



## Employability and Digitalization: A Bibliometric Analysis with Future Research Directions

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### Abstract

Digitalization is rapidly changing employment dynamics, demanding an understanding of how digital technologies impact employability. This study provides a comprehensive analysis of the relationship between digitalization and employability through a hybrid approach combining bibliometric analysis with a systematic theoretical review, based on the 4Ws framework (What, When, Where, and Why). Through the examination of thematic trends spanning the years 2010 to 2023, this study reveals significant domains in which digital transformation is influencing employability. The results underscore three primary thematic categories: the evolution of employment models catalyzed by digital technologies, the shift from Industry 4.0 to Industry 5.0, and theoretical advancements that concentrate on the informal economy alongside comparative analyses. This research contributes to addressing theoretical gaps regarding the lasting impact of digitalization on labor markets, with a particular focus on skill acquisition and job security. It presents targeted approaches for scholars, educators, and industry stakeholders to improve employability amid technological

change. These include creating adaptive skill development programs, using AI in workforce management, and encouraging policies that enhance workers' adaptability to new digital innovations. By presenting clear insights on how digitalization may affect employability, this research aims to enable more informed decisions for designing educational strategies and labor policies.

**Keywords:** Employability; Digitalization; Industry 4.0; SPAR-4-SLR.

## Introduction

The swift progression of digital technologies is significantly transforming the work and employment environment (Suarda et al., 2024). Such innovations are redefining conventional job functions while concurrently presenting new challenges and opportunities within the global labor market. With the rapid incorporation of digital technologies, comprehending their effects on employability has emerged as a crucial area of interest for researchers, corporations, and policymakers (Smaldone et al., 2022).

According to the World Economic Forum (2023), the adoption of technology is expected to be the main force behind business transformation in the coming years. The survey was conducted based on data from 803 organizations and included a total of 11.3 million people from 27 sectors. Over 85% of respondents held an optimistic view of the potential impact of new technologies and increased digital accessibility on their businesses. The imminent integration of big data, cloud computing, and artificial intelligence is approaching rapidly; over the next five years, it is anticipated that more than 75% of organizations intend to implement these technologies. In the forthcoming period, the enhanced utilization of these technological advancements will play a crucial role in shaping employment opportunities, influenced by several key factors: big data analytics, climate change, environmental management, encryption, and cybersecurity. Developments in agricultural technology, digital platforms, e-commerce, and artificial intelligence are expected to drive significant changes in how labor is practiced, likely leading to job losses in some areas. However, many organizations remain hopeful that new opportunities in other fields will offset these losses. It is forecast that all technologies, except robotics, will lead to the creation of new jobs in the next five years.

The term "digitalization" comes in many forms, and its meaning varies depending on the field to which it is applied. In the context of engineering research, it refers to the use of computer-based systems in converting analog information into digital data (Moreno-Garcia et al., 2019). This definition is generic and can be used in almost any context. Information technology science describes digitalization as the extensive use of powerful and inexpensive information technologies as engines of transformation and performance (Soomro et al., 2024; Hadoussa & Louati, 2023; Winkelhake & Winkelhake, 2022; Louati & Hadoussa, 2021). Management science typically associates the term "digitalization" with corporate innovation;

Agostini et al. (2020) describe it as the development and application of technology in the management process.

This study conducted a bibliometric analysis using VosViewer, a web-based application that provides a user interface for bibliometrics. It also includes an idea map and identifies a trending topic. To identify which regions have the most activity in this specific search area, we used the Bing search engine, and we used CiteSpace software to identify the cluster with the highest amount of activity. We then used the Rosado-Serrano et al. (2018) framework-based review model and the 4W technique to answer the study question, “What is the current situation?” We aimed to comprehend the connection between employability and digitalization. The following are the objectives of the bibliometric analysis:

- A) To collect bibliometric data on 155 articles retrieved from the Web of Science;
- B) To use VosViewer and CiteSpace to collect and document quantitative data from a variety of articles;
- C) To determine important authors in this field of study, using data such as authors per publication and an author dominance index;
- D) To get an overall network overview of this research stream through citation analysis and collaboration mapping.

The organization of this paper is delineated as follows: First, the Protocol Design and Structure Analysis details the approach employed for executing the bibliometric analysis. It is followed by the Results of the Bibliometric Analysis, which explains the main findings, including the number of publications, contributions by country, author evaluations, and emerging research themes. Previous Studies then investigate the 4W framework—What, When, Where, Why—to situate the current literature concerning employability and digitalization. The Future Research Agenda then highlights potential research directions, including new employment models and the transition from Industry 4.0 to Industry 5.0. Finally, the paper concludes with a Conclusion summarizing the findings and offering suggestions for future exploration in this evolving field.

## **Methodology**

A protocol is an essential component for analyzing a systematic literature review because it promotes precise planning, uniform execution, and transparency, allowing replication. The Quality of Reporting of Meta-analyses Conference (QUOROM) created a checklist and a companion flow diagram, which serve as a guide to the review process of meta-analyses (Moher et al., 1999). Because of the limitations in the QUOROM protocol, Moher et al. (2009) proposed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which is a modified version of the original QUOROM protocol to include systematic reviews and meta-analyses in one single document, thus addressing conceptual development in the field of systematic reviews. One might properly characterize the

constraints of the PRISMA framework as twofold: First, this framework was originally largely for systematic reviews located in the domain of medical and clinical trial research; Second, it has a significant emphasis on transparency and accountability using a checklist but lacks a clear-cut methodology to help authors at specific stages of the review. Additionally, the PRISMA framework lacks explanations that make decisions easier concerning the types of reviews (Paul et al., 2021).

Paul et al. (2021) proposed a novel protocol, “Scientific Procedures and Rationales for Systematic Literature Reviews” (SPAR-4-SLR), to overcome these limitations. In our study, we employed this protocol to organize, structure, and evaluate the literature. Figure 1 depicts the configuration of the model, consisting of three primary steps and six secondary steps.

