



Integration of Artificial Intelligence in Enterprise Resource Planning Systems: Opportunities, Challenges, and Future Research Directions

Sushil Kumar Sahoo^{1,2,*}, Dwarikanath Choudhury³, Prasant Ranjan Dhal^{1,2}, Supriya Sahu^{1,2}, Sudhakar Majhi^{1,2}, Ipsita Dhar^{1,2}

¹ Department of Mechanical Engineering, Indira Gandhi Institute of Technology, Sarang 759146, Odisha, India

² Biju Patnaik University of Technology, Rourkela 769015, Odisha, India

³ Great Lakes Institute of Management, Gurgaon Campus, Delhi NCR, 122413, Haryana, India

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ABSTRACT

Enterprise resource planning (ERP) systems have come a long way since their inception in 1989 and have grown from transaction processing systems to intelligent enterprise systems with the help of artificial intelligence (AI). This study aims to conduct a systematic literature review and bibliometric analysis of the current literature on the integration of AI in ERP systems from 1989 to 2026. Based on the PRISMA framework, relevant publications are identified in the major scientific databases in the context of bibliometric and thematic analyses, which highlight trends, impactful participants, new technologies, application fields, and future research directions. The review shows that research on AI-driven ERP is growing at a rapid pace, especially in recent years due to the development of machine learning, deep learning, NLP, generative AI, intelligent automation, and predictive analytics. The primary applications include finance, supply chain management, manufacturing, human resources, customer relationship management, and decision support. The study also presents a set of key research gaps on data governance, cybersecurity, interoperability, sustainable ERP, and human-AI collaboration, and outlines a conceptual framework and future research agenda to guide the creation of intelligent, trustworthy, and autonomous ERP ecosystems.

1. Introduction

Enterprise Resource Planning (ERP) systems are now the backbone of modern business, connecting key aspects of business processes like finance, manufacturing, supply chain, human resources, procurement, sales, customer relationship management, and enabling information sharing across these functional departments for strategic decision-making. ERP systems have been gradually introduced in commerce since 1989, and organizations have increasingly turned to ERP platforms to streamline business operations, improve organizational efficiency, and enhance the competitiveness of the organization by integrating enterprise-wide information management [1]. In the last 30 years, ERP systems have transformed from legacy transactional information systems to

* Corresponding author.

E-mail address: sushilkumar00026@gmail.com

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cloud-based, intelligent, data-driven enterprise platforms that can be used to run digital transformation programs [2]. At the same time, artificial intelligence (AI) has become one of the most game-changing technologies of the Fourth Industrial Revolution (4IR) [3]. Organizations have been experiencing a revolution in technology thanks to recent developments in machine learning (ML), deep learning (DL), NLP, computer vision, reinforcement learning (RL), and generative artificial intelligence (GenAI), which have unlocked intelligent automation, predictive analytics, autonomous decision-making, and cognitive computing capabilities [4].

Today, AI innovations are becoming part of enterprise applications in order to handle vast amounts of structured and unstructured data, uncover hidden patterns, forecast future events, optimize resource use, and participate in complex managerial decisions. AI is thus proving to be a strategic asset for organizations seeking to optimize their operations, drive innovation, and maintain a competitive edge. This marks a transformative shift in enterprise information systems when it comes to using AI and ERP systems. Traditional ERP systems mainly focused on documenting and managing business transactions, but the advent of AI makes ERP an intelligent business system that learns from past data, adapts to change, and provides real-time recommendations [5]. By leveraging AI, ERP systems can offer several intelligent features, such as predictive maintenance, automated financial analysis, intelligent procurement, inventory optimization, fraud detection, customer behavior analysis, intelligent workforce planning, and personalized decision support.

Additionally, the advent of GenAI and large language models (LLMs) has brought new conversational ERP interfaces, AI-driven enterprise assistants, automated report generation, intelligent document processing, and natural language queries, enhancing the ERP system's usability and decision-making capabilities [6]. With the surge of digital transformation, cloud computing, big data, Internet of Things (IoT), blockchain, robotic process automation (RPA), digital twins, and Industry 4.0 technologies, the use of AI-powered ERP systems has increased even more. The development of Industry 4.0, IoT, blockchain, RPA, digital twins, big data, and cloud computing further catalysed the adoption of AI-enabled ERP systems [7]. The digital transformation of ERP is evolving into intelligent ERP ecosystems that will involve real-time data capture, predictive analysis, autonomy, and continuous learning opportunities. These developments have enabled enterprises to run more agilely, to collaborate better with their teams, to manage resources optimally, to serve customers better, and to make decisions based on data for strategic planning. Recently, Industry 5.0 has focused on human-centric, resilient, and sustainable manufacturing systems, which further opens the door for human-centric AI to be incorporated into ERP platforms to assist with collaborative intelligence and sustainable enterprise management [8].

AI's increasing significance in ERP systems has garnered significant research interest, software vendor attention, and industry adoption. Current research has focused on various facets of AI-driven ERP, such as predictive analytics, intelligent automation, ML applications, cloud ERP, supply chain optimization, financial management, cybersecurity, business intelligence, and decision support systems. Similarly, there are many studies on AI technologies like ML, natural language processing (NLP), RPA, and GenAI in the context of enterprise use cases [9,10]. Although this volume of literature has grown, the current research is still scattered across various subjects such as information systems, computer science, operations management, business analytics, manufacturing engineering, and supply chain management. The majority of the studies centre on a particular technology, ERP module, or specific industry application, and do not offer a holistic synthesis of the integration of AI in the entire ERP system. While several narrative reviews have focused on specific AI applications in ERP, there are limited comprehensive systematic reviews that have brought together all the developments of AI technologies, ERP functionalities, implementation opportunities, organizational

challenges, bibliometric trends, thematic developments, and future research directions into a single analytical framework.

This paper is organized as follows: after the introduction, Section 2 is the literature review, summarizing the literature review study from the existing reviews in the field of AI and ERP systems. In Section 3, the research methodology is described, consisting of the framework of the PRISMA, the selection of the databases, the search strategy, and the inclusion and exclusion criteria. The bibliometric analysis of publications from 1989 to 2026 is presented in Section 4. Section 5 explores the thematic analysis, whereas Section 6 and Section 7 discuss the opportunities and challenges of this proposed study. Section 8 and Section 9 discuss the research gap, future directions, and conceptual framework. Section 10, Section 11, and Section 12 describe managerial and practical implications and limitations. Finally, the conclusion is discussed in Section 13 for the proposed study.

2. Literature Review

2.1 Evolution of Enterprise Resource Planning Systems

ERP systems have grown from Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRP II) to become enterprise information systems, which link business processes across organizational functions. One of the first and most influential studies was undertaken by Davenport [11], who defined ERP systems as enterprise-wide systems that could tie together the disjointed information in an organisation into a single business process architecture. Davenport also stressed that ERP cannot simply be a tool to automate business processes, but rather a tool to change them [11]. This led to the definition of ERP by Klaus *et al.* [12] as "configurable enterprise software packages that integrate information and business processes across and within organizational functional areas". They provided one of the most accepted academic definitions of ERP and pointed out its function in boosting operational coordination and enterprise integration [12].

In like manner, O'Leary [13] described ERP systems as a "whole enterprise solution" that integrates the enterprise solutions of finance, manufacturing, logistics, HR, procurement, and customer management in a centralized database architecture. O'Leary stated that ERP systems could be used for enterprise-wide information sharing and standardized business processes, which helps in strategic decision-making and organizational efficiency [13]. Elragal & Haddara [14] explained that ERP has evolved from a mere transactional system to a cloud-based enterprise system that facilitates digital transformation, service orientation, and organisational agility. Their research indicated that the development of ERP in the future would further put into practice intelligent technologies, predictive analysis, and real-time decision support [14]. This evolution towards AI-native ERP architectures is continued by more recent conceptual work.

2.2 Artificial Intelligence Technologies

AI is one of the most powerful technologies powering enterprise digital transformations. Russell & Norvig [15] introduced the theory of AI as intelligent systems that perceive, reason, learn, and act. They have categorized AI into 5 classes: ML, knowledge representation, NLP, computer vision, robotics, and intelligent agents as a conceptual framework for enterprise system applications of AI [15]. AI's role in organizations is highlighted by Kaplan & Haenlein [16], who discussed how AI-driven tools, such as ML, NLP, and intelligent assistants, could enhance business operations and managerial decision-making. AI is now acknowledged as a key factor in innovation and competitive advantage in business [16].

Duan *et al.* [17] looked at the development of AI in the big data era for decision-making. According to their study, AI tools can help improve the quality of organizational decision-making in several ways, such as the ability to deliver predictive insights, intelligent automation, and pattern recognition, and offer some challenges to address regarding ethics, transparency, and governance [17]. With the recent developments in GenAI and LLMs, enterprise AI capabilities have become more sophisticated with the introduction of intelligent assistants, enterprise knowledge management, automated document generation, and conversational interfaces. AI-driven ERP's main trends, as per contemporary assessments, are GenAI, automation AI, and analytics AI.

2.3 Artificial Intelligence Integration in ERP Systems

Van der Aalst *et al.* [18] demonstrated the great potential of AI to transform ERP systems from mere transaction processors into intelligent enterprise platforms by automating repetitive business processes, reducing operational costs, and enhancing an organization's efficiency. They developed automation to be a vital aspect of intelligent ERP systems [18]. Also, Duan *et al.* [17] stated that AI-driven ERP goes beyond process automation, offering strategic decision-making capabilities through predictive analytics and cognitive computing to help organizations leverage vast enterprise data to generate business intelligence [17].

