security, and smart contract capabilities, organisations can mitigate risks associated with data breaches and unauthorised access while fostering innovation and collaboration in knowledge sharing. As blockchain technologies continue to evolve, their application in knowledge management is expected to establish new standards for data security and governance in the digital age (Tripathi et al., 2023).

Furthermore, management science suggests that, under contemporary conditions, a structured and well-defined mechanism for replenishing and developing knowledge bases based on blockchain technologies enhances the efficiency of an organisation's management system in integrating, implementing, and combining advanced technologies within production processes. In addition, such mechanisms contribute to improved responsiveness to market changes (Li et al., 2023). Based on the findings of the aforementioned studies, the authors formulate the following hypotheses:

H1. The integration of knowledge management mechanisms with blockchain technologies enhances the effectiveness of management systems in Russian industrial companies.

The integration of knowledge management mechanisms and blockchain technologies significantly improves the efficiency of organisational management systems through several advantages. Knowledge management mechanisms support the collection, processing, and synthesis of information, thereby enabling the prediction and modelling of various processes. These mechanisms also facilitate the integration of information and knowledge-based technologies and support logical reasoning in decision-making.

Blockchain technologies, in turn, simplify project management processes, enhance security and transparency, and reduce operational inefficiencies. The advantages of using blockchain in organisational management include:

Increased transparency and accountability: Each transaction recorded on the blockchain is stored in a block and linked to the preceding one, forming a continuous chain. This structure creates an auditable record of all actions, allowing managers to trace who performed specific actions, when they occurred, and for what purpose.
Enhanced security: The decentralised nature of blockchain eliminates the risk of a single point of failure. As a result, even if one node is compromised, the overall integrity of the network is maintained.
Optimisation of supply chain management: Blockchain provides a transparent and immutable record of transactions, thereby improving the efficiency and reliability of supply chain management.
Facilitation of cooperation: By offering a shared and tamper-proof record of project activities, blockchain reduces the need for trust-based coordination between participants and promotes effective and transparent collaboration.

In summary, the integration of knowledge management mechanisms and blockchain technologies contributes to improved transparency, security, management efficiency, and collaboration within organisations.

H1a. The introduction of blockchain technologies facilitates an effective relationship between the development of knowledge management mechanisms and the execution of tasks aimed at ensuring the economic sustainability of Russian industrial companies.

Knowledge management mechanisms and blockchain technologies play a crucial role in ensuring organisational economic sustainability. These mechanisms enable organisations to optimise production processes, improve product quality, and reduce production costs. For example, the analysis of customer behaviour supports the prediction of demand trends and the adjustment of supply strategies. Similarly, digital inventory management systems allow for accurate monitoring of stock levels, thereby reducing excess inventory and associated costs.

Blockchain technologies further contribute to organisational stability and innovative growth. Key advantages of using blockchain to support economic sustainability include:

Enhanced data security: Blockchain employs cryptographic techniques to protect information and maintain the integrity of data blocks, preventing manipulation and falsification, which is especially important for organisations handling sensitive data.
Increased transparency and traceability: All data changes are recorded on the blockchain and made accessible to authorised network participants, enabling transparent tracking and verification of data origins and actions, and reducing the risk of fraud and corruption.
Creation of new business models: For example, smart contracts can automate and streamline the execution of contractual obligations between parties.
Support for international payments and financial transactions: Blockchain technologies accelerate and simplify international payments and financial transactions, offering secure and efficient methods for transferring digital assets among network participants.

Overall, the integration of blockchain technologies with knowledge management mechanisms substantially enhances production efficiency and supports the long-term economic sustainability of industrial enterprises.

Implementing blockchain technologies and ensuring transparency in supply chains

Supply chain transparency refers to the sharing of high-quality, specific business data within a supply chain relationship. Supply chain information flow management encompasses the concepts of information sharing, visibility, transparency, and traceability, which have often been used interchangeably in prior research. In this study, these concepts are distinguished using three main dimensions: data quality, data type, and relationship structure. Information sharing refers to the exchange of low-quality, general business data within a business-to-business (B2B) relationship, such as logistics costs and tax-related information shared between suppliers and buyers. Visibility, by contrast, involves the sharing of high-quality, specific business data within a B2B relationship, for example, information on suppliers' locations and materials exchanged between suppliers and buyers. Previous research provides a relatively comprehensive classification of visibility types, which helps clarify the distinctions among these concepts (Swink et al., 2024). Transparency refers to the sharing of high-quality, specific business data across a broader supply chain relationship, such as suppliers' locations, itemised costs, and materials data shared among suppliers, manufacturers, buyers, retailers, and customers (Wan et al., 2023). Traceability refers to the sharing of medium-quality, general organisational data within a public relationship, for example, information on suppliers' countries of origin, employees' demographic characteristics, and benefits data disclosed to the public (Swink et al., 2024). Traceability is sometimes described as external transparency in operations and supply chain management.

Well-established supply chain relationships are more likely to involve the sharing of high-quality information, thereby resulting in higher levels of transparency. Transparency positively influences the monitoring of supply chain subsystems, which can lead to improvements in overall supply chain performance. The availability and accessibility of business data among supply chain members significantly affect the capability of supply chains to respond to and manage disruptions (Wan et al., 2023). Swink et al. (2024) provided empirical evidence demonstrating the positive impact of supply chain analytics on transparency within supply chains. Zelbst et al. (2020) examined the relationship between transparency and enabling technologies such as radio-frequency identification, the industrial Internet of Things, and blockchain within technology-driven practices. Furthermore, Wang et al. (2023) investigated the relationship between transparency and suppliers' provision of trade credit, considering the moderating effects of market share and corporate social responsibility.

Several review studies have examined transparency in supply chains to inform future research directions (Montecchi et al., 2021), including studies on blockchain-based supply chains (Swink et al., 2024). However, relatively few empirical studies have explicitly examined the role of transparency in blockchain-based supply chains, with notable exceptions such as Zelbst et al. (2020), particularly when cyber resilience is a key focus. In light of these observations, a systematic approach to enhancing supply chain transparency through the use of blockchain technologies can offer a comprehensive set of solutions that reduce complexity and eliminate the risk of double spending. Nevertheless, prior research has also emphasised the importance of establishing robust relationships between cryptographic solutions and public-key infrastructures, as well as developing mechanisms for peer-to-peer networks based on decentralised consensus to synchronise distributed databases without reliance on a central authority (Munir et al., 2022).

We presume that introducing blockchain technologies into the supply chain management structure enables Russian industrial companies to enhance their relationships with key stakeholders by ensuring full transparency. This aspect is achieved through the decentralised nature of blockchain networks, which store two crucial pieces of information in each block, representing a comprehensive database and data structure that chronicles transactions. Each block is cryptographically linked to a hash value, facilitating the automatic updating of information when new or updated data become available.

Furthermore, the inherent transparency of blockchain technologies enables nodes to comprehend the reasons for, and consequences associated with, choosing a production and business environment. In contemporary circumstances, the availability of robust systems for accurate data collection, storage, and transmission empowers Russian industrial companies to obtain reliable information about both their internal operations and the external environment.

This literature review explores the transformative impact of emerging technologies, particularly the Internet of Things (IoT) (Udeh et al., 2024), blockchain (Shahzad et al., 2025a), and blockchain in combination with IoT (Swink et al., 2024), on enhancing transparency and efficiency within supply chains. The findings suggest that these technologies provide unprecedented visibility and control, enabling real-time tracking of goods and data flows (Udeh et al., 2024). The decentralised and immutable nature of blockchain enhances transparency and traceability, aiding compliance with regulatory standards and ethical sourcing practices (Gupta et al., 2024; Udeh et al., 2024). Moreover, blockchain addresses information uncertainty and equivocality in assuring regulatory compliance, fostering engagement and data sharing while protecting sensitive information (Wan et al., 2023).

The literature also indicates challenges, including the need for substantial infrastructure investment, cybersecurity measures, and collaborative stakeholder efforts. Recommendations include phased technology integration and prioritising cybersecurity to manage adoption hurdles. Overall, these technologies offer significant potential to revolutionise supply chain operations but require strategic planning and collaboration to fully realise their benefits. This literature review examines the impact of emerging technologies, such as IoT, blockchain, and their combination, on enhancing supply chain transparency and efficiency. Blockchain technology, with its decentralised and immutable nature, provides unprecedented visibility and control, enabling real-time tracking of goods and data flows. It enhances transparency, traceability, and compliance with regulatory standards, addressing information uncertainty and protecting sensitive information. Despite challenges such as infrastructure investment and cybersecurity requirements, strategic planning and collaboration can help realise the transformative potential of these technologies in revolutionising supply chain operations.

Specifically, blockchain technology enhances supply chain transparency by providing a decentralised, immutable ledger that records all transactions. This facilitates real-time tracking of goods and verification

of product origins, thereby reducing fraud and increasing trust among stakeholders within the supply chain. Blockchain technology has emerged as a significant innovation with transformative potential in various sectors, including supply chain management. By utilising blockchain, companies can enhance transparency, traceability, and security in supply chains, thereby improving sustainability outcomes. This technology enables accurate tracking from raw materials to finished products, ensuring compliance with quality standards and sustainable practices. Additionally, blockchain facilitates improved collaboration among supply chain stakeholders by providing a secure platform for data sharing. The implementation of blockchain technology in supply chains has been shown to lead to reduced wastage, increased resource transparency, improved monitoring of social standards, and decreased operational costs. However, challenges such as scalability, integration with existing systems, lack of expertise, safety concerns, and regulatory uncertainties need to be addressed. Companies can respond to these challenges through collaborative strategies and technical advancements to fully leverage the benefits of blockchain technology in enhancing supply chain sustainability and efficiency. Nevertheless, limitations such as scalability issues, integration difficulties with legacy systems, insufficient expertise, safety concerns, and regulatory uncertainties continue to hinder the widespread adoption of blockchain technology in supply chains.

Several studies have focused on the obstacles to adopting blockchain technology in sustainable supply chain management (SSCM). For example, Kouhizadeh et al. (2021) examined the barriers to blockchain adoption for SSCM through interviews with academics and industry experts, drawing on two theoretical frameworks: (1) Force Field Theory and (2) the Technology–Organisation–Environment (TOE) framework. Within the environmental dimension, the authors distinguished between supply chain and external perspectives. To analyse the relationships among these barriers, the DEMATEL method was employed. The findings highlighted the critical role of supply chain-related and technological barriers, which were consistently recognised in both academic and practitioner contexts. Zhang and Song (2022) also identified and evaluated potential risks associated with the implementation of blockchain in SSCM. These risks were classified into environmental, economic, and social categories in line with the Triple Bottom Line framework. Risk assessment was conducted by examining severity (S), occurrence (O), detection (D), and response (R) using the Best–Worst Method (BWM) and the Combined Compromise Solution (CoCoSo) technique. The results indicated that economic risks were more significant than environmental and social risks, with the most prominent risk factors being high training costs and resource inefficiencies arising from repeated audits and certifications.

A notable feature of the introduction of blockchain technologies is their capacity to ensure transparency in system functioning by enabling the convergence of distributed networks into a unified format for data formation, collection, and transmission, while operating under consistent network interaction rules. This eliminates the need for a centralised management mechanism. As a result, conditions are created in which any user can propose, submit, and implement system improvements that are accessible to other network participants, but are adopted only if consensus regarding their necessity is achieved. This, in turn, enhances the overall level of control and trust among network participants.

Based on the aforementioned analysis of the research conducted on the subject matter, the following hypotheses are proposed:

H2. The introduction of blockchain technologies has a positive impact on the supply chain transparency of Russian industrial companies.

Supply chain management encompasses the integration of critical business processes, commencing from the end user and extending to all suppliers of goods, services, and information that contribute to consumer and stakeholder value. At present, this integration requires robust information support, which can be effectively provided through blockchain technology. Several compelling reasons support this assertion:

Even the most prominent organisations lack the necessary capabilities, resources, and expertise to implement end-to-end information integration within their supply chains. Supply chains typically consist of numerous links (counterparties) that facilitate the movement of materials, information, and financial flows. These flows can be effectively managed within a unified information system that ensures equal rights for all participants due to its decentralised nature. In the industrial sector, blockchain technology demonstrates broad applicability, including quality control and support across the entire product life cycle. It ensures the reliability and traceability of flow parameters for all supply chain participants. The use of blockchain enables faster information integration among supply chain participants, thereby making their interactions fully transparent.

In contemporary business environments, information is often not transmitted simultaneously with physical cargo, making it difficult to ensure that all stakeholders are informed about shipment schedules and can plan their operations accordingly. This challenge can be substantially mitigated through the use of electronic labelling systems in combination with Distributed Ledger Technology (DLT) or blockchain-based systems. These technologies enable distributed and multi-user real-time tracking, management of letters of credit, and improved visibility of assets and liabilities. A distributed ledger, based on blockchain technology, continuously updates records of all transactions. Such a decentralised ledger maintains a complete record of every transaction occurring within the supply chain. With this technology, end consumers, among other benefits, can track shipments in real time and view cargo movement stages on a single electronic platform.

H2a. In contemporary circumstances, supply chain transparency is directly correlated with the relationship between the introduction of blockchain technologies and the economic sustainability of the operations of Russian industrial companies.

Blockchain technologies and transparency exert a significant influence on organisational economic sustainability by optimising business processes and enhancing security and transparency across multiple domains. These technologies enable companies to address challenges related to transaction traceability, cost reduction, and the strengthening of trust among participants. In the future, blockchain technology holds considerable potential to transform production management. The transparency, efficiency, and reliability it provides can play a critical role in enhancing organisational competitiveness. However, fully realising the potential of blockchain technologies requires overcoming technical, organisational, and legal challenges. Despite these obstacles, the application of blockchain in production management represents a promising direction with the potential to reshape standards and perceptions of modern production systems.

