



Bibliometric Analysis Of The Development Of Digital Systems, Applications, And Products In Data Processing (SAP) During The 2018–2024 Period

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ABSTRACT

This study aims to map the development of research on Systems, Applications, and Products in Data Processing (SAP) during the 2018–2024 period using a bibliometric approach. Research data were collected from the Scopus database through a literature selection process based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, resulting in 316 publications that met the inclusion criteria. Publication metadata were analyzed using VOSviewer through co-occurrence, overlay visualization, density visualization, and co-authorship network analyses to identify publication trends, thematic developments, and scientific collaboration patterns. The findings indicate that SAP-related publications remained relatively stable with moderate fluctuations, increasing from 42 publications in 2018 to a peak of 53 publications in 2022. The keyword network structure highlights SAP, Enterprise Resource Planning (ERP), and enterprise systems as core themes interconnected with digital transformation, cloud computing, process mining, artificial intelligence, machine learning, and SAP S/4HANA. Temporal analysis reveals a shift in research focus from conventional ERP implementation toward the development of enterprise systems increasingly integrated with digital technologies and data-driven capabilities. Furthermore, the co-authorship analysis demonstrates the emergence of international collaboration networks involving researchers from various countries in advancing SAP-related studies. Overall, the results provide a comprehensive overview of the evolution of SAP research and identify promising directions for future studies in the era of digital transformation.

INTRODUCTION

The digital transformation accelerated by the post-COVID-19 era has fundamentally reshaped how organizations conduct business operations, manage information, and make strategic decisions. Growing demands for operational efficiency, business agility, and real-time data integration have encouraged organizations to move away from fragmented systems toward more integrated digital platforms. As a result, the adoption of Enterprise Resource Planning (ERP) systems has increased significantly, as these systems enable the integration of various business functions, including finance, production, logistics, supply chain management, marketing, and human resource management within a unified platform (Bandara et al., 2024). Moreover, ERP systems have evolved beyond administrative tools into strategic digital infrastructures that support data-driven decision-making.

This digital shift is particularly evident in the development of Systems, Applications, and Products in Data Processing (SAP), one of the most widely adopted ERP platforms worldwide. The transition to SAP S/4HANA represents a major milestone in enterprise system innovation through the integration of artificial intelligence (AI), cloud computing, machine learning, big data analytics, and business process automation, enabling organizations to manage information more efficiently and effectively (Devarashetty, 2025; Patange, 2025). SAP implementation has expanded across diverse sectors, including manufacturing, energy, healthcare, education, logistics, and the public sector. Consequently, SAP is no longer viewed merely as ERP software but as a critical enabler of organizational digital transformation.

The increasing adoption of SAP has been accompanied by a substantial growth in academic publications examining its digital evolution. Existing studies have explored various topics, including AI integration, cloud ERP, the Internet of Things (IoT), process mining, big data analytics, data governance, information security, and decision-support optimization (Li et al., 2019; Jawad & Balázs, 2024). These developments indicate that SAP research has progressed beyond implementation-related issues and increasingly reflects broader digital transformation trends, particularly the integration of intelligent technologies and automated business processes.

Despite the growing volume of SAP-related publications, the overall direction of SAP research remains fragmented across multiple disciplines and has not yet been comprehensively mapped. Previous studies have primarily focused on SAP implementation within specific organizations, ERP effectiveness, system migration, and organizational performance outcomes (Tambunan et al., 2025). Consequently, the broader landscape of SAP research remains unclear, particularly regarding publication trends, author and country productivity, scientific collaboration patterns, keyword evolution, and thematic developments during the ongoing digital transformation era. Given the rapid advancement of digital technologies, AI integration, and cloud-based ERP migration, understanding these shifts has become increasingly important.

Bibliometric analysis provides a valuable approach for comprehensively examining the development of SAP research. This method enables the mapping of publication trends, scientific productivity, author and country collaborations, conceptual relationships, and emerging research themes through the analysis of publication metadata (Ernando & Tisno Atmojo, 2024). Furthermore, bibliometric analysis facilitates the identification of the evolution of SAP research, from conventional ERP studies to digitally enabled SAP systems characterized by AI integration, cloud computing, and business process automation. Such mapping can offer empirical insights into the trajectory of SAP research while highlighting future research opportunities.

The urgency of investigating SAP's digital development continues to grow alongside the global acceleration of organizational digital transformation. Existing bibliometric studies have largely examined ERP systems or digital information system transformation in general without specifically mapping the evolution of SAP research within the context of advanced digital technology integration (Ernando & Tisno Atmojo, 2024; Hastharita et al., 2026). This gap limits a

comprehensive understanding of SAP research developments, particularly in terms of publication trends, collaboration networks, keyword evolution, and thematic progression.

The selection of the 2018–2024 period is based on its representation of an accelerated phase of digital transformation marked by increasing migration to SAP S/4HANA, broader adoption of AI and cloud computing, and intensified organizational digital transformation following the COVID-19 pandemic. This period also witnessed growing research interest in digital ERP systems and SAP-based transformation initiatives, making it highly relevant for investigating the evolution of SAP-related scholarship.

Addressing this gap, the present study analyzes the development of SAP research from 2018 to 2024 using a bibliometric approach based on Scopus-indexed publications. Unlike previous bibliometric studies that primarily focused on ERP systems, accounting information systems, or digital transformation in general, this study specifically examines the SAP ecosystem as an ERP platform undergoing substantial transformation through the integration of AI, cloud computing, machine learning, and SAP S/4HANA technologies. The novelty of this study lies in its comprehensive mapping of publication trends, scientific productivity, international collaboration patterns, keyword evolution, and the intellectual structure of SAP research through co-occurrence, overlay visualization, density visualization, and co-authorship network analyses using VOSviewer.

This study offers both academic and practical contributions. Academically, it enriches the literature on SAP digital transformation by providing a systematic overview of research trends, dominant themes, and collaboration dynamics. Practically, the findings serve as valuable references for academics, organizations, technology developers, and information system consultants seeking to understand the future direction of digital SAP development and technology integration in enterprise systems. Furthermore, the results may assist future researchers in identifying research gaps and emerging opportunities within the SAP domain.

