

Review

Human Capital Readiness for Cloud–AI–Data Center Ecosystems: A Bibliometric Review

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Abstract: The expansion of cloud platforms, artificial intelligence (AI)-driven applications, and data center infrastructure has increased the need for workers and organizations that can operate, interpret, and govern complex digital ecosystems. However, research on human capital readiness for cloud–AI–data center ecosystems remains fragmented across technology adoption, digital skills, education, workforce development, and human resource management (HRM). This study maps the intellectual structure, thematic development, and research gaps of this field through a bibliometric review of 783 Scopus-indexed journal articles published between 2010 and 2025. Biblioshiny/R Bibliometrix and VOSviewer were used to conduct performance analysis and science mapping, including annual publication trends, keyword co-occurrence, thematic mapping, co-citation analysis, bibliographic coupling, and country collaboration analysis. The findings show that publication activity increased after 2019 and accelerated after 2023, indicating growing attention to digital workforce readiness in the AI era. The analyses reveal a divide between technology-oriented studies on AI, Industry 4.0, cloud computing, and digital transformation and human-centered studies on digital skills, literacy, competencies, and workforce readiness. Co-citation and bibliographic coupling results show that the field is shaped by technology adoption, behavioral readiness, strategic capability, future-of-work research, work psychology, and education-based digital competency development. Country collaboration patterns indicate that Asia-Pacific scholarship remains uneven despite the region's growing role in digital infrastructure expansion. This study contributes by repositioning human capital readiness as a strategic HR capability linking digital talent development, HR analytics, and workforce planning.

Keywords: digital talent; HR capability; HR analytics; digital skills; Asia-Pacific

1. Introduction

Digital transformation has moved beyond a narrow agenda of technology adoption and has become a strategic human capital challenge. The integration of cloud technologies with artificial intelligence (AI) has enabled platform-based ecosystems in which organizations, users, and partners co-create services and rely on data for continuous innovation (Beverungen et al., 2022). At the same time, the digital economy has expanded through cloud-based solutions, online commerce, digital services, and flexible work arrangements, increasing organizational demand for workers who can operate in data-rich environments (Xia et al., 2023). Fernandez-Vidal et al. (2022) emphasize that digital transformation requires leadership attention not only to technology investment but also to organizational redesign, talent development, and continuous learning. The labor implications of this shift are increasingly visible as AI changes employment structures and generates new

capability demands (Zhang, 2023), while the COVID-19 period accelerated the need for data-savvy talent in digitally mediated professional work (Y. Liu et al., 2024). These developments suggest that digital transformation depends not only on technological capacity, but also on the readiness of human capital to absorb, use, interpret, and govern advanced technologies.

The convergence of cloud computing, AI, and data center infrastructure makes this challenge more complex because it combines scalable platforms, algorithmic decision support, and the physical backbone of digital economies. Cloud–AI–data center ecosystems require workers who can connect technical, analytical, managerial, and governance-oriented competencies. Santana and Diaz-Fernandez (2022) argue that AI-era organizations need new competence profiles, while Bouwmans et al. (2024) identify digital work, collaboration, entrepreneurship, and adaptability as central skills for digital transformation. Workforce shortages in Big Data and AI further show that academic education and industry needs must be aligned more closely (Johnson et al., 2021), and interdisciplinary AI education is increasingly required beyond purely technical fields (Puzanova and Larina, 2025). Chen et al. (2022) also showed that digital skills may reduce workers' exposure to AI-driven job displacement. Recent HRM-oriented evidence suggests that digital literacy should be understood not merely as technical device use but as a human-capital capability associated with productivity, employability readiness, and institutional competitiveness (Iskandar et al., 2026). Therefore, cloud–AI–data center ecosystems should not be understood only as technical infrastructure. They are socio-technical workforce systems in which human capital determines whether digital infrastructure can become reliable, ethical, adaptive, and value-generating.

This argument is directly relevant to human resource management (HRM) because AI and analytics are also transforming HR functions themselves. Bouzerda et al. (2025) show that AI in HRM supports task automation and process transformation, while Upadhyay (2025) highlights the fairness, bias, privacy, recruitment, talent management, and learning challenges associated with AI-HRM adoption. Ravesangar and Narayanan (2024) further position HR analytics as a mechanism for improving data-driven HR decision-making. This emerging HRM evidence aligns with broader research showing that people analytics, AI-HRM, and digital HR capability require attention to data governance, ethical decision-making, and human resource development (Yoon et al., 2023; Gong et al., 2024; Damayanti et al., 2026). Nankervis and Cameron (2022) also suggest that HR professionals must acquire new competencies as intelligent technologies reshape HR work. Thus, human capital readiness for cloud–AI–data center ecosystems is not simply a question of hiring more technical workers to operate the systems. It also concerns how HR systems identify skill gaps, develop digital competencies, govern AI-enabled work, and align workforce planning with digital infrastructure strategies.

Despite this growing recognition, the construct of human capital readiness remains underdeveloped and fragmented. Michelotto and Jóia (2024) argue that digital transformation readiness must integrate human, technological, and managerial dimensions, while Adebajo et al. (2023) identify human resources as a critical readiness dimension in Industry 4.0 adoption. Qureshi (2023) similarly positions human capital as central to whether digital transformation supports development or reinforces inequality, and Satwekar et al. (2024) emphasize that people, processes, and technology must be orchestrated together. Cross-sector evidence also indicates that intellectual capital and governance mechanisms can help convert intangible

organizational resources into multidimensional performance outcomes (Nasim et al., 2026). Yet, existing studies often address digital skills, AI adoption, HR analytics, or organizational readiness separately rather than explaining how these elements form a coherent readiness capability. The skills literature confirms this gap: AI literacy is increasingly important for human resource development (HRD) (Kim, 2024), AI integration requires managerial and social competencies (Deepa et al., 2024), and AI professional frameworks emphasize data science, software development, and product management capabilities (Brauner et al., 2023). Molla et al. (2024) further show that digital skills are important beyond the IT workforce, while Nnadi et al. (2025) call for agile HRD strategies for emerging technologies. However, these streams have not yet converged into an integrated HRM framework for cloud–AI–data center human capital readiness.

The Asia-Pacific region provides a critical context for examining this issue because digital infrastructure expansion is occurring alongside uneven talent and institutional readiness. Elfaki and Ahmed (2024) identify digital technology adoption and globalization as important drivers of Asia-Pacific sustainable growth, yet the region continues to face workforce constraints. In Malaysia, employers report mismatches between demanded digital skills and graduate capabilities (Tee et al., 2024), while Vietnam's AI ambitions are constrained by shortages of AI specialists and limitations in intellectual property systems (Than and Liu, 2024). Indonesia illustrates a further challenge: digital development remains spatially uneven, with stronger readiness in metropolitan and western regions than in rural and eastern areas (Jaya et al., 2024; Kartiasih et al., 2022). These constraints also matter for data center development because skilled labor availability and infrastructure quality influence data center placement and cost in emerging economies (R. Liu et al., 2023). Rigley et al. (2023) show that AI readiness requires coordinated national skills strategies, while Putra (2025) emphasizes regional approaches to strengthening digital capacity in Southeast Asia. At the same time, East Asian value chains and China's digital expansion in the Global South raise broader questions about digital governance and development pathways (Morishita, 2023; Heeks et al., 2024). These studies indicate that Asia-Pacific is not merely a geographical setting, but a region where digital infrastructure growth and workforce readiness must be examined together.

A bibliometric review is therefore necessary because the literature is dispersed across HRM, digital transformation, information systems, education, AI, cloud computing, data center studies, and regional development. Traditional narrative reviews can summarize selected studies, but they are less effective for mapping how a fragmented field is structured, which intellectual foundations shape it, and where research communities remain disconnected. Accordingly, this study aims to map the scientific landscape of human capital readiness for cloud–AI–data center ecosystems through a bibliometric review of 783 Scopus-indexed journal articles published between 2010 and 2025. The study is guided by four research questions. These questions examine the evolution of the field during 2010–2025, its thematic structures and intellectual foundations, the research fronts linking digital talent, HR capability, and advanced digital infrastructure, and the conceptual and geographical gaps in Asia-Pacific human capital readiness research. This study contributes to the HRM literature in three ways. First, it clarifies human capital readiness as an HRM research problem by showing how the literature on digital skills, AI literacy, cloud computing, data center ecosystems, HR analytics, and workforce readiness remains fragmented

across several research streams. Second, it positions human capital readiness as a strategic HR capability rather than a narrow skills inventory, thereby linking digital talent development with workforce planning, HRD, analytics, and AI governance. Third, it brings an Asia-Pacific perspective to HRM debates on digital infrastructure by highlighting how rapid cloud, AI, and data center expansion creates workforce readiness and institutional coordination challenges that remain under-integrated in the literature. These contributions are based on bibliometric mapping and interpretive synthesis and therefore aim to clarify the structure of the field rather than test causal relationships.