Recently, Hurbean *et al.* [10] did a systematic overview of AI-driven ERP systems and identified automation, predictive analytics, and GenAI as the main research themes [10]. Their bibliometric analysis also identified governance, trust, and long-term strategic impacts as research areas that have received limited attention, and therefore hold great potential for future research. Similarly, Sarferaz [19] introduced a conceptual model for AI adoption within ERP systems by connecting different AI technologies such as GenAI, conversational AI, and agentic AI with ERP business workflows [19]. The framework focuses on four main levels of automation: data acquisition, information analysis, decision-making, and action execution, giving a clear view of the steps necessary for an ERP transformation using AI.

2.4 AI Applications in ERP Functional Modules

AI has made a considerable impact on ERP capabilities in various aspects of businesses. AI can help in financial management by predicting fraud, forecasting financial events, intelligent auditing, automated reporting, and regulatory compliance with predictive analytics and anomaly detection [20]. ML algorithms can be applied in the field of supply chain management to improve demand forecasting, inventory optimization, supplier evaluation, logistics planning, warehouse management, and procurement optimization. For HR, AI works for smart hiring, performance review, HR analytics, talent hunt, customised learning, and prediction of employee attrition.

Moreover, AI has revolutionized customer relationship management (CRM), facilitating intelligent recommendation systems, customer segmentation, sentiment analysis, conversational chatbots, and personalized customer services [21]. Additionally, modules that leverage AI for business intelligence offer executive dashboards, predictive analytics, enterprise reporting, scenario analysis, and enterprise decision support. Together, these changes make ERP more than just a database for transactions; it becomes a platform to facilitate smarter decision-making in the enterprise. Systematic reviews from the past few years confirm automation, predictive analytics, conversational AI, and GenAI as the key application areas.

2.5 Research Gap

While there are many studies that explore how AI can be used in ERP, the current literature is disjointed and tends to take a narrow approach by examining a specific AI technology or one ERP module. The existing review studies that have been found do not include a thorough synthesis that incorporates all the reviewed AI technologies, ERP functional areas, opportunities, challenges, and emerging trends.

2.6 Novelty

This review adopts a systematic literature review, bibliometric analysis, and thematic analysis of the studies published between 1989 and 2026 to analyse the topic of AI integration with ERP systems. It discusses the development of AI technologies, prominent application domains, research interest, opportunities, challenges, and future possibilities of new evolving AI technologies and suggests a conceptual model and research agenda for intelligent ERP systems.

2.7 Research Questions

- RQ1.* What has changed with AI integration in ERP from 1989 to 2026?
- RQ2.* What are the key AI technologies and the use cases for ERP?
- RQ3.* What are the good and the bad of AI-powered ERP systems?
- RQ4.* What are the current and future research directions, and gaps in AI-enabled ERP systems?

2.8 Research Objectives

- O1.* The literature review aimed to present a comprehensive overview of the research on AI's integration into ERP systems from 1989 until the present day.
- O2.* To analyse publication trends and research developments through bibliometric analysis.
- O3.* To understand the key AI technologies and their use in the various functional areas of ERP.
- O4.* To explore the Pros, Cons, and Research Challenges of AI-Driven ERP Systems.

3. Research Methodology

The purpose of this research is to conduct a systematic literature review (SLR) and a bibliometric analysis of the evolution, application, opportunities, challenges, and future directions of the use of AI in ERP systems. The review methodology is based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines so that the selection of the literature is transparent, reproducible, and applies methodological rigor [22]. The PRISMA framework consists of four phases that cover literature selection: identification, screening, eligibility, and inclusion, to simplify the literature selection process for systematic identification of high-quality and relevant publications related to the aims of this review. The data related to the literature were gathered from Scopus, as it contains a tremendous amount of peer-reviewed journals related to the theme of AI, ERP, IS, computer sciences, business, engineering, and management. The main choice of Scopus was motivated by the fact that it covers a large number of high-quality international journals, provides accurate information on citations, and is compatible with tools that can be used in bibliometric analysis, such as VOSviewer.

The literature search spans the entire history of ERP systems from their launch in the commercial market in 1989 until the present (up to 2026) (Figure 1). A detailed search strategy was compiled in order to find publications related to the three key research areas: AI, ERP, and enterprise business applications. Boolean logic (AND, OR) was used with relevant keywords to achieve the maximum number of relevant publications retrieved. In the AI domain, the following keywords were used for the search: artificial intelligence, AI, ML, DL, RL, NLP, computer vision, expert systems, knowledge-based systems, decision support systems, LLMs, GenAI, ChatGPT, GPT, Claude, and Gemini.

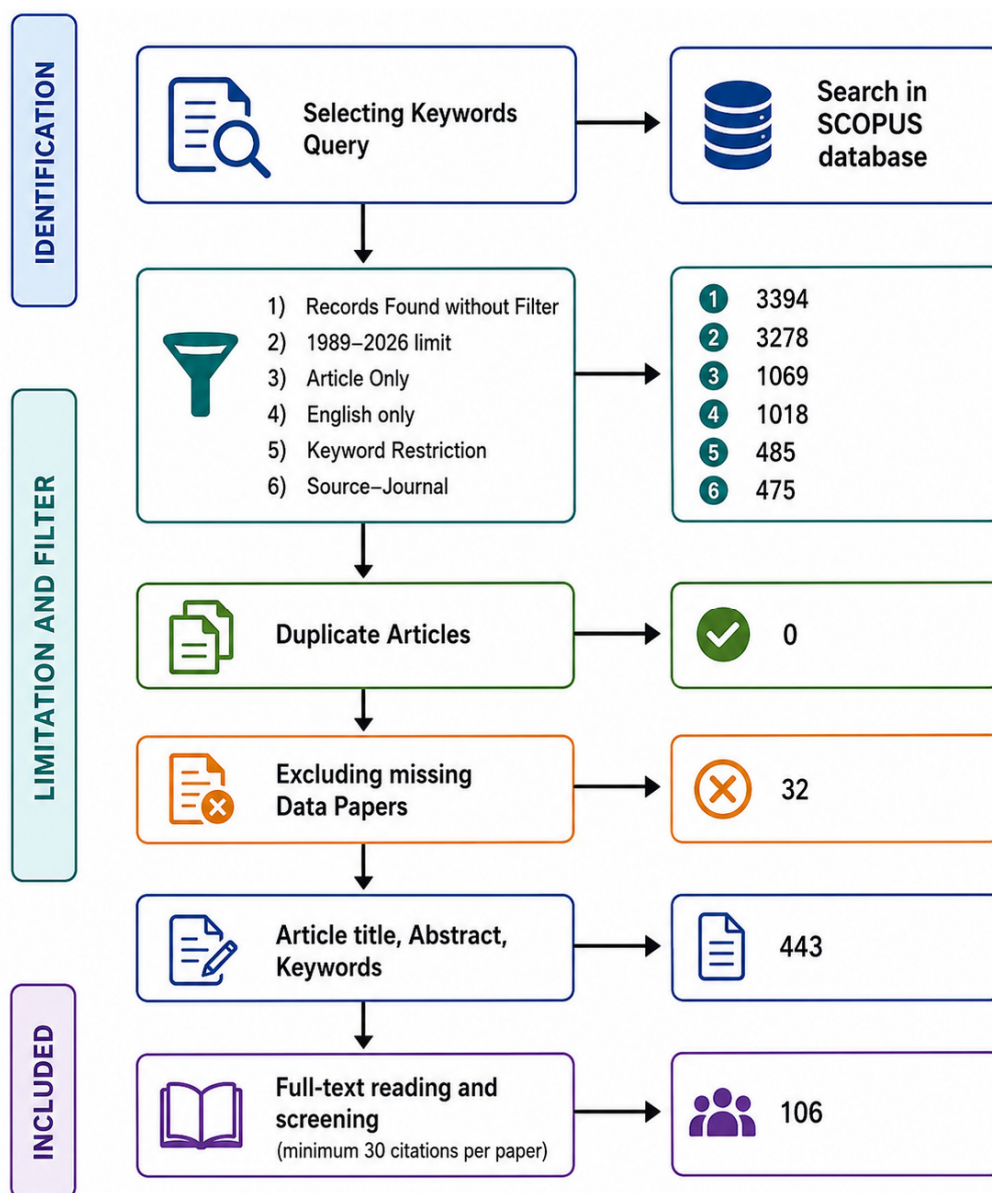


Fig. 1. PRISMA 2020 flow diagram illustrating the systematic literature review process

These terms reflect traditional AI methods, as well as the newest in intelligent enterprise technologies. The search for the ERP domain used the following keywords: enterprise resource planning, ERP, ERP systems, enterprise systems, business process management, business information systems, and enterprise information systems. Keywords used in the business application domain were digital transformation, automation, optimization, business intelligence, analytics, predictive analytics, decision-making, supply chain, and sustainability.

The retrieved publications were then screened based on the pre-defined inclusion/exclusion criteria. Articles published in English, peer-reviewed journals, and between 1989 and 2026 were included. The following types of documents were not used for the final analysis: conference papers, review papers, book chapters, editorials, notes, letters, non-English publications, duplicate records and studies not related to AI-enabled ERP systems. The filtering process helped to make sure that the selected publications had a high level of scientific quality and were directly relevant to the objectives of this review. The selection process for studies was carried out considering the PRISMA 2020 guidelines.