Implementing blockchain technologies and ensuring the economic sustainability of the organisation's functioning

In contemporary organisational settings, the functionality and efficiency of business processes are heavily dependent on the speed, volume, and quality of data receipt. These characteristics, both internal to the organisation and external to its environment, form the basis for the development and adoption of management decisions. In this context, management science posits that blockchain technologies provide a framework for constructing an end-to-end process that enables secure and stable interaction among a large number of participants without the need to create an expensive and complex infrastructure. At the same time, the information arrays circulating within such a system are fully encrypted while remaining auditable. Moreover, they do not require the establishment of additional mechanisms or data duplication and control mechanisms within management systems by either the participants or the network initiator (Munir et al., 2022). Furthermore, blockchain technologies are based on a single ledger that is accessible to all participants involved in the interaction. Concurrently, the process of

knowledge and data sharing among parties is carried out through a distributed network that operates without a centralised administrative system (Aslam et al., 2021; Wang et al., 2022). Despite the public accessibility of a single distributed ledger, the data stored within it can be made available only to primary stakeholders, in the form and to the extent specified by a predefined set of rules governing the creation and operation of such a ledger, as determined by the network participants (Munir et al., 2022). The distributed ledger, which contains arrays of data throughout the entire period of its use, remains unaltered, and all interactions and transactions are recorded within it. As a result, all parties gain access to information relevant to their respective status. Consequently, unauthorised instances of data transfer and the storage of multiple versions of data within the registry are effectively prevented (Sizan et al., 2025). In contemporary business environments, a key determinant of organisational efficiency lies in simplifying and accelerating data exchange processes and optimising business operations, including through the use of smart contracts, the reduction of operational costs, increased labour productivity, improved teamwork efficiency, and the establishment of a robust information security framework. Management science suggests that the introduction of blockchain technologies positively affects organisational productivity and operational effectiveness, while also contributing to socio-economic growth and the overall development of a country's economic system (Shahzad et al., 2025a). For example, Aslam et al. (2021) demonstrated that the implementation of blockchain technologies improves supply chain management practices, thereby enhancing enterprise sustainability and productivity. We argue that the introduction of blockchain technologies facilitates improvements in supply chain interactions, resulting in increased organisational efficiency. Based on the above analysis of the level of research on this issue, the following hypothesis is proposed: H3: The introduction of blockchain technologies has a positive impact on the economic sustainability of the operational functioning of Russian industrial companies.

Firstly, this technology enhances the overall security of the organisation. An attacker who gains access to a single node of the network will be unable to perform meaningful actions, and it is extremely difficult to immediately compromise other nodes. This ensures the protection of critical business documents, allowing the company to redirect capital that was previously allocated to more expensive protection measures or to covering the costs of cyberattacks towards business development.

Secondly, the transparency and immutability of data stored on the blockchain can increase the trust of customers, partners, and regulatory authorities. This increased level of trust can contribute to an improvement in the company's reputation, resulting in positive capital inflows. However, this effect is achievable only if the company consistently records its activities on the blockchain.

Thirdly, these technologies enable the use of smart contracts, which are inaccessible to malicious actors. These contracts are permanently recorded on the blockchain, thereby significantly enhancing transaction security. As a result, the organisation can achieve a higher level of economic stability, while the costs associated with relying on extensive legal services can be substantially reduced.

Supply chain transparency and economic sustainability of the organisation

The effectiveness of implementing the principle of supply chain transparency in its contemporary context can be ensured only through comprehensive integration with other methods and solutions (Irfan et al., 2020). At the same time, mechanisms for ensuring transparency in supply chains under modern conditions have become an increasingly important factor in achieving and maintaining organisational efficiency (Wan et al., 2023). Numerous authors in previous studies have examined various aspects of applying supply chain transparency solutions. For example, Wang et al. (2023) clarified the role of supply chain transparency mechanisms in organising functional activities and ensuring compliance with time constraints for specific steps and operations within supply chains. In this context, the implementation of supply chain transparency solutions represents a critical factor in reducing risks related to inventory safety and improving the efficiency of distribution mechanisms within supply chains. The implementation of supply chain transparency mechanisms also contributes to establishing and strengthening an integrated structure of interaction among organisational departments, ranging from production and finance to supply chain management (Gupta et al., 2024). Furthermore, management science suggests that the introduction of transparency mechanisms in external supply chains enhances the efficiency of business processes involving supply chain partners, enabling improvements in identifying supply chain participants as primary data sources, such as information on the organisational hierarchy of participating firms, which supports classification and optimisation of supply efficiency (Gupta et al., 2024). Numerous studies, including those by Bajar et al. (2024), have underscored the critical importance of establishing effective knowledge exchange mechanisms among participants in modern supply chains. Such mechanisms are essential for ensuring transparency and can be achieved by increasing participants' awareness of all processes, characteristics, and patterns of supply chain functioning. This increased awareness supports the identification of more effective strategies for retaining existing customers or attracting new ones, strengthening relationships with sales channels, and analysing competitors' behaviour, thereby enhancing an organisation's competitive position.

Furthermore, contemporary practice demonstrates that the absence of supply chain transparency mechanisms often leads participants to increase production volumes and inventory levels in order to mitigate perceived risks. The analysis conducted by the authors of this study further indicates that solutions and mechanisms aimed at ensuring supply chain transparency in contemporary conditions have become a key factor in improving productivity, efficiency, and overall performance of Russian industrial companies. This, in turn, has encouraged owners and top managers to invest in expanding the application of these tools.

Concurrently, a well-structured set of mechanisms and solutions in the domain of supply chain management guarantees the stability of organisational processes under various circumstances (Mahar et al., 2025). In addition, sustainable and efficient supply chains represent a key element for both individual companies and a nation's overall economic growth (Irfan et al., 2020). Mahar et al. (2025) highlighted that efficient and effective processes aimed at improving supply chains have a pivotal impact on ensuring the sustainability of an organisation's operations. They also concluded that an effectively designed mechanism for data exchange between divisions within the same organisation, as well as among organisations participating in the supply chain, enables the formation of a comprehensive understanding of the organisation's characteristics and the functioning of its counterparties and partners. In the contemporary market economy, an efficient and transparent supply chain is a fundamental element in ensuring an organisation's economic sustainability. Conversely, its absence constitutes a primary factor contributing to customer loss and the potential exit of an organisation from the market.

Based on the aforementioned stage of analysis of the problem's degree of study, the following hypothesis is proposed:

H4: Transparency of supply chains has a positive impact on the economic sustainability of the functioning of Russian industrial companies.

Transparency in supply chains is essential for an organisation's economic sustainability for several reasons:

Enhanced customer satisfaction: The speed, accuracy, and transparency of delivery processes create a positive customer experience, fostering loyalty and driving revenue growth.

Cost reduction: Process optimisation, automation, and effective inventory management help minimise costs and increase profitability.

Resilience to crises: Companies with flexible and transparent supply chains are better equipped to withstand external shocks, such as pandemics, natural disasters, or political instability.
Compliance with societal and regulatory requirements: Environmental responsibility is becoming increasingly important, and companies that neglect these aspects risk losing consumer trust and facing legal challenges.
Long-term growth and development: Investments in technology and sustainable practices establish a foundation for business expansion and strengthening of global market positions.

Knowledge management and ensuring the organisation's economic sustainability

In contemporary management science, knowledge management is understood as a structured and integral component of an organisation's management system. This system facilitates a continuous process of developing, acquiring, transforming, implementing, and safeguarding information, drawing on both the tacit and explicit knowledge possessed by the organisation and its employees (Sartori et al., 2022). Numerous researchers have emphasised the importance of an organisation's ability to absorb and exchange information with both its internal and external environments in determining organisational success. Furthermore, the stability and efficiency of information exchange channels have been identified as potential drivers for enhancing organisational efficiency and achieving competitive advantages (Shahzad et al., 2024b).

In management science, under current conditions, the key factors that contribute to a substantial increase in the value and efficiency of an organisation's activities are those that foster and support the development of knowledge management mechanisms. These mechanisms include the organisational hierarchy, the availability of support for recognising the importance of knowledge management at the ownership and executive levels, organisational culture and values that emphasise the expansion of knowledge application within the company, employees' attitudes and behaviours that promote the creation and development of new and existing knowledge, a well-developed information technology infrastructure, a sufficient number of highly motivated employees capable of generating and refining knowledge, and an organisational structure that facilitates the creation and exchange of knowledge (Philsoophian et al., 2022; Boamah et al., 2022). Numerous studies, including Shahzad et al. (2024a), have highlighted the significant impact of establishing and developing knowledge management mechanisms within organisations on their effectiveness in implementing projects and programmes aligned with corporate social responsibility and sustainability. Although the primary focus of these studies was on organisations operating in Asian countries, the authors of this study argue that the same principle applies to Russian industrial companies. Previous research demonstrates that mechanisms and solutions effectively implemented within Russian industrial companies have a stable and positive impact on both the quantitative and qualitative characteristics of corporate social responsibility mechanisms, as well as on the development and implementation of innovative business processes that promote sustainability and environmental responsibility. Based on the analysis conducted at this stage, the following hypothesis is proposed:

H5. The development and implementation of mechanisms and solutions in the field of knowledge management have a positive impact on the economic sustainability of the functioning of Russian industrial companies.

Knowledge management and an organisation's economic sustainability are closely interconnected. Knowledge management enhances an enterprise's competitiveness, while economic sustainability is ensured through effective management practices. Knowledge management involves the systematic formation, updating, and application of knowledge to optimise organisational effectiveness, with the primary objective of creating new and more robust competitive advantages. Economic stability, in turn, is achieved through sound financial management, which mitigates financial risks and increases the efficiency of economic activities. Consequently, knowledge management contributes to organisational competitiveness, while effective financial management supports long-term economic sustainability.

Based on the analysis of the theoretical foundations of the variables selected for this study and the preceding review of the literature, the authors argue for the necessity of integrating knowledge management tools and blockchain technologies—specifically mechanisms aimed at enhancing supply chain transparency—into a unified set of management actions within the management system in order to achieve the objective of ensuring the economic sustainability of organisational activities. The validity of this perspective and its key aspects will be examined through further empirical research. Figure 1 presents the research framework developed in this study.

Based on the logic introduced in Figure 1 and the results of the review of previous literature described above, the research questions are formulated as follows:

Does the introduction of blockchain technologies enhance the efficiency of knowledge management, the transparency of supply chains, and the attainment of objectives that ensure the sustainability of economic growth and the development of organisations operating in the Russian industry?
How does the introduction of blockchain technologies, while contributing to increased transparency of supply chains, ensure the interconnection of mechanisms and solutions in the domain of knowledge management and the attainment of objectives that support the sustainability of economic growth and the development of organisations operating in the Russian industry?

Research Methodology

Data collection and selection

This study aims to investigate the impact of the development and implementation of mechanisms for integrating digital solutions into the domain of knowledge management, specifically blockchain technologies. This integration is intended to ensure the sustainability of economic growth and development for Russian industrial companies.

The study's focus is on Russian industrial companies whose activities are certified in accordance with both ISO and national GOST standards, and whose shares are listed on the Moscow Exchange. This selection is motivated by the fact that, in contemporary conditions, over 90% of the branches of the manufacturing industry in Russia serve as sources of entrepreneurial activity in general and make a substantial contribution to the country's Gross Domestic Product (GDP). According to the Russian Statistical Agency (Rosstat), the share of industry in GDP was 25.9% in 2023. Additionally, the manufacturing industries accounted for 65% of the total workforce in the economy.

Industrial companies from the transport, metallurgy, and oil and gas sectors were chosen as the primary subjects of the research due to their significant contribution to the Russian economy and its export potential. The analysis focused on companies with production facilities in Central Russia, the Volga region, Western and Eastern Siberia, and the Far East. The selection criteria included production profitability, economic stability, regional contribution to GDP, industry position, and digital maturity. The annual rating of Russian industry compiled by RA Expert for 2021–2024 served as the primary source of information. After the initial stage, a list of 900 Russian industrial companies in the specified sectors was created. In the subsequent stage, additional information on the level, depth, and pace of digital transformation of the selected companies was gathered. This information, together with a questionnaire compiled during the same stage, was sent to company heads. As a result, a final list of 700 companies was formed, representing the most digitally mature and transformed organisations in the transport, metallurgy, and oil and gas industries.

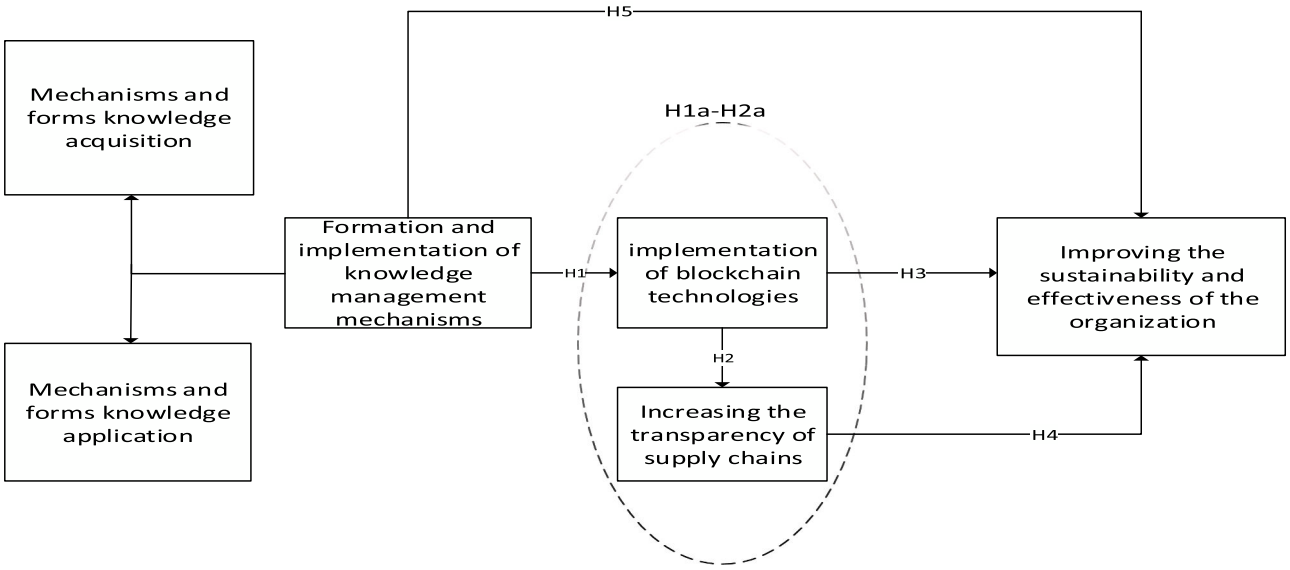

Figure 1. Research scheme of the study.