The phenomenon of SAP digital development can be interpreted through the perspectives of Dynamic Capability Theory and the Technology–Organization–Environment (TOE) Framework. Dynamic Capability Theory suggests that organizations must continuously adapt, integrate, and reconfigure their resources to respond effectively to dynamic business environments (Rahman et al., 2025). This perspective is particularly relevant for understanding the evolution of SAP as an ERP platform that continuously adapts through the integration of AI, cloud computing, machine learning, and business process automation. Similarly, the TOE Framework posits that technology adoption and development are influenced by technological characteristics, organizational readiness, and environmental factors that shape decisions regarding digital system implementation (Morawiec & Sołtysik-Piorunkiewicz, 2023). From these perspectives, SAP digital transformation can be understood not only as the technological evolution of ERP systems but also as an organizational response to changing business requirements, technological advancements, and increasing demands for efficiency in the digital transformation era.

LITERATURE REVIEW

Enterprise Resource Planning (ERP) systems have become critical digital infrastructures that integrate various organizational functions into a unified platform, enabling greater operational efficiency, business agility, and real-time information management (Bandara et al., 2024). Among the leading ERP platforms, Systems, Applications, and Products in Data Processing (SAP) has emerged as one of the most widely adopted enterprise systems globally. The evolution of SAP, particularly through the development of SAP S/4HANA, reflects the growing integration of advanced digital technologies such as artificial intelligence (AI), cloud computing, machine learning, big data analytics, and business process automation, transforming SAP from a

traditional ERP solution into a strategic enabler of digital transformation (Devarashetty, 2025; Patange, 2025).

The increasing implementation of SAP across various sectors has stimulated significant academic interest. Existing studies have examined topics such as cloud ERP, AI integration, Internet of Things (IoT), process mining, data governance, information security, and decision-support systems (Li et al., 2019; Jawad & Balázs, 2024). However, much of the literature remains fragmented, focusing primarily on implementation issues, ERP effectiveness, system migration, and organizational performance outcomes (Tambunan et al., 2025). Consequently, a comprehensive understanding of SAP research trends, collaboration networks, keyword evolution, and thematic development remains limited.

Bibliometric analysis provides a systematic approach to examining the evolution of scientific knowledge by identifying publication trends, research productivity, collaboration patterns, and conceptual structures through publication metadata (Ernando & Tisno Atmojo, 2024). Despite the growing importance of SAP in digital transformation, previous bibliometric studies have largely focused on ERP systems or digital information systems in general, leaving a gap in understanding the development of SAP-specific research (Hastharita et al., 2026). This study is further supported by Dynamic Capability Theory and the Technology–Organization–Environment (TOE) Framework, which explain how organizations adapt technological resources and respond to technological, organizational, and environmental factors in the digital transformation process (Rahman et al., 2025; Morawiec & Sołtysik-Piorunkiewicz, 2023).

METHODS

This study employed a bibliometric method with a quantitative descriptive approach to map the development of research on Systems, Applications, and Products in Data Processing (SAP) during the 2018–2024 period. Bibliometric analysis is widely used to examine the evolution of a scientific field through publication metadata, including authors, keywords, citations, affiliations, and publication sources. This approach enables researchers to identify publication patterns, dominant research themes, and relationships among concepts within a particular field of study (Ernando & Tisno Atmojo, 2024; Hastharita et al., 2026). The method was selected because it provides a systematic overview of the evolution of SAP research in the era of digital transformation while identifying emerging topics within the international scientific literature (Morawiec & Sołtysik-Piorunkiewicz, 2023; Patange, 2025).

The object of this study consisted of scientific publications discussing SAP in the context of Enterprise Resource Planning (ERP) and information systems indexed in the Scopus database. Scopus was chosen because of its extensive international coverage, comprehensive metadata, and widespread use in bibliometric studies aimed at mapping the development of scientific disciplines (Ernando & Tisno Atmojo, 2024; Nadiar et al., 2026). The unit of analysis was publication metadata, including article titles, abstracts, keywords, author names, affiliations, countries of origin, publication sources, publication years, and citation counts.

The study utilized secondary data collected from the Scopus database. According to Bougie and Sekaran (2019), secondary data refer to information that has already been collected and made available for research purposes. Data retrieval was conducted through the Title, Abstract, and Keywords (TITLE–ABS–KEY) search feature in Scopus using the following search query:

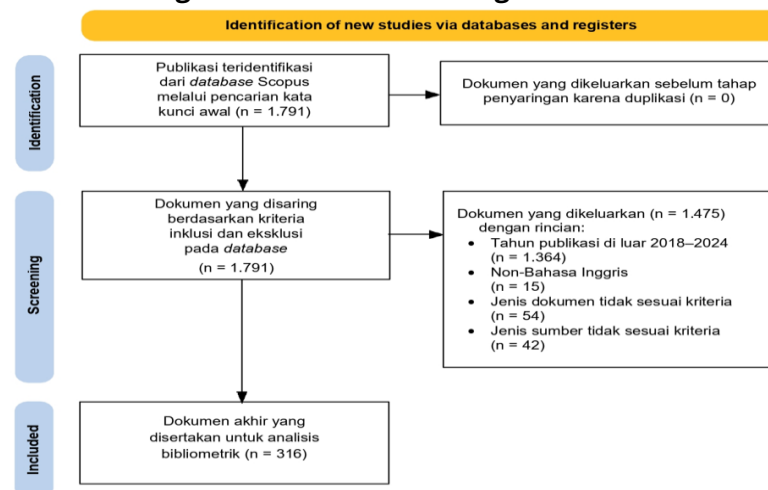
TITLE-ABS-KEY ("SAP" OR "SAP ERP" OR "SAP S/4HANA" OR "Systems Applications and Products") AND ("enterprise resource planning" OR "ERP" OR "information system")

The use of the AND operator ensured that the retrieved documents were directly related to SAP within the context of ERP and information systems, thereby aligning the search results with the objectives of the study. Data collection was performed in 2025 and initially yielded 1,791 publications.