A preliminary search in Scopus yielded on a total of 3,278 publications. After limiting to journal articles, the number of publications was reduced to 1,069. Reducing the language to English further narrowed down the set to 1,018 publications. After a second keyword relevance screening using the titles, abstracts, and author keywords, 485 publications were identified. Finally, following detailed manual screening of journal sources, abstracts and full text relevance, 443 peer-reviewed journal articles were selected for final systematic literature review and bibliometric analysis. The entire study selection process is shown in Figure 1 (PRISMA 2020 Flow Diagram). A bibliometric analysis and thematic analysis were used to analyse the selected publications. To examine the publication trends, the structures of citations, the leading journals, influential authors, the productivity of the institutions, the regional cooperation of countries, the keyword co-occurrence networks and the thematic evolution of AI enabled ERP, bibliometric analysis was carried out using the software VOSviewer. Such analyses give a good overall sense of the intellectual organization and research development of the field.

This was followed by a thematic analysis, which involves grouping the selected literature into broad research themes, such as AI technologies, ERP functional modules, business applications, implementation opportunities, organizational challenges, emerging technologies and future research directions. Moreover, a comprehensive conceptual development is provided to explain the interactions between the various AI technologies, the ERP functional modules, intelligent business processes, organizational performance and future intelligent business ecosystems, providing valuable guidance in theory and practice for researchers and practitioners, ERP vendors, and intelligent business ecosystem policymaking.

4. Bibliometric Analysis

In this section, the selected 443 journal articles covering the period from 1989 to 2026 are analysed in a comprehensive way. To gain insights into the intellectual structure, research productivity, collaboration patterns, and emerging research trends, bibliometric analysis was performed on this research field using the VOSviewer software. In particular, annual publication and citation trends, most productive publication sources, leading authors, influential institutions, and country-wise research contributions are analysed.

4.1 Annual Publication, Citation Trends

The trends in publications and citations were analysed every year to assess the development, impact, and change of research over time [23,24]. In the years from 1998 to 2026, the number of annual publications on the topic of integrating AI into ERP systems has been steadily increasing, reflecting its gradual maturation and increased academic interest. In the early years (1998–2017), the level of research activity was relatively low, and annual publications were invariably fewer than 15, reflecting the fledgling state of the field as shown in Figure 2. This started to grow significantly

from 2018 onwards and has continued to grow since 2020. The number of publications increased from 20 in 2021 to 21 in 2022, 20 in 2023, and nearly doubled to 39 in 2024. The year 2025 had the highest number of publications (118), with GenAI, LLMs, and Intelligent ERP systems becoming widely used. As of now, there are 59 publications from the last year in 2026, but it is still a year that has not ended, and it is likely to continue to gain interest in AI-driven ERP studies.

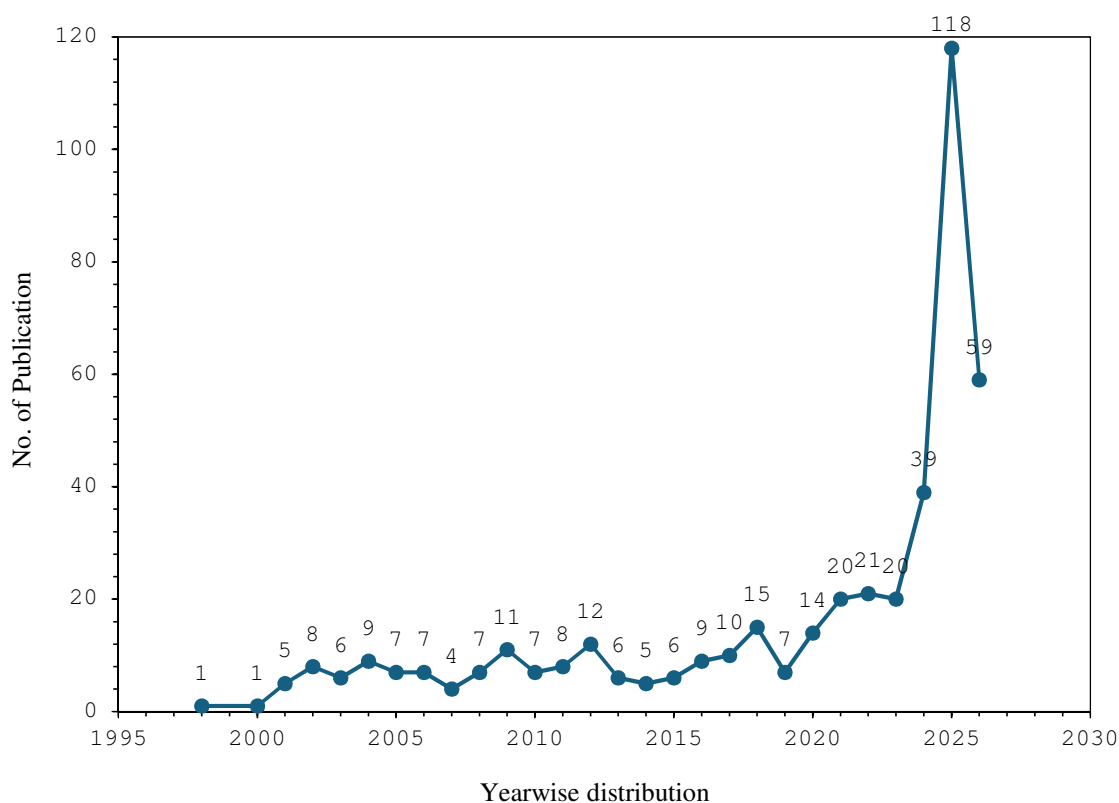


Fig. 2. Annual publication trend

The trends in publications and citations were analysed every year to assess the development, impact, and change of research over time [23,24]. In the years from 1998 to 2026, the number of annual publications on the topic of integrating AI into ERP systems has been steadily increasing, reflecting its gradual maturation and increased academic interest. The research activity was low in the early years (1998-2017), with fewer than 10 publications per year each year, and the fledgling stage of the field was reflected in the number of publications that were produced each year. This started to grow significantly from 2018 onwards and has continued to grow since 2020. The number of publications increased from 20 in 2021 to 21 in 2022, 20 in 2023, and nearly doubled to 39 in 2024. The year 2025 had the highest number of publications (118), with GenAI, LLMs, and Intelligent ERP systems becoming widely used. As of now, there are 59 publications from the last year in 2026, but it is still a year that has not ended, and is likely to continue to gain interest in AI-driven ERP studies.

4.2 Most Productive Sources

The most productive sources were analysed to determine the top journals that publish and support the research advancement [25,26]. The source analysis shows that there is a broad spectrum of research on the integration of AI into ERP systems, with research distributed widely across journals in all four of the above-mentioned fields. The most productive source is Expert Systems with Applications with 17 publications and 866 citations, followed by IEEE Access (15 publications) and

Applied Sciences (Switzerland) (10 publications). Although Decision Support Systems published only 7 articles, it received the highest citation count (920 citations), demonstrating its significant scholarly impact as shown in Figure 3. Similarly, Computers in Industry had 754 citations in nine publications, offering a glimpse of its impact on intelligent manufacturing and ERP studies. The source network visualization of the VOSviewer reveals two clusters of expert systems with applications and IEEE access, which occupy a central position with strong bibliographic connections, while other journals, including Enterprise Information Systems, Decision Support Systems, and International Journal of Production Research, form interconnected clusters, indicating the interdisciplinary and collaborative nature of the research related to AI-enabled ERP, as shown in Figure 4.