The data-collection process was conducted through a sociological survey of managers at all levels of Russian industrial companies. This survey utilised email and electronic messages to distribute questionnaires and obtain approval for participation. To collect data from the heads of various production organisations, both online and offline survey methods were employed. These organisations were asked to respond and provide their opinions on the effectiveness of the factors examined within their companies using a 5-point Likert scale ranging from 1 ('strongly disagree') to 5 ('strongly agree'). The primary participants in the survey were managers belonging to the category of department heads. In the context of this study, department heads were defined as managers with at least five employees under their supervision. During the survey, junior, middle, and senior managers of manufacturing organisations were invited to share their perspectives on the significance of implementing blockchain technologies and knowledge management mechanisms in the activities of their departments and the organisation as a whole. In addition, they were asked to explain how this approach contributes to the organisation's competitiveness and the environmental safety of its activities.

At the outset of the survey, the wording of the questions underwent rigorous lexical and stylistic checks. The most important aspect of any research study is the magnitude of the sample size. If the sample size is very large, it could result in inefficient use of resources by the researcher and the organisation, whereas if the sample size is small, it may not correctly represent the population under study. Therefore, it is very important to accurately estimate the sample size for the research under consideration. The factors associated with data required for the computation of sample size include:

(1) Magnitude of acceptable error (e) to provide the desired precision of measurement.
(2) Value associated with the desired confidence level (Z), which indicates the degree of confidence interval taken in the population mean. It is a percentage or decimal value that indicates how confident we can be in the research results.
(3) Variance, which is the estimator of the standard deviation of the population (σ). It indicates how heterogeneous the population is.

Thus, the desired sample size $n = (Z.\sigma/e)^2$

The sample size for the survey was determined based on the '1 to 10' rule, a commonly used statistical guideline that establishes the number of predictor variables that can be estimated based on data in regression analysis. This rule stipulates that for every 10 events, one predictive variable can be examined. In essence, this implies that one observation or label is required for each object. As a result of the survey, 293 fully completed questionnaires were received out of the 700 distributed to the heads of Russian industrial companies who had confirmed their participation. Consequently, the coverage rate reached 42%, which is sufficient to establish the representativeness of the study. Data relating to the primary demographic characteristics of the survey participants are presented in Table 1.

Formation of the analytical base of the study

The empirical data underpinning this study were meticulously selected based on an analysis of previous publications that met the criteria of adaptation to the characteristics of the objects under investigation. The collected data were subsequently categorised into four distinct subgroups. The first subgroup encompassed parameters that delineate the features of knowledge management methodologies

Table 1
Demographic characteristics of survey participants.

Characteristics of respondents	Numeric value	Percentage
Floor:		
Men	182	62,44
Women	111	37,56
Age:		
20–30 y old	86	29,40
31–40 y old	112	38,40
41–50 y old	85	22,20
More than 50 y	10	10
Education:		
Specialised secondary	40	13,70
Bachelor's	115	39,30
Master's	58	20
Specialist	80	27
Experience:		
Less than 5 y	50	17,10
5–10 y	97	33,22
More than 10 y	146	49,68
Job title		
Head of Department	50	17,12
Head of Department	90	30,72
Executive Director	110	43,00
General Director	43	9,16

Source: compiled by the authors

employed in the context of the digitalisation of industrial enterprise activities. These parameters were derived from the research conducted by Darroch (2005) and Wang et al. (2025). The second subgroup encompassed parameters that characterise the features of blockchain technology implementation in industrial enterprise activities and their supply chains. These parameters were derived from the analyses conducted by Clarinval et al. (2023) and Zhang et al. (2024). The parameters collected within the first two subgroups served as the foundation for the survey questionnaires, from which data were obtained from the respondents. This data-collection process enabled the authors to assess the applicability and effectiveness of blockchain technologies in the context of the digital transformation of production processes. The third subgroup encompassed parameters that characterise the current state and potential future development of supply chains for Russian industrial enterprises. These parameters were derived from the research conducted by Gosain et al. (2004) and Thornton et al. (2024). The primary objective of the parameters within this subgroup was to obtain data from respondents regarding the current level of transparency within the supply chains of Russian industrial enterprises. In addition, this data-collection process aimed to ascertain the impact of supply chain transparency on companies' efficiency and effectiveness. Furthermore, it sought to identify potential opportunities for utilising blockchain technologies and knowledge management methodologies to enhance supply chain transparency under contemporary conditions. The fourth subgroup encompassed parameters that delineated the principles governing the development and implementation of goals to ensure the economic viability of the organisation's activities. These parameters were derived from research conducted by Yousaf (2021) and Wang et al. (2025). The parameters aimed to elicit data from respondents regarding the methodologies employed in developing and implementing goals that ensure the economic sustainability of Russian industrial companies' activities. In addition, the parameters sought to identify the characteristics of the associated digital transformation of mechanisms designed to enhance companies' operational efficiency.

Data analysis

A primary analytical tool employed in this study is the resource-oriented approach proposed by J.B. Barney. The core tenet of this approach posits that an organisation can attain competitive advantages by enhancing its capacity to effectively utilise its available resources (Barney et al., 2011). Furthermore, the underlying principles of this approach suggest that an organisation can effectively execute its tasks of meeting the evolving requirements of its environment only if the requisite capabilities are readily available. Moreover, tangible, intangible, and asset-based capabilities, as well as capabilities inherent within an organisation, are largely non-transferable and constitute fundamental and defining components of a resource-centric approach (Riccio et al., 2024).

At the current stage of development of management science, the scope of research opportunities for the application of the resource-oriented approach has been significantly expanded through the incorporation of studies examining the potential of business analytics in achieving optimal performance. In addition, for organisations to attain their objectives of enhancing organisational efficiency, resources must possess inherent value, uniqueness, rarity, and irreplaceability (Andersén, 2023). Within management science, a prevailing view exists whereby individuals, based on their knowledge, skills, and abilities, demonstrate increasing interest in both information and business processes underpinned by these factors—specifically in strategic management, innovation management, and scientific research within these domains (Li et al., 2023; Sizan et al., 2025). Furthermore, the proliferation of innovation opportunities has consistently led to the steady accumulation of scientific and practical achievements of humanity over extended periods of time (Barney et al., 2011).

In contemporary organisational contexts, a pivotal direction in the advancement of management science and practice is the study and application of knowledge as a key factor in organisational effectiveness. This stream within management science is commonly referred to as the knowledge-oriented approach (Shahzad et al., 2024a). The knowledge-based approach constitutes an extension and enhancement of the resource-oriented approach (Shahzad et al., 2025a; Zkik et al., 2024). As a foundational theoretical postulate, it defines knowledge and establishes mechanisms for its analysis and implementation within management systems as a defining strategic asset or resource of the organisation. In this context, the knowledge-based approach represents a continuation of the resource-oriented approach in analysing organisational activities.

Furthermore, in contemporary organisational settings, relying solely on a resource-oriented approach when analysing an organisation's activities represents a limited perspective. By contrast, the simultaneous application of both resource-oriented and knowledge-based approaches enables the construction of a more comprehensive understanding of the resources, knowledge, and capabilities available to the organisation, thereby supporting the formation of a sustainable set of competitiveness factors that ensure the long-term effectiveness of its operations (Shahzad et al., 2024). Moreover, in the context of digitalisation, this combined analytical approach facilitates a more holistic assessment of both the external competitive environment and the organisational logic underlying the application of technological solutions within the domain of blockchain technologies, contributing to enhanced supply chain transparency and improved operational efficiency.

Given that the task outlined at the end of the preceding paragraph constitutes one of the core objectives of the empirical research presented in this study, it is essential to provide a comprehensive analysis of the degree of development in previous publications relating to the scientific direction of a unified theory of technology adoption and utilisation.

In contemporary conditions, the problem of forecasting the introduction and utilisation of technologies has emerged as a highly demanded area of analysis within management science. Zhang et al. (2024) introduced the concept of the unified theory of technology adoption and utilisation (UTAUT) for the adoption of novel technologies. This theory is constructed by integrating the key structural elements of existing models, ranging from human behaviour to computer science. The main factors influencing the intention to use information technology include expected productivity and effort, facilitating conditions, and social influence (Zhang et al., 2024). Despite the broad recognition of the initial version of the theory, its authors concluded that a process of modernisation was required. During this process, three additional factors were incorporated into the original four factors (Zhang et al., 2024): hedonic motivation, the ratio of the value created by the factor to its monetary cost, and habit. Compared with the initial version of the model, the inclusion of these additional factors, together with the new design methodologies proposed in the second version, resulted in a substantial improvement in the explanatory power of behavioural intention (from 56% to 74%) and technology utilisation (from 40% to 52%). At the same time, the application of the second version of the theory revealed a stronger and more consistent relationship between perceived usefulness of the technology and behavioural outcomes associated with its utilisation, surpassing the influence of perceived ease of use. Thus, perceived ease of use may act as a causal antecedent to perceived usefulness (Shahzad et al., 2025a).

The increasing trends in emissions of hazardous substances that pose risks to the environment and significantly contribute to climate change substantially hinder the achievement of sustainable economic development goals at the global level. Within management science, a prevailing view holds that an essential condition for achieving sustainable development goals is the expansion of domains for introducing environmentally friendly innovative technologies into the economy. At the same time, the implementation of this task largely depends on the effectiveness of policies aimed at developing, implementing, and monitoring the use of these technologies in the context of achieving the Sustainable

Development Goals at both global and national levels. At the current stage of development of management science, expanding the scope of blockchain technology implementation by enhancing management decision-making processes, as explained within the UTAUT framework, may serve as an effective tool for addressing this challenge (Shahzad et al., 2025a).

To analyse the collected data, partial least squares structural equation modelling (PLS-SEM), as recommended by Hair et al. (2023), was employed. PLS follows the general logic of structural equation modelling (SEM), and the integration of these approaches is referred to as PLS-SEM. PLS-SEM provides mechanisms for refining linear and multiple regression analysis. It consists of two main components. The first component involves the construction of the measurement model, also referred to as the external model. The second component involves the formulation of the structural model, known as the internal model. Subsequently, a cause-and-effect prediction mechanism is developed, allowing for the prioritisation of predictions when evaluating statistical models aimed at explaining causal relationships (Hair et al., 2023). The application of PLS-SEM enhances both the quality and scope of research across a wide range of fields. In addition, PLS-SEM is capable of analysing relatively small samples, employing formative and reflective constructs simultaneously (Liengaard et al., 2021). This makes it particularly suitable for the exploratory nature of blockchain technology and knowledge management adoption in the management systems of industrial companies in countries that are at an early stage of economic transformation in the context of digitalisation, such as Russia.

Based on the assessment standards of the two-stage approach proposed by Hair et al. (2023), the evaluation of the measurement model primarily includes reliability analysis, convergent validity analysis, and discriminant validity analysis. The assessment of the structural model mainly comprises covariance analysis, validity analysis, and path relationship analysis.

The subsequent PLS-SEM analysis was conducted using SmartPLS 4.0 software, which is widely applied for the theoretical verification of hypothesised models and comprehensive evaluation of research hypotheses. Initially, the measurement models of the three independent variables, the mediator variable, the moderator variable, and the dependent variable were constructed based on the relevant theoretical foundations and measurement items.

Subsequently, the structural model of this study was established based on the previously proposed hypothesised path relationships. The output of the PLS-SEM model, including both the measurement and structural models, is presented in Figure 2. The subsequent analysis of the model is primarily based on the PLS algorithm, bootstrapping, blindfolding, and IPMA analysis functions implemented in SmartPLS 4.0.

PLS-SEM is considered a soft modelling approach in which no strong assumptions regarding data distributions, sample size, or measurement scale are required. PLS-SEM follows SEM notations and symbols, including the use of a path diagram to illustrate the relationships among LVs (latent variables) and between each MV (measurement variable) and the corresponding LV.

A PLS-SEM model is composed of two elements: the outer model (also referred to as the measurement model), which describes the relationships between the MVs and their respective LVs, and the inner model (also referred to as the structural model), which describes the relationships among the LVs.

Structural equation models are schematically represented using specific configurations of three geometric symbols: circles, squares, and single-headed arrows. By convention, circles represent LVs, squares represent MVs, and single-headed arrows represent the influence of one variable on another. When constructing a model of a particular structure under investigation, researchers employ these symbols within the framework of four basic configurations, each representing an essential component of the analytical process (see Figure 2).

The Measurement Model

An LV is an unobservable variable (or construct) indirectly described by a block of observable variables q_i known as MVs. There are two ways to relate MVs to their LVs:

1 - Reflective (mode A)

2 - Formative (mode B)

The reflective (mode A)

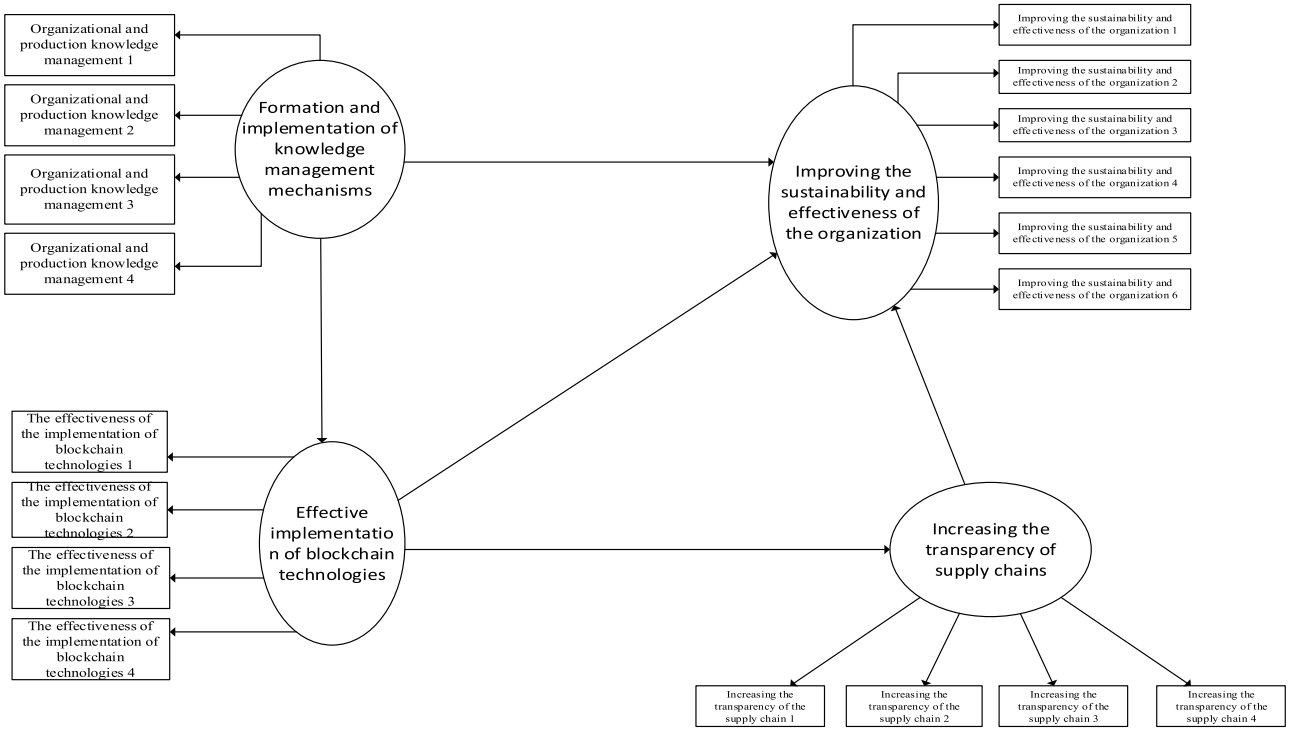

Figure 2. PLS-SEM model.

