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Review

A Systematic Review of Industry 4.0 Technology on Workforce Employability and Skills: Driving Success Factors and Challenges in South Asia

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Abstract: The purpose of this study is to systematically analyze the impact of Industry 4.0 technologies on workforce employability and skills in the South Asian region. The study investigates the driving success factors, challenges, and needed skills by analyzing 48 peer-reviewed articles. The authors searched keywords on the Web of Science database for articles published between 2013 and 2022. The review was conducted using the preferred reporting items for systematic reviews and meta-analyses (PRISMA 2020) and pareto principles. The analysis identifies nine critical success factors, such as artificial intelligence, digital skills, and big data analytics, that contribute to Industry 4.0's productivity and efficiency. It also identifies six types of challenges, such as training and development, financial constraints, and regulatory issues that must be addressed to grab maximum potential. In addition, the research categorizes five different skills, including the technical, digital, and social skills that are essential for the evolving labor market. The proposed "Industry 4.0 SEI Framework" provides stakeholders with a comprehensive view of the dynamics of Industry 4.0, thereby facilitating policy and industry strategies.

Keywords: Industry 4.0; South Asia; workforce employability; artificial intelligence; data analytics; digital skills; labor market

1. Introduction

The Fourth Industrial Revolution (Industry 4.0 or I4.0) has gained increasing attention both in the academic and non-academic domains. Industry 4.0 was a term coined in 2011 in Germany. Since then, the academic literature describing and analyzing I4.0 technologies has grown considerably (Cannavacciuolo et al. 2023; Rad et al. 2022; Pereira et al. 2018). While so-called Industry 3.0 introduced computers, Industry 4.0 is characterized by advancements in computing technology including expanded digitalization in logistics, cognitive and connected machines in various industrial processes, and data analytics (Rahman et al. 2022). Leong et al. (2020) refer to I4.0 as having nine technological pillars: the Internet of Things, cloud computing, robots and autonomous systems, big data analytics, augmented reality, cybersecurity, simulation, system integration, and additive manufacturing. This new technological frontier is transforming the way businesses create value, how individuals perform their work, and the manner in which people connect and communicate with each other. I4.0 has significantly transformed job roles and the skill profiles required of workers

(Ghislieri et al. 2018). These technologies are the cornerstones of changing industrial processes to substantially enhance productivity.

However, the rapid shift in robotization and digitalization are also a growing concern. Particularly in South Asian countries (e.g., Bangladesh, India, Pakistan, Nepal, Bhutan, Sri Lanka, Maldives, and Afghanistan), unemployment resulting from replacing jobs with robots is feared. Yet, employers and employees can adopt to technological changes in a timely way for the better of the future labor market (Bajaj et al. 2018). Researchers from engineering to management have increasingly concentrated their academic research on enabling Industry 4.0 technologies (Weerasekara et al. 2022; Perez Perales et al. 2018). Several studies particularly focused on the success factors and benefits of Industry 4.0 technologies while bypassing their downsides (Kadir et al. 2019; Bolbot et al. 2022; Echchakoui and Barka 2020). Studies are lacking that examine the effects of Industry 4.0 technologies on employment and skills. To address these gaps, the current study integrates the driving potential success factors, challenges, and skills gaps with a regional focus in South Asia. By answering the following research questions, the current study aims to identify the required skills and competencies to be ready for the future of work challenges and to benefit from the I4.0 technologies in South Asian countries.

RQ1: What are the key driving factors contributing to the success of I4.0 technology implementation in South Asia?
RQ2: What challenges exist regarding the adoption of I4.0 technologies in the region, and how do they impact the labor market and workforce skills?
RQ3: What are the key skill requirements and gaps resulting from the integration of I4.0 technologies?