2. Literature Review

Human capital readiness for cloud–AI–data center ecosystems can be understood through four connected layers: strategic HR capability, socio-technical digital infrastructure, workforce competence development, and regional talent readiness. The Resource-Based View and Dynamic Capabilities perspective provide the theoretical basis for framing readiness as both a strategic human resource and an adaptive organizational capability.

2.1. Human Capital Readiness as a Strategic HR Capability

Human capital readiness in digital transformation refers to the organizational capacity to develop, mobilize, and renew employee competencies in response to technological change. Kampoowale et al. (2025) show that human capital mediates the relationship between digital transformation and firm performance, indicating that digital investment becomes strategically meaningful when organizations possess the people-related capability to absorb and apply it. The Resource-Based View provides the theoretical foundation for this argument by positioning human resources as valuable, rare, and difficult-to-imitate resources that can support sustained advantage when embedded in organizational systems (Barney, 1991). In cloud–AI–data center ecosystems, digital knowledge, AI literacy, analytical capability, infrastructure awareness, and HR systems for workforce development therefore form part of a strategic human capital base rather than a set of isolated skill assets.

The Dynamic Capabilities perspective extends this argument by shifting attention from skill possession to capability renewal. Organizations facing cloud adoption, AI implementation, data center expansion, and digital governance pressures must continuously integrate, reconfigure, and redeploy workforce capabilities as technologies and work roles evolve (Teece et al., 1997). Human capital readiness therefore depends on learning routines, reskilling mechanisms, workforce planning, HR analytics, role redesign, and governance processes that allow the human capital base to adapt to changing digital infrastructure demands. In AI-enabled recruitment, HR competencies can contribute to intellectual capital and dynamic capability development when technology adoption is aligned with organizational learning and renewal (Sandeep et al., 2025; Xiong, 2024).

Recent HRM scholarship supports this framing by showing that digital transformation, AI, and analytics are reshaping both workforce capability requirements and HR functions. Studies link digital transformation strategy, data-driven decision-making, HR digital competence, and organizational agility to innovation and performance outcomes (Cortes, 2023; Goraya et al., 2025; Yu and Moon, 2021). AI and analytics also reshape recruitment, ethical decision-making, employee participation, talent management, learning development, retention, and

workforce decisions. These changes require HR professionals to develop stronger digital and analytical competencies (Bouzerda et al., 2025; Nankervis and Cameron, 2022; Ravesangar and Narayanan, 2024; Upadhyay, 2025). Together, this literature positions human capital readiness as a strategic HR capability. It links technology, people, analytics, governance, and organizational adaptation in the AI-era digital transformation (Baranyi, 2026; Michelotto and Jóia, 2024; Santana and Diaz-Fernandez, 2022).

2.2. Cloud–AI–Data Center Ecosystems as Socio-Technical Workforce Systems

Cloud–AI–data center ecosystems represent advanced digital infrastructure in which platforms, algorithms, and physical computing facilities become interdependent. Existing research has explained many technical aspects of this ecosystem, yet its workforce implications remain less integrated. Zahoor (2023), for instance, highlights security challenges in AI-enhanced cloud platforms and the need for mechanisms that protect data, preserve trust, and strengthen AI decision-making environments. Boichuk et al. (2025) show that Industry 4.0 technologies such as AI and the Internet of Things can improve smart city management, although the emphasis remains largely on technological implementation. These studies indicate that more sophisticated digital infrastructure also requires workers who can operate across technical, analytical, managerial, and governance boundaries.

Cloud and AI reshape how organizations create, coordinate, and use value. Beverungen et al. (2022) describe digital transformation as increasingly organized through platform ecosystems and public data spaces, where collaboration, data sharing, and service co-creation become central. Related technologies, such as the Internet of Things, edge–fog–cloud computing, and blockchain, further intensify the need for competencies that extend beyond conventional information technology specialization (Firouzi et al., 2023). From an HRM perspective, data centers should therefore be viewed as workforce-dependent organizational systems rather than passive infrastructure. Their operation requires coordinated talent pipelines, learning systems, role redesign, cross-functional collaboration, and digital governance to support reliable, secure, adaptive, and value-generating digital services.

2.3 Digital Skills, AI literacy, and HRD for Advanced Digital Infrastructure

Digital skills and AI literacy form the competence foundation of human capital readiness, but the literature remains dispersed across HRD, education, information systems, and technology management. Kim (2024) conceptualizes AI literacy in HRD through competencies related to skills, relevance, value, and knowledge. This indicates that AI readiness requires employees to understand how AI affects work, decision-making, professional roles, and organizational responsibility. Deepa et al. (2024) extend this discussion by identifying managerial competencies for integrating AI into HRM, including cognitive capability, human capital, and social capital. Competency frameworks for AI professionals also identify data science, AI software development, and AI product management as important domains for aligning educational preparation with industry requirements (Brauner et al., 2023).

The broader digital skills literature reinforces the need for a multi-level approach. Bouwmans et al. (2024) develop the Digital Transformation Skills Framework, emphasizing digital work, entrepreneurship, collaboration, and adaptability as competencies required for digital transformation. Molla et al. (2024)

argue that non-IT workers also contribute to digitalization value through their ability to use, interpret, and integrate digital tools into work processes. In project-based work, data-savvy talent has become central because digitalized environments require workers to manage and interpret data-rich workflows (Y. Liu et al., 2024). These studies suggest that readiness for cloud–AI–data center ecosystems requires both specialized technical competence and broader organizational digital capability.

Strategic HRD becomes essential because skills supply does not automatically match infrastructure demand. Nnadi et al. (2025) call for agile HRD strategies for emerging technologies such as information and communication technology, robotics, data science, and cyber-physical systems, especially where academic training remains misaligned with industry needs. This point is important for cloud–AI–data center ecosystems, where workforce requirements evolve faster than conventional education and training systems. Human capital readiness therefore requires an integrated HRD architecture that links AI literacy, digital competence, interdisciplinary learning, and industry-responsive training.

2.4 Asia-Pacific Talent Readiness and Institutional Gap

The Asia-Pacific region provides a relevant context for studying human capital readiness because digital infrastructure expansion has not been matched evenly by talent and institutional readiness. Elfaki and Ahmed (2024) identify digital technology adoption and globalization as important drivers of green and sustainable economic growth in the region, including economies such as Malaysia, Indonesia, and Singapore. Yet digital growth is accompanied by workforce constraints. In Malaysia, employers report gaps between industry demand for digital skills and graduate capabilities, particularly in communication, teamwork, and problem-solving (Tee et al., 2024). Than and Liu (2024) similarly show that Vietnam’s AI development ambitions are constrained by shortages of AI specialists and weaknesses in intellectual property regulation.

Indonesia illustrates how readiness gaps can also be spatial and institutional. Digital development remains stronger in metropolitan and western regions than in rural and eastern areas, although the digital divide has shown signs of narrowing (Jaya et al., 2024; Kartiasih et al., 2022). These inequalities matter for data center development because skilled labor availability, infrastructure quality, and geographic conditions influence where high-availability geo-distributed data centers can be located in emerging economies (R. Liu et al., 2023). Regional readiness is therefore shaped not only by the supply of digital talent, but also by education systems, labor market institutions, infrastructure quality, and policy coordination.