In the reflective way, each MV reflects the corresponding LV. A block is defined as reflective. This implies that the relationship between each MVq_i and the corresponding LV is modeled as:

$$q_i = \alpha_i \mathrm{LVR} + \varepsilon_i \quad (1)$$

Where α_i is the simple regression coefficient between MV and LV.

In this study, all algebraic formulas for the reflective (mode A) of the measured model are presented in Table 2.

Table 2
Algebraic formulas for the reflective (mode A) the measured model.

Latent Variables/ value in the formula	Measurement Variables	Formulas	References
Formation and implementation of knowledge management mechanisms E	Organisational and production knowledge management 1 Organisational and production knowledge management 2 Organisational and production knowledge management 3 Organisational and production knowledge management 4	$q_1 = \alpha_1 \mathrm{E} + \varepsilon_1$ $q_2 = \alpha_2 \mathrm{E} + \varepsilon_2$ $q_3 = \alpha_3 \mathrm{E} + \varepsilon_3$ $q_4 = \alpha_4 \mathrm{E} + \varepsilon_4$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
Effective implementation of blockchain technologies Y	The effectiveness of the implementation of blockchain technologies 1 The effectiveness of the implementation of blockchain technologies 2 The effectiveness of the implementation of blockchain technologies 3 The effectiveness of the implementation of blockchain technologies 4	$q_1 = \alpha_1 \mathrm{Y} + \varepsilon_1$ $q_2 = \alpha_2 \mathrm{Y} + \varepsilon_2$ $q_3 = \alpha_3 \mathrm{Y} + \varepsilon_3$ $q_4 = \alpha_4 \mathrm{Y} + \varepsilon_4$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
(Improving the sustainability and effectiveness of the organisation Θ	Improving the sustainability and effectiveness of the organisation 1 Improving the sustainability and effectiveness of the organisation 2 Improving the sustainability and effectiveness of the organisation 3 Improving the sustainability and effectiveness of the organisation 4 Improving the sustainability and effectiveness of the organisation 5 Improving the sustainability and effectiveness of the organisation 6	$q_1 = \alpha_1 \Theta + \varepsilon_1$ $q_2 = \alpha_2 \Theta + \varepsilon_2$ $q_3 = \alpha_3 \Theta + \varepsilon_3$ $q_4 = \alpha_4 \Theta + \varepsilon_4$ $q_5 = \alpha_5 \Theta + \varepsilon_5$ $q_6 = \alpha_6 \Theta + \varepsilon_6$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
(Increasing the transparency of supply chains Ξ	Increasing the transparency of the supply chain 1 Increasing the transparency of the supply chain 2 Increasing the transparency of the supply chain 3 Increasing the transparency of the supply chain 4	$q_1 = \alpha_1 \Xi + \varepsilon_1$ $q_2 = \alpha_2 \Xi + \varepsilon_2$ $q_3 = \alpha_3 \Xi + \varepsilon_3$ $q_4 = \alpha_4 \Xi + \varepsilon_4$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)

The formative (mode B)

In the formative, the LV is supposed to be generated by its own MVs:

$$\mathrm{LVR} = \Sigma_{i=1}^{N} \alpha_i q_i + \varepsilon \quad (2)$$

Where is α_i the simple regression coefficient between the MV and LV and N is the number of MVs in the block of latent variables.

In this study, all algebraic formulas for the formative (mode B) of the measured model are presented in Table 3.

The Structural Model

The structural model, or inner model, specifies the relationships between the LVs. If an LV is assumed to depend on other LVs, it is referred to as dependent; otherwise, it is considered independent. In the structural model, each independent LV is linked to the other LVs through the following multiple regression model. For our model, the regression relations are:

$$LVR_1 = \beta_0 + \beta_1 LVR_2 + \beta_2 LVR_4 + \beta_3 LVR_3 + \varepsilon \quad (3)$$

$$LVR_4 = \beta_5 LVR_3 + \varepsilon \quad (4)$$

Where is β_i the path coefficients, LVR_1 is LV (Formation and implementation of knowledge management mechanisms), LVR_2 is LV (Effective implementation of blockchain technologies), LVR_3 is LV (Improving the sustainability and effectiveness of the organisation), LVR_4 is LV (Increasing the transparency of supply chains).

Results

Analysing the Measurement Model

To ensure the suitability of the measurement instrument, the reliability and validity of the measurements are first assessed. Reliability quantifies the consistency of the results obtained using the instrument, while validity reflects the reliability of indicators and variables within a specific construct. The initial step in evaluating the measurement model involves assessing the internal consistency of the factors. This is achieved by calculating Cronbach's alpha (α), composite reliability (CR), the reliability coefficient rhoA, and the average variance extracted (AVE). These measures are presented in Table 4.

Table 2 presents the results of the internal consistency evaluation. The values of the standardised coefficients in the external model exceed the threshold value of 0.70 (Hair et al., 2023). Furthermore, the values of Cronbach's alpha for all constructs exceed the threshold value, indicating the reliability and convergence of the measurement approach used in this study. Table 2 presents the primary indicators evaluated to assess the internal consistency of the measurement model.

Discriminant Validity Assessment

As previously mentioned, the obtained factors have Cronbach's alpha and composite reliability (CR) values exceeding 0.7, which indicates a high level of reliability of the indicators. To distinguish between the analysed factors, two methods for testing discriminant validity were employed: the Heterotrait–Monotrait (HTMT) ratio and the Fornell–Larker test.

Table 3 presents the results of the analysis of the discriminant validity of the studied indicators based on the Fornell–Larcker criterion (Fornell & Larcker, 1981). This method, as demonstrated by the authors' preliminary analysis conducted prior to the study, is a widely used technique for evaluating the discriminant validity of constructs within structural equation models. The rationale underlying this criterion is that the average variance extracted by the indicators of a construct must exceed the squared correlation between that construct and other

Table 3
Algebraic formulas for the formative (mode B) the measured model.

Latent Variables/ value in the formula	Measurement Variables	Formulas	References
Formation and implementation of knowledge management mechanisms E	Organisational and production knowledge management 1 Organisational and production knowledge management 2 Organisational and production knowledge management 3 Organisational and production knowledge management 4	$E = \Sigma_{i=1}^{N=1}\alpha_1 q_1 + \varepsilon$ $E = \Sigma_{i=1}^{N=2}\alpha_2 q_2 + \varepsilon$ $E = \Sigma_{i=1}^{N=3}\alpha_3 q_3 + \varepsilon$ $E = \Sigma_{i=1}^{N=4}\alpha_4 q_4 + \varepsilon$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
Effective implementation of blockchain technologies Y	The effectiveness of the implementation of blockchain technologies 1 The effectiveness of the implementation of blockchain technologies 2 The effectiveness of the implementation of blockchain technologies 3 The effectiveness of the implementation of blockchain technologies 4	$Y = \Sigma_{i=1}^{N=1}\alpha_1 q_1 + \varepsilon$ $Y = \Sigma_{i=1}^{N=2}\alpha_2 q_2 + \varepsilon$ $Y = \Sigma_{i=1}^{N=3}\alpha_3 q_3 + \varepsilon$ $Y = \Sigma_{i=1}^{N=4}\alpha_4 q_4 + \varepsilon$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
(Improving the sustainability and effectiveness of the organisation Θ	Improving the sustainability and effectiveness of the organisation 1 Improving the sustainability and effectiveness of the organisation 2 Improving the sustainability and effectiveness of the organisation 3 Improving the sustainability and effectiveness of the organisation 4 Improving the sustainability and effectiveness of the organisation 5 Improving the sustainability and effectiveness of the organisation 6	$\Theta = \Sigma_{i=1}^{N=1}\alpha_1 q_1 + \varepsilon$ $\Theta = \Sigma_{i=1}^{N=2}\alpha_2 q_2 + \varepsilon$ $\Theta = \Sigma_{i=1}^{N=3}\alpha_3 q_3 + \varepsilon$ $\Theta = \Sigma_{i=1}^{N=4}\alpha_4 q_4 + \varepsilon$ $\Theta = \Sigma_{i=1}^{N=5}\alpha_5 q_5 + \varepsilon$ $\Theta = \Sigma_{i=1}^{N=6}\alpha_6 q_6 + \varepsilon$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)
(Increasing the transparency of supply chains Ξ	Increasing the transparency of the supply chain 1 Increasing the transparency of the supply chain 2 Increasing the transparency of the supply chain 3 Increasing the transparency of the supply chain 4	$\Xi = \Sigma_{i=1}^{N=1}\alpha_1 q_1 + \varepsilon$ $\Xi = \Sigma_{i=1}^{N=2}\alpha_2 q_2 + \varepsilon$ $\Xi = \Sigma_{i=1}^{N=3}\alpha_3 q_3 + \varepsilon$ $\Xi = \Sigma_{i=1}^{N=4}\alpha_4 q_4 + \varepsilon$	Hair et al. (2023), Liengaard et al. (2021) Shahzad et al. (2025a)

constructs. The selection of this criterion for assessing discriminant validity in the present study is attributed to its simplicity and clarity. The results presented in Table 5 indicate that the square root of the average variance extracted for all studied constructs was higher than the corresponding squared correlations with other variables. Consequently, the presence of discriminant validity for the model can be confirmed.

Based on the methodological guidance presented by Henseler et al. (2015), the HTMT correlation coefficient was calculated. As previously noted, this represents the second tool employed to assess the discriminant validity of the model constructed within the framework of this study. Hair et al. (2023) and Henseler et al. (2015) indicated that the HTMT criterion is calculated by dividing the average correlation coefficient between indicators of different constructs (heterotrait) by the average correlation coefficient between indicators of the same construct (monotrait). Ideally, the HTMT value should fall below a predetermined threshold, typically 0.85 or 0.90, which indicates adequate discriminant validity. Conversely, a value exceeding 0.90 suggests insufficient discriminant validity. Table 6 presents the HTMT criterion values for all evaluated indicators, which comply with the aforementioned thresholds. The data analysis demonstrates that the model developed in this study exhibits adequate discriminant validity.

Assessment of the general methodological error

Given that the same analytical method is applied to multiple variables in this study, it was deemed necessary to employ a method to detect the presence of common method bias in the model constructed within the framework of this research. For this purpose, the univariate Harman test was utilised. The results indicated that a single factor in the constructed model accounted for approximately 27.07% of the variance, which is below the threshold of 40%. This finding suggests the absence of common method bias in the constructed model (Babin et al., 2016). Furthermore, based on the research conducted by Kock (2015), a collinearity analysis was performed to assess the linear relationships among the explanatory variables. This analysis involved the calculation of the variance inflation factor (VIF), which measures the extent to which the variance of the estimated regression coefficient is 'inflated' due to correlations among predictor variables in the model. The results presented in Table 5 indicate that the highest inner VIF value was 2.789, which is below the threshold value of 4. This result further supports the earlier conclusion, based on the Harman test, that the model constructed within the framework of this study is free from common method bias. To further enhance the robustness of the assessment of common method bias, as recommended by Bagozzi and Yi (1990), a correlation matrix was constructed to identify the potential presence of such bias. This matrix was analysed under the assumption that common method bias would be indicated by excessively high correlations between the main constructs (i.e., $r > 0.90$). Table 7 demonstrates the absence of such high correlation coefficients among the latent constructs, thereby confirming the absence of common method bias in the model developed in this study.

Analysis of the structural model

To evaluate the hypotheses derived from the structural model analysis, structural equation modelling (SEM) was employed. Initially, the values of the coefficient of determination (R^2), which quantifies the model's explanatory power, and the coefficient of predictive relevance (Q^2), as determined within the framework of the study, were assessed. Subsequently, the bootstrapping procedure (using 5,000 resamples) was applied to test the statistical significance of the hypotheses. The results are presented in Table 8 and Figure 3.

The findings of the regression analysis corroborate the initial hypotheses regarding the significant positive impact of implementing organisational and production knowledge management mechanisms on the effectiveness of blockchain technology utilisation (H1, $\beta = 0.471$), as well as the impact of introducing organisational and production knowledge management mechanisms on enhancing supply chain transparency (H5, $\beta = 0.273$). Furthermore, the impact coefficients for the effectiveness of blockchain technology implementation in improving supply chain transparency (H2, $\beta = 0.245$) and for the role of blockchain technology implementation in enhancing organisational economic sustainability (H3, $\beta = 0.178$) were also positive and statistically significant. Finally, the impact of enhanced supply chain visibility on

Table 4
Assessment of internal consistency of core indicators.

Indicator name	The importance of the factor	Cronbach coefficient alpha	Reliability factor rho_A	CR Composite Reliability	Extracted average variance
Efficiency of blockchain technology implementation	0,799 0,803 0,820 0,827	0,825	0,840	0,876	0,658
Organisational and Operational Knowledge Management	0,800 0,814 0,807 0,829	0,833	0,838	0,881	0,672
Improving the organisation's economic sustainability	0,805 0,816 0,805 0,849 0,868 0,835	0,909	0,914	0,929	0,699
Increase supply chain visibility	0,858 0,902 0,832 0,884	0,899	0,956	0,924	0,759

Source: compiled by the authors

Table 5
Results of the analysis of the discriminant validity of the studied indicators (based on the Fornell–Larker criterion).