The literature selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a systematic and transparent identification, screening, and selection procedure. During the identification stage, 1,791 records were retrieved from the Scopus database. The screening process applied the following inclusion criteria: publications published between 2018 and 2024, written in English, categorized as journal articles or conference proceedings, and relevant to SAP and ERP research.

A total of 1,475 documents were excluded during the screening stage, comprising 1,364 publications outside the specified publication period, 15 publications written in languages other than English, 54 documents with unsuitable document types, and 42 publications originating from sources that did not meet the study criteria. After completing all selection stages, 316 publications met the eligibility requirements and were included as the final sample for bibliometric analysis. The detailed literature identification and selection process is presented in Figure 1.

Figure 1. PRISMA Flow Diagram



The publication metadata that met the inclusion criteria were subsequently exported in Comma-Separated Values (CSV) format and analyzed using VOSviewer software. The use of VOSviewer enables researchers to map relationships among bibliographic elements and systematically visualize the conceptual structure of a research field (Ernando & Tisno Atmojo, 2024; Hastharita et al., 2026). The analyses conducted included annual publication trends, keyword distribution, highly cited publications, and the evolution of SAP research topics.

Research themes were mapped through co-occurrence analysis to identify relationships and linkages among keywords appearing in the selected publications. Furthermore, overlay visualization was employed to examine the temporal development of research topics and identify emerging themes in recent years. Density visualization was used to illustrate research intensity based on the frequency of keyword occurrences and the strength of relationships among keywords within the research network (Hastharita et al., 2026; Nadiar et al., 2026). In addition, co-authorship analysis was performed to map international scientific collaboration patterns and to illustrate the research cooperation networks established within SAP-related studies (Morawiec & Sołtysik-Piorunkiewicz, 2023).

The visualization outputs generated by VOSviewer were subsequently analyzed and interpreted descriptively to explain the development of SAP research, shifts in research focus, scientific collaboration dynamics, and potential directions for future research. Through these procedures, this study is expected to provide a comprehensive overview of the evolution of SAP research during the 2018–2024 period while identifying promising research areas that may gain greater attention in the future.

RESULTS

Trends in SAP Research Publications

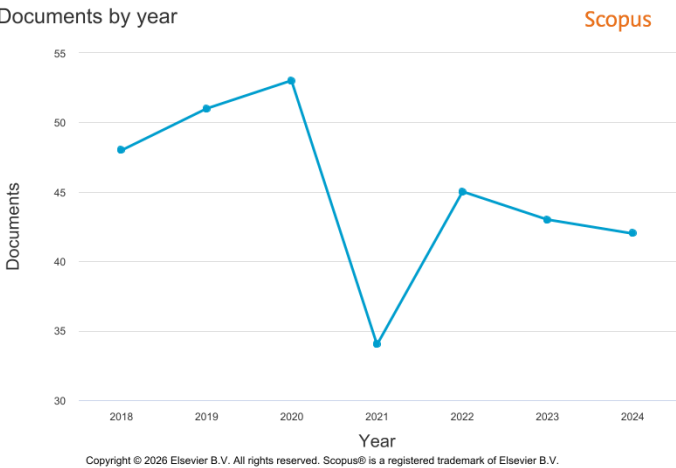
The development of publications on Systems, Applications, and Products in Data Processing (SAP) during the 2018–2024 period demonstrates a relatively stable trend with moderate fluctuations. Based on the literature search and selection process conducted using the PRISMA guidelines, a total of 316 publications met the inclusion criteria for analysis. The number of publications increased from 42 documents in 2018 and reached its peak of 53 documents in 2022, followed by a slight decline in 2023 and 2024. Nevertheless, the consistently high publication output indicates that SAP remains a relevant and important research topic, continuing to attract scholarly attention in the fields of information systems and Enterprise Resource Planning (ERP). These findings suggest sustained academic interest in SAP, driven by ongoing digital transformation initiatives, technological advancements, and the growing integration of intelligent technologies into enterprise systems.

Table 1. Trends in Digital SAP Research Publications Based on Scopus-Indexed Articles (2018–2024)

Publication Year	Number of Publications
2018	42
2019	43
2020	45
2021	34
2022	53
2023	51
2024	48
Total	316

Source: Processed by the Authors from Scopus Data (2026).

Figure 2. Publication Trends Based on Scopus Data



The growth in publication output reflects the increasing academic interest in the role of SAP in supporting organizational digital transformation. As organizations face growing demands for business process integration, real-time data management, and operational efficiency, SAP has continued to evolve through technological innovations that enhance modern enterprise systems. This development is evident in the expanding body of research on SAP S/4HANA, cloud

computing, process mining, and data-driven technologies integrated within ERP environments (Patange, 2025; Mandava, 2024).

Overall, the relatively consistent publication trend indicates that SAP research is no longer limited to the implementation of conventional ERP systems. Instead, it has increasingly shifted toward digital transformation and the enhancement of enterprise system capabilities. This transition reflects a growing research emphasis on leveraging digital technologies to improve information integration, optimize business processes, and strengthen organizational responsiveness in an increasingly dynamic business environment (Morawiec & Sołtysik-Piorunkiewicz, 2023; Tambunan et al., 2025).

Distribution of SAP Research Keywords

SAP research during the 2018–2024 period was primarily centered on the keywords SAP, Enterprise Resource Planning (ERP), and enterprise systems. These keywords exhibit strong connections with numerous related topics within the research network, indicating that SAP remains a central focus in the development of enterprise systems and organizational business process integration. The prominence of these themes is consistent with the continuing importance of ERP systems as the foundation for information management and business process coordination across a wide range of industries and organizational settings (Patange, 2025; Morawiec & Sołtysik-Piorunkiewicz, 2023).