The Asia-Pacific region also illustrates how digital transformation is embedded in wider governance and development dynamics. The AI skills policy requires coordinated national strategies, while regional digital initiatives in Southeast Asia can support efforts to reduce digital divides and strengthen capacity development (Putra, 2025; Rigley et al., 2023). Simultaneously, digital value chain development in East Asia and China’s digital expansion in the Global South raise broader questions about digital governance and institutional capacity (Heeks et al., 2024; Morishita, 2023). These studies position human capital readiness as both an organizational and regional capability. It depends on firm-level HR systems as well as regional talent systems, institutional capacity, and the ability of education and workforce institutions to respond to digital infrastructure transformation.

The literature therefore reveals three unresolved gaps. First, human capital readiness has not been sufficiently defined for the specific demands of cloud–AI–

data center ecosystems. Second, existing studies discuss digital skills, AI adoption, infrastructure readiness, or education separately, but rarely explain how HR systems recruit, develop, measure, retain, and deploy the capabilities required for advanced digital infrastructure. Third, Asia-Pacific is increasingly important in cloud, AI, and data center expansion, yet its workforce readiness challenges remain dispersed across policy, education, technology, and HRM literatures. These gaps justify a bibliometric review that maps how knowledge has accumulated, where research communities remain disconnected, and how digital talent development, HR capability, and regional infrastructure readiness can be more closely integrated.

3. Materials and Methods

This study employed a bibliometric review to map the intellectual structure, thematic development, research fronts, and collaboration patterns of human capital readiness research in cloud–AI–data center ecosystems. The method was selected because the topic is distributed across human resource management, digital transformation, artificial intelligence, cloud computing, data center studies, education, and regional development. Rather than relying on narrative synthesis alone, the study examined publication metadata, keyword relationships, citation structures, thematic development, and scientific collaboration patterns through a systematically reported screening and analysis procedure.

3.1. Research Design

This study used bibliometric analysis as its primary methodological approach, combining descriptive bibliometric profiling, performance analysis, thematic mapping, and science mapping. Bibliometric analysis is appropriate for examining large bodies of literature because it enables researchers to identify publication patterns, intellectual structures, and research trends through bibliographic metadata (Donthu et al., 2021). In this study, the approach was used to examine how scholarship on human capital readiness for cloud–AI–data center ecosystems has evolved and how its main themes, intellectual foundations, research fronts, and collaboration structures are connected.

The research design consisted of two complementary analytical orientations. First, descriptive and performance-oriented analyses were used to examine annual publication trends, source productivity, country contributions, and the general development of the field. Second, science mapping was used to identify conceptual clusters, intellectual linkages, contemporary research fronts, and collaboration patterns. Zupic and Čater (2015) emphasize that science mapping techniques, including co-word analysis, co-citation analysis, and bibliographic coupling, are useful for revealing how a scientific field is structured and how knowledge evolves. This design is suitable for the present study because human capital readiness for cloud–AI–data center ecosystems remains fragmented across technology, HRM, education, and regional development literatures.

3.2. Database Selection and Conceptual Search Strategy

Scopus was selected as the bibliographic database for this bibliometric review because it provides the structured metadata required for bibliometric mapping, including titles, abstracts, author keywords, publication years, source titles, authorship information, affiliations, references, and citation data. Scopus was also appropriate for this study because human capital readiness for cloud–AI–data center ecosystems spans several fields, including human resource management, management,

information systems, engineering, digital transformation, cloud computing, artificial intelligence, data center studies, and education.

The search strategy was designed to capture the intersection of three areas: workforce and human capital, cloud–AI–digital infrastructure, and readiness or capability development. These areas were combined using Boolean operators and applied to the Title, Abstract, and Keywords fields in Scopus through the TITLE-ABS-KEY function. The resulting Scopus query was as follows:

(TITLE-ABS-KEY ("digital talent" OR "digital skills" OR "human capital" OR "workforce readiness" OR "technology readiness" OR "IT workforce" OR "digital competency" OR "employee digital skills" OR "digital literacy" OR "technical skills" OR "STEM skills" OR "ICT skills")) AND (TITLE-ABS-KEY ("cloud computing" OR "cloud adoption" OR "cloud transformation" OR "cloud engineering" OR "AI" OR "artificial intelligence" OR "machine learning" OR "data center" OR "data centre" OR "hyperscale" OR "digital infrastructure" OR "computing infrastructure")) AND (TITLE-ABS-KEY (readiness OR capability OR competencies OR "skills gap" OR "talent development" OR upskilling OR reskilling))

The records retrieved through this query formed the initial pool for screening and dataset construction.

3.3. Screening and Dataset Construction

The initial Scopus search produced 1,685 documents before any publication-year, document type, or language filters were applied. The dataset was then refined through a multi-stage screening process following a PRISMA-style logic of transparent identification, screening, and inclusion. Although this study is a bibliometric review rather than a conventional systematic review, the PRISMA 2020 framework was used as a reporting reference to document how records were identified, filtered, and retained (Page et al., 2021).

The first screening stage applied a publication year filter between 2010 and 2025. This period was selected because cloud computing, AI applications, and data center expansion became increasingly relevant to contemporary digital transformation during this timeframe. The year filter excluded 29 documents and reduced the dataset from 1,685 to 1,656 documents. The second screening stage limited the dataset to journal articles to maintain consistency in the type of scholarly output that was analyzed. At this stage, 829 non-article records were excluded, and the dataset was reduced to 827 documents. The third screening stage retained only English-language publications to support terminological consistency during the keyword normalization and bibliometric mapping. This stage excluded 44 non-English records and produced a final dataset of 783 Scopus-indexed English journal articles.

This screening procedure also defined the bibliographic scope of the review. The final dataset was limited to Scopus-indexed English-language journal articles and therefore did not include conference papers, books, book chapters, editorials, policy reports, industry reports, grey literature, non-English publications, or publications indexed only in databases outside Scopus. These boundaries were applied to maintain consistency in the bibliographic data used for the analysis, while recognizing that relevant work on human capital readiness may also exist beyond the dataset examined in this study. The complete filtering sequence is summarized in the PRISMA-style dataset screening flow diagram in **Figure 1**.