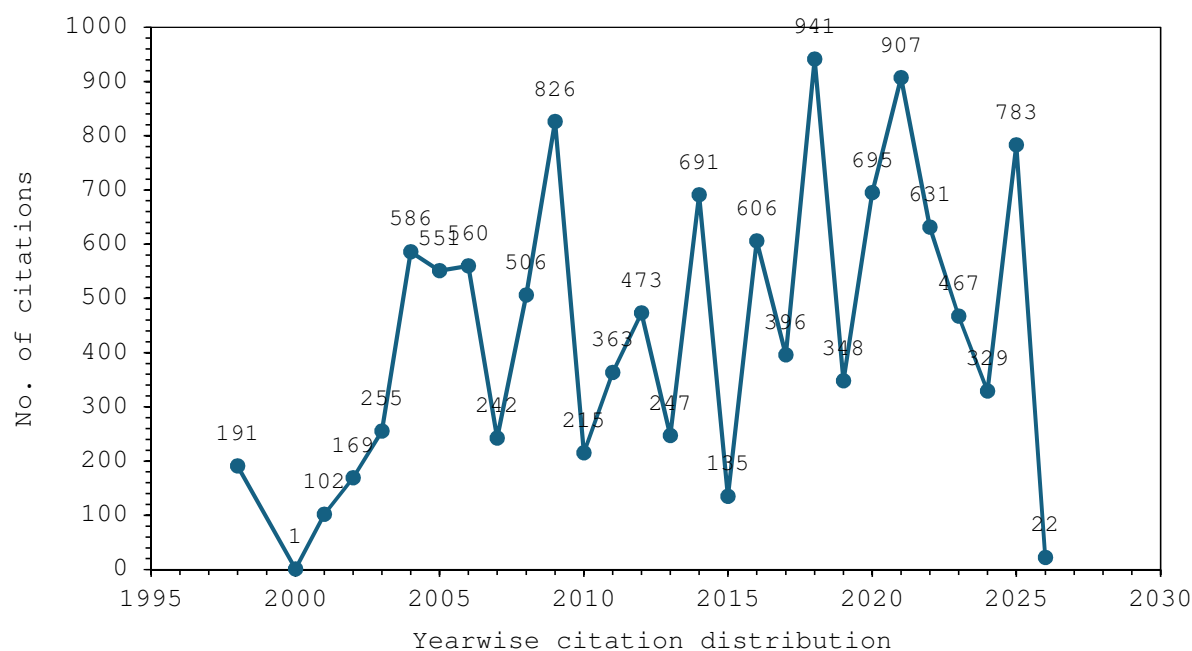


Fig. 3. Annual citation trend

4.3 Leading Authors

The productivity analysis of the authors indicates the researchers who have contributed most widely to the development of ERP with AI. Sarferaz, Siar is the most productive author with 5 publications, followed by Lin, Binshan and Michel, Roberto with 4 publications each. Despite publishing only 3 articles Saeed Rouhani had the largest number of citations (155 citations) and had the greatest scientific impact among other researchers. Pamucar, Dragan also has a very large research impact profile, with 3 publications and 55 citations. Pellerin, Robert and Zhao, Jing are the other strong research impact performers (49 and 44 citations, respectively). The VOSviewer author network visualization shows how the researchers co-authored papers and shows bibliographic connections between them; bigger nodes correspond to authors who have produced more papers and more proximity of nodes to each other means closer collaboration or citation relationship between authors as shown in Figure 5. Sarferaz, Siar, Pamucar, Dragan, Rouhani, Saeed, and Zhao, Jing are the key authors in the network that have been involved in the study and development of AI-enabled ERP, and have played an influential role in the cross-disciplinary areas of AI and enterprise systems as well as intelligent decision support.

illustrates the collaboration patterns among the institutions, with larger nodes denoting institutions with a stronger research influence and the closeness of the nodes reflecting stronger collaboration or bibliographic relationships. The network illustrates the multidisciplinary and cross-border character of AI-integrated ERP research, with the interconnectedness of computer science and information systems departments, engineering and business administration departments, and other institutions.

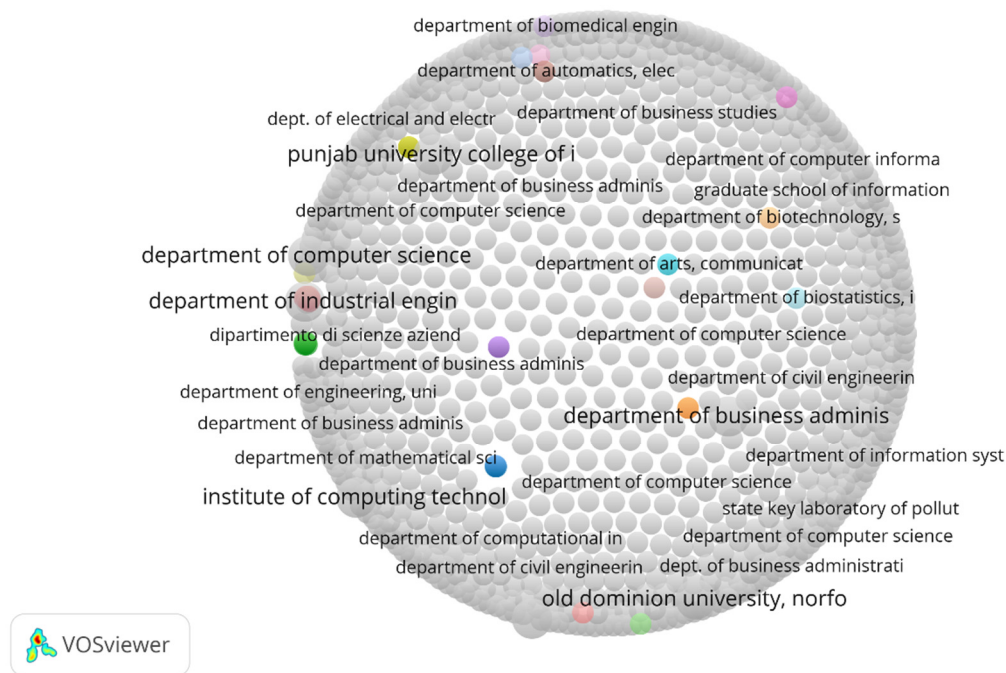


Fig. 6. Institutional collaboration network visualization

4.5 Top Country-wise Research Contribution

The country-wise analysis shows that the research on AI in ERP systems is spread across the world and has a strong presence in both developed and emerging economies [31,32]. China has the largest publication volume of documents (87), followed by the United States (78), India (36), United Kingdom (32) and Germany (28) as presented in Figure 7. Nevertheless, scientific impact, with the USA (3,842 citations), followed by China (1,974 citations), United Kingdom (1,028 citations) and Germany (970 citations). The country network visualization in VOSviewer displays collaborations between countries, the size of the nodes indicating the productivity and scientific influence of the countries, and the distance of the nodes indicating the strength of the collaboration. The United States, China, the United Kingdom, Germany and India are among the most prominent players in the network, spearheading the research and development in AI-driven ERP, and promoting scientific collaboration in AI and enterprise systems, including digital transformation.

4.6 Keyword Analysis

The analysis of the keyword can provide insights into the key research themes and research trends of AI enabled ERP [33,34]. The most common keyword is Artificial Intelligence (99 times) followed by Enterprise Resource Planning (40), ERP (35), Machine Learning (34) and Decision Support Systems (22) which is in line with the primary research focus on intelligent decision-making as shown in Figure 8.

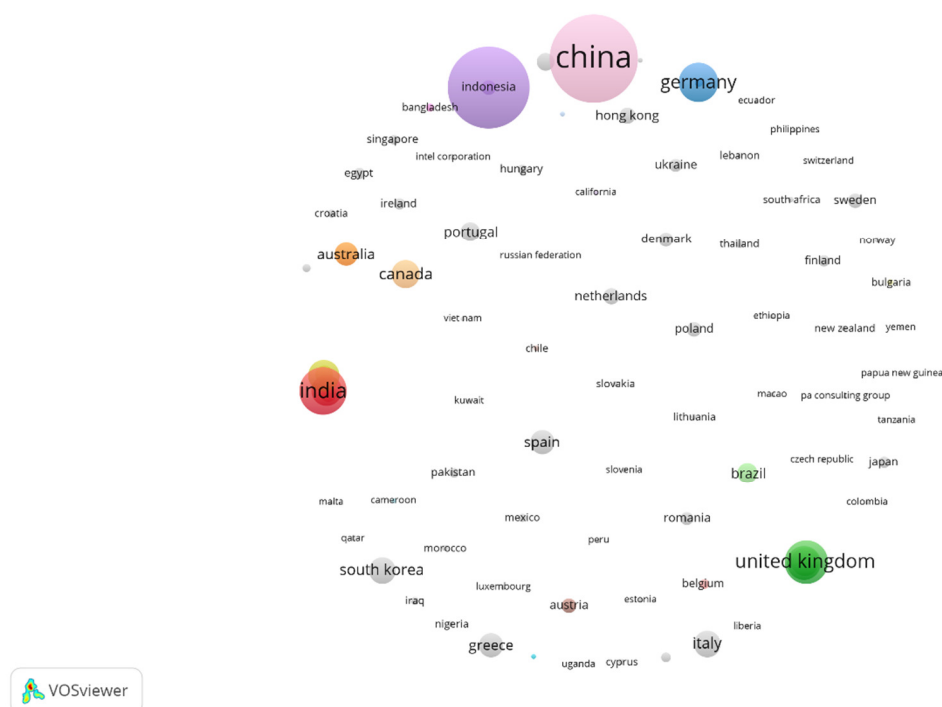


Fig. 7. Country collaboration network visualization

Other related terms like Industry 4.0, business process management, digital transformation, DL, business intelligence, Big Data, IoTs, and RL indicate the growing penetration of more advanced AI capabilities in enterprise systems. The VOSviewer keyword co-occurrence network visualization depicts the relations between the keywords; the size of the nodes is influenced by the frequency of the keywords, and the number of co-occurrences of the keywords influences the thickness of the lines. AI is at the core of the field and is closely connected to ERP, ML, Decision Support systems, digital transformation, and business process management, highlighting that AI is an important aspect of ERP and is currently being applied to intelligent automation and decision support systems, digital transformation, and business process management (Figure 8).

5. Thematic Analysis

Thematic analysis was used to classify and synthesize 443 selected journal articles in accordance with the major research themes, AI technologies, ERP functional modules, implementation strategy, and emerging technologies and future research directions. Thematic analysis offers a more detailed insight into the knowledge structure, technological developments, and the practical applications, opportunities, and challenges of AI-supported ERP systems, in contrast to bibliometric analysis, which reflects publication trends and citation patterns [35,36]. The literature was classified into four broad themes:

- i. evolution of AI in ERP systems;
- ii. ERP system and AI technologies;
- iii. AI and ERP functional modules;
- iv. AI and digital technologies in support of next generation intelligent ERP systems.

Overall, these themes represent the shift from traditional ERP systems to intelligent, autonomous, and data-driven enterprise platforms.

business operations were introduced by major ERP vendors, such as SAP, Oracle, Microsoft Dynamics, and Infor [42]. AI has brought a massive transformation to the capabilities of ERP systems. ML algorithms can uncover data trends within a company and use them to forecast customer needs, optimize inventory, prevent fraudulent transactions, and suggest managerial measures. The use of NLP allows the creation of conversational interfaces and intelligent virtual assistants, and computer vision has applications in automating quality inspection and warehouse management. Production scheduling, logistics planning, and dynamic resource allocation are further enhanced using RL and optimization algorithms [43].