Name of the indicator	Efficiency of blockchain technology implementation	Organisational and Operational Knowledge Management	Improving the organisation's economic sustainability	Increase supply chain visibility
Efficiency of blockchain technology implementation	0,815			
Organisational and Operational Knowledge Management	0,468	0,805		
Improving the organisation's economic sustainability	0,359	0,417	0,827	
Increase supply chain visibility	0,239	0,231	0,311	0,862

Source: compiled by the authors

Table 6
Results of the analysis of the studied indicators' discriminant validity (based on the HTMT criterion).

Name of the indicator	Efficiency of blockchain technology implementation	Organisational and operational knowledge management	Improving the organisation's economic sustainability	Increase supply chain visibility
Efficiency of blockchain technology implementation				
Organisational and operational knowledge management	0,538			
Improving the organisation's economic sustainability	0,397	0,449		
Increase supply chain visibility	0,228	0,241	0,325	

Source: compiled by the authors

improving an organisation's economic resilience (H4, $\beta = 0.200$) was likewise positive and statistically significant.

In addition, the coefficient of determination R^2 in the structural model constructed in this study yielded values of 0.221 for the efficiency of blockchain technology utilisation, 0.055 for supply chain transparency enhancement, and 0.243 for organisational economic sustainability. The subsequent step involved assessing the Q^2 coefficient, which quantifies the level of predictive relevance of the structural model. This assessment was guided by the approach proposed by Stone (1974).

As a result of the analysis, the Q^2 predictive relevance coefficient of the structural model constructed in this study yielded values of 0.143 for blockchain technology utilisation, 0.028 for supply chain transparency enhancement, and 0.166 for organisational economic sustainability. These findings indicate that, since the constructed structural model exhibits Q^2 values greater than zero, it can be characterised by the presence of a high level of predictive relevance for the endogenous constructs.

Mediation test

A primary objective of this study was to investigate the intermediary role of the effectiveness of blockchain technology utilisation and the enhancement of supply chain transparency in the development of knowledge management mechanisms and the subsequent improvement of organisational economic sustainability. To address this objective, the type of mediation was examined. Within the framework of the constructed model, a series of analyses was conducted using the bootstrapping approach, drawing on the methodological developments presented by Hair et al. (2023).

In the initial phase of the study, the indirect effect of organisational and production knowledge management practices on enhancing organisational economic sustainability through the adoption of blockchain technologies and the improvement of supply chain transparency was assessed. The results revealed a significant indirect effect of the implementation of knowledge management mechanisms ($\beta = 0.079$) and blockchain technologies ($\beta = 0.040$) on improving organisational

Table 7
Results of the analysis of the discriminant validity of the studied indicators (based on the method of assessing the bias of the general method).

Name of the indicator	Efficiency of blockchain technology implementation	Organisational and operational knowledge management	Improving the organisation's economic sustainability	Increase supply chain visibility	Variance inflation rate (VIF)
Efficiency of blockchain technology implementation 1	0,808	0,316	0,247	0,163	1,998
Efficiency of blockchain technology implementation 2	0,799	0,381	0,323	0,209	1,763
Efficiency of blockchain technologies implementation 3	0,817	0,486	0,354	0,218	1,659
Efficiency of blockchain technologies implementation 4	0,820	0,335	0,231	0,173	2,164
Organisational and operational knowledge management 1	0,363	0,805	0,299	0,207	1,921
Organisational and operational knowledge management 2	0,423	0,826	0,320	0,210	1,919
Organisational and operational knowledge management 3	0,328	0,816	0,376	0,203	1,946
Organisational and operational knowledge management 4	0,445	0,831	0,362	0,155	1,899
Improving the organisation's economic sustainability 1	0,268	0,249	0,801	0,227	2,384
Improving the organisation's economic sustainability 2	0,246	0,275	0,819	0,220	2,443
Improving the organisation's economic sustainability 3	0,366	0,396	0,800	0,270	2,124
Improving the organisation's economic sustainability 4	0,300	0,349	0,848	0,295	2,624
Improving the organisation's economic sustainability 5	0,355	0,387	0,869	0,311	2,843
Improving the organisation's economic sustainability 6	0,274	0,364	0,830	0,237	2,555
Improve supply chain visibility 1	0,218	0,186	0,254	0,862	2,451
Improving supply chain visibility 2	0,296	0,312	0,339	0,899	2,524
Improving supply chain visibility 3	0,064	0,105	0,155	0,829	2,693
Improving supply chain visibility 4	0,156	0,138	0,294	0,885	2,890

Source: compiled by the authors

Table 8
Results of hypothesis testing.

Hypothesis	Initial value (β)	Standard deviation	T is Student's coefficient	p-value (significance level)	Result
The impact of the efficiency of blockchain technologies on increasing an organisation's economic sustainability	0,178	0,054	3,052	0,001	Confirmed
The impact of blockchain implementation efficiency on increasing supply chain transparency	0,245	0,052	3,851	0,000	Confirmed
The impact of the implementation of organisational and production knowledge management Mechanisms on the efficiency of the use of blockchain technologies	0,471	0,043	9,496	0,000	Confirmed
The impact of organisational and operational knowledge management on improving supply chain visibility	0,273	0,057	4,335	0,000	Confirmed
The impact of improving supply chain visibility on improving an organisation's economic sustainability	0,200	0,039	3,632	0,000	Confirmed

Source: compiled by the authors

economic sustainability.

In the subsequent phase, the direct effects were evaluated. The analysis identified a significant positive effect of the implementation of knowledge management mechanisms ($\beta = 0.274$) and blockchain technologies ($\beta = 0.173$) on enhancing organisational economic sustainability.

The analysis presented in Table 9 demonstrates the presence of partial mediation among the investigated constructs. These findings confirm the existence of indirect effects ($p1 \times p2 \times p3$) and indicate that the adoption of blockchain technologies and the enhancement of supply chain transparency function as complementary partial mediators. This implies a substantial intermediary role in the development of knowledge management mechanisms and the subsequent enhancement of organisational economic sustainability, thereby supporting the initial hypotheses (H1a–H2a).

Importance and Performance Map Analysis

Importance–performance map analysis (IPMA) is a systematic analytical framework within structural equation modelling (SEM) that visually represents the disparity between variables' importance and their overall performance. It extends standard path coefficient estimates to enhance diagnostic accuracy. The primary objective of this analytical framework is to identify which antecedent factors demonstrate high overall performance despite low importance, and vice versa (Hair et al., 2023). This analysis allowed us to postulate that enhancing an organisation's economic sustainability represents a dependency structure

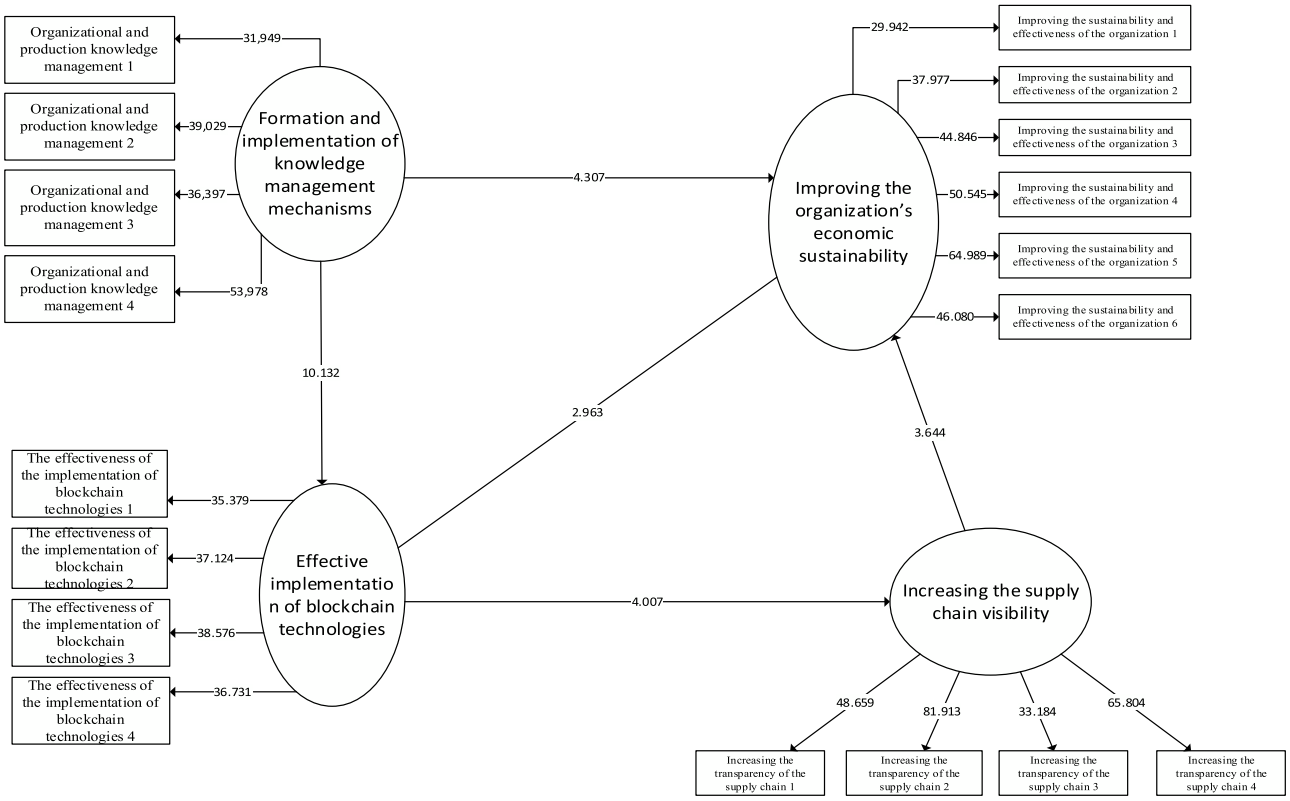

Figure 3. Analysis of the structural model.

based on three antecedent factors: knowledge management, blockchain technology implementation, and increased supply chain transparency.

Figure 4 illustrates that the importance value of knowledge management is 0.472, while its performance value is 70.578. Similarly, the importance of blockchain adoption is 0.234, with a performance value of 69.984. Finally, the importance value of improving supply chain visibility is 0.173, and its performance value is 62.421.

The regression analysis results indicate that, when evaluating the relationship between the implementation of knowledge management mechanisms and blockchain technologies, as well as the enhancement of supply chain transparency through these technologies and targeted approaches, the implementation of knowledge management mechanisms exhibits greater importance and overall effectiveness. Furthermore, when other factors remain constant, an increase in the overall efficiency of knowledge management mechanism implementation within a specific department results in a corresponding increase in the organisation's overall efficiency by 0.474 units. Consequently, this analysis supports the assertion that, in contemporary industrial conditions, Russian enterprises should prioritise the implementation of knowledge management mechanisms, alongside the introduction of blockchain technologies and the enhancement of supply chain transparency based on these technologies. This is because the overall performance indicators associated with knowledge management mechanism implementation exceed the corresponding indicators of the other factors examined in this study.

Degree of Compliance (GoF)

The primary methods for evaluating a model's explanatory power are the coefficient of determination (R^2) and the degree of goodness of fit (GoF). These measures indicate whether the model is 'economical and plausible' (Henseler et al., 2015). To assess the degree of conformity (GoF), this study employs the analytical approach proposed by Tenenhaus et al. (2005).

The standardised root mean square residual (SRMR) is a measure of absolute fit that quantifies the overall discrepancy between the model's predicted covariance matrix and the observed data. It is calculated by taking the square root of the mean of the squared standardised residuals. Standardised residuals are obtained by dividing the differences between observed and predicted covariances by the estimated standard errors.

The SRMR value ranges from 0 to 1, with lower values indicating a better model fit. The formula for assessing the degree of GoF is expressed as $GoF = \sqrt{[AVE \times R^2]}$, calculated as the square root of the product of the average variance extracted (AVE) and the coefficient of determination R^2.

The threshold values for assessing the GoF are 0.10 for a low level, 0.25 for a medium level, and 0.36 for a high level of model fit, respectively (Wetzels et al., 2009).

In accordance with the SRMR calculation method and the GoF formula described above, these coefficients were calculated, and the results are presented in Table 10.

As shown in Table 10, the GoF value is 0.349, indicating a moderate level of model fit. In addition, the SRMR value is 0.056, which is below the threshold value of 0.080, suggesting satisfactory overall fit and internal consistency of the proposed research model (Hair et al., 2022).

The findings presented herein corroborate our hypotheses, substantiating the existence of stable correlations between the introduction of blockchain technologies and knowledge management mechanisms and the enhanced efficiency of management systems within Russian industrial enterprises. Furthermore, these enterprises have experienced increased transparency within their supply chains, which represents a pivotal factor in establishing and sustaining the effectiveness of industrial organisations, both domestically and internationally. Our research reveals substantial progress made by Russian industrial companies in adopting blockchain technologies and knowledge management mechanisms within the framework of digital transformation. This progress has resulted in the development of more resilient management systems and increased transparency within their supply chains. By comparing the performance of the organisations included in our research, we identified

Table 9
Results of the mediation test.