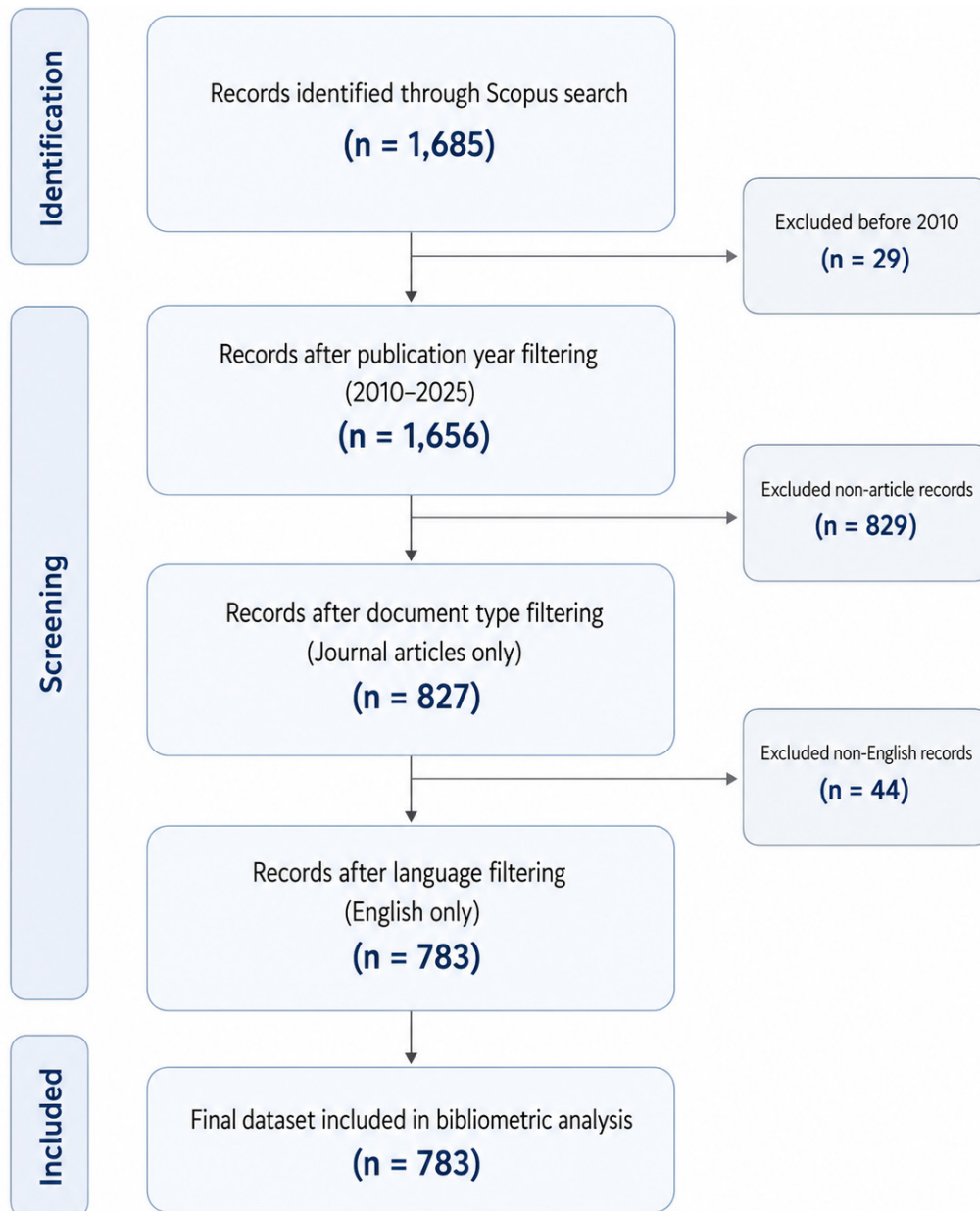


Figure 1. PRISMA-style dataset screening flow diagram

3.4. Data Preparation and Keyword Normalization

The exported Scopus metadata were prepared before analysis to improve the reliability and interpretability of the bibliometric outputs. This preparation included checking duplicate records, reviewing author name inconsistencies, standardizing source titles, examining keyword variations, handling abbreviations, and normalizing plural and singular forms. Metadata preparation was necessary because inconsistent spelling, abbreviations, alternative labels, and synonymous terms can create redundant nodes and weaken the clarity of co-word, co-citation, bibliographic coupling, and collaboration maps.

Keyword normalization was conducted conservatively to reduce redundancy while preserving meaningful conceptual variation in the dataset. The cleaning process included the consolidation of synonymous or closely related terms that clearly referred to the same concept. “AI” and “artificial intelligence” were standardized under “artificial intelligence.” Similarly, “data center,” “data centre,” “data centers,”

and “data centres” were harmonized as “data center.” Terms such as “digital skill,” “digital skills,” “digital competence,” and “digital competencies” were reviewed and consolidated where they carried the same conceptual meaning. Abbreviations such as “HRM” were also standardized with “human resource management” where appropriate. Highly generic terms were reviewed carefully and were not treated as substantive thematic labels when they did not add interpretive value to the bibliometric maps. This conservative normalization reduced redundant nodes while preserving the conceptual structure needed for reliable bibliometric interpretation.

3.5. Bibliometric Analysis Procedures

The final dataset of 783 Scopus-indexed journal articles was analyzed using Biblioshiny/R Bibliometrix and VOSviewer software. Biblioshiny, the web-based interface of the Bibliometrix R package, was used to support descriptive bibliometric profiling, performance analysis, annual publication trend analysis, source and country contribution analysis, thematic mapping, and general bibliometric output. Aria and Cuccurullo (2017) developed Bibliometrix as an R-based tool for comprehensive science mapping and bibliometric analysis, making it suitable for examining annual scientific production, source productivity, author and country contributions, thematic structures, and the general evolution of research fields. The combined use of Biblioshiny and VOSviewer is also consistent with recent bibliometric applications that integrate publication trend analysis, keyword mapping, network visualization, and thematic clustering to examine the structure and evolution of emerging research domains (Marlina et al., 2026).

VOSviewer was used to support bibliometric network visualization and science mapping. Van Eck and Waltman (2010) describe VOSviewer as a tool for constructing and visualizing bibliometric networks, including keyword, citation, co-citation, bibliographic coupling, and collaboration networks. In this study, keyword co-occurrence analysis was used to identify recurring concepts and thematic clusters related to artificial intelligence, digital transformation, digital skills, human capital, cloud computing, data centers, and future-of-work-related topics. Thematic mapping was used to assess the relative development and relevance of major themes, including motor themes, basic themes, niche themes, and emerging or declining themes.

Co-citation analysis was used to identify the intellectual foundations of the field by examining how frequently authors or documents were cited together. This analysis helped reveal the theoretical and disciplinary bases of human capital readiness research, including technology adoption, behavioral readiness, strategic capability, and future-of-work perspectives. Bibliographic coupling was used to identify contemporary research fronts by mapping documents that shared similar reference patterns. Country collaboration analysis was conducted to examine the geographical structure of knowledge production and to assess the position of Asia-Pacific countries within the global research network. Mapping parameters, keyword normalization, and visualization outputs were reviewed consistently to improve interpretability, reduce redundant terms, and ensure that the resulting maps reflected meaningful conceptual, intellectual, and collaboration structures. Together, these procedures enabled the study to map the conceptual structure, intellectual base, current research fronts, and international collaboration patterns of human capital readiness research in cloud–AI–data center ecosystems.

4. Results

This section presents the bibliometric findings from 783 Scopus-indexed

journal articles published between 2010 and 2025. The results are organized into six analytical components: annual publication trends, keyword co-occurrence, thematic mapping, co-citation analysis, bibliographic coupling, and country collaboration. Annual publication trends and thematic mapping are treated as Biblioshiny/R Bibliometrix-supported descriptive and thematic outputs, while keyword co-occurrence, co-citation, bibliographic coupling, and country collaboration are interpreted through VOSviewer-supported network visualizations. Together, these analyses indicate how the field has developed, how its conceptual and intellectual structures are organized, and how collaboration patterns reveal the position of Asia-Pacific scholarship within the wider knowledge network.

4.1. Annual Publication Trends

The annual publication trend shows that scholarly attention to human capital readiness in cloud–AI–data center ecosystems increased substantially during the 2010–2025 period. As shown in **Figure 2**, publication activity was limited during the earlier years of the dataset, particularly from 2011 to 2018. During this phase, research related to digital workforce readiness, AI-related competencies, cloud adoption, and data center workforce issues was still relatively dispersed and had not yet formed a consolidated research stream.



Figure 2. Annual publication trends

A more visible increase appears after 2019, indicating that human capital readiness began to receive stronger scholarly attention alongside the broader expansion of digital transformation, cloud adoption, AI implementation, and digital skills research. The growth becomes more pronounced after 2023, suggesting that the

relationship between digital infrastructure and workforce readiness has become an increasingly central research concern. This pattern indicates that the field is no longer limited to technology adoption or infrastructure management alone, but is increasingly connected to workforce capability, digital competence, and organizational readiness.

For human resource management (HRM) scholarship, this publication pattern suggests that digital infrastructure expansion is generating a distinct workforce-readiness agenda involving digital capability, learning systems, HR analytics, and strategic talent planning. The acceleration of publications does not yet mean that the field is conceptually mature, but it indicates that researchers are increasingly recognizing the human and organizational dimensions of AI-enabled digital infrastructure. The publication trajectory therefore provides an empirical starting point for understanding why a more integrated HRM-oriented framework is needed.

4.2. Keyword Co-occurrence and Thematic Structure

The keyword co-occurrence network in **Figure 3** illustrates the conceptual structure of the literature. The visualization shows that “artificial intelligence” occupies a central position in the network, connecting themes associated with digital transformation, cloud computing, Industry 4.0, digital skills, digital literacy, machine learning, education, and human readiness. This centrality suggests that AI functions as a key organizing concept in the field, linking technological, organizational, and workforce-oriented discussions.