With Industry 4.0 comes a convergence of ERP with new digital technologies: IoT, cyber-physical systems, cloud computing, big data analytics, blockchain and digital twins. ERP systems have become the central point of all manufacturing intelligence, real-time data exchange with sensors, equipment, processes, suppliers, and customers. They are intelligent ERP systems that help in predictive maintenance, autonomous production planning, smart inventory management, and intelligent supply chain optimization [44]. The next era of smart ERP [45] has been launched with the development of GenAI and LLMs. The rise of technologies like ChatGPT, GPT-4, Gemini, Claude, enterprise AI copilots, and others is revolutionizing ERP, providing natural language query capabilities, report generation, intelligent document processing, code generation, knowledge management, and human-like decision support. In today's ERP systems, it is about not only recording business transactions, but it can also be considered an intelligent assistant that understands the business context, gives suggestions, and helps in decision-making [46].

The shift towards Industry 5.0 adds to this trend, focusing on human-centric, sustainable, and resilient manufacturing systems. Industry 5.0 is not only about automation and connectivity, but also about humanization with intelligent machines. In summary, AI-driven ERP systems are becoming an essential part of achieving operational efficiency and sustainability, with the ability to empower employees, ensure ethical AI use, and create resilient supply chains as detailed in Table 1. ERP systems are therefore evolving from transactional information systems to intelligent enterprise systems that learn, adapt, and continue to innovate within organizations.

Table 1

Evolution of artificial intelligence in enterprise resource planning systems

Period	ERP generation	Major characteristics	AI capability	References
1989–1999	Traditional ERP	Transaction processing, centralized database, integrated business functions	None	Chou <i>et al.</i> [47]
2000–2009	ERP II	Web-enabled ERP, CRM, SCM, BI integration	Rule-based expert systems, DSS	Rashid & Tjahjono [48]
2010–2018	Cloud ERP	SaaS, cloud computing, mobile ERP, real-time integration	Machine Learning, Predictive Analytics	Zughoul <i>et al.</i> [49]
2019–2022	Intelligent ERP	AI-driven automation, IoT integration, Digital Twin, Industry 4.0	ML, DL, NLP, Computer Vision	Sarkar & Paul [50]
2023–2026	AI-driven ERP	Generative AI, LLMs, AI Copilots, Industry 5.0, autonomous enterprise	Generative AI, LLMs, Multi-Agent AI	Bandhana & Vokřínek [51]

5.2 AI Technologies in Enterprise Resource Planning Systems

AI has become the key technology to make traditional ERP systems intelligent, adaptive, and autonomous enterprise platforms. As technology evolves, the integration of AI capabilities is

increasingly prevalent in today's ERP systems, facilitating automation, efficiency, resource optimization, and strategic decision-making. As opposed to traditional ERP, AI-powered ERP systems learn from historical data and real-time data, enabling predictive, prescriptive, and autonomous decision-making. A thematic analysis of chosen literature was conducted to identify a variety of AI technologies being widely used and established in the ERP domain: ML, DL, RL, NLP, computer vision, expert systems, knowledge-based systems, decision support systems, LLMs, GenAI, and multi-agent systems.

5.2.1 Machine Learning

ML is another of the most popular AI tools used in ERP systems due to its capability to detect patterns, make predictions, and continually evolve and enhance decisions based on data. The most common applications of ML algorithms include demand forecasting, sales prediction, customer segmentation, inventory optimization, predictive maintenance, fraud detection, supplier evaluation, and production planning. With supervised learning, methods like decision trees, random forests, support vector machines, and artificial neural networks have enhanced the accuracy of the forecasts, compared to traditional statistical approaches. The unsupervised learning algorithms also help identify relationships in enterprise data that are hidden, which can be used for customer clustering, anomaly detection, and process optimization [52].

5.2.2 Deep Learning

DL is an advanced field of ML that involves an understanding of multi-layered neural networks for learning complex attributes from structured and unstructured data. In the realm of ERP systems, DL has shown great promise in enhancing image recognition, speech processing, demand forecasting, predictive analytics, quality inspection, and financial risk analysis. CNNs are being used for automated visual quality inspection in manufacturing, and RNNs and long short-term memory (LSTM) networks are used to improve time-series forecasting for inventory management and sales prediction. DL's ability to analyse gigabytes of data in the enterprise has significantly enhanced business intelligence and enterprise performance [53].

5.2.3 Reinforcement Learning

Some considerable attention has been paid to RL for solving complex optimization problems in ERP environments [54]. RL is a learning method that allows intelligent agents to learn optimal actions from interacting with dynamic business environments. It can be used in production scheduling, optimizing warehouses, logistics routing, dynamic pricing, inventory replenishment, and even for autonomous supply chain management. RL is continuously learning new decision policies based on the evolving operating environment and is well suited to real-time enterprise optimization and adaptive resource allocation.

5.2.4 Natural Language Processing

NLP is a powerful tool that allows ERP systems to interpret, understand, and generate human language, thereby facilitating communication between ERP and users and making it more streamlined and efficient [55]. NLP can be applied to intelligent chatbots, conversational ERP interfaces, automated report creation, document classification, invoice processing, sentiment

analysis, and contract management. ERP vendors are increasingly adding virtual assistant, which is based on NLP so that managers can retrieve enterprise information simply with natural language queries, instead of complicated database commands. This can greatly enhance the usability of the system, the speed of decision-making, and the productivity of the organization.

5.2.5 Computer Vision

By accessing visual data via cameras, drones, and industrial sensors, Computer Vision allows ERP systems to process and analyze visual information. Over the last few years, Computer Vision has been widely adopted by manufacturing companies for automated defect detection, quality inspection, inventory tracking, warehouse automation, equipment tracking, and occupational safety management. The integration with ERP systems ensures that production details are automatically uploaded and updated in the inventory, maintenance plans, and quality management modules, minimizing manual work and boosting efficiency.

5.2.6 Expert Systems

One of the earliest AI technologies that were introduced into ERP systems is expert systems. These systems mimic experts with pre-programmed rules and an inference engine to facilitate managerial decision-making [57]. The applications of Expert Systems are many in the field of financial planning, production scheduling, procurement, maintenance management, risk assessment, etc. While the flexibility of expert systems is less than that of current ML systems, they offer value to solve really well structured enterprise decision problems.

5.2.7 Knowledge-based Systems

In addition to the ERP platform, knowledge-based systems also include organizational knowledge repositories, ontologies, and reasoning mechanisms [58]. Knowledge-based systems support knowledge sharing, enterprise knowledge management, technical support, maintenance planning, supplier evaluation, and organizational learning. These systems help to enhance the quality of decision-making processes within the organization by capturing and retaining the knowledge of experts and making it available to different departments.

5.2.8 Decision Support Systems

One of the most significant parts of the ERP system that harnesses AI is decision support systems [59]. A decision support system incorporates enterprise databases, analytical models, optimization methods, and visualization tools to help in managerial decision-making. AI-driven DSS offer predictive suggestions for financial planning, procurement choices, inventory optimization, production scheduling, and supply chain coordination. Today, decision support systems are increasingly being developed to be intelligent, context-aware, and incorporate ML algorithms to give intelligent and context-aware business recommendations.

5.2.9 Large Language Models

In recent times, LLMs have become a revolutionary technology that has become a key element in intelligent ERP systems [62]. Enterprise language models like GPT, Claude, Gemini, and others make

it possible to interact with the model through natural language, retrieve knowledge, generate reports, get help with code, automate workflows, and search intelligently through the enterprise. LLMs enable conversational interactions with ERP systems, making them much more usable than traditional ERP software. They can summarize documents, answer business questions, create SQL statements, and automate repetitive reporting, among other valuable features, showing a significant leap in enterprise intelligence.

5.2.10 Generative Artificial Intelligence

GenAI takes the power of LLMs to a new level by generating new content such as reports, dashboards, business recommendations, software code, product descriptions, and technical documentation. In the realm of ERP, GenAI can be used for automated financial reporting, procurement documentation, customer communication, demand planning, marketing content generation, and knowledge management. As AI copilots become commonplace in ERP systems, they are helping users complete mundane tasks, which leads to a boost in productivity and cost savings.

5.2.11 Multi-Agent Artificial Intelligence

A multi-agent system consists of a group of autonomous agents with intelligence that collaborate with each other to resolve enterprise problems in several locations [61]. The application areas of multi-agent systems are supply chain coordination, autonomous procurement, warehouse management, production scheduling, logistics optimization, and collaborative manufacturing. Intelligent agents run specific tasks and interact with other agents to accomplish enterprise goals.

5.3 Artificial Intelligence Applications across ERP Functional Modules

The fusion of AI with ERP has revolutionized how enterprise resources are managed, providing intelligent automation, predictive analytics, and data-driven insights for various business processes. While conventional ERP systems mainly concentrated on documenting and incorporating business transactions, AI ERP systems use ML algorithms, NLP, computer vision, and sophisticated analytics to enhance organisational performance. The chosen literature is surveyed in a thematic manner to show that AI is embedded in almost all functional ERP components like finance, supply chain management, manufacturing, inventory management, procurement, human resources, customer relationship management, sales and marketing, project management, maintenance, and business intelligence.

5.3.1 Finance and Accounting

One of the first ERP modules to embrace AI technologies is finance and accounting. Most of the financial forecasting, fraud detection, cash flow prediction, credit risk assessment, budgeting, and automated auditing are increasingly being attempted using machine learning algorithms. Through financial analytics, AI can identify unusual or fraudulent financial activities, make better predictions, automate invoice handling, and improve compliance with regulations. NLP can also support automated financial reporting by scouring financial documents for pertinent data and crafting management reports. In recent years, there have also been breakthroughs in GenAI, which have given rise to intelligent financial assistants that can generate reports, analyze financial performance, and respond to accounting-related questions via conversations.