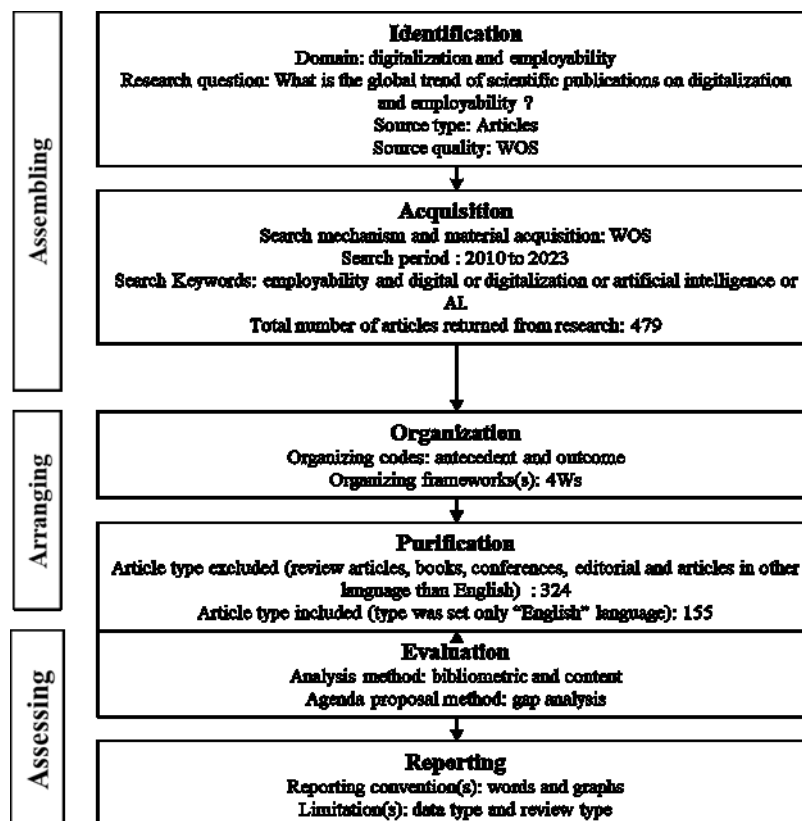


Figure 1. Application of the SPAR-4-SLR protocol

The initial stage of the process involves determining the specific area of focus, which in this case is “employability and digitalization”. Next, we established the study inquiries: “Can we identify an overarching pattern in scholarly articles about the relationship between employability and digitalization?”, “From this trend, what insights can we extract?”. Finally, we established that the sources consisted of original publications, and we verified their quality using the Web of Science.

The first sub-step of acquisition was the utilization of the Web of Science (WoS), widely recognized for being the most precise literature indexing tool for scientific knowledge and

providing high-yielding insights into many different branches of science. Forliano et al. (2021) proved that WoS is superior to Scopus in terms of compliance with stricter quality standards. According to Merigo et al. (2015), WoS, using complementary keywords, exhibited a lower rate of false positive results concerning authors as well as disambiguation keywords. Thus, we should highlight that relying solely on WOS restricted our database to Clarivate, potentially omitting pertinent studies from other sources such as Elsevier's Scopus and Google Scholar.

Our study entailed an evaluation to investigate the correlation between employability and digitalization, with a specific emphasis on the latest advancements in artificial intelligence. We limited the article identification process to the period from January 2010 to December 2023. We followed a systematic three-step search process, utilizing a search database with academic filters relevant to the field of linguistics to selectively retrieve publications written in the English language. We carefully defined the inclusion and exclusion criteria to be applied in our review and aligned them with the standards established by previous studies (Cheng et al., 2023; Tigre et al., 2023). To mitigate selection bias, our analysis is restricted to peer-reviewed publications, given the difficulties associated with evaluating the quality of published books and conference proceedings. We employed a diverse array of search terms sourced from previous reviews (e.g., Goodell et al., 2021; Wu et al., 2020), which encompass the following: “employability” OR “perceived employability”; as well as “digitalization” OR “digital” OR “Artificial Intelligence” OR “AI.” This selection guarantees a comprehensive review of the manifold dimensions of the field, including the technological impacts on the labor market and the new skill requirements.

A total of 479 results were found. Next, we initiated the structuring process by choosing the organization. There are various types of reviews: structured reviews that are based on theories, constructs, and methods (Kahiya, 2018; Paul & Singh, 2017); reviews that are based on frameworks (Goodell et al., 2021; Lim et al., 2021); hybrid/integrated reviews (Bahoo et al., 2020; Dabić et al., 2020); theory-driven reviews (Gilal et al., 2019); meta-analysis-based reviews (Knoll & Matthes, 2017); and bibliometric studies (Ballouk et al., 2022).

A hybrid integrated review methodology was adopted for the current study to undertake an in-depth analysis concerning the relationship between employability and digitalization. We utilized Chakma et al.'s (2021) framework entitled the 4Ws in the review process. The document type was purified to only include original articles written in the English language through the purification substep. Moreover, CiteSpace was utilized to exclude any duplicate data. A literature search was carried out after setting specific academic and linguistic criteria in the databases to retrieve a total of 150 publications that fulfilled the set selection criteria for bibliometric analysis.

During the assessment stage, bibliometric techniques were used to determine key attributes, in this case quantitatively, related to a specific area of study (Junquera & Mitre, 2007). In this stage, one may validate relevant data regarding a research topic, including

leading authors involved in the area of inquiry, the amount of material published, and relevant terms. Hence, it enables an analysis of the correlation between variables (employability and digitalization) and data in different nations (Casadesus-Masanell & Ricart, 2011). This approach also enables the utilization of scientific cartographic instruments (Aria & Cucurullo, 2017). This study employed bibliometric analysis using VOSviewer software, a web-based program that offers a user-friendly interface for bibliometrics. In addition, it encompasses a concept map and identifies a current popular subject. To identify the areas with the most intense activity within this specific search location, we used the Bing search engine. In addition, we utilized CiteSpace software to identify the cluster exhibiting the most pronounced level of activity. Following that, we employed the framework-based review model put forward by Rosado-Serrano et al. (2018) and utilized the 4Ws approach to address the study questions: “What is the present state of affairs?” and “What is the relationship between employability and digitalization?”. The aims of the bibliometric analysis were as follows: A) To collect bibliometric data from 155 scientific publications in WOS; B) To use Vosviewer and CiteSpace to compile and document quantitative data from a selection of designated articles; C) To identify major authors in this discipline by considering the number of authors per article and an author dominance index; D) To gain an in-depth understanding of the network in this research area through analysis of citations and mapping of collaborative relationships.