Factors	Initial Value (O)	Standard deviation	T is Student's coefficient	p-value (significance level)
Impact of blockchain implementation efficiency > addressing organisational sustainability challenges	0,046	0,014	2,607	0,005
The impact of the implementation of organisational and production knowledge management mechanisms > Solving problems in ensuring the organisation's economic sustainability	0,109	0,028	3,317	0,001
Impact of organisational and manufacturing knowledge management Implementation > increased supply chain visibility	0,114	0,030	3,187	0,001
Impact of the implementation of organisational and production knowledge management mechanisms > Impact of the effectiveness of blockchain technologies' implementation > Solving problems in ensuring the organisation's economic sustainability	0,085	0,025	2,734	0,004
Impact of implementing organisational and operational knowledge management mechanisms > Increasing supply chain visibility > Meeting organisational sustainability challenges	0,042	0,013	2,604	0,006
Impact of organisational and manufacturing knowledge management implementation > Impact of blockchain adoption efficiency > Increased supply chain visibility > Addressing organisational sustainability challenges	0,018	0,007	2,466	0,009
Impact of the implementation of organisational and production knowledge management mechanisms > Impact of the effectiveness of blockchain technologies' implementation > Increased transparency of the supply chain	0,111	0,029	3,183	0,001

Source: compiled by the authors

leaders that have successfully integrated an optimal combination of blockchain technologies and knowledge management mechanisms into their digital transformation initiatives. Specific cases will be discussed in greater detail below. In addition, we posit that the coordinated implementation of blockchain technologies and knowledge management mechanisms, as part of the development of management systems and enhanced supply chain transparency, optimises risks and improves the quality of corporate governance within Russian industrial companies. The data collected further support our assumption that the introduction of these technologies and methodologies into management systems expands data analysis capabilities, enhances forecasting accuracy, and facilitates more informed management decisions. This finding is consistent with the results reported in the international management literature. Moreover, our data suggest that the effectiveness and efficiency of using blockchain technologies and knowledge management methods, as key components of digital transformation, management system development, and supply chain transparency, are significantly influenced by the specific activities and size of an industrial company. This conclusion is relevant for both Russian and international industrial enterprises.

Discussion

The results of the analysis, described in detail in the preceding section, demonstrate the primary incentive for developing and implementing mechanisms for integrating digital solutions into the field of knowledge management by Russian industrial companies. This incentive lies in the recognition that, under contemporary conditions, the key to enhancing economic sustainability is embedded in the organisational structure of elements that, on the one hand, enable the optimal utilisation of both tacit and explicit knowledge and, on the other, establish conditions for maximising the actions of owners and top managers in expanding the volume of available knowledge in accordance with the logic and requirements of the company's development. Furthermore, the analysis indicates that, in contemporary conditions, digital knowledge management mechanisms are emerging as a pivotal management approach that ensures increased supply chain transparency and guarantees the economic sustainability of Russian industrial companies' operations.

The empirical findings of this study corroborate the assumptions articulated in the hypotheses proposed, namely that the development and implementation of knowledge management mechanisms within the digitalisation of socio-economic relations constitute key factors ensuring the effective implementation of blockchain technologies within management systems, on the one hand, and the integration of blockchain technologies with mechanisms for ensuring the economic sustainability of organisational functioning, on the other. As previously noted, the empirical results substantiated the hypotheses concerning the significant positive impact of implementing organisational and production knowledge management mechanisms on the effectiveness of blockchain technology utilisation (H1, $\beta = 0.471$) and on enhancing supply chain transparency (H5, $\beta = 0.273$), respectively. These findings are consistent with previous research conducted by Geng et al. (2021), Sizan et al. (2025), Shahzad et al. (2024a; 2024b), Zhang et al. (2024), and Shahzad et al. (2025a; 2025b). Moreover, prior studies have primarily focused on

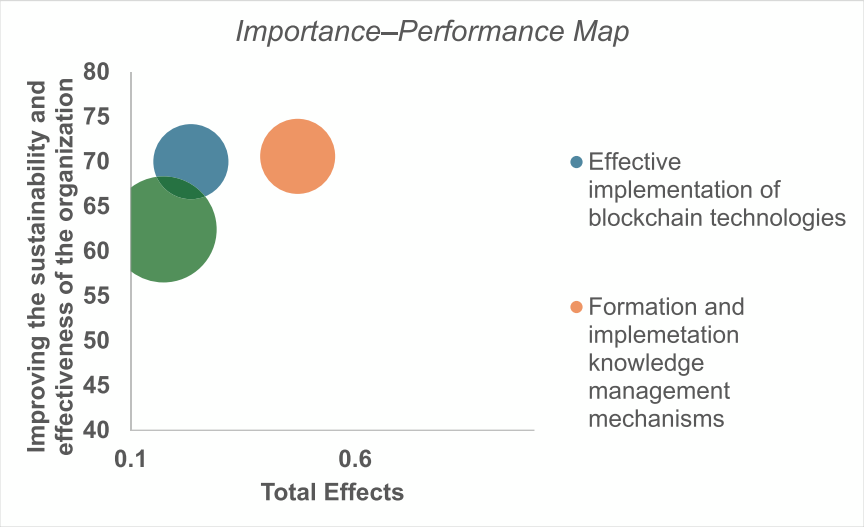

Figure 4. Importance and Performance Map Analysis.

the integration of digital solutions in the domain of knowledge management and blockchain technologies to ensure the economic sustainability of organisational functioning and development across various sectors and countries. The results obtained in this study align with these findings and indicate a convergence between Russian trends in this area and global developments.

The assessment of the impact of blockchain technology implementation effectiveness on enhancing supply chain transparency (H2, $\beta = 0.245$) and organisational economic sustainability (H3, $\beta = 0.178$) revealed positive and statistically significant relationships. In addition, the impact of improved supply chain visibility on enhancing organisational economic sustainability (H4, $\beta = 0.200$) was also positive and statistically significant. These findings are consistent with data reported in previous studies by Li et al. (2023) and Wang et al. (2023). The introduction and application of blockchain technologies in the production and sale of industrial and other product categories facilitate the tracking of goods throughout the supply chain, enabling both sellers and consumers to directly verify product origin and authenticity. From the perspective of business transparency, a notable advantage of this area of digital transformation is that virtually any participant in the blockchain network can, with appropriate equipment and software, obtain access to up-to-date accounting information. This accessibility supports the development of effective mechanisms for real-time tracking and analysis of supply chain processes. At the same time, concerns related to data security and protection are addressed through a fundamental element of blockchain technology, namely the distributed ledger, which provides each participant with control over a specific segment of the information flow.

Table 10
Results of the degree of conformity assessment (GoF).

Factors	Extracted Mean Dispersion (AVE)	Coefficient of determination R^2
Implementation of organisational and production knowledge management mechanisms	0,678	-
Implementation of blockchain technologies	0,669	0,228
Solving problems in ensuring the organisation's economic stability	0,697	0,244
Increase supply chain visibility	0,764	0,055
Medium	0,698	0,176
AVE* R2	0,126	-
GoF = $\sqrt{(AVE \times R^2)}$	0,355	-

Source: compiled by the authors

During the study, several noteworthy examples of the use of blockchain technologies and knowledge management mechanisms within Russian industrial companies were identified. For example, in March 2018, Surgutneftegaz, the United Metallurgical Company (UMK), and Russian Railways launched a pilot project based on blockchain technology. This project applied blockchain technology to the supply chain process of Surgutneftegaz, involving the procurement of metal pipes from the Vyksa Metallurgical Plant, a subsidiary of UMK. A blockchain-based audit log was introduced to record the entire process, including shipment from the factory, transportation, acceptance of goods, and verification of defect status. In the event of defects, the defective goods were returned. Russian Railways was responsible for transporting the pipes from the manufacturer to the customer. The primary function of blockchain in this project was to store all transactional data related to the process in a cloud-based system. The manufacturer indicated in the cloud that the goods were ready for shipment, while Russian Railways recorded the goods as being in transit. Upon delivery to Surgutneftegaz, the company recorded receipt of the goods. If a defect was detected, a corresponding entry was made in the blockchain cloud, enabling the return of the pipes to the manufacturer. Product certificates were also stored in the cloud, allowing all participants access to transaction records. Access to the cloud was available from any device. In this context, blockchain addressed the challenge of auditing and controlling counterfeit goods, as information relating to operations performed on a specific pipe at the levels of Surgutneftegaz, suppliers, and logistics providers could be disclosed at any time.

Such solutions are considered limited blockchain technologies and are often referred to in the literature as 'quasi-blockchain' systems (Lipnitsky, 2019). In quasi-blockchain systems, algorithms designed to enhance data reliability are generally absent. As a result, quasi-blockchain functions primarily as an applied business tool rather than as a driver for the further technological evolution of blockchain. Trust in the contents of the ledger in such systems continues to depend on trust in the ledger custodian. However, the ability of participants to audit each other enhances confidence among counterparties. These partially scalable systems have become increasingly affordable for industrial applications. For example, from July 2020, Russia planned to introduce mandatory labelling of medicines. However, due to the circumstances associated with the COVID-19 pandemic and the resulting surge in demand for medicines, pharmaceutical market participants

were unable to prepare for the new requirements, and the implementation of mandatory labelling was postponed until 1 January 2021.[1] A mechanism for tracking medicines from the manufacturer to the consumer is also currently being implemented using quasi-blockchain technology. Consequently, any participant in the pharmaceutical market, from the manufacturer to the consumer, can verify the authenticity of a drug. With the aid of a QR code placed on the packaging, it has become possible to easily trace the entire path of the medicine. Some researchers argue that supply chain tracking should begin at the stage of raw material acceptance by a pharmaceutical plant. However, identifying suppliers in this case represents a trade secret that not all companies are willing to disclose publicly. This issue can be addressed by creating either a separate blockchain-based supply chain for raw material suppliers or an exclusive blockchain framework in which access to data is restricted (for example, by publishing only information about the country of origin of imported raw materials).

Since 2017, MMC Norilsk Nickel has been actively implementing blockchain technologies in its operations. For example, in 2019, the company established a Competence Centre to conduct research and train specialists in the development of digital technologies for the mining industry. The centre's primary objective is to create digital ecosystems and develop effective practices for using information technologies in the areas of blockchain, the Internet of Things, and optimisation systems.

In January 2021, MMC Norilsk Nickel joined the Responsible Sourcing Blockchain Network (RSBN), an international blockchain network that facilitates the procurement and sale of minerals and their by-products. Blockchain technologies enable a responsible approach to procurement and support responsible production throughout the mining process, from extraction to the sale of finished products. In October 2022, MMC Norilsk Nickel conducted a test of a water-based 'environmental drone'. Equipped with additional devices, the drone is capable of recording various indicators, while data transmission and storage are decentralised using blockchain technology.

While blockchain technologies and knowledge management mechanisms have been implemented in certain areas, many other domains remain under development and await pilot projects within Russian manufacturing enterprises. To stimulate the adoption of digital technologies in Russian industrial companies, national standards are currently being developed. In 2021, a new national standard in the 'Numerical Modelling' series, GOST R 57700.37-2021 'Computer Models and Modelling. Digital Twins of Products. General Provisions', was approved by an order of Rosstandart.

During this research, the authors identified multiple scenarios for the effective application of blockchain technologies within Russian oil companies. Russia has more than 175,000 oil wells, approximately 150,000 of which are production wells. Only about 3% of these wells are currently connected to information systems. One such scenario involves the detection of malfunctions followed by the manual entry of all accounting values into a computer system.

Given the need to improve the quality and efficiency of decision-making processes, minimising the human factor and focusing on the use of digital decision-making technologies is essential. Approximately 40 intellectual property (IP) fields exist in the country, accounting for 27% of total national oil production, equivalent to around 140 million tonnes.

In early 2018, Gazprom Neft PJSC and Gazpromneft-Snabzhenie LLC initiated a pilot project based on blockchain technology. This technology facilitates secure data storage and enables the automation of various processes, including

- Supplier settlements;
- Quality monitoring;
- Object permit issuance.

Currently, Gazpromneft PJSC is engaged in developing a blockchain platform aimed at establishing a supplier rating system within the oil and gas industry. This initiative seeks to streamline the procurement process and enhance its operational efficiency. Gazpromneft and VK (formerly Mail.Ru Group) are also collaborating on the creation of a comprehensive business management system that will facilitate unified online regulation of the production, sale, and delivery of products from Gazpromneft's global production assets. In addition, a mechanism for expedited mutual settlements at gas stations using blockchain technology is being conceptualised.

The culmination of these collaborative efforts will result in prototypes of contemporary sales processes equipped with the capability to promptly detect market fluctuations. This is expected to lead to cost reductions and the mitigation of payment transaction risks. Gazpromneft currently holds a leading position in the industry in terms of the number of high-tech wells incorporated into its production drilling portfolio. As a cornerstone of its strategic approach, digitalisation has been integrated across all aspects of the company's operations, ranging from field development to well operation and maintenance. This transformation has reduced drilling time from several months to a matter of minutes, thereby increasing decision-making efficiency by approximately 20%–25%.

This study examined the relationship between the implementation of organisational and production knowledge management mechanisms and the resolution of issues related to enhancing organisational economic sustainability through the adoption of blockchain technologies and the associated increase in supply chain transparency. The findings indicate that the introduction of blockchain technologies and improved supply chain transparency exert an indirect yet stable influence on the formation of this relationship, thereby confirming hypotheses H1a–H2a.

Furthermore, the application of the importance–performance map analysis confirmed that the implementation of organisational and production knowledge management mechanisms is a critical factor in enhancing efficiency in forecasting and in formulating management actions aimed at addressing challenges related to economic stability.

Significant methodological advancements were achieved within the framework of the applied research approaches, including the knowledge-oriented approach and the unified theory of technology adoption and use (UTAUT). These advancements demonstrate the importance of introducing mechanisms for managing organisational and production knowledge in the context of expanding the use of blockchain technologies by Russian industrial companies. In addition, they confirm the necessity of integrating these mechanisms into the supply chain structures of Russian industrial enterprises in order to enhance transparency. Moreover, all three factors—the implementation of knowledge management mechanisms, the adoption of blockchain technologies, and increased supply chain transparency—were identified as critical for addressing challenges related to economic stability, both for the industrial companies examined and for the Russian economy as a whole. This is because these factors enable greater efficiency in accounting for the interests of the state, society, suppliers, manufacturers, distributors, end users, and other stakeholder groups within management decision-making processes.

Theoretical and managerial implications

This study expands the scope of theoretical and practical research devoted to addressing the challenges of ensuring the economic sustainability of organisations in the context of digitalisation. From a theoretical perspective, its significance lies in addressing the knowledge gap in management science associated with the limited understanding of Russian organisational and production knowledge management

[1] Decree of the government of the Russian Federation from 02.11.2020 No 1779 "On amendments to the regulations on the system of monitoring the movement of medicinal products for medical use." Legal reference system "Konsultant Plyus." URL: http://www.consultant.ru/document/consdocLAW366581/ (date accessed: 12.25.2024). (In Russian).

mechanisms and blockchain technologies as a foundation for enhancing supply chain transparency and resolving issues related to organisations' economic sustainability. This contribution is achieved through the integration of three key theoretical approaches in contemporary management science: the resource-oriented approach, the knowledge-oriented approach, and the concepts underpinning the unified theory of technology adoption and utilisation.