5.3.2 Supply Chain Management

AI-powered ERP systems have emerged as one of the most crucial fields for their applications: Supply Chain Management (SCM). Demand Forecasting, supplier selection, inventory optimization, transportation planning, warehouse management, and logistics scheduling are enabled with ML and predictive analytics. The combination of RL and IoT devices that continuously feed operational data to the system enables dynamic routing and adaptive inventory replenishment. AI can also help increase supply chain resilience by detecting potential disruptions and suggesting proactive measures to mitigate them. This means that firms can reduce inventory costs, delivery times, and improve customer satisfaction.

5.3.3 Manufacturing and Production

AI is increasingly being used by manufacturing organizations to enable intelligent production planning, predictive maintenance, quality control, and production scheduling. The production data is fed into ML models to detect performance bottlenecks, maximize machine efficiency, and predict equipment failure before it actually breaks down. Computer Vision makes product inspection and defect detection automatic, and Digital Twins make production processes simulations to enhance operational efficiency. AI ERP systems, as a result, have improved manufacturing flexibility, minimized downtime, boosted product quality, and supported smart factory initiatives of Industry 4.0.

5.3.4 Inventory and Warehouse Management

One of the most popular applications of AI in ERP is inventory optimization. ML models provide estimates on future product demand, optimize inventory levels, and minimize stockouts or overstocking. Warehouse management systems (WMS) powered by AI use computer vision, mobile robots, RFID technologies, and IoT sensors to manage inventory, warehouse navigation, and order fulfilment. Additionally, predictive analytics can help businesses optimise their warehouse space usage and reduce carrying costs.

5.3.5 Procurement

The use of AI technologies has revolutionized the procurement process, enhancing supplier evaluation, generation of purchase orders, contract analysis, and procurement risk assessment. ML algorithms analyse past transaction data, delivery dependability, quality metrics, and pricing trends to rate suppliers. NLP helps procurement managers to automatically analyse contracts, pinpoint contractual risk, and uncover key clauses within supplier contracts. AI-powered procurement helps reduce costs, increase supplier visibility, and make better buying decisions.

5.3.6 Human Resource Management

AI-powered ERP systems have revolutionized the Human Resource Management (HRM) landscape. AI can be used to aid in the recruitment process, employee selection, performance evaluation, workforce planning, payroll management, employee retention, and learning management. ML programs analyse resumes and look for appropriate job prospects, forecast staff attrition, and suggest individual training courses. Another benefit of chatbots for HR is that they can provide answers to HR-related queries, schedule interviews, and automate repetitive administrative

tasks, further improving employee service. These smart HR solutions cut down on hiring expenses and boost the productivity of the employee pool and employee satisfaction.

5.3.7 Customer Relationship Management

AI has begun to be increasingly associated with customer relationship management (CRM) to improve customer engagement and customer service. Customer buying patterns and preferences, along with customer reviews, can be used to create ML models that provide personalized recommendations for products and marketing campaigns, improving customer interaction and satisfaction. By analyzing customer data, including purchase patterns, preferences, and feedback, ML models can make personalized product recommendations and marketing campaigns that could enhance the customer experience and satisfaction. NLP enables intelligent customer service chatbots to respond to customers' queries throughout the day. Sentiment analysis can also be used to help businesses identify customers' thoughts and feelings expressed on social media and online reviews and respond to customers promptly.

5.3.8 Sales and Marketing

AI-driven ERP systems can revolutionize sales forecasting, pricing optimization, campaign management, and market analysis. Predictive analytics can help to predict sales trends, and recommendation systems can target marketing based on customer preferences. GenAI helps marketing teams to create promotional content, product descriptions, e-mail marketing campaigns, and advertising. These capabilities help improve customer acquisition, increase conversion rates and make decision-making easier decision making for strategic marketing.

5.3.9 Project Management

AI is becoming more and more crucial in the ERP-backed project management software. Project managers for project scheduling, resource allocation, budget estimation, risk assessment, and project monitoring use AI algorithms. ML models predict project delay, project cost and optimize the utilization of the company's workforce based on historical project data. The AI dashboards provide real-time analytics and insights, helping project managers identify potential delays or issues and take proactive steps to prevent them from negatively affecting the project and ensure its successful completion.

5.3.10 Maintenance and Asset Management

One of the most valuable AI applications in ERP systems is predictive maintenance. Information from equipment sensors is used to power ML algorithms that predict equipment failures and maintenance schedules without equipment failure. By connecting with IoT, ERP can constantly monitor the health of machines, such as vibration patterns, temperature checks, and operational parameters. This translates to considerably reduced maintenance costs, virtually no downtime in production, and prolonged equipment life.

5.3.11 Business Intelligence and Analytics

The analytical heart of today's AI-powered ERP systems is business intelligence (BI). AI technologies analyse huge amounts of enterprise data to create dashboards, predictive reporting, performance metrics and strategy recommendations. Advanced analytics can help managers spot business trends, assess organizational performance, maximize resource usage and aid executive decision-making. With the advent of GenAI, businesses can now benefit from conversational analytics, generate reports automatically, and query enterprise databases using natural language.

5.4 AI-Enabled ERP Technologies

AI powered ERP solutions have come a long way thanks to the rapid advancements of digital technologies. These complementary technologies (i.e., cloud computing, IoT, Big Data analytics, Blockchain, digital twins, RPA, edge computing and cyber-physical systems) enable the infrastructure that supports intelligent enterprise operations. The combination of these technologies gives rise to the transformation of the traditional ERP system into an interconnected, autonomous, and data-driven ERP enterprise system, ready to support Industry 4.0 and Industry 5.0. The thematic analysis shows that these enabling technologies work together to enhance operational efficiency, agility in business, real-time monitoring, and enterprise-wide collaboration.

5.4.1 Cloud ERP

Cloud Computing has transformed ERP Implementation by moving enterprise applications from on-premises infrastructure to cloud-based infrastructure. Cloud ERP can be delivered as SaaS, Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS). Cloud ERP offers higher scalability, lower implementation costs, automatic software updates, better accessibility, and better collaboration within a geographically spread organization than traditional ERP. The integration of AI enhances Cloud ERP capabilities, including intelligent forecasting, automated workflows, anomaly detection, and real-time business intelligence. AI features are becoming integrated into the cloud as leading ERP vendors like SAP S/4HANA Cloud, Oracle Fusion Cloud ERP, Microsoft Dynamics 365, and Infor CloudSuite are adding AI features to their cloud platform offerings to help with the management of the intelligent enterprise.

5.4.2 Internet of Things

The IoT allows ERP systems to gather real-time operational data from physical machines, sensors, vehicles, warehouses, and industrial equipment. IoT devices are constantly sending production, inventory, logistics, and equipment data to ERP databases that allow real-time monitoring and intelligent decision-making. AI algorithms can then process these data streams to provide optimization for production scheduling, inventory management, predictive maintenance, and supply chain management.

5.4.3 Big Data Analytics

Structured and unstructured data is created in huge quantities from ERP transactions, customers, production systems, social media, and IoT devices in modern enterprises. With Big Data Analytics, businesses can leverage distributed computing technologies and advanced data analysis techniques

to process these volumes of data. With the help of ML models embedded in Big Data platforms, the segmentation of customers, forecasting of demand, financial analysis, fraud detection, and optimization of operations can be realized. In turn, organizations make more precise forecasts and evidence-based decisions, and gain more competitiveness in organizations.

5.4.4 Blockchain

Blockchain technology's attributes of security, decentralization, and immutability make it a valuable addition to ERP systems. Blockchain enhances transparency in the supply chain, procurement management, financial auditing, contract management, and product traceability. Smart contracts execute business transactions automatically, eliminating the need for any third party, thus lowering administrative expenses and increasing trust in operations. AI can be used with blockchain to assist in executing intelligent contracts, preventing fraud, verifying suppliers, and other data sharing-related security protocols within enterprise networks. These are valuable features when it comes to global supply chain management and regulatory requirements.

5.4.5 Digital Twin

Digital Twin technology generates virtual copies of physical assets, manufacturing systems, and enterprise operations. These virtual models are constantly updated with real-time operational data from IoT sensors and can be used to simulate, monitor and optimize the production process before changes are made in the real world. AI algorithms even make Digital Twins more powerful by forecasting equipment issues, scheduling production optimizations, and analysing other operational scenarios. Digital Twins have become a key element of the implementation of intelligent manufacturing and smart factories in the context of Industry 4.0.

5.4.6 Robotic Process Automation

RPA is a technology that can automate repetitive, rule-driven administrative tasks in ERP systems. RPA software robots perform repetitive tasks, like processing invoices, creating purchase orders, processing payroll, updating customer data, and generating reports, with little human involvement. With the addition of AI capabilities like ML and NLP, RPA becomes intelligent process automation (IPA), which introduces cognitive decision-making, understanding documents, and adaptable workflow management. This integration helps to significantly increase the productivity of organizations and help to reduce human error and cost.

5.4.7 Edge Computing

Edge computing is the capability to make use of the information on the edge of the community instead of sending all information to the central cloud servers. Edge computing in industrial environments enables real-time processing of data collected from sensors, machinery, and production lines, bypassing the need for delays associated with relying on cloud servers. With AI algorithms deployed on the edge, they can detect anomalies instantly, perform predictive maintenance, and manage processes autonomously. Hence, edge computing is helpful for the response time, bandwidth consumption, and reliability of Industrial ERP systems.