## Results

### Conceptualization (what)

The rapid evolution of researchers’ interest in employability has precluded the formation of a consensus regarding its definition (Römgens et al., 2020). Swift changes driven by technology and societal developments have made understanding employability and its characteristics a priority for both practitioners and theorists. The analysis of research on employability reveals the emergence of two perspectives: one objective, focusing on technical and organizational aspects, and the other subjective, approaching employability from a psychological standpoint.

The objective orientation of employability is characterized by constant and interconnected evolution, reflecting the shared interest of academics and professionals in establishing a clear and stable framework for this concept. Generally, employability is viewed as a tool that enables individuals to participate in the labor market (Berntson et al., 2006). From a macroeconomic perspective, enhancing employability is recognized as an effective strategy to reduce unemployment (Dello Russo et al., 2020; Fernández-Valera et al., 2020; Panari and Tonelli, 2022). Accordingly, major policies have been implemented to provide training and financial support, facilitating the integration of the unemployed into the labor market across various countries (Tomlinson & Nghia, 2020; Olo et al., 2022). From a microeconomic viewpoint, strengthening employability is essential for enhancing employee skills (Fajaryati et al., 2020; Rakowska & De Juana-Espinosa, 2021; Mahajan et al., 2022) and improving



business performance (Manjushree et al., 2021; Abas-Mastura et al., 2013). Hillage and Pollard (1998) defined employability from an individual perspective, identifying three key elements: the ability to secure a first job based on educational skills, the ability to retain it, and the ability to find another position within an organization if necessary. This individual perspective aligns with the views of Peck and Theodore (2000), who describe employability as a combination of characteristics, attitudes, and behaviors that enable an employee to find and maintain employment or easily transition to new opportunities.

However, this approach is limited because it focuses solely on the individual, without considering employer intervention in enriching employability. Currently, the responsibility does not rest with the employee alone; rather, companies are also expected to enhance their workforce's skills through various HR practices (Itam & Swetha, 2022; Colin et al., 2022). A study conducted by Ybema et al. (2020), involving 312 HR directors, demonstrated that employees who engaged in company-driven efforts reported higher satisfaction with their employability, which in turn led to increased productivity.

Employability is also perceived from a subjective perspective, where the concept extends beyond formal frameworks to encompass psychological insights through its perception. Vanhercke et al. (2014) defined the perception of employability as the impression an employee has about their chances of obtaining and retaining a job. Rothwell and Arnold (2007) differentiated between internal and external employability; the former refers to an employee's perception of how effective their employer's efforts are in enhancing employability within the same company, while the latter focuses on the employee's ability to secure a job outside their current position. While the majority of research has traditionally focused on students' perceived employability upon completing their studies (Tavitiyaman et al., 2023; Chen et al., 2023), recent years have seen a growing interest in examining how this subjective perspective influences workplace well-being (Nimmi & Donald, 2023) and career development (Zhou et al., 2022). In a longitudinal study of 358 employees, Doden et al. (2024) explored two contrasting hypotheses about the relationship between job insecurity and changes in perceived employability over three and a half years. Their findings indicated that job insecurity positively impacts the perception of employability, with employees increasingly developing their external employability to enhance their marketability.

### **The evolution of employability research (when)**

The concept of employability emerged during the Industrial Revolution in Anglo-Saxon countries towards the end of the 19th century. This phenomenon has continued to evolve up to the present day, with our understanding of employment gradually developing. Three main phases characterize the evolution of this concept. The first phase saw the emergence of certain capitalist approaches and the industrialization of the economy at the beginning of the 20th century. During this time, obtaining full-time employment became synonymous with social belonging, dividing the active population into employable individuals capable of working and

those deemed unemployable due to social, physical, or mental constraints, who required assistance (Finot, 2000). This selection criterion, referred to as “dichotomous” by Gazier (2003), was primarily used by doctors to determine soldiers’ assignments during wars.

After the Second World War, the traditional dichotomous view of employability was redefined to include three new forms: sociomedical employability, labor policy employability, and employability-performance in the labor market (Nosal, 2007, p.3). The first form addressed the exclusion of people with disabilities from the labor market. It was used by doctors to assess the physical and mental abilities necessary to hold a position. This individual approach was enhanced by social acceptability criteria, introducing a political dimension to employability that aligned with humanistic theories of the time, which emphasize social belonging as a key factor in individual success (e.g., Elton Mayo’s management theory). Thus, an individual’s ability to obtain employment depended not only on their physical and moral capabilities but also on the absence of “social deficiencies” (Gazier, 2003). This form of employability facilitated more targeted interventions in terms of training and job search. Employability-performance in the labor market extends beyond the individual level to include a macroeconomic dimension, which is influenced by the overall state of the labor market and economic conditions. This notion of employability transcends the basic goal of securing a job to include the likelihood of obtaining employment, its duration, and the associated compensation.

In the third phase, employability evolved to reflect the characteristics of the active population, as well as the dynamics of the job market. With the changing nature of work and widespread use of technology, simply obtaining a job no longer signifies career stability. Instead, the effectiveness of employability is now measured by an employee’s ability to secure and maintain a position.

### **Areas of application of the relationship of employability and digitalization (where)**

Digitalization has transformed the workplace, continually redefining the standards for professional skills and capabilities. As a result, countries are adapting their educational policies to ensure fluid and sustainable employability in the labor market. However, noticeable disparities exist between regions, especially in terms of educational quality and government policies on digitalization. In Europe, Jandrić and Randelović (2018) identified three clusters of countries based on their adaptability to digital changes in the labor market: high performance (Northern and Western Europe), average performance (Central Europe and Baltic countries), and weak performance (Southern and South-Eastern Europe).

Other researchers have explored the differences between Europe and Latin America. Despite advancements in technology adoption in Latin countries, Liboni et al. (2019) highlighted that Europe continues to lead, attributed to the high technical skills of its workforce and institutional support that fosters innovation and digital transition. They note that enhancing employability in Latin America requires greater efforts to improve access to



quality education and professional training, which remains limited. Didier (2022) cites Chile as an example, where 83.6% of employees experience educational mismatch and employment polarization. He emphasizes the need for political actions tailored to the unique needs of Latin American countries to ensure a successful transition to a more digital economy.