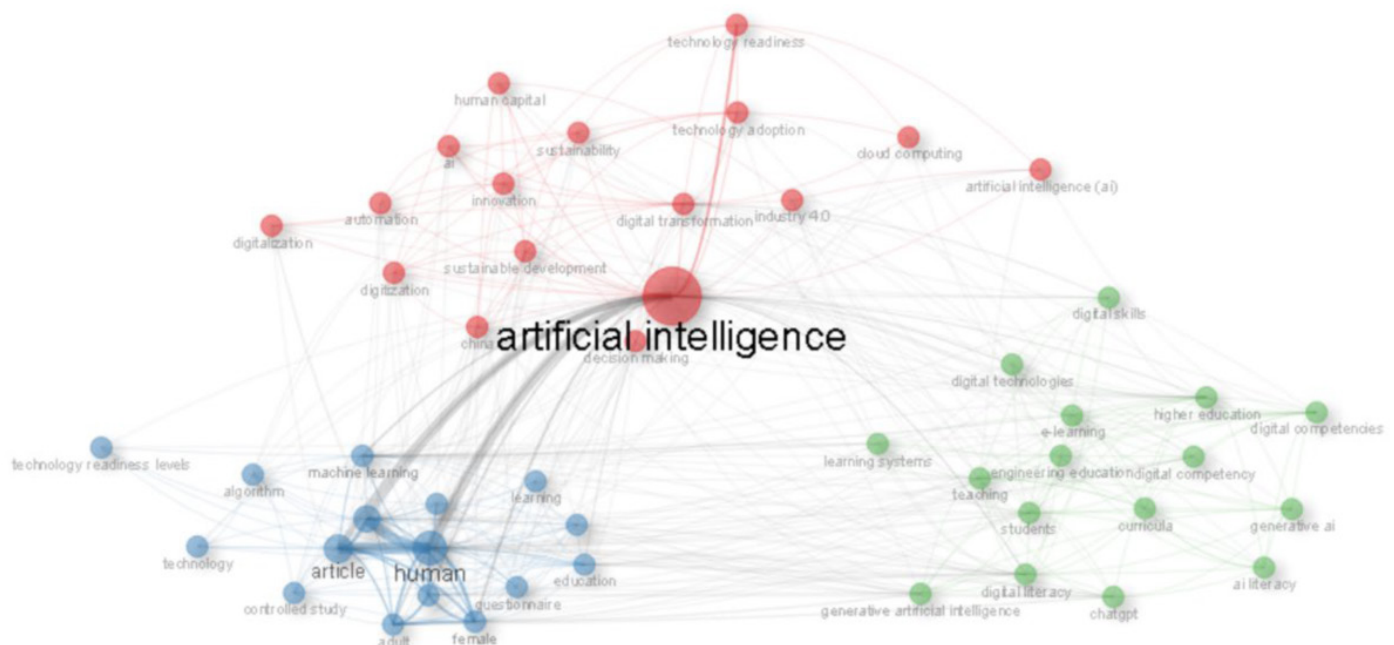


Figure 3. Keyword co-occurrence network visualization

The VOSviewer-supported keyword network reveals several interrelated thematic groupings. One cluster is strongly oriented toward advanced technologies, including artificial intelligence, digital transformation, Industry 4.0, innovation, technology readiness, and cloud computing. This cluster reflects a stream of scholarship that approaches readiness primarily through technological adoption, digital infrastructure, and organizational transformation. The presence of cloud computing and digital transformation within this cluster confirms that human capital readiness is frequently discussed in relation to the ability of organizations to adopt

and manage advanced digital technologies.

Another cluster is more human-centered and competence-oriented. It includes terms such as digital skills, digital literacy, learning systems, curricula, higher education, and digital competencies. This cluster indicates that the literature also addresses the education and workforce development dimensions of readiness. In this stream, readiness is not only a matter of whether organizations possess technological infrastructure, but also whether individuals and institutions can develop the competencies required to operate within digital environments.

A further grouping is associated with empirical and data-oriented terms, including machine learning, students, questionnaires, controlled study, and education. This suggests that a portion of the literature measures readiness through educational, behavioral, or quantitative assessment settings. Taken together, the keyword structure indicates a persistent division between technology-oriented studies and human-centered readiness studies. For HRM, this separation suggests that workforce readiness is still often treated as an educational or skills issue rather than as an integrated HR capability linked to recruitment, learning, analytics, and workforce planning. This gap directly supports the need to reposition human capital readiness as an organizational capability for AI-era digital infrastructure.

4.3. Thematic Map and Research Maturity

The thematic map in **Figure 4** provides a complementary view of the field by positioning major themes according to their relevance and development. The map is organized around four quadrants: niche themes, motor themes, emerging or declining themes, and basic themes. This Biblioshiny/R Bibliometrix-supported thematic mapping helps clarify which topics are already central and developed, which remain foundational but underdeveloped, and which represent areas requiring further consolidation.

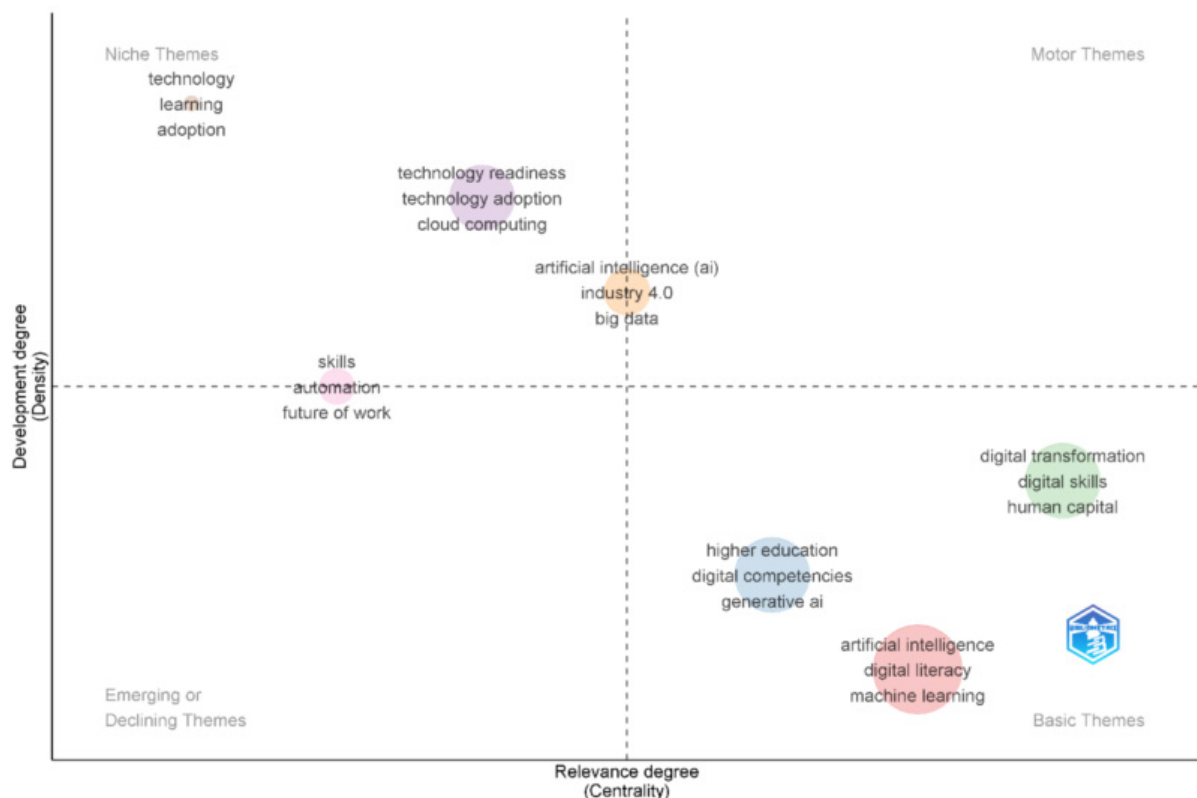


Figure 4. Thematic map of research development and relevance

In the niche themes quadrant, terms such as technology, learning, and adoption show relatively high internal development but lower centrality to the broader field. This indicates that these topics are developed within specific scholarly communities but do not yet function as major connectors across the overall literature. Their position suggests that learning and technology adoption remain important, but they are often examined in specialized contexts rather than as part of an integrated HRM framework for digital infrastructure readiness.

The motor themes quadrant contains artificial intelligence, Industry 4.0, and big data. These themes show both high relevance and strong development, indicating that they play a central role in shaping the field. Their position confirms that the current literature is strongly driven by advanced technology themes. For the purposes of this study, this finding suggests that AI and Industry 4.0 are not merely background topics, but central forces shaping new competency requirements, organizational readiness, and digital workforce transformation.