The keyword network further demonstrates that SAP research has expanded beyond traditional ERP implementation issues to encompass broader digital transformation initiatives. Emerging topics such as cloud computing, process mining, artificial intelligence, machine learning, data analytics, and SAP S/4HANA have become increasingly interconnected with core SAP themes, highlighting the growing integration of advanced digital technologies into enterprise systems. This trend suggests that future SAP research will continue to focus on enhancing organizational agility, data-driven decision-making, and digital innovation within enterprise environments.

Table 2. Dominant Keywords in SAP Research Based on Occurrences and Total Link Strength

Keyword	Occurrences	Total Link Strength
Enterprise Systems	5	13
Satisfaction	5	11
Machine Learning	5	8
Cloud Computing	5	7
HANA	4	15
SAP HANA	4	9
Artificial Intelligence	4	8
Odoo	4	6
Business Processes	4	6
Digitalization	4	4
Total	45	87

Source: Processed by the Authors (2026).

Based on Table 2, the keywords enterprise systems, satisfaction, machine learning, and cloud computing recorded the highest frequency of occurrence, each appearing five times. In terms of network connectivity, HANA exhibited the highest Total Link Strength (TLS) value of 15, followed by enterprise systems with a TLS of 13 and satisfaction with a TLS of 11. These findings indicate that SAP research extends beyond traditional ERP implementation and increasingly encompasses system evaluation, user satisfaction, and the development of SAP HANA technologies, which play a crucial role in enabling real-time data processing, business process integration, and enhanced organizational analytics capabilities (Patange, 2025).

The presence of keywords such as artificial intelligence, machine learning, cloud computing, and digitalization further demonstrates the growing convergence between SAP research and emerging digital technologies. This shift suggests that the focus of SAP-related studies has expanded from conventional ERP implementation toward the utilization of data-driven technologies aimed at improving operational efficiency, organizational agility, and decision-making quality (Mandava, 2024; Jawad & Balázs, 2024; Devarashetty, 2025). From the perspective of Dynamic Capability Theory, these developments reflect organizational efforts to leverage digital technologies in strengthening their adaptive capabilities and responsiveness to rapidly changing business environments. Moreover, the diversity of keywords identified in the network highlights the multidisciplinary nature of SAP research. The literature encompasses a broad range of interconnected themes, including enterprise systems, business processes, digital transformation, cloud technologies, and intelligent analytics. This thematic diversity suggests that SAP remains a dynamic and evolving research field with substantial opportunities for future investigation and theoretical development.

Most Influential Publications in SAP Research

Highly cited publications represent scholarly works that have made significant contributions to the development of SAP research during the study period. These publications serve as key references because they address critical issues related to enterprise systems, digital transformation, technological innovation, and organizational performance. Identifying the most influential publications provides valuable insights into the research themes, concepts, and technological developments that have received the greatest attention within the SAP literature and have shaped the direction of subsequent studies.

Table 3. Most Influential Publications in SAP Research Based on Citation Counts

Authors	Year	Article Title	Journal/Source	Citations
Sishi & Telukdarie	2020	Implementation of Industry 4.0 Technologies in the Mining Industry: A Case Study	International Journal of Mining and Mineral Engineering	57
Schreieck et al.	2022	From Product Platform Ecosystem to Innovation Platform Ecosystem: An Institutional Perspective on the Governance of Ecosystem Transformations	Journal of the Association for Information Systems	48
Berti & van der Aalst	2023	OC-PM: Analyzing Object-Centric Event Logs and Process Models	International Journal on Software Tools for Technology Transfer	45
Mahendrawathi et al.	2018	Analysis of Production Planning in a Global Manufacturing Company with Process Mining	Journal of Enterprise Information Management	44
Olson et al.	2018	Open Source ERP Business Model	Robotics and Computer-	42

Authors	Year	Article Title	Journal/Source	Citations
		Framework	Integrated Manufacturing	
Beranič & Heričko	2022	The Impact of Serious Games in Economic and Business Education: A Case of ERP Business Simulation	Sustainability	41
Heinzelmann	2018	Occupational Identities of Management Accountants: The Role of the IT System	Journal of Applied Accounting Research	40
Li et al.	2019	Barriers of Embedding Big Data Solutions in Smart Factories: Insights from SAP Consultants	Industrial Management & Data Systems	39
Elbahri et al.	2019	Difference Comparison of SAP, Oracle, and Microsoft Solutions Based on Cloud ERP Systems: A Review	Proceedings of the 2019 IEEE 15th International Colloquium on Signal Processing and Its Applications	31
Angolia & Pagliari	2018	Experiential Learning for Logistics and Supply Chain Management Using an SAP ERP Software Simulation	Decision Sciences Journal of Innovative Education	30

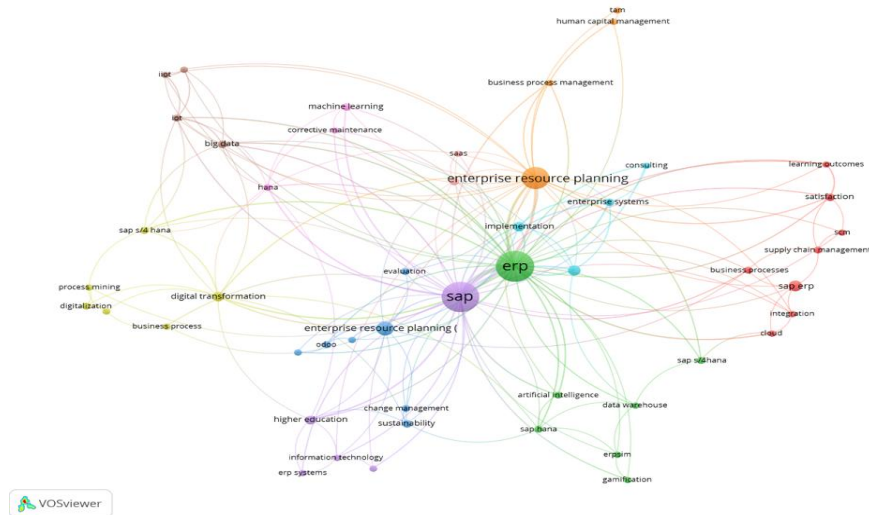
Source: Processed by the Authors (2026).