Our systematic review significantly contributes to the understanding of Industry 4.0 technology adoption in South Asian countries. However, the findings also reveal a notable gap in scientific research contribution from four countries, i.e., Bhutan, Sri Lanka, Afghanistan, and the Maldives, which needs to be addressed. The study identifies key driving factors, ranging from artificial intelligence to digital skills, shedding light on what fuels technological progress in the region. Additionally, the research pinpoints the challenges and obstacles faced, including workforce shortages and infrastructure limitations, which is crucial for formulating effective strategies. Moreover, by categorizing the required skills into distinct types, such as technical and communication skills, it provides actionable insights into the skill gap and the need for reskilling efforts. Finally, the proposed "*Industry 4.0 SEI Framework*" offers a conceptual understanding of the dynamics of I4.0 and its impact, which makes this research a valuable resource for policymakers and industry leaders in South Asia. The study consists of 48 articles from the Web of Science database, and the authors used the Microsoft Excel application for analyzing and visualizing the data. The objectives of the research have driven the remaining part of the study. Following the introduction, Section 2 introduces the background and literature, by presenting a historical overview of industrialization and the conceptualization of Industry 4.0, while paying close attention to I4.0 in South Asia. Section 3 describes the methodology, data collection and sources, inclusion and exclusion criteria, and data analysis. Section 4 shows the results and discusses the main findings. Section 5 provides the conclusion, implications, limitations, and avenues for future research.

2. Literature Reviews

2.1. Concept of Industry 4.0

Since the industrial trade fair Hannover Messe, Germany in 2011, the term "Industrie 4.0" has ignited a vision of a new industrial revolution and has been inspiring a lively, ongoing debate about the future of work (Dregger et al. 2016). The Fourth Industrial Revolution refers to the transformation of technology in the 21st century. It is creating a radical shift for employees, organizations, and society as a whole, given the impact of included and emerging technologies such as artificial intelligence and Internet of Things (Ross and Maynard 2021; Kowalikova et al. 2020). Savytska and Salabai (2021) consider

I4.0 a trend within the Fourth Industrial Revolution. They found that businesses could benefit from new opportunities, expand operations, and increase efficiencies by integrating digital processes. Industry 4.0 covers a wide range of topics, such as production methods, productivity, data management, consumer relationships, and competitiveness. (Piccarozzi et al. 2018). According to Culot et al. (2020), I4.0 has evolved significantly, leading to similar concepts often referred to as "smart manufacturing", "digital transformation", and "fourth industrial revolution". However, Erboz (2017) identified that the development of highly automated industries through human–machine interaction is one of the main aspects of Industry 4.0. Freund and Al-Majeed (2021) highlighted the effect of Industry 4.0 on both the micro and macro levels, including the financial, political, and socio-cultural spheres.

2.2. Historical Overview of the Industrial Revolution

Technological trends have a historical perspective. Figure 1 utilizes two sources to illustrate the history of industrial revolutions. The first industrial revolution, which started at the end of the 18th century, shifted production from labor-intensive to more capital-intensive production. The biggest changes came in the form of mechanization. The invention of steam-powered machines combined with the division of labor changed production technology from piece-to-piece production to mass production. The second industrial revolution started at the end of the 19th century, and by the middle of the 19th century, there were technological advancements helped the emergence of new sources of energy. This era saw the spread of electrification across the world, and radical transformation in transportation including the development of the automobile and the airplane. The third wave of industrialization started in the early 1970s with the development of the computer. This third industrial revolution led directly into the fourth because of how those computing technologies advanced. By the beginning of the 21st century, huge developments in communication and information technologies and software-based production technologies enabled the development of smart systems. Davies (2015) reported that the Europe Union was at the beginning of a new industrial revolution—Industry 4.0—in 2015. Member states began sponsoring national initiatives, such as "Industrie 4.0" in Germany, "the Factory of the Future" in France and Italy, and the Catapult centers in the United Kingdom. In the few short years since then, Industry 4.0 has spread everywhere and changed the production paradigm through a shift from work previously done by humans to work that is now automated (Klingenberg et al. 2022). Today, managers cannot ignore the technological revolution in the field of robotics, artificial intelligence, the Internet of Things, cyber-physical systems, augmented reality, virtual reality, biotechnology, nanotechnology, autonomous vehicles, cloud computing, and 3D printing (Sharma et al. 2021).
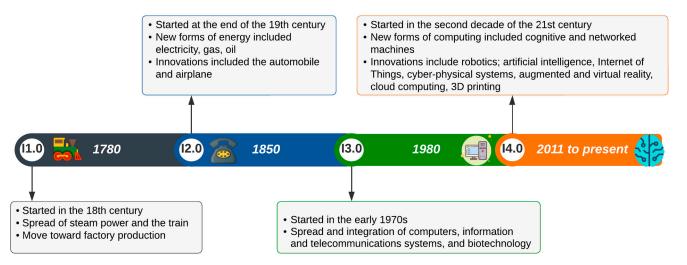