The emerging or declining themes quadrant includes skills, automation, and the future of work. This quadrant was interpreted cautiously because its position does not, by itself, indicate whether a theme is losing relevance or is still developing toward stronger integration. In the context of this dataset, these themes are better understood as under-consolidated within the HRM-oriented literature on human capital readiness rather than as definitively declining. Skills, automation, and the future of work are closely related to AI-era changes in work design, job roles, competency demands, and employee adaptation. However, their lower centrality and development indicate that they have not become fully integrated into the core discussion of human capital readiness for cloud–AI–data center ecosystems. This interpretation is also consistent with the keyword and bibliographic coupling results, which show that workforce-related themes remain distributed across education, work psychology, and future-of-work research rather than being consolidated into a unified HR capability perspective.

The basic themes quadrant includes digital transformation, digital skills, human capital, digital competencies, generative AI, and higher education. These themes are central to the field but remain less internally developed than the motor themes. This position is significant because it indicates that the conceptual foundations of the field are already recognizable, but not yet sufficiently integrated. For HRM scholarship, the presence of human capital, digital skills, and digital competencies as basic themes shows that workforce readiness is foundational to the field, while also confirming the need for stronger theoretical development around how these capabilities are built, measured, managed, and renewed.

4.4. Intellectual Structure Through Co-citation Analysis

The co-citation network in **Figure 5** reveals the intellectual architecture that underpins research on human capital readiness in digital transformation. The visualization shows several clusters of interrelated authors and documents, indicating that the field draws from multiple disciplinary traditions. These include information systems, technology adoption, organizational behavior, strategic capability, digital economy, education, and future-of-work research.

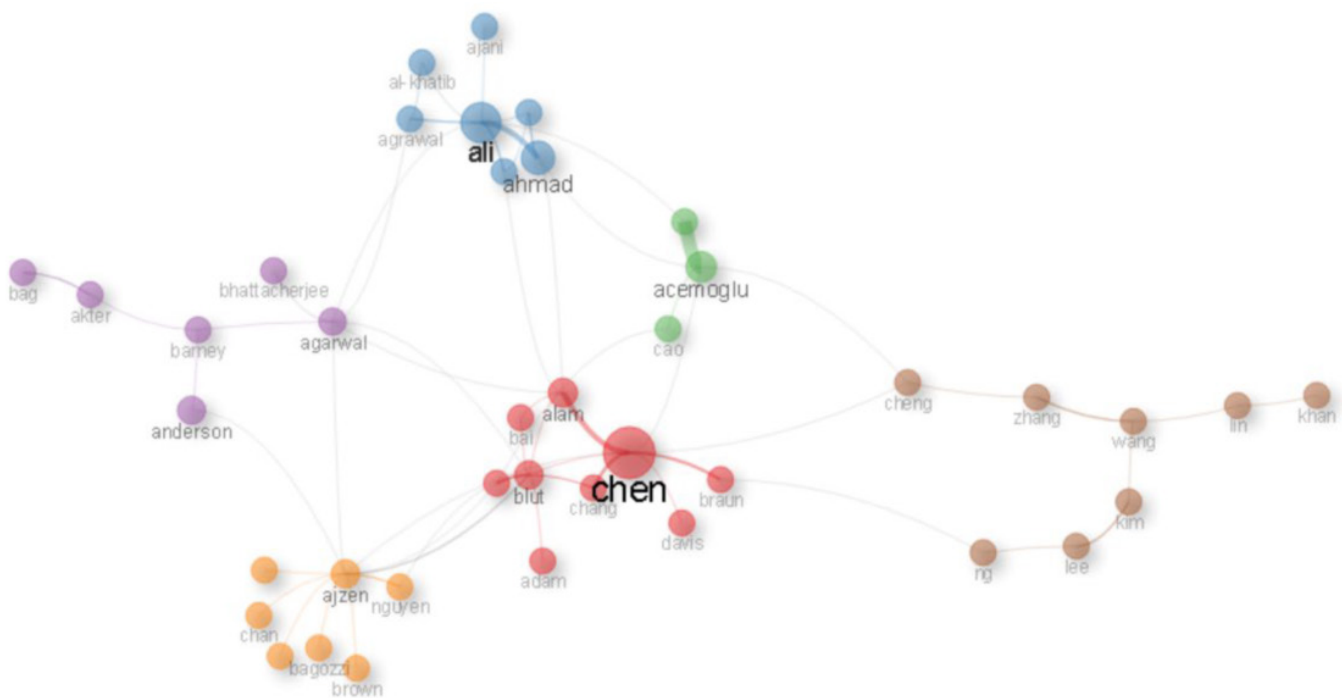


Figure 5. Co-citation network analysis

The first major intellectual foundation is associated with technology adoption and information systems research. The centrality of authors connected to technology acceptance, technology adoption, and information system use indicates that the literature has been strongly shaped by models explaining how individuals and organizations accept, adopt, and continue using digital technologies. This foundation is useful because it explains readiness as a behavioral and cognitive response to new systems. However, it also shows that a significant part of the field remains rooted in adoption logic rather than broader HR capability development.

The second foundation is psychological and behavioral readiness. This stream emphasizes attitudes, intentions, perceived behavioral control, motivation, and individual responses to technological change. Its presence in the co-citation network suggests that human capital readiness is not simply a matter of skill possession or technology availability. It also depends on whether individuals feel capable, willing, and supported in using advanced digital systems. For HRM, this finding is relevant because workforce readiness requires attention to both competence and behavioral acceptance.

The third intellectual foundation connects strategic capability, automation, AI economics, future-of-work scholarship, digital competencies, and education. This stream broadens the field beyond individual technology adoption by linking readiness to organizational resources, workforce transformation, and talent development. The presence of strategic capability perspectives indicates that human capital readiness can be interpreted not only as individual technology acceptance, but also as an organizational capability built through HR systems, learning routines, and workforce renewal. Overall, the co-citation findings show that the field is multidisciplinary, but its intellectual base remains distributed across technology adoption, behavioral readiness, strategic capability, and education-oriented traditions.

4.5. Contemporary Research Fronts Through Bibliographic Coupling

The bibliographic coupling network in **Figure 6** identifies contemporary

research fronts by mapping documents that share similar reference patterns. Unlike co-citation analysis, which reveals intellectual foundations, bibliographic coupling highlights more recent areas of research activity. The network indicates that current scholarship on digital human capital readiness is organized around several related but distinct knowledge domains.