Based on Table 3, the publication with the highest citation count is the study by Sishi and Telukdarie (2020), which examines the implementation of Industry 4.0 technologies in the mining sector. Other highly cited publications include those by Schreieck et al. (2022), Berti and van der Aalst (2023), Mahendrawathi et al. (2018), and Olson et al. (2018). The substantial number of citations received by these studies indicates that topics such as digital transformation, process mining, digital ecosystem development, and ERP innovation have attracted considerable attention within the SAP research community.

Highly cited publications make significant contributions to the advancement of SAP research because they address critical issues relevant to modern organizations, including digital transformation, business process management, enterprise system innovation, and data-driven decision-making. Their high citation counts suggest that these studies have been widely recognized and frequently used as foundational references for subsequent research, thereby shaping the direction of SAP-related scholarship across various organizational contexts. From the perspective of Dynamic Capability Theory, these contributions highlight the strategic importance of technology and information systems in enhancing an organization's ability to adapt, integrate resources, and respond effectively to changing business environments. Therefore, highly cited articles not only demonstrate strong academic impact but also play a pivotal role in influencing the evolution of SAP research over time.

Co-occurrence Network Visualization

The relationships among keywords in SAP research during the 2018–2024 period form a conceptual structure that reflects the evolution of research themes within the field of Systems, Applications, and Products in Data Processing (SAP). In the network visualization, the size of each node represents the frequency of keyword occurrence, while the connecting lines indicate the strength of relationships among topics within the analyzed publications (Önden, 2026). Consequently, the network structure provides valuable insights into dominant research themes, conceptual linkages, and the intellectual foundations underlying SAP-related studies.

Figure 3. Data Processed Using VOSviewer (2026)

The network visualization reveals several research clusters distinguished by different colors, each representing a specific research focus. The red cluster represents studies centered on ERP implementation and business process integration, characterized by keywords such as *SAP*, *ERP*, *enterprise resource planning*, and *implementation*. The green cluster reflects the growing connection between SAP research and digital technologies, as indicated by the presence of keywords such as *artificial intelligence*, *machine learning*, *big data*, *Internet of Things (IoT)*, and *cloud computing*. Meanwhile, the yellow cluster illustrates the evolution of SAP toward a digital transformation platform through the interrelationships among *digital transformation*, *digitalization*, *process mining*, *SAP HANA*, and *SAP S/4HANA*. In addition to these major clusters, several supporting clusters are associated with *human capital management*, *supply chain management*, *learning outcomes*, *satisfaction*, and *higher education*, highlighting the broad application of SAP research across various organizational and industrial contexts.

The keywords *SAP*, *ERP*, and *enterprise resource planning* occupy the most central positions in the network, as indicated by their larger node sizes. This finding confirms that ERP systems remain the primary foundation of SAP research throughout the study period. Their extensive connections with other keywords suggest that most SAP-related studies continue to revolve around business process integration, information management, and enterprise system development.

The prominence of keywords such as *artificial intelligence*, *machine learning*, *big data*, and *cloud computing* reflects the increasing research interest in integrating digital technologies into ERP environments. These topics highlight the growing utilization of SAP for data analytics, business process automation, and information-driven decision-making. This trend is consistent with the findings of Jawad and Balázs (2024), who emphasized the role of machine learning in enhancing ERP predictive capabilities, and Bandara et al. (2024), who highlighted the contribution of big data technologies to improving ERP responsiveness.

These findings can be interpreted through the lens of Dynamic Capability Theory, which emphasizes the importance of organizational capabilities in responding to environmental changes through the effective utilization of resources and emerging technologies. The strong connections between ERP and technologies such as artificial intelligence, machine learning, big data, and cloud computing indicate that SAP research is increasingly focused on developing digital capabilities that enable organizations to sense, seize, and transform opportunities arising from digital transformation.

The evolution of SAP research is further demonstrated by the strong relationships among *SAP HANA*, *SAP S/4HANA*, *digital transformation*, and *process mining*. These topics reflect

growing scholarly interest in next-generation ERP systems that support real-time data processing and business process optimization. This trend is consistent with the studies of Mahendrawathi et al. (2018), Berti et al. (2023), and Patange (2025), which identify process mining and SAP S/4HANA as critical components of organizational digital transformation.

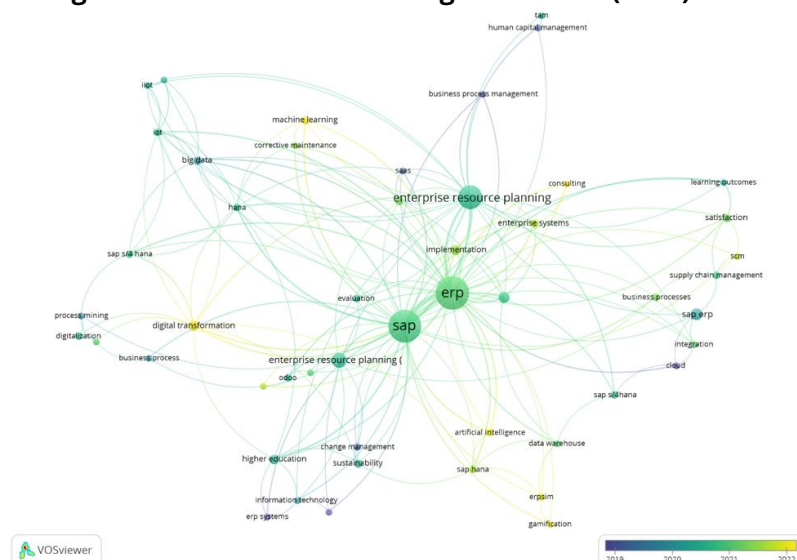
The resulting keyword network structure is closely aligned with the most highly cited publications identified during the study period. Themes such as *Industry 4.0*, *big data*, *process mining*, and *digital transformation*, extensively discussed by Sishi and Telukdarie (2020), Li et al. (2019), Mahendrawathi et al. (2018), and Berti et al. (2023), also emerge as prominent topics within the co-occurrence network. This finding suggests that the development of SAP research between 2018 and 2024 has been increasingly influenced by digital technology integration, data analytics, and technology-driven business process optimization.