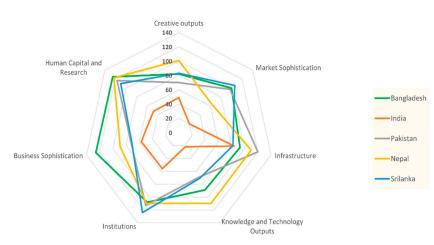**Figure 1.** Timeline of the Industrial Revolutions based on: (Kagermann et al. 2013; Vaidya et al. 2018).

2.3. South Asia and Industry 4.0

South Asia is comprised of India, Pakistan, Bangladesh, Sri Lanka, Nepal, Bhutan, the Maldives, and Afghanistan. With its large population, emerging markets, government support, innovative culture, global supply chain presence, and digital infrastructure development, it is indeed an important region for the adoption of I4.0 technologies (Katekar and Deshmukh 2021; Rajamanickam 2016). According to the International Monetary Fund (2023), South Asian countries had a GDP of $4.65 trillion U.S. dollars, around 5% of the world economy, in 2023. Among these, India contributes the highest GDP of $3.73 trillion with Bangladesh at $446.35 billion U.S. dollars. Nepal, Bhutan, and Sri Lanka were among the countries with the lowest GDP in the Asia-Pacific region. In South Asia, the main economic activities include the services, industrial, and manufacturing sectors. Despite having tremendous economic potential, previous studies by Imrana et al. (2021) and Bishwakarma and Hu (2022) found gaps in human capital and innovation including the skills and training of the region's current workforces.

As these countries continue to modernize their industries, I4.0 is poised to play a pivotal role in shaping their economic future and addressing critical social challenges. Studies, such as those by Su et al. (2017) and Schöning (2018), show productive outcomes in accelerating production, enhancing processes, and creating new opportunities by integrating I4.0 technologies. But there are significant challenges that need to be overcome. For example, in Bangladesh, the lack of awareness, insufficient capital, infrastructure limitations, shortage of skilled workers, and weak government policies are hindrances to the implementation of I4.0 (Bhuiyan et al. 2020; Suha and Sanam 2022). They emphasize the need for an information and communications (ICT) policy that focuses on integrating ICTs with smart industrialization. Hossain et al. (2023) found technical knowledge in the manufacturing industry is a key barrier to adopt the I4.0 in Bangladesh. In Pakistan, studies by Ali and Xie (2021) and Imran et al. (2018) found managerial challenges in adopting I4.0 technologies, including the need for competitive management, infrastructure, and economic stability in the textile industry and service sector. In India, the manufacturing and service sectors need more productivity and efficiency to manage these digital transformations (Jha 2021; Smolka and Papulova 2023). Researchers Kanji and Agrawal (2020) and Mezina et al. (2022) found I4.0 may increase social inequality while creating a heightened need for highly qualified personnel. The authors argue that appropriate policies and partnerships need to be implemented to ensure inclusive development in developing countries, especially in India, Bangladesh, and Pakistan.

I4.0 has significant implications on the future of work and skills required. The changes in the value chain and increased competitiveness among firms and consumers can impact global labor markets (Anuşlu and Frat 2019; Mohiuddin et al. 2022). According to Asian Development Bank (2021), 4IR technologies like the IOT, artificial intelligence, cloud computing, and cognitive computing could profoundly influence jobs and skills.