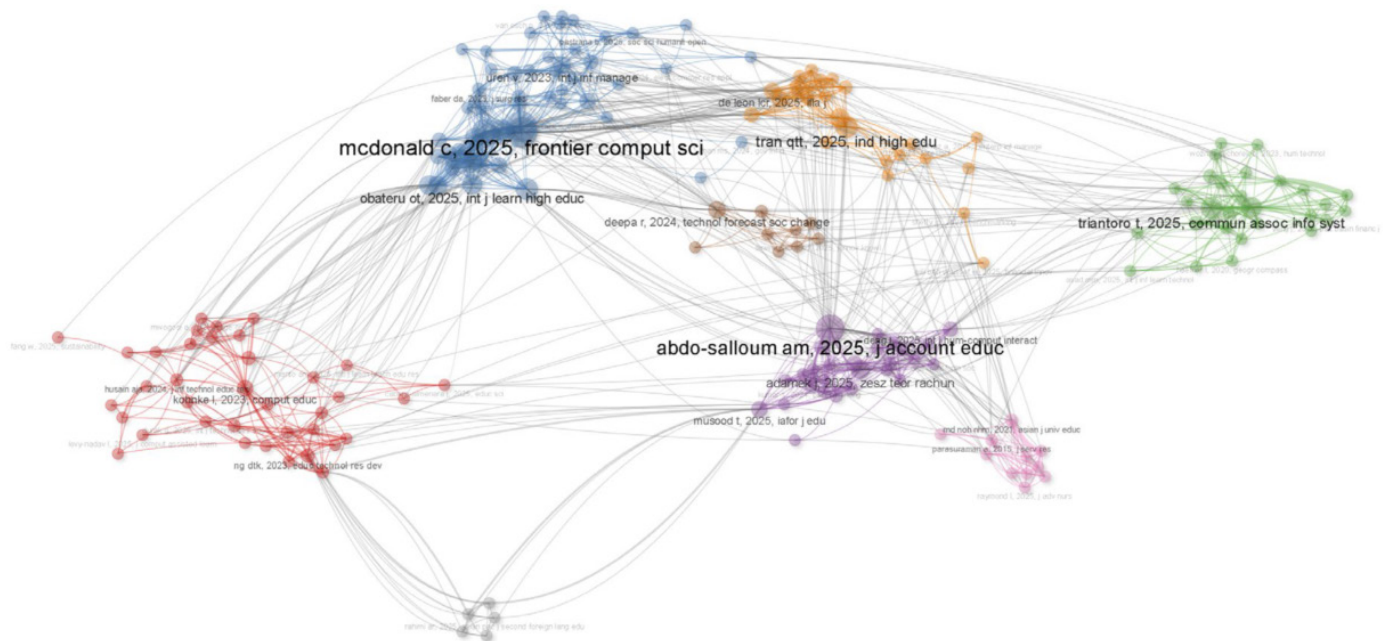


Figure 6. Bibliographic coupling network

The first domain centers on work psychology and behavior. Studies in this domain examine how individuals perceive automation, AI, and digital workplace change, as well as how employees respond psychologically and behaviorally to new technologies. This domain represents the micro-level dimension of human capital readiness because it focuses on whether individuals are prepared to accept, use, and adapt to AI-enabled and digitally mediated work environments.

The second domain focuses on the future of work and competence evolution. This stream examines how AI, automation, and data-driven work reshape occupational roles, skill requirements, and professional competencies. Its connection with the work psychology domain suggests that readiness is both structural and behavioral. Changes in job roles and competency expectations are inseparable from the ways individuals experience and respond to technological disruption.

The third domain is associated with digital education and literacy. Studies in this cluster emphasize curriculum transformation, digital literacy, computational thinking, AI-assisted learning, and higher education readiness. This domain highlights the role of educational institutions in preparing the workforce before individuals enter organizations. Its presence in the bibliographic coupling network confirms that human capital readiness is not produced only inside firms; it is also shaped by educational systems, training institutions, and broader talent pipelines.

The bibliographic coupling pattern therefore suggests that current research fronts remain distributed across micro-level employee responses, meso-level competency change, and pre-employment education systems rather than being integrated into a unified HRM readiness model. This finding is important for interpreting the field because it shows that cloud–AI–data center readiness cannot be addressed

only through short-term employee training. It depends on the interaction between employee psychology, evolving competency demands, educational systems, and organizational HR capability.

4.6. Country Collaboration and Asia-Pacific Research Gap

The country collaboration network in **Figure 7** shows how knowledge production on human capital readiness, digital transformation, AI, cloud computing, and data center-related topics is distributed across national and regional research networks. The VOSviewer-supported visualization indicates that the field is shaped by several major collaboration blocs, with strong participation from developed economies and emerging contributions from Asia-Pacific and Global South countries.

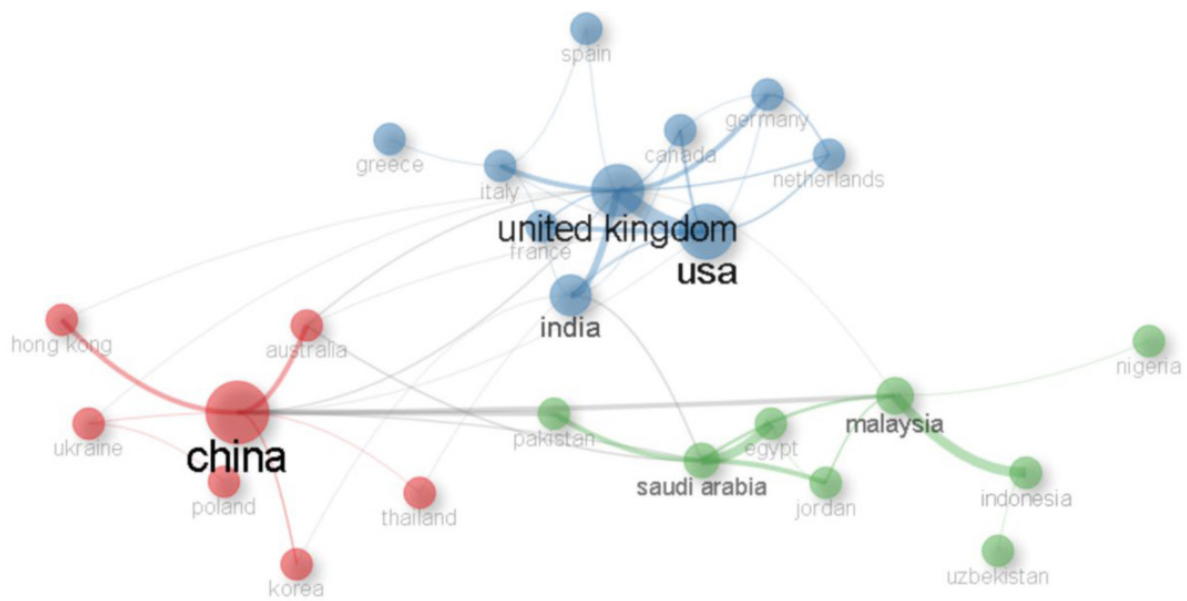


Figure 7. Country collaboration network

The first major collaboration bloc is led by the United Kingdom, the United States, and Western European countries such as the Netherlands, Germany, Canada, Italy, and Spain. These countries occupy central positions in the network, indicating strong publication output and international collaboration. Their strong centrality suggests that much of the theoretical and conceptual development of research on digital readiness, AI adoption, future-of-work issues, and organizational preparedness continues to be shaped by Global North research systems.

The second major bloc is led by China and includes collaboration with Hong Kong, South Korea, Australia, Poland, and Ukraine. China's strong position indicates its growing role in research on digital skills, educational technology, AI-related learning, and workforce readiness. The visible connection between China and Australia also reflects the increasing importance of Asia-Pacific collaboration in digital transformation research. This bloc is particularly relevant because it shows that Asia-Pacific countries are becoming more visible in the literature, although their contribution remains uneven across countries and subregions.

A third collaboration pattern appears across South Asia, Southeast Asia, the Middle East, and parts of Africa, including countries such as Malaysia, Saudi Arabia, Pakistan, Egypt, Jordan, Nigeria, and Indonesia. Malaysia appears as an important regional node, including links with Indonesia. This suggests that emerging economies are beginning to contribute more actively to research on digital competence,

educational readiness, and technology adoption, particularly in higher education and institutional contexts. However, the network also shows that Asia-Pacific participation remains less consolidated than the UK–USA–Europe bloc.

The country collaboration findings reveal a geographical gap that is directly relevant to the HRM focus of this study. Asia-Pacific is increasingly important in cloud adoption, AI development, and data center expansion, yet research on human capital readiness for these ecosystems remains uneven and comparatively less centralized. The presence of China, Australia, Malaysia, and Indonesia indicates growing regional engagement, but the overall network suggests that Asia-Pacific scholarship has not yet matched the region's strategic importance in digital infrastructure development. This gap supports the need for future HRM research that examines digital talent readiness, organizational capability, and workforce policy in Asia-Pacific cloud–AI–data center ecosystems.

5. Discussion

The findings indicate that research on human capital readiness for cloud–AI–data center ecosystems has become more visible, but remains conceptually fragmented across technology-oriented, education-oriented, behavioral, and HRM-related research streams. This fragmentation matters for HRM scholarship because the literature has not yet converged around a clear explanation of how organizations identify, develop, deploy, govern, and renew the workforce capabilities required for advanced digital infrastructure. The contribution of this study should therefore be interpreted as an integrative bibliometric interpretation rather than as a causal test of the relationship between human capital readiness and organizational performance.