Overall, the keyword network structure demonstrates a significant shift in SAP research from conventional ERP implementation toward broader digital technology integration. The interconnected emergence of topics such as *artificial intelligence*, *machine learning*, *big data*, *cloud computing*, *process mining*, and *SAP S/4HANA* indicates that contemporary SAP literature is increasingly oriented toward the development of enterprise systems that support automation, advanced analytics, and organizational digital transformation.

Co-occurrence Overlay Visualization

The evolution of SAP research themes during the 2018–2024 period can be further examined through overlay visualization, which maps keywords according to their average year of occurrence. In this visualization, color gradients represent the temporal dimension of research development, where blue indicates topics that emerged earlier, green represents themes that developed during the intermediate period, and yellow highlights relatively recent and emerging topics within the research network (Önden, 2026).

Figure 4. Data Processed Using VOSviewer (2026)



The overlay visualization shows that the keywords *SAP*, *ERP*, and *enterprise resource planning* remain at the center of the research network, predominantly represented by green-colored nodes. This position indicates that these topics serve as the foundational concepts linking the development of various SAP research themes throughout the observation period. In

other words, despite the emergence of new research topics, ERP systems continue to constitute the core of the SAP literature.

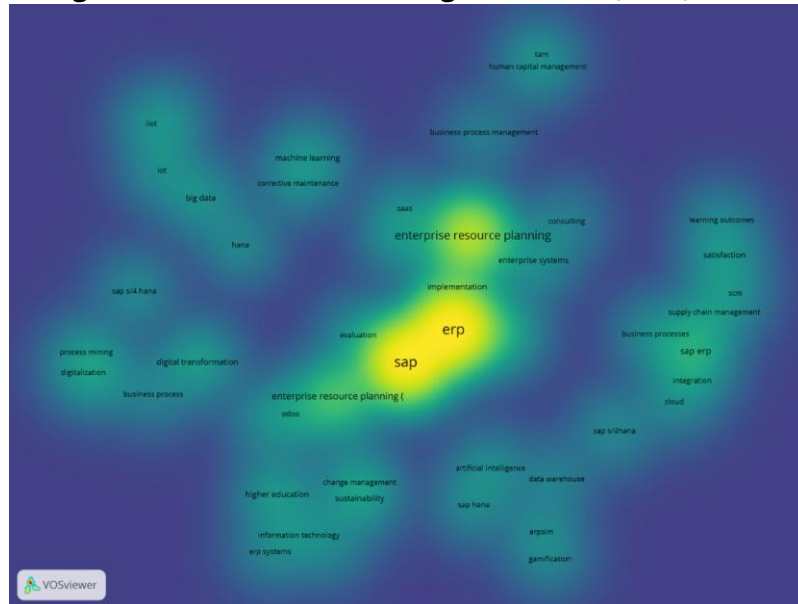
Blue and blue-green colors are observed in keywords such as *cloud*, *SAP ERP*, *information technology*, *business process management*, *human capital management*, and *supply chain management*. The presence of these topics suggests that earlier studies primarily focused on ERP implementation, organizational function integration, business process management, and the use of information systems to enhance operational efficiency. This trend is consistent with the findings of Heinzelmann (2018), Angolia and Pagliari (2018), and Elbahri et al. (2019), who emphasized ERP as a tool for integrating business activities and managing organizational resources.

Subsequent developments are reflected in the emergence of keywords such as *big data*, *Internet of Things (IoT)*, *process mining*, *digitalization*, *HANA*, and *SAP S/4HANA*, which are predominantly represented by green nodes. These topics indicate a shift in research attention toward data utilization and digital transformation within ERP environments. The emergence of *process mining* highlights the increasing use of process data to evaluate and optimize organizational performance, as discussed by Mahendrawathi et al. (2018) and Berti and van der Aalst (2023). Simultaneously, the appearance of *SAP HANA* and *SAP S/4HANA* reflects the evolution of ERP systems into platforms capable of supporting real-time data processing and faster information integration (Patange, 2025). Yellow-colored nodes associated with keywords such as *artificial intelligence*, *machine learning*, *digital transformation*, *gamification*, and *ERPSIM* represent the most recent themes within the research network. Their position indicates that scholarly attention has increasingly shifted toward the application of intelligent technologies to enhance ERP capabilities in data analytics, process automation, and decision support. This development aligns with the findings of Jawad and Balázs (2024), who highlighted the role of machine learning in ERP optimization; Bandara et al. (2024), who emphasized the contribution of big data to ERP responsiveness; and Devarashetty (2025), who discussed the integration of artificial intelligence and SAP S/4HANA in supporting organizational digital transformation. From the perspective of the Technology–Organization–Environment (TOE) Framework, the evolution of these research themes demonstrates the growing dominance of the technological dimension in the development of enterprise systems. The shift from conventional ERP implementation toward topics such as artificial intelligence, machine learning, and SAP S/4HANA suggests that organizations are increasingly leveraging digital technologies to improve business process effectiveness, information integration, and strategic decision-making.

The color patterns within the network further reveal that emerging topics did not develop independently from earlier ERP research. Instead, *artificial intelligence*, *machine learning*, *digital transformation*, and *SAP S/4HANA* remain directly connected to the core keywords *SAP* and *ERP*. This interconnectedness indicates that SAP research has not moved away from the ERP paradigm; rather, it has expanded ERP capabilities through the integration of digital technologies and more intensive data utilization. Overall, the overlay visualization demonstrates a clear evolution in SAP research focus during the 2018–2024 period. Early themes related to ERP implementation, business process management, and system integration gradually evolved into studies emphasizing digital transformation, process mining, artificial intelligence, machine learning, and SAP S/4HANA. This pattern suggests that contemporary SAP research is increasingly oriented toward intelligent, data-driven enterprise systems capable of supporting the digital transformation needs of modern organizations.