Labor markets in developing and developed countries are likely to undergo major transformations in the coming years and decades. By 2030, the region is expected to create more jobs than it displaces (Balliester and Elsheikhi 2018). Yet, the Global Innovation Index (GII) of 2023 shows that South Asian countries are not yet ready for I4.0 technology adoption. The index provides a comprehensive assessment of the innovation ecosystem across 132 economies in the world. The analysis shows (Figure 2) that India leads among lower middle-income countries in the world and ranks overall 40th in the world. Among other South Asian countries, Bangladesh, Nepal, Pakistan, and Sri Lanka exhibit poor ranking in creative outputs, impeding their ability to generate new ideas and innovations, and infrastructure readiness, which are critical factors for I4.0 success. These countries, along with India, face challenges in other key areas such as market sophistication, knowledge and technology outputs, and institutions. Moreover, many displaced workers may struggle to transition smoothly to new roles. South Asian countries need to prepare their workforce for the impending labor market changes with substantial and timely investments
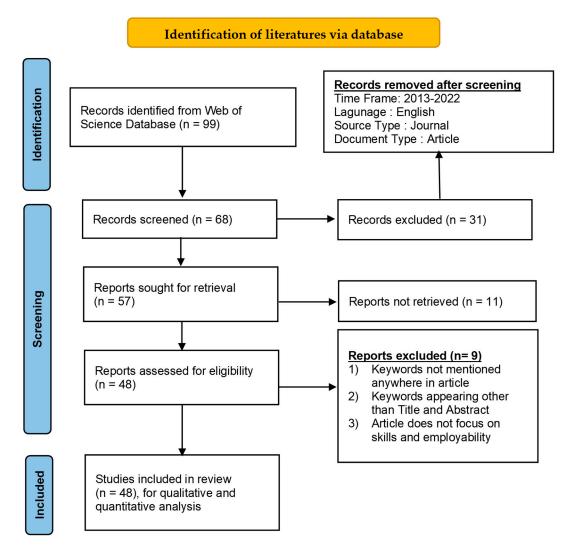
in skills development, especially within the key sectors of the automotive industry, textiles, and tourism.

Figure 2. Global innovation index on seven pillars. Source: Brás (2023).

These findings motivated us to undertake this research with the aim of developing strategies to prepare the workforce. Improving capacity in line with GII measurable areas should be a priority for South Asian nations to bolster their global competitiveness and embrace the transformative potential of I4.0 technologies. Considering these gaps, the current research strives to systematically extract the driving forces, challenges, and future skills required for the adoption of I4.0 technologies in the South Asian region. We also highlight the need for comprehensive strategies to foster innovation ecosystems, enhance business sophistication, and for investment in education.

3. Methodology

The current study was conducted using the preferred reporting items for systematic review and meta-analyses (PRIZMA). PRISMA offers detailed guidance for different information sources and methods not covered in other guidelines. It includes instructions for reporting study registry searches, web searches, multi-database searches, and updates. This helps authors report their searches for more transparent reporting (Rethlefsen et al. 2021). Systematic review is essential for helping researchers and practitioners stay up to date with a large and rapidly growing body of evidence. According to Pollock and Berge (2018), systematic reviews answer predefined research questions using explicit, reproducible methods to identify, critically appraise, and combine the results of primary research studies. Such a review is a comprehensive summary of all the important research on a specific question. The method finds, selects, and evaluates the high-quality evidence related to the research questions. It also gathers all the relevant evidence based on certain criteria set beforehand. Moreover, systematic review works to reduce bias by following a clear and thorough process (Harris et al. 2014). The PRISMA 2020 statement offers revised guidelines for systematic reviews, ensuring clarity and accuracy. It includes a 27-item checklist for transparent, evidence-based reporting (Page et al. 2021). Our research follows the latest PRISMA flow chart with three steps: identification, screening, and inclusion. While there are other literature review techniques (Moher et al. 2009), the authors chose PRISMA for its wide usage and systematic, user-friendly approach. Figure 3 illustrates the information flow based on PRISMA 2020, with detailed steps discussed in the following sections.

Figure 3. PRISMA flowchart illustrates the systematic reference selection process adapted from Page et al. (2021).