The bibliometric findings support this interpretation in several ways. The keyword and thematic results show that artificial intelligence, Industry 4.0, cloud computing, digital transformation, digital skills, human capital, and digital competencies are connected but unevenly developed. This pattern suggests that workforce readiness is central to the field, whereas the HRM mechanisms through which readiness is built remain less consolidated. The co-citation and bibliographic coupling results further indicate that readiness is often treated through technology adoption, behavioral readiness, competence development, education, and future-of-work perspectives. It is less frequently treated as an integrated HR capability. Taken together, these findings support a cautious interpretation of human capital readiness as an organizational capability that depends on HR systems, learning routines, workforce planning, analytics, and organizational governance.

The theoretical implication is that human capital readiness can be understood as both a strategic human resource base and a capability renewal process. Barney's (1991) Resource-Based View helps frame human capital as a strategic resource when it is valuable, difficult to imitate, and embedded in organizational systems. Teece et al.'s (1997) Dynamic Capabilities perspective further explains why organizations must renew and reconfigure workforce capabilities as technologies, roles, and institutional demands change. In the context of cloud–AI–data center ecosystems, these perspectives help connect fragmented literatures on technology adoption, behavioral readiness, digital competence, and future-of-work research. The findings do not imply that HRM alone determines the success of cloud, AI, or data center transformation. Rather, they indicate that technological readiness and workforce readiness are structurally connected in the literature but not yet fully integrated into a coherent HRM framework.

For HRM practice, the findings suggest the need for more structured approaches to building human capital readiness. Nankervis and Cameron (2022) argue that HR professionals require new competencies as intelligent technologies reshape HR work. Consistent with this view, the present review indicates that HR functions need stronger capabilities in AI literacy, HR analytics, digital workforce analysis, digital infrastructure awareness, and ethical technology governance. Recruitment should move beyond generic technical hiring toward role-based readiness profiles that consider technical expertise, data interpretation, cross-functional collaboration, cybersecurity awareness, adaptability, and responsible AI understanding. Training and HRD should also be treated as continuous capability-building systems rather than one-off digital skills programs.

These findings also have implications for workforce planning and AI governance. Bouzerda et al. (2025) show that AI is reshaping HR task automation and process transformation, while Upadhyay (2025) highlights concerns related to fairness, bias, privacy, recruitment, talent management, and learning development in AI-HRM. Ravesangar and Narayanan (2024) further position HR analytics as a mechanism for improving data-driven HR decision making. These studies reinforce the practical implication that HR functions should become more anticipatory in identifying skill gaps, forecasting competency needs, monitoring talent pipeline risks, and supporting ethical technology use. As AI becomes embedded in recruitment, talent management, learning systems, employee monitoring, and workforce analytics, HR should play a stronger role in ensuring fairness, transparency, privacy protection, human oversight, and employee trust.

The Asia-Pacific findings add a regional dimension to this discussion. The country collaboration pattern suggests that Asia-Pacific scholarship is becoming more visible but remains less consolidated than research networks centered in the United Kingdom, the United States, and Western Europe. This does not prove that Asia-Pacific organizations are less ready or less capable. Rather, it indicates that the region's growing importance in cloud, AI, and data center expansion is not yet matched by equally consolidated scholarly attention to HR readiness, workforce policy, and digital talent systems. For HRM research, this creates an opportunity to develop more context-sensitive studies on digital talent pipelines, education–industry alignment, public–private training partnerships, institutional readiness, and workforce planning for advanced digital infrastructure.

Overall, this study contributes to HRM scholarship by repositioning human capital readiness as an integrative concept linking digital talent development, HR analytics, workforce planning, AI governance, and capability renewal. The bibliometric evidence suggests that the field already contains the components of such a framework, but these components remain dispersed across different research communities. This mapping provides a basis for more integrated HRM research on the human capabilities required to sustain cloud–AI–data center ecosystems.

6. Conclusion

This study mapped the scientific development of human capital readiness for cloud–AI–data center ecosystems through a bibliometric review of 783 Scopus-indexed journal articles published between 2010 and 2025. The findings indicate that scholarly attention to this topic has increased markedly since 2019 and accelerated after 2023, reflecting the growing importance of digital workforce readiness in the AI era. However, the field remains conceptually fragmented. Technology-oriented studies

have developed strongly, while human-centered studies on digital skills, AI literacy, competencies, and workforce readiness remain central but are less theoretically consolidated. The co-citation and bibliographic coupling results further show that the field draws from technology adoption, behavioral readiness, strategic capability, future-of-work, work psychology, and education-based digital competency research, but these streams have not yet converged into an integrated HRM framework.

This study contributes to HRM scholarship by reframing human capital readiness as an integrative capability for AI-era digital infrastructure. The review shows that readiness is increasingly connected with HR analytics, workforce planning, HRD, AI governance, digital competence, regional talent systems, and continuous capability renewal. This contribution shifts the discussion from technology adoption and individual skill development toward the HR systems through which organizations build, deploy, govern, and renew the human capabilities required for cloud–AI–data center ecosystems. In doing so, the study provides a conceptual bridge between digital transformation research, AI-HRM, HR analytics, workforce development, and regional talent readiness.

Several boundaries should be considered when interpreting the findings. The review is based on Scopus-indexed English-language journal articles, which means that conference papers, policy reports, industry documents, non-indexed publications, and local-language studies were not included. In addition, bibliometric mapping depends on metadata quality, keyword standardization, database coverage, and interpretive cluster analysis. These boundaries define the scope of the review and indicate opportunities for future research to deepen, contextualize, and operationalize human capital readiness for cloud–AI–data center ecosystems across organizational, sectoral, and regional settings.

Future Research Directions

First, future research should develop an integrated competency framework for cloud–AI–data center human capital readiness. Such a framework should combine technical competencies, AI literacy, digital skills, data capability, cybersecurity awareness, infrastructure governance, sustainability awareness, and managerial competencies. It should also distinguish the readiness needs of different role groups, including engineers, HR professionals, facility managers, data analysts, operations leaders, compliance actors, sustainability specialists, and strategic decision makers. A role-based competency framework would help move the field beyond generic digital skills and toward measurable readiness profiles for advanced digital infrastructure.

Second, longitudinal research is needed to examine how digital talent readiness evolves over time. Cloud adoption, AI implementation, and data center operations do not create one-time skills requirements; they generate continuing demands for learning, adaptation, reskilling, and capability renewal. Longitudinal studies could examine how organizations identify emerging skills gaps, redesign jobs, update training systems, and renew workforce capabilities as technologies and operational requirements change. This direction is especially important for understanding readiness as a dynamic process rather than a static condition.

Third, future studies should advance sector-specific research on data center workforce readiness. Data centers differ from general digital transformation contexts because they combine computing infrastructure, physical operations, cybersecurity, energy management, sustainability, compliance, service continuity, resilience, and infrastructure risk. Research is needed to identify how these operational demands

shape workforce profiles, training needs, career pathways, and HR planning. This would help clarify what kinds of human capital are required to support reliable, secure, sustainable, and resilient cloud–AI–data center ecosystems.

Fourth, AI-HRM governance deserves more focused attention in digital infrastructure contexts. As organizations use AI and analytics for recruitment, performance assessment, workforce planning, learning systems, and employee monitoring, they must also address fairness, bias, transparency, privacy, accountability, and employee trust. Future research can examine how HR functions design governance mechanisms that support responsible AI use while maintaining employee participation, organizational legitimacy, and ethical workforce decision-making.

Fifth, Asia-Pacific comparative research should be expanded. The region is increasingly important in cloud, AI, and data center expansion, yet its human capital readiness scholarship remains uneven. Future studies should compare economies such as Indonesia, Malaysia, Singapore, Vietnam, China, Australia, and other regional contexts to examine how higher education systems, public–private training partnerships, labor market institutions, digital policy, and industry ecosystems shape workforce readiness. This research can help explain why some countries develop stronger digital talent pipelines while others face persistent readiness gaps.

Sixth, future research should develop HR analytics and workforce intelligence models for cloud–AI–data center ecosystems. Such models could support skills forecasting, talent pipeline monitoring, competency gap detection, training effectiveness evaluation, and strategic workforce planning. This direction would strengthen the practical relevance of human capital readiness research by helping organizations translate bibliometric and conceptual insights into workforce decisions. Overall, the future of cloud–AI–data center ecosystems will depend not only on technological investment, but also on the capacity of HR systems, educational institutions, and policy actors to build integrated human capital readiness.

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