At the same time, the findings of this study contribute to refining and extending the knowledge-based management perspective, which conceptualises knowledge in contemporary conditions as a multifaceted set of production factors constituting the potential of organisational resources. However, investments in knowledge alone do not lead to increased operational efficiency unless knowledge management technologies are integrated into both organisational management systems and supply chain structures (Geng et al., 2021).

Furthermore, it is essential to acknowledge the increasing complexity of socio-economic relations, which has led industrial companies to become participants not only in their own supply chains, ensuring the delivery of goods to specific consumers, but also in broader supply chains operating at both national and global levels. This development presents new and significantly more complex management challenges for owners and senior executives, including those related to consumer demand and the integration of emerging technologies into dynamically evolving supply chain mechanisms and systems.

In light of these considerations, this study presents several key findings. First, the results corroborate the initial hypothesis concerning the direct and substantial impact of introducing organisational and production knowledge management mechanisms on the processes of integrating blockchain technologies into the management systems of Russian industrial companies and on addressing challenges related to ensuring the economic viability of their operations. Second, the findings confirm the validity of the assumption regarding the significant impact of the effectiveness of blockchain technology implementation on enhancing supply chain transparency in Russian industrial companies. Third, the results allow the assertion that the stability of the relationship between the effectiveness of blockchain technology implementation and the resulting increase in supply chain transparency, together with the introduction of organisational and production knowledge management mechanisms, has a substantial and positive effect on resolving issues related to the economic sustainability of Russian industrial companies. Fourth, the findings confirm the relevance of the management science assumption regarding the sustained and significant impact of blockchain technology implementation on improving knowledge processing within organisational and production knowledge management mechanisms. The examples of blockchain technology utilisation by Russian industrial companies presented in this paper support the interpretation of this assumption by accounting for the specific characteristics of the objects under study. The essence of this interpretation is that the introduction of blockchain technologies expands the capabilities of organisational management systems and facilitates the development of new digital mechanisms for information exchange and the integration of strategic, tactical, and operational domains of company activities, thereby increasing the speed and efficiency of responses to changes in both internal and external environments. Based on the findings of this study, the authors conclude that most Russian industrial companies, when addressing tasks related to the digitalisation of business processes through knowledge management mechanisms and the adoption of blockchain technologies, will prioritise an integrated approach involving the seamless integration of business processes across all supply chain participants. At the same time, such solutions may be grounded in the tools and approaches discussed within the scope of this paper.

The study also analysed in detail the feasibility of utilising blockchain technologies in the business processes of Russian industrial companies and the associated enhancement of supply chain transparency. This enhancement can be achieved by establishing linkages between the introduction of organisational and production knowledge management mechanisms and the resolution of challenges related to ensuring the economic sustainability of organisational activities. The findings of the study indicate that, under contemporary conditions, the introduction of blockchain technologies into the business processes of Russian industrial companies, and the consequent increase in supply chain transparency, represent key factors in achieving the economic sustainability of their operations. To develop a comprehensive understanding of the digital technologies and knowledge management mechanisms required to address emerging challenges faced by Russian industrial companies, a classification of digital technologies—particularly those related to intercorporate interactions (suppliers, sellers, and buyers)—was developed and is presented in Table 11.

The classification was developed based on the following criteria:

The underlying technologies that facilitate intercorporate relations.
The level of automation of information processing.
The level of expertise required for employees.
Compatibility with other technologies.

Based on the presented classification, a method that aligns with the specific requirements of a particular industrial company can be selected.

This classification enables manufacturing enterprises to select the most suitable digital technologies for interacting with counterparties, taking into account their specific characteristics, requirements, and available resources. The findings of the study indicate that blockchain technologies and knowledge management mechanisms demonstrate the highest economic value from a business perspective, primarily through reducing transaction costs, enhancing transparency, and increasing accessibility.

Hybrid technologies (IoT, Big Data, AI) also exhibit high levels of efficiency; however, they require a higher level of employee expertise and deeper integration with existing systems. It is important to acknowledge that the technological solutions examined in this study are subject to continuous development and improvement. Consequently, the enhancements currently being developed are expected to strengthen the interaction between the industrial Internet of Things and blockchain technologies. This, in turn, necessitates the establishment of a unified technical standard for communication and data transmission. During the study, evidence was identified indicating that such standards are already being actively implemented in Russian industrial companies. The introduction of these standards is expected to increase interoperability, transparency, and security beyond the levels offered by existing systems and platforms.

Based on the outcomes of this study, a set of practical recommendations was formulated that is of particular relevance to the authors' organisation and may also be useful for researchers seeking further theoretical development and, in practical terms, for managers of companies across various economic sectors engaged in digital business transformation. In the authors' view, the recommendations outlined

Table 11
General classification of digital technologies used in Russian industrial enterprises.

Classification feature	Types of digital technologies
Based on centralised data storage and processing mechanisms	Electronic document management; Customer relationship management (CRM) systems; Electronic trading platforms
Based on decentralised data storage and processing mechanisms	Blockchain technologies: - Public blockchain technologies - Corporate blockchain technologies -Smart contracts
Hybrid technologies	Cloud services: - Technologies in the field of the Internet of Things - Big data analysis tools - Neural network-based tools

Source: compiled by the authors

below may also be of considerable interest to representatives of government agencies.

In practice, it is important to avoid overestimating the significance of digital knowledge management mechanisms and blockchain technologies in their current state. Hybrid solutions alone do not fully realise the potential of these technologies. Based on the practical implementation of these solutions in Russian industrial companies, the most promising areas for deploying digital knowledge management mechanisms and blockchain technologies in the industrial sector are as follows:

Replacement of a multi-user database with a distributed ledger. Blockchain technology can be used to create a fully accessible registry for parties with a high level of mutual trust.

Quasi-blockchain implementation. A quasi-blockchain architecture, representing an advanced decentralised database, may be adopted if an appropriate number of distributed copies and consensus mechanisms can be established. While this approach improves security, it may reduce performance and increase operational costs.

Revolutionising production and logistics processes. This involves transforming the complex technological logic governing production, transportation, and logistics systems. Although blockchain technologies and digital knowledge management mechanisms can overcome certain limitations, it is necessary to recognise the constraints of their current development. These include the inability to automate all business cases within an industrial company, as well as the decreasing universality and flexibility associated with the evolution of smart contract technologies.

Developing solutions to address performance and cost challenges associated with blockchain technologies. Blockchain systems require continuous incentives for nodes to store ledgers and validate transactions, which leads to high integration costs when embedding blockchain technologies into overall business processes, particularly those aimed at enhancing supply chain transparency. At the same time, a limited number of nodes within a management system may reduce productivity, negatively affecting efforts to ensure economic stability. In this context, one potential solution involves strengthening the analytical capabilities of organisational management systems through the integration of organisational and production knowledge management mechanisms.

At the current stage of development, it is evident that owners and top managers, regardless of the industry in which they operate, must ensure the economic sustainability of both their organisations and their associated supply chains. The primary means of addressing this challenge lies in the continuous integration of advanced digital technologies into everyday business operations.

This research suggests that a comprehensive response to this challenge can be achieved through the development and implementation of solutions based on blockchain technologies and knowledge management mechanisms. Such solutions are capable of generating added value simultaneously for individual industrial companies and for their supply chain partners.

Furthermore, this study underscores the importance of accelerating the development and implementation of blockchain technologies and digital knowledge management mechanisms for Russian industrial companies. Doing so enables them to strengthen their capacity to acquire and assimilate both open and concealed knowledge, thereby accelerating their response to market fluctuations.

In addition, the process of effective integration observed in recent years has facilitated the realisation of the substantial intellectual and production potential of the Russian industrial sector. This has contributed to overcoming the economic recession experienced at the national level of the Russian economy and has supported an increase in the rate of value maximisation among the industrial companies examined in this study. As a result, these companies have been able to offer innovative products to customers in a timely manner, in the required volume, and across a comprehensive product range.

The findings of this study indicate that Russian industrial companies actively implementing blockchain technologies and digital knowledge management methods have the opportunity to expand the range of digital management tools used to enhance their understanding of industry dynamics and to broaden their knowledge base regarding potential development trajectories. With respect to knowledge acquisition and application, the results once again confirm the validity of a key thesis in management science: the development and implementation of blockchain technologies and digital knowledge management mechanisms provide more effective tools for collecting both hidden and open knowledge about an organisation's current state and future prospects from diverse sources, including consumers, suppliers, company personnel, and key stakeholders. Another important function of blockchain technologies and digital knowledge management mechanisms within the management systems of industrial companies and their supply chains is the transformation of this knowledge into a usable format that can serve as the foundation for accelerating organisational growth and development. Moreover, the introduction of blockchain technologies and digital knowledge management mechanisms should serve as a basis for fostering a culture of information exchange and trust among employees of Russian industrial companies in contemporary conditions. The development and implementation of these solutions are expected to encourage employees to expand the scope of intra-organisational cooperation, contribute to the enhancement of communication skills among personnel, and provide both financial and non-financial incentives to deepen employee engagement in information and knowledge exchange systems, as well as to reward those who propose the most promising innovative and creative ideas.

Conclusion and future lines of research

Within the scope of this study, the primary focus was directed towards analysing the impact of implementing organisational and production knowledge management mechanisms on the development and implementation of blockchain technologies within an organisation's management systems. In addition, the study sought to address tasks aimed at ensuring the economic sustainability of organisational functioning through the integration of these mechanisms into supply chain management, thereby enhancing transparency. The objectives of the study were limited to industrial companies operating in Russia. The principal methodological approaches applied were the resource-oriented and knowledge-oriented approaches, together with the concept of the unified theory of acceptance and use of technology (UTAUT). At the initial stage of the study, based on an analysis of previous publications, five hypotheses were formulated and subsequently tested using structural equation modelling with partial least squares estimation (PLS-SEM). The empirical results of hypothesis testing revealed a direct relationship between the effectiveness of mechanisms for managing organisational and production knowledge and the efficiency of developing and implementing blockchain technologies within management systems. Moreover, the implementation of these mechanisms also facilitates the execution of tasks aimed at ensuring the economic sustainability of Russian industrial companies. The findings further indicate that the effectiveness of developing and implementing blockchain technologies within organisational management systems, together with the associated enhancement of supply chain transparency, directly influences the successful achievement of objectives related to economic sustainability in Russian industrial enterprises. Overall, the results suggest that the effectiveness of blockchain technology development and implementation, along with increased supply chain transparency, can be regarded as mediating factors in establishing the relationship between the introduction of digital mechanisms for managing organisational and production knowledge and the fulfilment of tasks ensuring an organisation's economic sustainability in contemporary conditions.

The findings of this study provide convincing evidence that, in modern business environments, a central direction of digitalisation involves establishing a strong linkage between digital mechanisms for managing organisational and production knowledge and blockchain technologies. At the same time, as previously noted, the effectiveness of implementing digital knowledge management mechanisms has emerged as a critical factor determining both the success of blockchain technology integration into organisational management systems and the implementation of measures aimed at ensuring the economic viability of business operations. The conclusions and recommendations presented in this study may serve as valuable inputs for further theoretical and practical research. In addition, they may provide a foundation for the development of regulatory measures in the areas overseen by relevant authorities.

As indicated earlier, this research aimed to elucidate the characteristics of digital transformation in the business processes of Russian industrial companies through the integration of knowledge management mechanisms and blockchain technologies into their management systems. Digital transformation in socioeconomic relations is unfolding at an accelerated pace worldwide, driven by rapid technological advancement and the continuous expansion of applications within organisational management systems. However, this dynamic environment presents a substantial challenge in analysing the specific features of business process digitalisation across diverse sectors of the Russian economy within the scope of a single study.

In view of this challenge, the authors deliberately focused on representatives of Russian industry, which exhibit particularly complex structures of construction and operation, as well as highly flexible supply chains that enable a high degree of adaptability. Another important limitation of this study was the need to establish common parameters for constructing a unified data-collection framework applicable to respondents representing closely related yet structurally diverse industrial companies. Consequently, examining the application of the factors analysed in this study within other sectors of the Russian economy represents a promising direction for future research. These sectors include the financial and banking system, urban management, public administration, communications, and the service sector. In addition, specific industries such as automotive manufacturing, machine tool building, aircraft construction, and shipbuilding can be identified as particularly important areas for further investigation, given their exceptionally high levels of digitalisation in contemporary conditions. In this context, analysing the integration of organisational and production knowledge management mechanisms and blockchain technologies into their business processes appears highly relevant for both the development of theoretical research models and the formulation of practical recommendations. Equally important as a future research direction is the examination of the impact of knowledge management mechanisms and blockchain technologies on the implementation of tasks aimed at ensuring the economic sustainability of companies operating in these sectors. One of the key limitations of this study is the absence of a comparative analysis between the results obtained for the Russian economy and analogous processes occurring in regions such as BRICS+, the EAEU, and the CIS. While acknowledging this limitation, the authors consider the development of methodological approaches to address it as a priority for future research.

CRediT authorship contribution statement

Mikhail Vladimirovich Khachaturyan: Writing – review & editing, Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Evgeniia Valeryenva Klicheva:** Validation, Methodology, Investigation.

References

Abbas, Z., & Myeong, S. (2024). A comprehensive study of blockchain technology and its role in promoting sustainability and circularity across large-scale industry. *Sustainability, 16*, 4232.

Alhasan, H., & Hamdan, A. (2023). Blockchain Technology and Environmental Sustainability. In R. El Khoury, & N. Nasrallah (Eds.), *Emerging Trends and Innovation in Business and Finance. Contributions to Management Science*. Singapore: Springer. https://doi.org/10.1007/978-981-99-6101-6_54.

Andersén, J. (2023). Green resource orchestration: A critical appraisal of the use of resource orchestration in environmental management research, and a research agenda for future study. *Business Strategy and the Environment, 32*(8), 5506–5520. https://doi.org/10.1002/bse.3433

Asa, K. J., & Zosu, S. J. (2023). Enhancing procurement and supply chain management for sustainable development through digital transformation. *International Journal of African Research Sustainability Studies, 2*(2), 62–76.