3.1. Identification

In the first step, a search strategy was developed to identify the relevant literature using the Web of Science database. Compared to functionality, record quality, and coverage in other databases such as Google Scholar and Scopus, Web of Science provides more quality records. It has widespread use and a range of applications, along with reliable sources in various research fields (Birkle et al. 2020; Phethean et al. 2016). In light of incorporating the Scopus database, it was found that the results were not sufficiently specific to the keywords used. This meant that the number of articles directly relevant to the study was insufficient for conducting a systematic review (Gusenbauer and Haddaway 2020).

A combined search string (Figure 4) was constructed using the topic field (TS) in the advanced search option of the Web of Science database. The 'TS' field in WoS encompasses titles, abstracts, author keywords, and Keywords Plus. Three sets of keywords were employed using Boolean operators to ensure highly relevant search results. The Boolean 'AND' operator combined the concepts of Industry 4.0, employability, skills in labor markets, and the geographical focus of South Asia. 'OR', on the other hand, was used to broaden the search, including various synonyms and related terms (Pranckutė 2021). The first set of keywords encompassed terms related to Industry 4.0 and its associated technologies. These terms represent the integration of digital technologies in industrial settings (Schwab 2017). Keywords such as 'Digitalization', 'Automation', and 'Artificial Intelligence' were selected

to embody the technological pillars of Industry 4.0 (Ghobakhloo 2020). Additionally, 'Internet of Things' and 'Big Data Analytics' were included to reflect the data-driven aspects of modern industries (Wortmann and Flüchter 2015). The second set of keywords was centered around employability and labor market skills. This set aimed to explore the evolving job roles and skill requirements brought about by technological advancements (Acemoglu and Restrepo 2020). For example, terms such as 'Employment Trends' and 'Job Displacement' were chosen to highlight the dynamic nature of the labor market in response to technological shifts. Additionally, 'Skills Development' and 'Skill Gap' were included to emphasize the changing requirements of the workforce. The third set of keywords focused on South Asian countries. As Industry 4.0 is an emerging topic with multifaceted effects in the South Asian region, particularly on labor markets and employability. This geographical focus aims to capture the diverse range of developing economies in the region, each presenting unique challenges and opportunities in the context of Industry 4.0 (Mukherjee and Satija 2020). Our broad search strategy identified a total of 99 articles after searching for each combination of keywords in the title, abstract, or keywords shown in the Figure 3 in identification process. All the documents include the used terms and were focused on South Asian regions in different industry sectors, e.g., manufacturing, mining, education, nursing, health. Only peer-reviewed articles were included using the combined set of keywords.
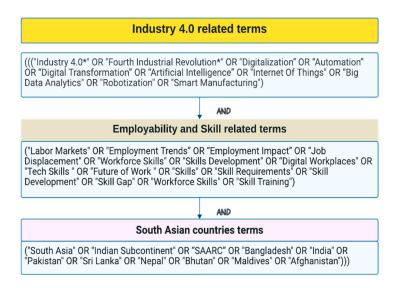

Figure 4. Database search terms using Web of Science advanced search criteria.

3.2. Screening

After identifying the relevant documents from the database, the screening process was defined and performed. The search span was set from 2013 to 2022 and all the documents before 2011 were removed. The term Industry 4.0 became popular after 2011, and the authors wanted to do a literature review on the more recent data since the term came into widespread use. The research fields for this research study were selected and narrowed down to business, accounting and management, economics, and finance. Only the documents that were full articles were selected. The search criteria were restricted to peer-reviewed articles excluding conference proceedings, books, and books chapters. Furthermore, the study included articles published until 2022 to consider the full calendar year. The language of research papers was set to English. A total of 31 documents were excluded at the screening stage, and 57 research papers were moved to the next stage for eligibility and final inclusion.

3.3. Inclusion

In this step, all the extracted papers were reviewed to assess the quality. The abstract of each paper was read and checked to ensure the relevance of the papers was consistent with the research questions. A total of 11 papers were excluded due to lack of relevance, and a further nine papers were removed based on three criteria: (1) keywords not mentioned anywhere in article, (2) keywords appearing other than title and abstract, and (3) the article not focusing on skills and employability. Finally, a total of 48 articles were selected to perform the literature review.