5.4.8 Cyber-Physical Systems

Cyber-physical systems are a combination of computational intelligence and physical manufacturing processes where the two continuously interact, acting through software, sensors, machines, and communication networks. CPS forms the technological backbone of smart factories of Industry 4.0, enabling autonomous production processes, intelligent robotics, and real-time control of production. ERP systems are the nerve centre and coordination mechanism for CPS and enterprise decision-making. Moreover, AI is improving the skills of CPS with self-scheduling, quality monitoring, predictive maintenance, and adaptive manufacturing, underlining production efficiency and operational resilience.

6. Opportunities of Artificial Intelligence Integration in ERP Systems

AI and ERP systems have ushered in a new era in which ERP systems are becoming more intelligent, adaptive, and data-driven, offering a fantastic opportunity for organizations. The AI-powered capabilities of ERP systems can help streamline repetitive tasks, provide predictive analytics, streamline resource allocation, and facilitate strategic decision-making in various business operations. In the age of digital transformation, AI-driven ERP solutions are crucial for enhancing operational efficiency, organizational agility, business resilience, and competitive edge. The most significant opportunity is intelligent decision support, where ML, expert systems, and decision support systems process the large volume of enterprise information and provide a clear set of recommendations to support strategic and operational decisions. AI features in ERP systems enable managers to gain insights from trends and patterns in the business, assess risks, forecast customer demand, and optimize use of resources, reducing uncertainty and improving decision-making. Another major advantage of process automation is that it eliminates repetitive manual processes, such as financial reporting, payroll management, procurement, invoice processing, etc., and updates inventory.

By combining RPA, NLP, and GenAI, the technology minimizes human involvement, boosts operational efficiency, and cuts down on mistakes, while empowering workers to work on tasks that are more valuable. Another benefit of AI is its ability to improve predictive analytics, which uses past and present information from enterprises to predict customer demand, equipment failures, inventory needs, financial performance, and market trends. Predictive models can be used to inform business decision-makers and optimize production planning, inventory management, and develop effective business continuity plans by leveraging data-driven decision-making. AI-driven ERP systems have the potential to improve supply chain management by allowing you to assess suppliers, plan logistics, optimize inventories, manage warehouses, and even schedule shipments. Real-time monitoring and predictive analytics provide additional support for chain resiliency, prevent operational challenges, improve demand forecasting, and allow agility in reacting to market conditions. With better utilization of resources, fewer downtimes in the equipment, lower inventory holding costs, and optimized business processes, organizations can enjoy substantial cost savings and productivity enhancements.

With the support of AI-driven predictive maintenance, intelligent scheduling, and automated workflows, organizations can experience improved equipment uptime, employee efficiency, and overall operational performance, all contributing to increased productivity and profitability. AI is also contributing to enhancing the customer experience by providing personalized product suggestions, intelligent customer relationship management, automated customer support, and sentiment

analysis. AI Chatbots and virtual assistants offer quicker response times to customers, enhance service quality, boost customer engagement, and elevate customer satisfaction and loyalty.

Another opportunity that is coming is sustainable enterprise management, as AI-driven ERP systems help optimize energy use, reduce waste, monitor carbon emissions, and adopt and support circular economy and sustainable supply chain solutions. Intelligent resource planning helps organizations meet their economic, environmental, and social sustainability goals, as well as helping to support their Environmental, Social and Governance (ESG) initiatives and sustainable development goals. Last, but not at all least, AI is greatly enhancing real-time business intelligence, which is constantly analyzing enterprise data from a range of sources inside and outside the organization. The ability to analyze and process data using AI features, create reports automatically, and present real-time data and insights on interactive dashboards can help managers make quick decisions to respond to changing markets and improve strategic planning. Together, these opportunities reveal that AI-powered ERP systems have become more than just a transactional tool; they are now intelligent enterprise ecosystems that can foster innovation, resilience, operational excellence, digital transformation, and long-term organizational competitiveness.

7. Challenges of Artificial Intelligence Integration in ERP Systems

Although AI can bring numerous advantages to ERP systems, some technical, organizational, and compliance hurdles come with its use. Data quality and availability are another one of the challenges, as AI systems must have accurate, complete, consistent, and current data to make informed predictions and recommendations. Ensuring the accuracy, completeness, consistency, and timeliness of data is another key challenge, as AI algorithms depend on such data to generate accurate predictions and recommendations. The lack of quality data can result in skewed models and flawed decision-making.

One of the major challenges is legacy ERP integration, as older system architectures, software incompatibility, and disconnected databases make it difficult to integrate modern AI solutions, adding to the complexity of the implementation process and risk of migration. As they become more reliant on interconnected enterprise systems, cybersecurity and privacy issues also arise as the organization's sensitive data is at risk of being targeted by cyber threats or accessed without authorization. Ethical AI and governance are further themes for discussion by organizations, with a focus on ensuring fairness, accountability, transparency, and responsible use of AI-driven decisions. As many AI models are regarded as "black boxes", managers closely link the challenge of explainability and trust to the difficulty of understanding and justifying automated decisions.

The cost of implementation can also be substantial, including the investment in infrastructure, cloud platforms, AI software, and system customization, which can be challenging for organizations, particularly SMBs. Other hurdles to effective implementation are a lack of AI personnel, employee resistance to change, and inadequate training. Last but not least, regulatory and legal changes, such as data protection laws, AI governance regulations, and industry compliance standards, create a need to continuously update ERP systems, ensuring security, transparency, and legal compliance. The difficulties highlight the need for a comprehensive implementation strategy, robust governance, and organizational learning to maximize the value of an AI-driven ERP system.

8. Research Gaps and Future Research Directions

While AI has rapidly made its way into ERP systems, there are still major gaps in research that hinder the creation of complete autonomous ERP systems. Although popular and high-profile in the

industry, very few instances have been reported of GenAI use in ERP, and those that do have been those focused on automating workflows and tasks. The real integration of enterprise ERP AI copilots to help with complex business decisions seems to be a bit down the road, according to reports. Similarly, while there has been a growing demand for transparent and interpretable AI models to help enhance management confidence and regulatory compliance, there has been limited research interest in explainable AI for ERP.

AI governance research is still in the early stages, and there are still no complete frameworks that tackle AI ethics, accountability, fairness, and responsible AI use in an enterprise context. The other significant gap is Human–AI collaboration, where user acceptance, collaborative decision-making, and human-centered ERP design aspects are not explored. In addition, while Digital Twin has shown great promise in smart manufacturing, its linkage with ERP is not well studied. Multi-agent systems are another promising field and, so far, there is little work done on autonomous ERP architectures based on intelligent agents. As cyber threats continue to become more complex, the demand for AI-based cybersecurity solutions that safeguard enterprise data and combat AI-driven attacks is also increasing.

Sustainability is also a new field of study, and there are comparatively few studies that combine the three pillars of ESG goals with AI-powered ERP systems. However, the future of AI in ERP holds significant potential for advancement and innovation, and further research is needed in the following areas:

- i. developing GenAI assistants for ERP systems;
- ii. creating autonomous AI agents for ERP;
- iii. enhancing Explainable ERP systems;
- iv. implementing Digital Twin functionality in ERP;
- v. exploring Federated Learning for privacy-preserving analytics;
- vi. investigating Quantum AI for complex enterprise optimization;
- vii. developing comprehensive AI governance frameworks;
- viii. advancing sustainable intelligent ERP;
- ix. integrating human-centered AI collaboration;
- x. leveraging Industry 5.0 ERP systems.

9. Conceptual Framework

The concept map presented in Figure 9 illustrates the linkage between AI technologies and ERP systems to create intelligent, data-driven, and sustainable enterprises. The framework shows the stages of integration that begin with the advanced core AI technologies, like ML, DL, LLMs, GenAI, and NLP, which allow for advanced learning, reasoning, prediction, and intelligent automation capabilities. Complementary digital technologies include IoT, Big Data analytics, cloud computing, Blockchain, and Digital Twin, which aid in the collection of real-time data, secure data sharing, scalable computing, and intelligent connectivity throughout enterprise operations. These built-in technologies are then used throughout the key functional modules of ERP such as finance, human resources, supply chain management, manufacturing, customer relationship management, procurement, inventory management, and maintenance. This synergy unlocks the potential of the ERP to automate, predict, optimize, make intelligent decisions, find knowledge, etc., contributing to streamlining operations and making better business decisions for the organizations. To sum it up, these capabilities have enormous business impact, including operational efficiency, operational cost reduction, increased productivity, enhanced customer satisfaction, increased supply chain resiliency,

sustainable business practices, and competitive advantage. Overall, the conceptual framework highlights the process of digital transformation and the era of Industry 5.0, where AI-powered ERP systems serve as a comprehensive solution that enables businesses to thrive in a digital age.