Co-occurrence Density Visualization

Keyword density mapping was employed to identify the themes that have received the greatest attention within SAP research during the 2018–2024 period. Density levels reflect a combination of the frequency of keyword occurrences and the strength of their relationships with other keywords in the research network (Önden, 2026).

Figure 5. Data Processed Using VOSviewer (2026)

The highest thematic concentration is observed around the keywords *SAP*, *ERP*, and *enterprise resource planning*, which occupy the center of the network and exhibit the highest density levels. The dominance of these three keywords confirms that SAP research remains primarily focused on the development and utilization of ERP systems as the core infrastructure supporting business process integration, information management, and organizational coordination. The central position of ERP within the density map indicates that most developments in SAP research continue to be rooted in the fundamental functions of enterprise systems as the operational backbone of organizations.

Surrounding these core themes are dense clusters of keywords related to *implementation*, *enterprise systems*, *integration*, *business processes*, *supply chain management*, and *cloud computing*. The concentration of these topics suggests that ERP implementation, business process integration, and supply chain management continue to represent dominant areas of interest within the SAP literature. These findings demonstrate that SAP research is not solely concerned with technological aspects but also with how enterprise systems contribute to organizational efficiency, coordination, and value creation (Mandava, 2024).

Another area of significant density is formed by keywords such as *digital transformation*, *process mining*, *SAP HANA*, *SAP S/4HANA*, *artificial intelligence*, *machine learning*, *big data*, and *Internet of Things (IoT)*. Although their density levels are not yet as high as those of the core ERP themes, the presence of these keywords reflects the growing integration of digital technologies and data analytics within SAP research. The increasing attention devoted to intelligent technologies in ERP environments is consistent with the evolution of next-generation SAP platforms that incorporate advanced analytics, process automation, and real-time data processing capabilities to support organizational decision-making (Jawad & Balázs, 2024; Bandara et al., 2024; Patange, 2025).

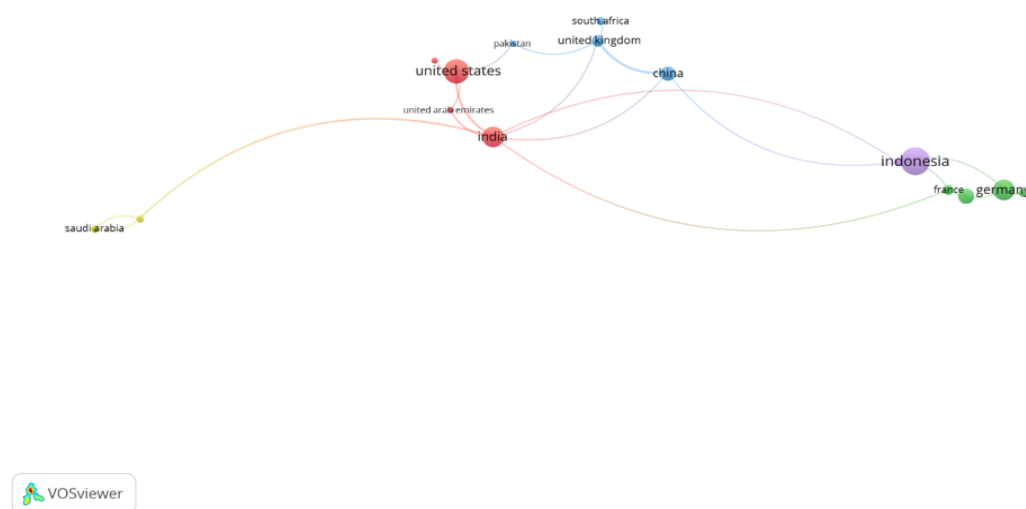
Meanwhile, themes such as *human capital management*, *higher education*, *learning outcomes*, *ERPSim*, *gamification*, and *sustainability* are located in areas with relatively lower density. Although these topics have not yet become major research focuses, their presence indicates that SAP applications have expanded into diverse research contexts, including education, user competency development, and organizational management. This finding highlights the multidisciplinary nature of SAP research, which extends beyond the technical dimensions of information systems to encompass human and organizational perspectives (Angolia & Pagliari, 2018; Beranič & Heričko, 2022).

The resulting thematic structure demonstrates that ERP remains the central pillar of knowledge development within SAP research. However, the increasing prominence of *artificial intelligence, machine learning, big data, process mining, and SAP S/4HANA* indicates a gradual shift toward the development of intelligent enterprise systems. This trend reflects the evolution of SAP from a platform primarily designed for business process integration into a comprehensive digital ecosystem that supports data analytics, process automation, and organizational digital transformation.

Co-authorship Network Visualization

Research collaboration in SAP studies during the 2018–2024 period formed an extensive international network involving countries from Asia, Europe, North America, the Middle East, and Africa. The connectivity patterns observed within the network suggest that knowledge development in SAP research has not occurred in isolation within specific regions but has instead evolved through cross-national interactions among countries with a shared interest in ERP implementation, digital transformation, and enterprise system development. This finding is consistent with the perspective of Schrieck et al. (2019), who argued that digital innovation increasingly depends on collaboration among diverse actors and interconnected knowledge ecosystems.

Figure 6. Data Processed Using VOSviewer (2026)



Indonesia occupies the most dominant position within the collaboration network, as indicated by the largest node size compared to other countries. This substantial contribution reflects the high level of participation of Indonesian researchers in SAP-related publications that met the study's inclusion criteria. In addition to Indonesia, India plays a significant role in the network, maintaining collaborative links with several countries, including the United States, China, the United Arab Emirates, Indonesia, and Saudi Arabia. The breadth of these collaborative relationships suggests that India serves as one of the principal connecting hubs within the SAP research network (Tambunan et al., 2025; Morawiec & Sołtysik-Piorunkiewicz, 2023).