The situation in Africa mirrors that of Latin America in terms of the challenges associated with employability and digitalization (Ramnund-Mansingh and Reddy, 2021). In sub-Saharan Africa, many see digitalization as a pivotal strategy for reducing poverty and fostering technological advancement. For instance, the Rwandan government has significantly invested in training young people in digital skills to cultivate a future workforce equipped for employability (Dinika, 2022). Additionally, with over 20 hubs and incubators now established in Kigali, Rwanda is nurturing an active startup ecosystem that is boosting job creation in the digital sector.

### **The relationship between employability and digitalization (why)**

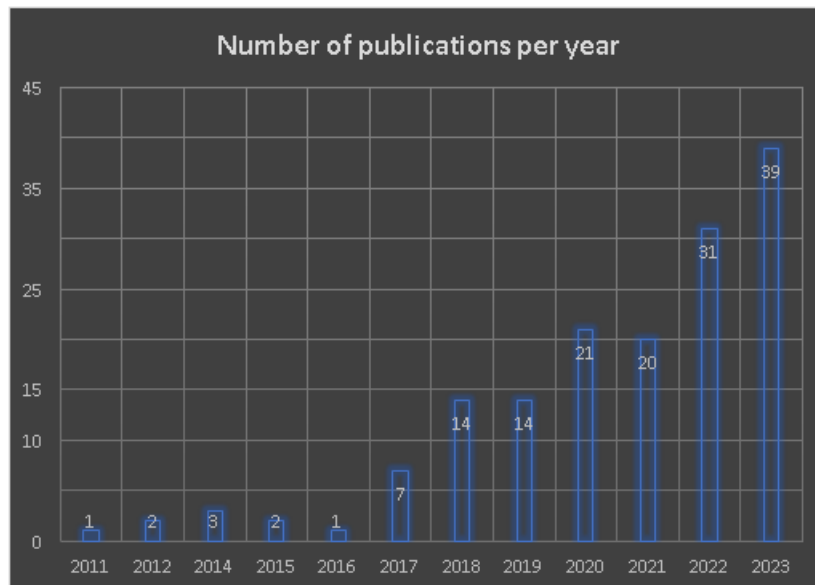
Before discussing the relationship between employability and digitalization, we would like to clarify the ambiguity surrounding the understanding of the term digitalization. To do so, it is necessary to revisit the debate on the distinction between digitization and digitalization, two concepts often used interchangeably. Digitization refers to the creation of digital artifacts through technical processes of conversion, representation, and enhancement (Gradillas et Thomas, 2023). Digitalization can be defined as the transformation of the socioeconomic environment through the adoption, application, and utilization of digital artifacts (Gradillas et Thomas, 2023). In this paper, we focus on the latter concept.

Research exploring the relationship between employability and digitalization forms a continuum that begins with the initial training of employees and extends to their integration into the job market. This early preparation equips future employees to meet new employer requirements for technological skills (Nayan et al., 2021; Jung et al., 2024). The literature reveals two main streams of research. One focuses on integrating digital tools into the education system (Murphy et al., 2022), examining how these tools are used to familiarize future graduates. Debates among theorists often revolve around how improvements in educational content and the incorporation of new digital skills can enhance employability. These studies continue into the labor market phase, concentrating on how employability and digitalization intersect within human resource management practices (Hamzah et al., 2022; Seevaratnam et al., 2023). Researchers in this field are particularly interested in examining how these two concepts influence and transform recruitment strategies, training, and skills development (Wafi et al., 2022).

### **Number of publications per year**

The annual distribution of publications from 2010 to 2023 is illustrated in Figure 2. Our database shows no research in 2010, with the first study emerging in 2011. From 2011 to

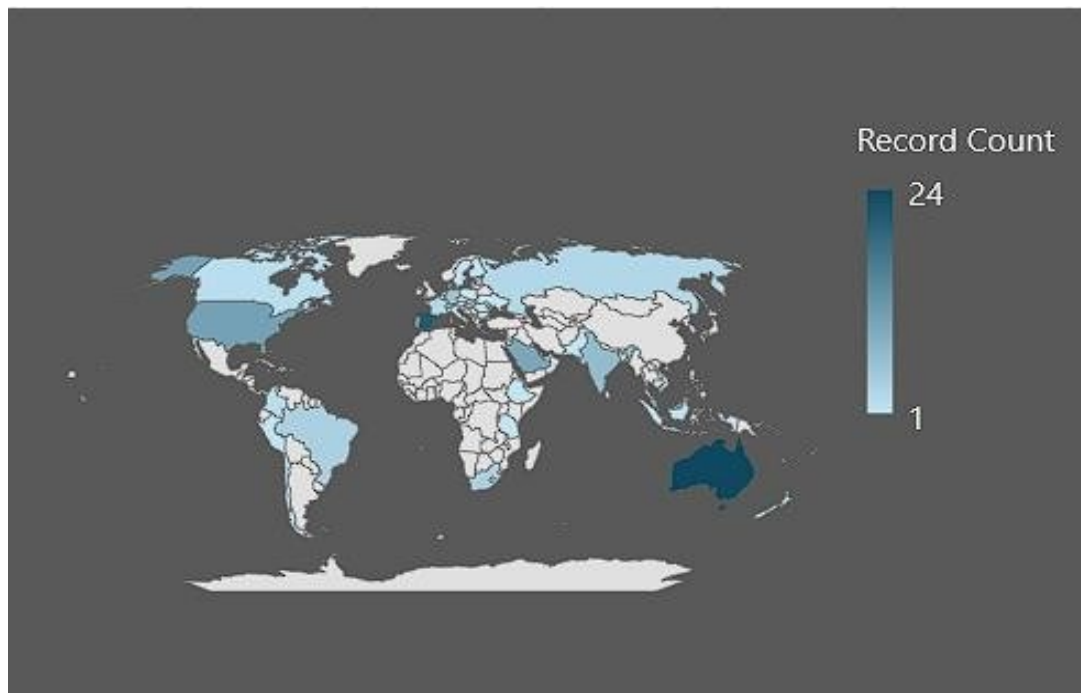
2016, the highest number of papers per year was three. A notable increase in studies exploring the relationship between employability and digitalization began in 2017, starting with seven papers. This trend continued, culminating in significant breakthroughs in 2022 (N=31) and 2023 (N=39).