3.4. Data Analysis

The research was conducted based on the analysis of each article's relevant metadata, which included details such as the publication year, journal source, and the reported driving factors, challenges, and skills required for the future of jobs. Using Microsoft Excel, a data summary sheet of 48 articles was created to systematically record these factors (Table 1). The study focused on relevant articles published between 2013 and 2022, as there were no relevant scientific papers found from the previous years. In addition, a Pareto analysis was used to determine the most influential success factors and challenges driving the adoption of Industry 4.0 technologies. After calculating the frequencies, the study converted these figures into cumulative percentages. All of these factors were systematically categorized and then ranked in accordance with the needs of the research. The Pareto analysis is a quality control tool that arranges data classifications in descending order, with the most frequent at the top (Karuppusami and Gandhinathan 2006; Wuni 2022). The Pareto principle, also known as the 80/20 rule, states that roughly 80% of the effects result from 20% of the causes. In our context, the technique, as done by Bajaj et al. (2018), was appropriate because it allowed for the ranking of cumulative frequencies, which totaled 100. The rationale behind using this principle was to streamline our focus on the most significant factors impacting the labor markets under the influence of Industry 4.0. Previous studies also used this principle in economic studies to extract various factors and assess their individual impact (Hill et al. 2018; Tushar et al. 2023). However, to facilitate this analysis, the authors used Pareto charts, such as clustered column and line charts to identify the most influential factors on the adoption of Industry 4.0 technologies.

Table 1. Summary of 48 articles on the impact of Industry 4.0 technologies on employment and skills in the South Asian region.

Driving Success Factors	Challenges/Obstacles	Skills Requirement and Gaps	References
Increased efficiency, productivity improved customer service and cost savings, automation, quality, and cost advantages	Investment cost, skill gap, reluctant to implement industry 4.0, lack of funds, uncertainties of the investment, data security and lack of qualified employees, employee resistance	Analytical skills, skills in data security, and data management	(Hoque and Shahinuzzaman 2021; Singhal 2021)
Top management support, high driving power, financial support	Employee resistance, insufficient maintenance of support systems	Specialized training and skills	(Jain and Ajmera 2022, 2021)
Flexibility, accuracy, and speed to business operations.		Technical and interpersonal skills, conceptual skills, social skills, managerial skills	(Joshi 2021)