Aslam, J., Saleem, A., Khan, N. T., & Kim, Y. B. (2021). Factors influencing blockchain adoption in supply chain management practices: A study based on the oil industry. *Journal of Innovation and Knowledge, 6*(2), 124–134. https://doi.org/10.1016/j.jik.2021.01.002

Babin, B. J., Grif n, M., & Hair, J. F. (2016). Heresies and sacred cows in scholarly marketing publications. *Journal of Business Research, 69*(8), 3133–3138. https://doi.org/10.1016/j.jbusres.2015.12.001

Bagozzi, R. P., & Yi, Y. (1990). Assessing method variance in multitrait-multimethod matrices: The case of self-reported affect and perceptions at work. *Journal of Applied Psychology*, (5), 75. https://doi.org/10.1037/0021-9010.75.5.547

Bajar, K., Kamat, A., Shanker, S., & Barve, A. (2024). Blockchain technology: A catalyst for reverse logistics of the automobile industry. *Smart Sustain. Built Environ, 13*(1), 133–178. https://doi.org/10.1108/SASBE-11-2021-0203

Barney, J. B., Ketchen, D. J., D, J., & Wright, M. (2011). The future of resource-based theory: Revitalization or decline? *Journal of Management, 37*(5), 1299–1315. https://doi.org/10.1177/0149206310391805

Boamah, F. A., Zhang, J., Wen, D., Sherani, M., Hayat, A., & Horbanenko, O. (2022). Enablers of knowledge management: practical research-based in the construction industry. *International journal of innovation science, 14*, 121–137.

Cagigas, D., Clifton, J., Diaz-Fuentes, D., Fernandez-Gutierrez, M., & Harpes, C. (2023). Blockchain in government: Toward an evaluation framework. *Policy Design and Practice, 6*, 397–414.

Clarinval, A., Simonofski, A., Castiaux, A., Gao, A., Y, & Janssen, M. (2023). Formulating Open Data-Based Value Propositions: An Evaluation and Comparison of Two Canvas Tools. *Proceedings of the 24th Annual International Conference on Digital Government Research (dg.o '23)* (pp. 327–337). New York, NY, USA: Association for Computing Machinery. https://doi.org/10.1145/3598469.3598506

Daidai, F., & Tamnine, L. (2023). Blockchain technology in finance: A literature review. In S. Motahhir, & B. Bossoufi (Eds.), *Digital technologies and applications* (pp. 218–229). Nature Switzerland: Springer.

Darroch, J. (2005). Knowledge management, innovation and firm performance. *Journal of Knowledge Management, 9*(3), 101–115.

Ejairu, E., Filani, O., Nwokocha, G., & Alao, O. (2022). Resilience in Global Supply Chains: Conceptual Frameworks for Operational Flexibility and Post-Pandemic Business Recovery Strategies. *Gyanshauryam International Scientific Refereed Research Journal, 5*, 410–450.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurements error. *Journal of Marketing Research, 18*(4), 39–50.

Geng, D., Hung, L. K., & Zhu, Q. (2021). Eco-innovation and its role for performance improvement among Chinese small and medium-sized manufacturing enterprises. *International Journal of Production Economics, 231*(July 2020), Article 107869. https://doi.org/10.1016/j.ijpe.2020.107869

Gosain, S., Malhotra, A., & Sawy, O. A. E. L. (2004). Coordinating for flexibility in e-business supply chains. *Journal of Management Information Systems, 21*(3). https://doi.org/10.1080/07421222.2004.11045816

Gupta, A., Singh, R. K., & Kamal, M. M. (2024). Blockchain technology adoption for secured and carbon neutral logistics operations: barrier intensity index framework. *Ann. Oper. Res.*. https://doi.org/10.1007/s10479-024-05824-w

Haber, S., & Stornetta, W. S. (1991). How to time-stamp a digital document. *J. Cryptology, 3*, 99–111. https://doi.org/10.1007/BF00196791

Hafeez, S., Shahzad, K., & De Silva, M. (2025). Enhancing digital transformation in SMEs: The dynamic capabilities of innovation intermediaries within ecosystems. *Long Range Planning, 58*(3). Article 102525.

Hair, J. F., Sharma, P. N., Liengaard, B. D., Sarstedt, M., & Ringle, C. M. (2023). Predictive model assessment and selection in composite-based modeling using PLS-SEM: extensions and guidelines for using CVPAT. *European Journal of Marketing, 57*(6), 1662–1677. https://doi.org/10.1108/EJM-08-2020-0636

Haq, S. H. U., Dan, S., & Shahzad, K. (2024). Leadership competencies and blockchain implementation in public sector organizations: A sensemaking approach. *International Journal of Public Sector Management*.

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Irfan, M., Wang, M., Zafar, A. U., Shahzad, M., & Islam, T. (2020). Modeling the enablers of supply chain strategies and information technology: Improving performance through TISM approach. *VINE Journal of Information and Knowledge Management Systems*. https://doi.org/10.1108/VJIKMS-06-2019-0082

Jin, C., Shahzad, M., Zafar, A. U., & Suki, N. M. (2022). Socio-economic and environmental drivers of green innovation: Evidence from nonlinear ARDL. *Economic Research-Ekonomska Istrazivanja, 0*(0), 1–21.
Kayani, U., & Hasan, F. (2024). Unveiling cryptocurrency impact on financial markets and traditional banking systems: Lessons for sustainable blockchain and interdisciplinary collaborations. *Journal of Risk and Financial Management, 17*, 58.
Kim, J. S., & Shin, N. (2019). The impact of blockchain technology application on supply chain partnership and performance. *Sustainability*, (21), 11. https://doi.org/10.3390/su11216181 (Switzerland).
Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of E-Collaboration, 11*(4), 1–10. https://doi.org/10.4018/ijec.2015100101
Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. *International Journal of Production Economics. Volume, 231*, Article 107831. https://doi.org/10.1016/j.ijpe.2020.107831
Li, L., Wu, J., & Cui, W. (2023). A review of blockchain cross-chain technology. *IET Blockchain, 3*, 149–158.
Liengaard, B. D., Sharma, P. N., Hult, G. T. M., Jensen, M. B., Sarstedt, M., Hair, J. F., & Ringle, C. M. (2021). Prediction: Coveted, Yet Forsaken? Introducing a Cross-Validated Predictive Ability Test in Partial Least Squares Path Modeling. *Decision Sciences,, 52*, 362–392. https://doi.org/10.1111/deci.12445
Lipnitsky, D. V. (2019). Opportunities and challenges for blockchain in the new industrialization. *Ekonomika Promyshlennosti., 1*(85), 82–100.
Mahar, A. S., Zhang, Y., Sadiq, B., & Gul, R. F. (2025). Sustainability Transformation Through Green Supply Chain Management Practices and Green Innovations in Pakistan's Manufacturing and Service Industries. *Sustainability, 17*(5), 2204. https://doi.org/10.3390/su17052204
Mahula, S., Tan, E., Crompvoets, J., & Timmers, P. (2025). What motivates public sector organisations to use blockchain? *International Journal of Public Sector Management, 38*(1), 118–138.
Montecchi, M., Plangger, K., & West, D. C. (2021). Supply chain transparency: A bibliometric review and research agenda. *International Journal of Production Economics, 238*. https://doi.org/10.1016/j.ijpe.2021.108152. Article 108152.
Munir, M. A., Habib, M. S., Hussain, A., Shahbaz, M. A., Qamar, A., Masood, T., et al. (2022). Blockchain adoption for sustainable supply chain management: Economic, environmental, and social perspectives. *Frontiers in Energy Research, 10*(May). https://doi.org/10.3389/fenrg.2022.899632, 1 24.
Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. Available https://bitcoin.org/bitcoin.pdf.
Naseem, M. H., Yang, J., Zhang, T., & Alam, W. (2023). Utilizing fuzzy AHP in the evaluation of barriers to blockchain implementation in reverse logistics. *Sustainability, 15*(10), 7961. https://doi.org/10.3390/su15107961
Philsoophian, M., Akhavan, P., & Namvar, M. (2022). The mediating role of blockchain technology in improvement of knowledge sharing for supply chain management. *Management decision, 60*, 784–805.
Pinto, C. (2020). Knowledge management as a support for supply chain logistics planning inpandemic cases. *Brazilian Journal of Operations & Production Management, 17*(3), 1–11.
Rejeb, A., Rejeb, K., Simske, S., & Treiblmaier, H. (2021). Blockchain technologies in logistics and supply chain management: A bibliometric review. *Logistics, 5*(4), 72. https://doi.org/10.3390/logistics5040072
Riccio, C., Menanno, M., Zennaro, I., & Savino, M. M. (2024). A New Methodological Framework for Optimizing Predictive Maintenance Using Machine Learning Combined with Product Quality Parameters. *Machines, 12*(7), 443. https://doi.org/10.3390/machines12070443
Sartori, J. T. D., Frederico, G. F. & Fátima Nunes Silva, H. (2021). Organizational knowledge management in the context of supply chain 4.0: A systematic literature review and conceptual model proposal. Knowledge and process management.
Shahzad, K., Helo, P., Ranta, M., & Nousiainen, E. (2024a). Blockchain technology for operational excellence and supply chain resilience: A framework based on use cases and an architecture demonstration. *Technology Analysis & Strategic Management*, 1–18.
Shahzad, K., Dan, S., Imran, F., Holtkamp, P., Niemi, M. K., & Meyer, M. (2024b). Limits of open innovation during the organizational change: a case study of a Partner Campus. *R&D Management, 54*, 1063–1086. https://doi.org/10.1111/radm.12675
Shahzad, K., Hafeez, S., Heimo, T., Maenpaa, A., Mubarak, M. F., & Evans, R. (2025a). Developing the innovation capabilities of SMEs: The role of intermediary firms in knowledge ecosystems. *IEEE Transactions on Engineering Management, 72*, 604–618.
Sizan, N. S., Dey, D., Layek, M. A., Uddin, M. A., & Huh, E.-N. (2025). Evaluating blockchain platforms for IoT applications in industry 5.0: A comprehensive review. *Blockchain: Research and Applications.*. https://doi.org/10.1016/j.bcra.2025.100276. Article 100276.
Stone, M. (1974). Cross-Validatory Choice and Assessment of Statistical Prediction (with Discussion). *Journal of the Royal Statistical Society (Series B), 36*, 111–147.
Swink, M., Sant'Ana Gallo, I., Defee, C., & da Silva, A. L (2024). Supply chain visibility types and contextual characteristics: A literature-based synthesis. *Journal of Business Logistics, 45*(1). https://doi.org/10.1111/jbl.12366. Article e12366.
Tan, E., Dan, S., & Shahzad, K. (2025). Bridging the chasm between "what could be" and "what is": The impact of blockchain technologies on public service management. *International Journal of Public Sector Management, 38*(1), 1–11.
Tenenhaus, M., Vinzi, V. E., Chatelin, Y.-M., & Lauro, C. (2005). PLS path modeling. *Computational Statistics & Data Analysis,, 48*(1), 159–205.
Thornton, L. M., Darby, J. L., Morgan, T. R., & Roath, A. S. (2024). Well-being insights from the food insecurity supply chain: A logistics service quality perspective. *Journal of Business Logistics, 45*, Article e12374. https://doi.org/10.1111/jbl.12374
Tripathi, G., Ahad, M. A., & Casalino, G. (2023). A comprehensive review of blockchain technology: Underlying principles and historical background with future challenges. *Decision Analytics Journal, 9*. Article 100344.
Udeh, E. O., Amajuoyi, P., Adeusi, K. B., & Scott, A. O. (2024). The integration of artificial intelligence in cybersecurity measures for sustainable finance platforms: An analysis. *Computer Science & IT Research Journal, 5*(6), 1221–1246.
Wan, X., Jha, A. K., Kazantsev, N., & Boh, W. F. (2023). Online-to-offline platforms: Examining the effects of demand-side usage on supply-side decisions. *Information & Management, 60*(2). https://doi.org/10.1016/j.im.2023.103757. Article 103757.
Wang, Z., Shahid, M. S., Binh An, N., Shahzad, M., & Abdul-Samad, Z. (2022). Does green finance facilitate firms in achieving corporate social responsibility goals? *Economic Research-Ekonomska Istraživanja, 35*(1), 5400–5419. https://doi.org/10.1080/1331677X.2022.2027259
Wang, Y., Liu, B., Chan, H. K., & Zhang, T. (2023). Who pays buyers for not disclosing supplier lists? Unlocking the relationship between supply chain transparency and trade credit. *Journal of Business Research, 155*. https://doi.org/10.1016/j.jbusres.2022.113404. Article 113404.
Wang, M., Wei, Y., Wang, C. L., & Azumah, G. (2025). International knowledge transfer through international entrepreneurship: A systematic review and research agenda. *International Journal of Management Reviews, 27*, 519–543. https://doi.org/10.1111/ijmr.12400
Wetzels, M., Odekerken-Schroder, G., & Van Oppen, C. (2009). Using PLS Path Modeling for Assessing Hierarchical Construct Models: Guidelines and Empirical Illustration. *MIS Quarterly, 33*, 177–195.
Yousaf, Z. (2021). Go for green: Green innovation through green dynamic capabilities: Accessing the mediating role of green practices and green value. *Environmental science and pollution research*.
Zelbst, P. J., Green, K. W., Sower, V. E., & Bond, P. L. (2020). The impact of RFID, IIoT, and Blockchain technologies on supply chain transparency. *Journal of Manufacturing Technology Management, 31*(3), 441–457. https://doi.org/10.1108/JMTM-03-2019-0118
Zhang, F., & Song, W. (2022). Sustainability risk assessment of blockchain adoption in sustainable supply chain: An integrated method. *Comput. Ind. Eng., 171*, Article 108378. https://doi.org/10.1016/j.cie.2022.108378
Zhang, Y., Tavalaei, M. M., Parry, G., & Zhou, P. (2024). Evolution or involution? A systematic literature review of organisations' blockchain adoption factors. *Technological Forecasting and Social Change, 208*. Article 123710.
Zkik, K., Belhadi, A., Kamble, S., Venkatesh, M., Oudani, M., & Sebbar, A. (2024). Cyber resilience framework for online retail using explainable deep learning approaches and blockchain-based consensus protocol. *Decision Support Systems, 182*. https://doi.org/10.1016/j.dss.2024.114253. Article 114253.