**Figure 1. Evolution of the number of publications indexed in WOS**

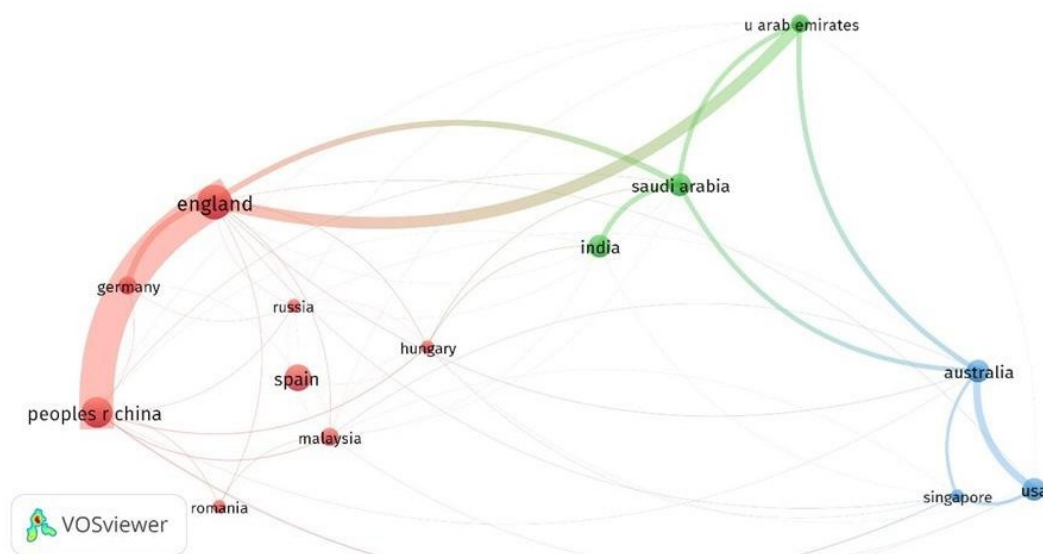
### **Contribution of countries to research**

Between 2010 and 2023, 47 countries contributed to this study, totaling 207 papers. Figure 3 displays the geographic distribution of publications by country. Leading the list, Australia and England each contributed 24 papers, followed by Spain with 21. Most contributions came from economically advanced countries, including China (N=12), the United States (N=11), the Netherlands, and Germany (each contributing 6 papers). Ensuring competitive adaptability and aligning workforce employability with labor market demands remained a priority. However, developing countries were notably underrepresented, with only a few exceptions, such as Jordan (N=2) and South Africa (N=4).



**Figure 2. Top 10 most productive countries**

Figure 4 illustrates the degree of collaboration among researchers by their countries of origin. The nodes represent the contributing countries, while the links show the density of collaboration between researchers. The analysis of the figure identifies three major clusters. The first cluster includes cooperative research between China and European countries, particularly England and Germany. The second cluster features collaboration between two Persian Gulf States, Saudi Arabia and the United Arab Emirates, and India, a relationship bolstered by the continued migration of Indians to the Middle East (Percot & Rajan, 2007; Storbeck, 2011). The third cluster comprises Australia, Singapore, and the United States.



**Figure 3. Country cooperation network**

### Analysis of authors and co-authors

Figure 5 lists the authors who have published the most on the relationship between digitalization and employability. Due to the recent emergence of this theme, our database shows that most authors published only two papers between 2010 and 2023. Meanwhile, Figure 6 displays the affiliations of the authors of these research papers. Notably, King Abdulaziz University in Saudi Arabia and the “Universiti Sains Malaysia” each contributed four papers.