Table 1. *Cont.*

Driving Success Factors	Challenges/Obstacles	Skills Requirement and Gaps	References
Competitive advantages	Resistance to change, barriers of adoptions, coordination and collaboration, government initiatives and policy, customer pressure, environmental regulation	Analysis, skills and expertise, digital transformation	(Goswami and Daultani 2022; Nudurupati et al. 2022; Chenoy et al. 2019)
Holistic development, lifelong learning, and outcome-based education	Lacks the availability of basic infrastructure	Research skills, computing skills, data management and soft skills	(Gadre and Deoskar 2021; Yadav 2022)
Technology proficiency	Training retraining of people	Technical skills, entrepreneurial and soft skills, communication, and interpersonal skills	(Mehta and Awasthi 2019; Jain et al. 2022; Jadhav et al. 2022)
External support, investments in technologies, transformation, knowledge sharing	Readiness in operations technology, international finance, international experience, and international network	Leadership skills, adaptability skill, team development	(Dutta 2017; Karki and Hadikusumo 2023; Chen et al. 2023)
Networking and automation, government policies for bridging skill gaps, forging partnerships and policies	Digital learning, crisis of human resources, learning strategy, professional skills	Virtual reality, non-cognitive skills,	(Shreenath and Manjunath 2021; Hiremath et al. 2021; Joshi 2021; Kumar 2019; Hasan et al. 2021; D'souza et al. 2021)
Hybrid workplaces, industry 4.0, humans and collaborative robots, leadership vision,	Institutional pressure on workforce skill, capital accumulation, cost of employment	Creativity, human resources, digital transformation skill, technical and managerial skills	(Verma and Singh 2022; Bhattacharyya and Mitra 2020; Vasconcellos Oliveira 2021; Alam and Dhamija 2022; Nizami et al. 2022)
Robotics, artificial intelligence, internet of things, automation, very high-capacity networks, big data analytics, Internet of Things, ICT, learning, smart sensors	Adaptability of workers and reforms in education sector, public investment and public provision, job security	Digital transformation and entrepreneurship, and sustainable knowledge management, ICT job skills, software developers, technical skill, digital skills,	(Nizami et al. 2022; Reddy 2020; Brigitta 2022; Mazhar et al. 2022; Jony et al. 2022; Hammer and Karmakar 2021; Islam et al. 2021; Islam et al. 2017; Bhasin and Rajesh 2022; Abuzaid et al. 2021; Tiwari 2021; Behl et al. 2022; Sachdeva et al. 2022; Tay et al. 2018; Kattimani and Naik 2013)
Personal innovativeness, leadership vision	Social influence, anxiety, long-term consequences, and job relevance, security, and access options	Communication skills, technical skills, problem-solving, relationship management skills.	(Yildirim and Bostanci 2021; Kar et al. 2021; Bhattacharya et al. 2021)
Job flexibility, human capital and knowledge transfer, digital transformation	Lack of autonomous system	Data analysis, complex cognitive, decision making and continuous learning skills, digital skill, technical skill	(Jaiswal et al. 2022; Bhattacharyya and Nair 2019; Jamil 2022; Park-Poaps et al. 2021; Andrade and Goncalo 2021)

4. Results and Discussion

The initial analysis is based on descriptive information, for example, the trend of annual scientific publications, the country-wide distribution of studies, and the top journals published in the field of I4.0 technologies on employability and skills. Following the

descriptive analysis, the authors present the main findings and discussion based on the research questions posed in the introduction section.

4.1. Descriptive Analysis of Systematic Review

    The current study considers 48 eligible papers, published between 2013 and 2022. Figure 5 indicates that before 2016, there was minimal research activity, with no more than one article published in 2013. This represents 0% growth in the topic and indicates a low level of interest since the term gained popularity after 2011 (Zhou et al. 2015). In recent years (2019–2022), the most significant growth in research articles occurred, with 11.25 articles published on average each year in four countries (Bangladesh, India, Pakistan, and Nepal). These represent substantial surges and signify a mature and rapidly expanding area of research. There were no studies published by corresponding authors or carried out within the country in Sri Lanka, Bhutan, or Afghanistan.
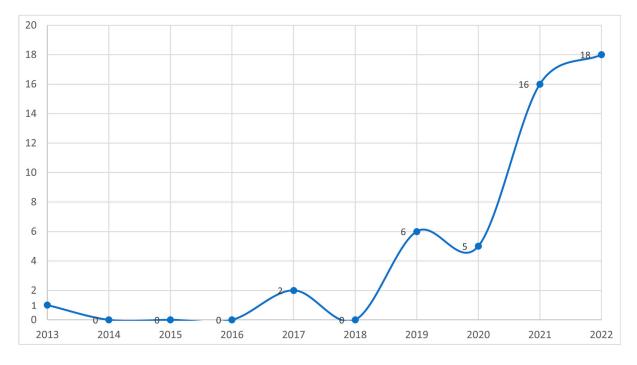

Figure 5. Annual distribution of included studies.

    Figure 6 represents the contribution of scientific articles from four South Asian countries to the discourse on I4.0 technologies and their impact on employment and skills. It shows that India emerges as a prominent contributor, accounting for 75% of the total number of articles. India, being a major global player in technology and outsourcing, plays a crucial role in making a strong research contribution. Pakistan and Bangladesh also exhibit significant research activity, contributing 15% and 8% of the studies, respectively. On the other hand, Nepal's contribution, at 2%, is relatively low, suggesting that research on this subject is in the early stages of development in the country. It's essential for Nepal, Bhutan, Sri Lanka, and Afghanistan to increase its engagement in this area as I4.0 technologies are increasingly shaping the global employment and labor market.