Significant contributions are also evident from the United States and China, both of which demonstrate extensive connections with multiple collaboration clusters within the research network. In Europe, Germany and France exhibit relatively strong collaborative relationships, indicating the continued involvement of these countries in advancing SAP-related research. The participation of countries with strong research capacities suggests that the development of SAP scholarship is influenced not only by the practical need for technology implementation but also by research activities focused on digital innovation, organizational

capability development, and technology-driven business transformation (Rahman et al., 2025; Mandava, 2024).

The involvement of the United Kingdom, South Africa, Pakistan, the United Arab Emirates, and Saudi Arabia further demonstrates that SAP research has expanded across diverse geographical contexts and varying levels of digital maturity. From the perspective of the Technology–Organization–Environment (TOE) Framework, this pattern of international collaboration highlights the importance of environmental factors in facilitating knowledge exchange, implementation experiences, and innovation diffusion across countries. Overall, the collaboration structure indicates that the development of SAP research is increasingly supported by international networks involving both ERP users and developers. These collaborative relationships contribute to the expansion of knowledge, the dissemination of best practices, and the advancement of innovation within the field of enterprise systems (Schrieck et al., 2019; Tambunan et al., 2025).

DISCUSSION

The findings of this study demonstrate that SAP research has undergone a significant transformation during the 2018–2024 period, reflecting the broader evolution of enterprise systems in the digital era. While traditional themes related to ERP implementation, business process integration, and information management continue to form the foundation of SAP research, increasing attention has been directed toward emerging technologies such as artificial intelligence, machine learning, cloud computing, big data analytics, and SAP S/4HANA. This shift indicates that SAP is no longer viewed merely as an enterprise resource planning system but as a strategic platform that supports organizational digital transformation and data-driven decision-making. The prominence of keywords associated with digital technologies suggests that organizations are increasingly seeking intelligent enterprise solutions capable of enhancing operational efficiency, automation, and organizational agility. These findings support the perspective of Dynamic Capability Theory, which emphasizes the importance of leveraging technological resources to adapt to rapidly changing business environments. The integration of advanced digital technologies into SAP systems enables organizations to strengthen their capabilities in sensing opportunities, seizing technological innovations, and transforming business processes.

Furthermore, the international collaboration network identified in this study highlights the growing global interest in SAP-related research. The participation of countries from different regions indicates that SAP development is influenced by diverse technological, organizational, and environmental factors. This observation aligns with the Technology Organization Environment (TOE) Framework, which explains that technology adoption and innovation are shaped by organizational readiness, technological advancement, and external environmental conditions. Overall, the results suggest that the future direction of SAP research will likely focus on the development of intelligent, cloud-based, and data-driven enterprise systems. The increasing convergence of SAP with artificial intelligence, machine learning, process mining, and advanced analytics presents substantial opportunities for future research aimed at enhancing organizational performance, digital innovation, and business transformation in an increasingly competitive and dynamic environment.

CONCLUSION

This study found that the development of Systems, Applications, and Products in Data Processing (SAP) research during the 2018–2024 period remains centered on Enterprise Resource Planning (ERP) as the fundamental foundation of enterprise systems. However, the scope of SAP research has expanded considerably in line with ongoing digital transformation

initiatives. The strong interconnections between ERP and emerging technologies such as artificial intelligence, machine learning, big data, process mining, cloud computing, the Internet of Things (IoT), and SAP S/4HANA indicate that SAP research has evolved beyond its traditional focus on business process integration. Instead, it increasingly emphasizes the development of intelligent enterprise systems that support data analytics, process automation, and data-driven decision-making. Furthermore, the prominent roles of Indonesia, India, China, and the United States within the international collaboration network suggest that SAP research is no longer concentrated solely in technology-developing countries but has expanded to nations actively adopting and implementing enterprise systems across various organizational sectors. These findings support the perspectives of Dynamic Capability Theory and the Technology–Organization–Environment (TOE) Framework, which emphasize the importance of digital capabilities and the interaction of technological, organizational, and environmental factors in facilitating organizational digital transformation.

This study has several limitations. First, the analysis relied exclusively on the Scopus database, which may not fully represent the entire body of SAP-related literature available in other international databases. Second, the bibliometric approach focused primarily on publication metadata and therefore did not provide an in-depth examination of the substantive content, methodological quality, or empirical findings of the individual studies analyzed. Future research is therefore encouraged to broaden data sources by integrating multiple international databases and combining bibliometric techniques with systematic literature reviews, bibliographic coupling, or thematic evolution analyses. Such approaches would provide a more comprehensive understanding of theoretical developments, thematic dynamics, and future directions in SAP research.

The findings of this study offer several important implications. For academics, they provide a foundation for identifying promising research areas, particularly those related to the integration of digital technologies within enterprise systems. For practitioners, the results highlight the need to strengthen digital capabilities through the integration of data-driven and artificial intelligence technologies to support sustainable organizational digital transformation. For system developers and policymakers, the increasing prominence of themes such as artificial intelligence, machine learning, big data, and SAP S/4HANA underscores the importance of developing robust digital ecosystems capable of supporting organizational needs in an increasingly dynamic and competitive business environment.

LIMITATION

This study has several limitations. First, the analysis was conducted using only the Scopus database, which may not fully capture all SAP-related publications available in other international databases. Second, the bibliometric approach relied primarily on publication metadata, including authors, keywords, citations, and publication sources, without examining the detailed content, methodological rigor, or empirical findings of the individual studies. Consequently, the results provide a broad overview of research trends and intellectual structures rather than an in-depth assessment of the substantive contributions of the literature. Future studies are encouraged to incorporate multiple databases and combine bibliometric techniques with systematic literature reviews or content analyses to obtain a more comprehensive understanding of the evolution and future directions of SAP research.

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