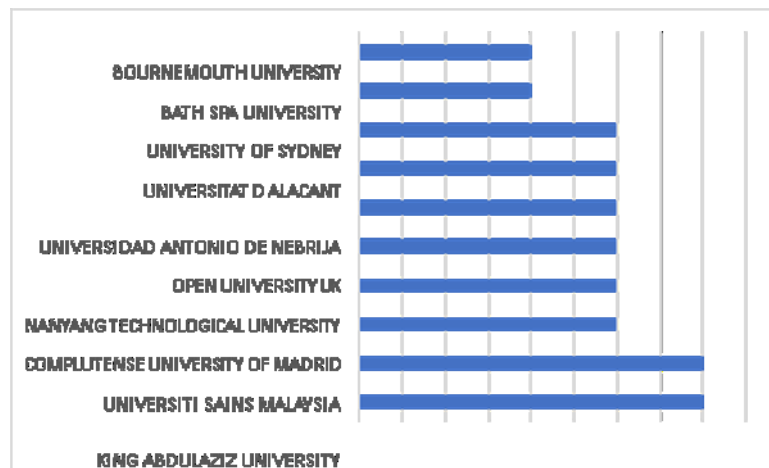


Figure 4. The 10 most productive researchers between 2010 and 2023

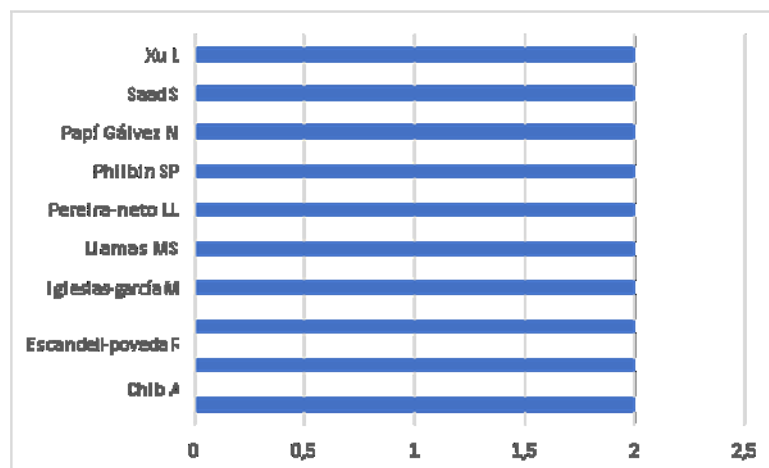
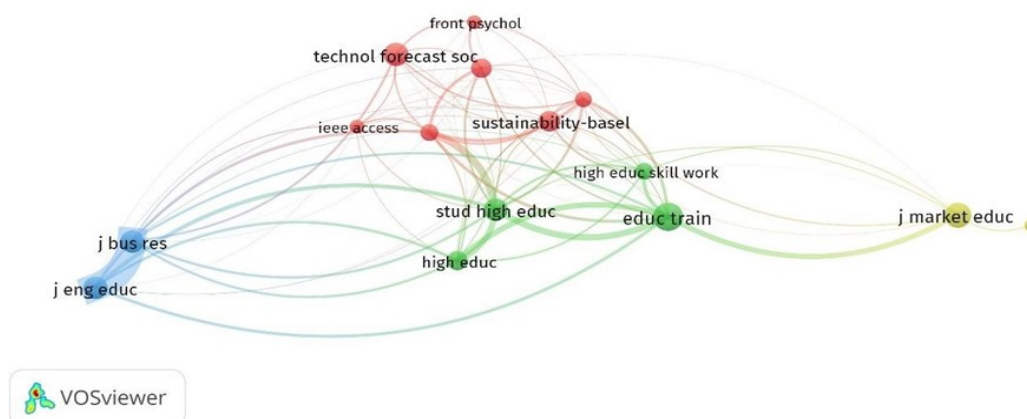


Figure 6. The 10 most productive universities between 2010 and 2023

### Journal Analysis

To analyze the journals, a co-citation study was conducted to examine the internal relationships between different journals, as shown in Figure 7. This method was chosen due to the limitations of statistical analysis in assessing the influence of each journal. The size of the journal nodes in the diagram indicates that “Education and Training” and “Technological Forecasting and Social Change” were the most significant contributors to the theme. The journals in the diagram are clustered by major disciplines. For example, one cluster includes

journals such as “Studies in Higher Education”, “Education and Training”, and “Higher Education Skills and Work-based Learning”, which primarily focus on the digitalization of the education system and its adaptation to enhance the employability of new graduates.



**Figure 5. Co-citation of journals**

## Discussion

### Current topics in employability and digitalization

The scope and depth of the subjects studied justify changes in research themes, theoretical frameworks, and methodological approaches over time. Analyzing co-citations of studies allows us to understand the degree of connection among articles, based on their citation frequency within the same set of publications. By examining the groupings and essential nodes within the co-citation networks, we can reveal the structure, foundational knowledge, evolving characteristics of the study area, and the integration of emerging literature. Figure 8 displays the final network topology. The data analysis identifies eight large, distinct clusters, based on the frequency of certain keywords appearing together, specifically: Industry 4.0, skills, improving the employability of graduates, organizational culture, digital skills, theoretical conceptualization, adult training, and mastery of digital engineering. The largest cluster addresses the shift in corporate culture needed to integrate technology into management, encompassing the attitudes and behaviors that employees develop regarding their employability and job security. The second-largest cluster examines the consequences and challenges associated with the implementation of Industry 4.0 and its impact on skill development and employability.

### Industry 4.0 and Skills Development

Industry 4.0 emerged in Germany in 2011, following the implementation of a high-tech strategy by the German government (Xu et al., 2021). It refers to the automation of the production system and the integration of computerized techniques into companies (Xu, 2020). Optimization and flexibility in resource utilization, including labor, are key to the success of this transition from a traditional to a digital economy. Sharma et al. (2021) emphasized the

importance of adapting worker skills within the framework of Industry 4.0 to ensure improved interaction between humans and machines. Nardo et al. (2020) reflected on how today's employees are not limited to a single task but must be versatile and capable of handling multiple responsibilities, especially at the digital level. Consequently, skill development policies at both macroeconomic and microeconomic levels have been established to ensure more effective human-machine synergy. Hernandez-de-Menendez et al. (2020) noted that the successful implementation of technologies in companies depends on their efforts in terms of content learning, IT comprehension, and the development of a skills management system with certifications.

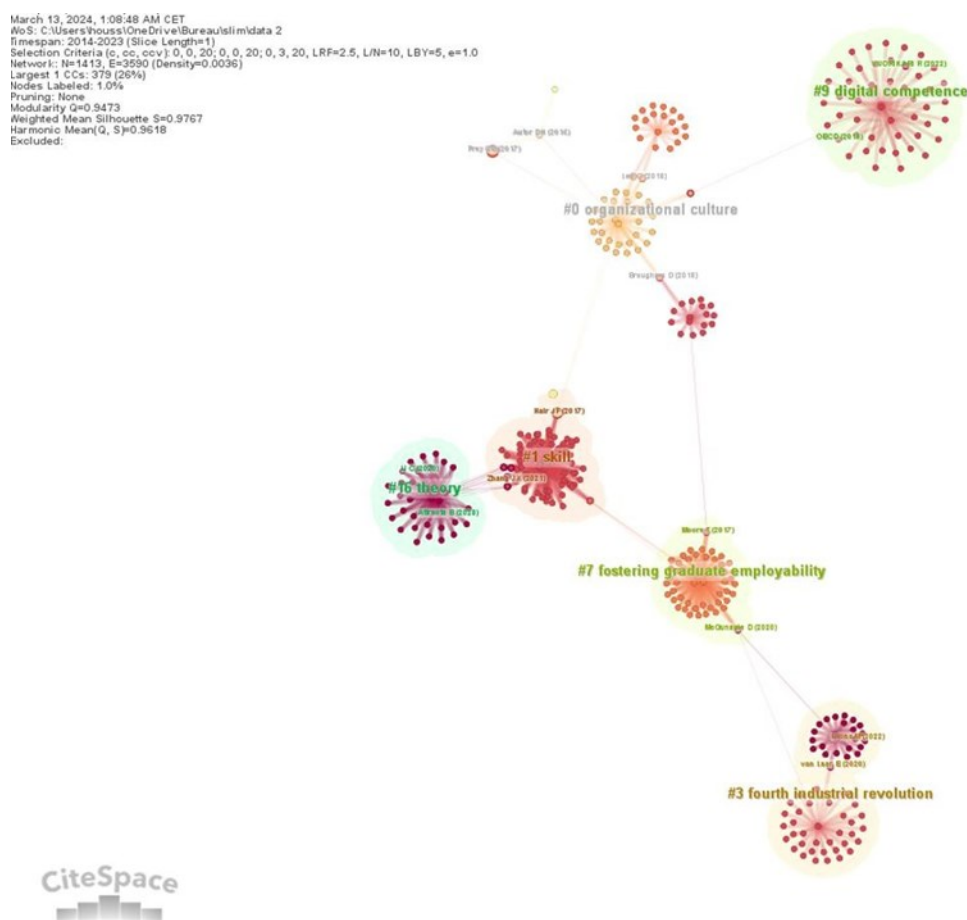
### **Theoretical Conceptualization of Employability and Digitalization**