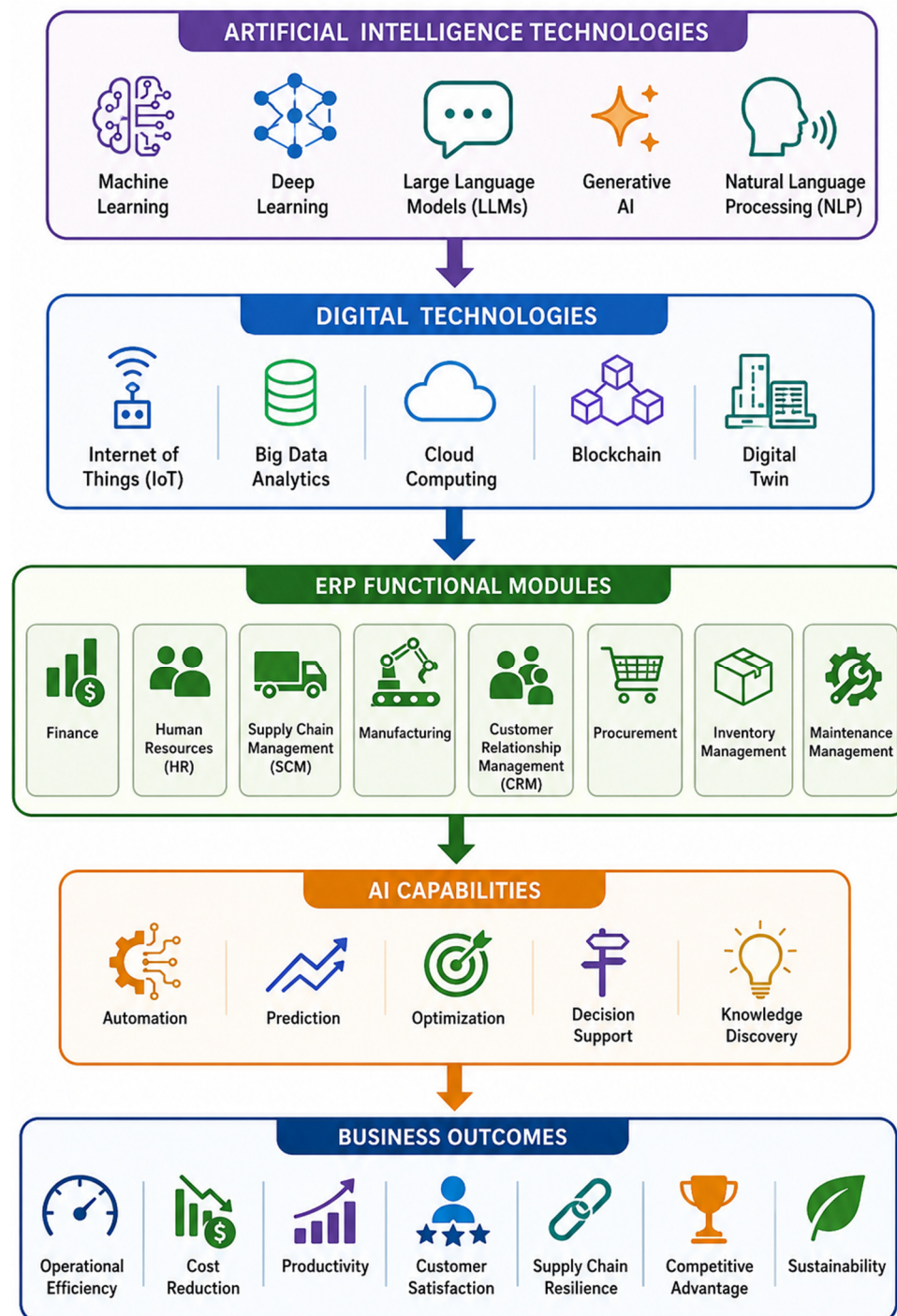


Fig. 9. Conceptual framework illustrating artificial intelligence integration in enterprise resource planning systems

10. Managerial Implications

This systematic literature review offers some valuable managerial implications for organizations wanting to use AI in their ERP. The results underpin the importance of vendors of ERP systems like

SAP, Oracle, and Microsoft Dynamics continuously improving ERP systems by integrating cutting-edge AI features, such as ML, LLMs, GenAI, explainable AI, and intelligent automation. To meet evolving business needs, the future of ERP solutions should be user-friendly AI copilots, predictive analytics, real-time decision support, and secure cloud-native infrastructures. In manufacturing, AI-driven ERP systems offer significant benefits, particularly in areas like production planning, predictive maintenance, inventory management, quality control, and supply chain optimization. To enhance the efficiency of operations and an organization's resilience, managers should establish detailed digital transformation strategies, combining AI with Industry 4.0 technologies such as IoT, Digital Twins, and Big Data analytics.

To overcome financial and technological constraints of SMEs and to make them competitive in the market by having smart business processes, they must invest in scalable cloud-based ERP systems that can be integrated with AI tools. The results also give hints to those implementing digital transformation, such as chief information officers and digital transformation managers, who are important in the implementation of AI. The organisations should prioritise data governance, cybersecurity, workforce preparation, change management and ethical AI usage as key areas for the adoption of AI in the long term. Investments in high-quality data, state-of-the-art digital infrastructure and cross-disciplinary expertise in AI will be important for a successful rollout within the enterprises. The review also emphasizes the importance of effective governance mechanisms, such as ethical guidelines, standards for interoperability, data privacy regulations, and AI governance frameworks, in ensuring responsible AI usage, transparency, accountability, and trust, from a policy perspective.

11. Practical Implications

Some practical implications for organizations that are implementing AI-based ERP systems are discussed in the review. The roadmap for implementing AI should start with an evaluation of the organization's readiness to implement AI, setting clear objectives, ensuring enterprise data quality, identifying suitable AI tools and capabilities, executing pilot projects, and gradually expanding AI solutions to various ERP functional modules. This transformation from legacy on-premises ERP to cloud-based solutions with AI, real-time analytics, and integration capabilities is an essential step for businesses to succeed in the digital era. Yet, sustained employee training is crucial for developing digital skills, AI literacy, and analytical capabilities to effectively use AI. Workshops should be tailored to support managers and workers to work effectively with AI systems without the apprehension of change.

Furthermore, organizations need to establish strong AI governance mechanisms to ensure transparency, accountability, fairness, data privacy, and compliance with regulations and laws throughout the AI lifecycle. Furthermore, the role of good risk management practice should not be ignored. Organizations must not only continuously monitor and improve the performance of AI models but also protect their sensitive enterprise data, ensure compliance with ethical guidelines and practices, and enhance their cybersecurity practices. This should go hand in hand with the use of AI to change the way the business works to eliminate any inefficient processes, automate repetitive processes, and optimise enterprise operations. Last but not least, intelligent decision support systems powered by AI should be integrated throughout finance, manufacturing, supply chain, procurement, customer relationship management, and human resource management to aid evidence-based strategic planning and enhance the organisation's performance. These practical tips provide organizations with an all-encompassing blueprint for transforming a traditional ERP system into an intelligent enterprise system.

12. Limitations

Although this study has extensively reviewed the integration of AI in ERP systems, it does come with some limitations. Firstly, the review was limited to the Scopus database and may have missed relevant articles published in other scholarly databases like Web of Science, IEEE Xplore, ACM Digital Library, ScienceDirect, SpringerLink, and others. Second, only English-language peer-reviewed journal articles were chosen, which may result in language and publication bias and the omission of valuable research in other languages. Third, papers in conference proceedings, books, book chapters, editorials, and review reports were excluded to maintain methodological consistency, but these sources may feature important developments that are occurring in the field, especially in AI technologies that change rapidly. Fourth, the results of the bibliometric analysis are highly dependent on the accuracy of the databases to be analysed, the way in which the publications are cited, and the quality of the metadata provided, which can influence the publication trends, the citation network, and collaboration patterns that are reported. Last but not least, the rapid evolution of GenAI, LLM, and autonomous AI technologies can affect the future results of this research and future applications after the period of data collection (1989 – 2026). Therefore, regular revisions of systematic reviews will be needed to reflect new trends and advancements in AI-powered ERP solutions.

13. Conclusion

This study was conducted in a systematic manner using the PRISMA 2020 methodology, bibliometric analysis, and thematic analysis to examine 443 journal articles from the Scopus database from 1989 to 2026 to analyse the integration of AI in ERP systems. The results indicate that there was a significant surge in research, especially since 2020, with an emphasis on the widespread integration of ML, DL, NLP, LLMs, GenAI, and explainable AI in contemporary ERP systems. A bibliometric analysis was used to determine influential journals, authors, institutions, countries, and research themes, highlighting the increasing interdisciplinary nature of AI-enabled ERP research.

Based on thematic analysis, AI technologies are gradually being applied in various areas, including finance, manufacturing, supply chain management, procurement, inventory management, customer relationship management, human resource management, maintenance, and business intelligence. The above technologies bring great opportunities in the areas of intelligent decision support, process automation, predictive analytics, optimization of operations, better customer experience, sustainable enterprise management, and competitiveness of the organization. But the adoption of AI in the ERP industry is still hindered by issues such as data quality, integration with legacy ERP, cybersecurity, ethics and governance of AI, implementation cost, employee skill gaps, AI explainability, and regulatory compliance.

The review also highlighted key research gaps, including GenAI, Explainable AI, AI governance, Human–AI collaboration, Digital Twin integration, multi-agent systems, cybersecurity, and sustainability, and suggested a future research agenda focused on AI copilots, autonomous ERP systems, federated learning, quantum AI, Industry 5.0, and sustainable intelligent enterprises. Last but not least, the proposed conceptual framework offers an integrated view of how the various AI technologies, digital technologies, ERP functional modules, AI capabilities, and business outcomes interact to form intelligent, resilient, and sustainable enterprise ecosystems. Overall, this review provides a comprehensive knowledge base to researchers, practitioners, ERP vendors, and policymakers and gives strategic directions on where the future of AI-enabled ERP might go.

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Conflicts of Interest

The authors have no conflict of interest.

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