The relationship between digitalization and employability is a relatively recent field of study, characterized by constantly evolving theoretical research. Theoretical work addressing this relationship often begins before labor market integration, focusing on evaluating the effectiveness of training processes. This research continues post-integration, analyzing the development of professional skills and new management models for the digital era.

Initial conceptualizations that continue to emerge in the literature focus on adapting education and training to meet labor market demands (Juravleva et al., 2020; Akimov et al., 2023; Ivanenko et al., 2023). Preparing students for professional life involves integrating digital tools into the education system to familiarize them with technology (Bejinaru, 2019; Nataliia et al., 2020). Kpolovie and Lale (2017) emphasized the urgency for universities to adapt to the realities of a digitalized economy by modifying traditional programs, which could be achieved through the inclusion of virtual education and digital learning technologies.

Research on the effect of digitalization on employability extends beyond education and impacts other areas of application. In human resource management, researchers explore the adaptation of HR practices in terms of ongoing training and the integration of technologies within companies (Fenech et al., 2019; Zhang & Chen, 2023; Aripin et al., 2024). In entrepreneurship and economic sciences, digitalization is regarded as a means to create new employment opportunities (Dabbous et al., 2023; Fossen & Sorgner, 2021; Youssef et al., 2021). Additionally, other researchers are examining the opportunities and challenges associated with using digitalization in the informal economy and its role in enhancing the employability of populations in developing countries (Mdoe et al., 2024; Rani & Gobel, 2022; Valenduc, 2019).





**Figure 6. Map of employability and digitalization knowledge groups during the period 2010-2023**

### Future research agenda

Co-citation group timelines over the period from 2010 to 2023, displayed in Figure 9, along with time axis analysis, indicate that research on skills management, theoretical conceptualization, and Industry 4.0 continues to emerge in the literature. However, other areas such as graduate upskilling and digital skills have seen a decline in recent years. This trend can be attributed to the substantial efforts by researchers at the beginning of the last decade, which led to a consensus on these themes. Consequently, this part of the paper focuses on themes emerging from these clusters; specifically, new employment models in response to digitalization, the transition from Industry 4.0 to Industry 5.0, and further theoretical conceptualization.

The primary advantage of bibliometric study is its capacity to identify future research directions. Following literature review studies that have addressed the topic of employability (Hoedemakers et al., 2023; Noori & Azmi, 2021), this research has led to the reformulation of suggestions for future research avenues. Studies exploring the relationship between employability, or its perception and digitalization remain scarce, and the novelty of these issues broadens the scope for research opportunities. Through the analysis of clusters and

literature, theoretical and practical developments can be undertaken to deepen our understanding of this evolving relationship.



Figure 7. Timeline of co-citation groups from 2000 to 2021

### New models of employment and skills development in the face of digitalization

Digitalization is radically transforming the world of work, influencing employability requirements, and giving rise to new employment models. Dabić et al. (2023) presented two contrasting perspectives on the effects of digitalization on the labor market: a utopian vision and a dystopian vision. The former highlights the opportunities provided by digitalization, such as increased productivity, the creation of quality jobs with advanced skills, and work flexibility. In contrast, the dystopian vision points to significant challenges, including massive unemployment among low-skilled workers and a polarized labor market that mainly benefits the high-skilled, while middle-skilled jobs diminish. The researchers underscore the importance of developing sustainable human resource management practices that adapt employee skills to meet new market demands. They recommend further studies to establish a roadmap for sustainable human resource management, particularly in young, innovative companies—a sector with untapped potential, despite its significant capabilities. Typically, these companies start with a highly qualified entrepreneurial team and extensive use of technology (Lazar et al., 2020; Yusubova et al., 2020). As these enterprises expand and their production processes become established, the need to recruit a less qualified workforce becomes apparent, raising questions about the interactions between these two diverse groups of employees.

Furthermore, leadership plays a crucial role in addressing the challenges associated with digitalization and employability. Effective leadership acts as a bridge, facilitating the

adaptation of team skills to organizational changes (Rojas Romero et al., 2021) and reducing resistance to change (Kar et al., 2021). Varshney (2020) highlights the importance of managing employees' fears of change and feelings of obsolescence by providing continuous support and adopting an agile management style. Recommendations for future research include studying the impact of leadership roles on the development of employee skills during the digital transition. This involves exploring methods that promote experimentation and continuous learning. Additional studies are needed to assess the influence of leadership styles on implementing practices that enhance inclusion, diversity, and equity in accessing opportunities created by digitalization.

### **Employability and digitalization from the era of Industry 4.0 to Industry 5.0**

Industry 4.0 leverages the Internet of Things, cloud computing, and Big Data to enhance production processes, making them smarter and more connected. It emphasizes the automation of production and adapts employees' technical skills to accommodate these changes. In contrast, Industry 5.0, also known as the fifth revolution, builds on the technical advancements of its predecessor while incorporating a human dimension. Ghobakhloo et al. (2022) note that Industry 5.0 prioritizes sustainable development, transitioning individuals from simple operators to central, decisive actors within the industrial ecosystem. This shift underscores the need to enhance employees' creativity and decision-making capabilities to improve the interaction between humans and machines. However, Leng et al. (2022) point out that research on Industry 5.0 is still nascent, with findings that are sparse and not systematically gathered.

Consequently, numerous research opportunities exist to deepen our understanding of the human aspect of human resource management within the context of Industry 5.0. The transition from Industry 4.0 to Industry 5.0 remains poorly defined in academic literature, suggesting that further clarification on training models and the integration of technical and soft skills would be beneficial. Moreover, the ongoing changes in production processes pose significant challenges to employee well-being. Future research should investigate the impact of these changes on the work environment, particularly concerning the mental and physical health of workers.

### **Theoretical conceptualization: A point on the informal economy and comparative studies**

The informal economy encompasses all economic activities that operate outside the legal and regulated frameworks of a country (Khuong et al., 2021). Recent figures from the International Labor Organization indicate that at least 60% of workers globally are part of the informal economy. Its substantial size and economic impact, particularly in less developed countries (Mdoe et al., 2024; Kpognon, 2022), draw significant interest from theorists who explore its conceptualization, opportunities, and challenges (Dell'Anno, 2022). Today, the widespread use of technology and the digitalization of the labor market present both

opportunities and threats to actors within the informal economy. In sub-Saharan Africa, where policies aimed at curbing the informal economy have seen limited success, Ngumkeu and Okou (2021) suggest leveraging technology to reduce poverty and enhance productivity in informal activities. This approach, which focuses on adapting to rather than eliminating problems, has seen notable success in Bangladesh with the microcredit initiative launched by economist Muhammad Yunus.

Additionally, Remeikienė et al. (2022) conducted a comparative study of 11 European countries to assess the short- and long-term effects of digitalization on the informal economy. Their findings indicate that investments in information and communication technology and human capital significantly reduce the size of the informal economy, a sentiment echoed by Elbahnasawy (2021), who noted that the digitalization of governance markedly decreases the informal economy. The nexus between employability and digitalization within the informal economy is an area of burgeoning research but remains underexplored. In-depth studies on how digitalization impacts the employability of informal workers, tailored to specific contexts, will enable stakeholders to refine their inclusion policies for this demographic. These policies might include strategies to broadly enhance digital skills and paths for incorporating informal entrepreneurs into the formal economy. Moreover, exploring how socio-economic, demographic, and cultural differences affect access to technology could illuminate labor market inequalities and help formulate solutions for integrating informal workers into the formal sector.

Intra-regional comparative studies that focus on enhancing employability in response to digitalization are scarce, raising critical questions about the cultural similarities and differences between nations within the same region or across continents. In their systematic review of the literature on digitalization's role in the workplace, Liboni et al. (2019) found that research was predominantly conducted in developed countries, with 90% of studies originating there, compared to just 10% from developing countries. This finding is consistent with other bibliometric research, which has similarly highlighted the geographic concentration of academic output in developed regions, often attributed to better access to resources, funding, and research infrastructure in these areas (Çiğdem, 2021). Therefore, conducting comparative studies between developed and developing nations could foster policies that enhance the employability of vulnerable populations in the face of economic digitalization. Additionally, examining variations in investment and educational systems within the same country should be a priority in future research.

## Conclusion

This paper addresses the growing challenge of understanding the effects of digitalization on employability. The main objective is to uncover theoretical insights and offer concrete strategies to adapt to the rapidly changing demands of the workforce. By doing so, the paper

seeks to bridge the existing gap in the literature where the impacts of digitalization on job creation, skill development, and employment security have not been fully integrated.

This work presents a comprehensive bibliographic analysis of the relationship between digitalization and employability. It combines a thorough examination of existing literature reviews with proposals for future research directions. Initially, the paper provides an overview of various previous studies, enhancing our understanding of how digitalization is transforming the educational and work landscapes through employability. Subsequently, a detailed literature review is conducted to identify key advancements and emerging perspectives in the field, utilizing various analytical software tools. Finally, the paper outlines recommendations for future research, suggesting areas for further exploration to deepen our understanding of this relationship.

In total, this study analyzed 155 research papers, highlighting a growing interest in the relationship between employability and digitalization. Despite limited contributions in the early years of the study, a significant increase in research is evident from 2018 (N=14) to 2023 (N=39). Countries that are advanced in digitalization, such as England, Germany, and China, are leading in studies on this topic while developing nations with fewer initiatives lag in exploring this relationship. To date, no pioneering researchers have emerged in this field. Throughout the period analyzed, each researcher contributed to a maximum of two studies; this limitation is attributable to the recent emergence of the relationship, presenting an opportunity for researchers to venture into new areas of exploration.

Furthermore, the analysis of frequently cited references and quantitative assessments of keyword frequency and centrality reveal that research trends are constantly evolving, primarily impacting the development of skills that enable employees and students to adapt to changes in the digitalized labor market. This trend underscores the growing interest in linking employability with Industry 4.0, leveraging its potential to enhance skill adaptability and capabilities. Additionally, the conceptualization and enhancement of theoretical work have become priorities for researchers, aiming to achieve a consensus on the implications of digitalization for employability.

The added value of this paper is that it has succeeded in giving a truly holistic approach to identifying potential future research directions that would fill the gaps in understanding how digitalization impacts employability. Based on the bibliometric analysis supported by a structured theoretical framework, the paper has highlighted the four most relevant research perspectives and pointed out the need for intra- and inter-regional comparative studies in evaluating regional adaptations to digital transformations. The most significant contribution of this work is the focus on the transition from Industry 4.0 to Industry 5.0, since this transition has to be deeper in terms of the level of study it may redefine the models of employment because it joins human creativity with technological advancement. The study further points out that considering the research on the informal economy in light of digitalization opens largely new perspectives that might reveal how changes in technology

influence the most vulnerable parts of the workforce. These insights will inform not only future research but also provide pragmatic recommendations for various stakeholders, including researchers, policymakers, and businesses, on how to address both the emerging challenges and opportunities within a digitalized labor market. On a practical level, the paper offers actionable strategies for researchers, educators, and businesses to enhance employability, including fostering adaptive skill development programs, integrating AI into workforce management, and shaping policies that support workforce adaptability in response to technological changes. These insights not only guide future research but also provide concrete recommendations for stakeholders to address the evolving challenges and opportunities in the digitalized labor market.

As with any research paper, there are inherent limitations. This study relies solely on the Web of Science database, which accounts for the limited number of papers analyzed (N=155). Expanding the research base by incorporating sources from other platforms, such as Scopus, could provide a more comprehensive understanding of the relationship between digitalization and employability. Additionally, the nascent nature of this relationship constrains the depth of study into its characteristics.

### **Conflict of interest**

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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