    The authors also identified the top 10 journals (Figure 7) that published papers on I4.0 effects on employability and skills. Among them, the *Indian Journal of Labor Economics* from Springer and the *International Journal of Manpower* from Emerald are the top journals in this area.

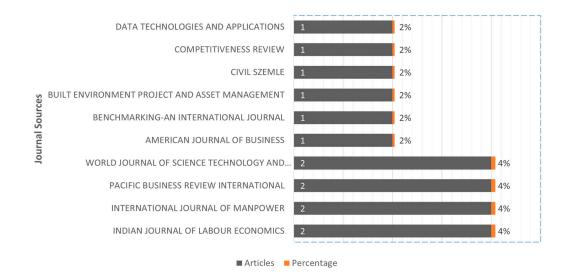**Figure 6.** Distribution of articles published by South Asian Countries.

Figure 7. Top 10 journal distribution.

4.2. Findings and Discussion

RQ1: What are the key driving factors contributing to the success of Industry 4.0 technology implementation in South Asia?

Identifying the influential driving factors of Industry 4.0 technologies is the primary objective of this study. Based on the findings, the authors extracted 20 factors from the 48 included articles. A Pareto chart was used to highlight the most important driving factors in descending order, from the highest frequency of occurrences to the lowest frequency of occurrences. (see Figure 8).

According to the Pareto principle of 80/20, the vital view items occupy a substantial majority (80%) of cumulative occurrences, which indicates the nine most important factors in the South Asian region: artificial intelligence, digital skills, ICT, big data analytics, productivity and efficiency, external support, automation, top management and human resources, government policy and support, IOT, and smart sensors. The remaining factors—high driving power, competitive advantages, technology proficiency, quality and cost advantages, very high-capacity networks, capital accumulation, human and collab-

orative robots, and leadership vision—have a lower impact but are critical for success in the workplace. Our findings emphasize that artificial intelligence, digital skills in ICT, big data analytics, productivity, and efficiency are the top driving factors, with a cumulative percentage of 46% in research in India, Bangladesh, Pakistan, Nepal, and Sri Lanka. Overall, artificial intelligence plays a substantial role in the region in the context of Industry 4.0, especially in the manufacturing and services sectors, in improving operational efficiency and productivity since they reflect the central goals of different industries. AI has the ability to process data, make predictions, and automate tasks to digitally transform industries. Previous studies (Kagermann et al. 2011; Rodriguez et al. 2015) also suggest that artificial intelligence and autonomous robots can communicate with one another to boost productivity and product quality. Additionally, they are capable of handling unforeseen issues and more difficult tasks. According to Holm and Lorenz (2022), AI, digital skills, and big data analytics have connections with jobs in terms of enhancing and supplementing skills requiring the adoption of high-performance work practices, external support, and HR support. This study also found adverse effects on jobs and disparities in the labor market in Denmark.
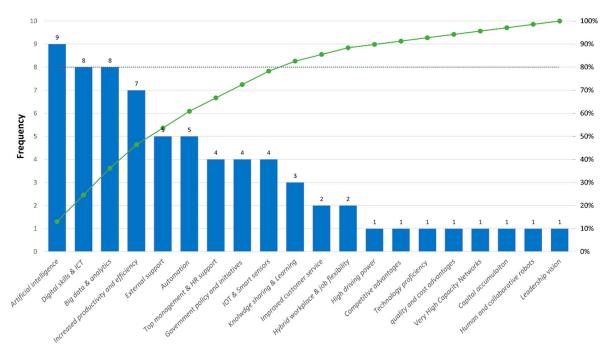

Figure 8. Driving success factors of Industry 4.0 technology.

Over the past few years, the availability of big data, cloud computing, and machine learning has made artificial intelligence extremely powerful. It is likely to reshape the work of many industries by changing the content and design of jobs. By facilitating human—machine collaboration and assisting employees in physical tasks, these enablers can play a significant role in increasing efficiency and productivity (Lane and Saint-Martin 2021). Despite creating economies of scale, researchers also found potential threats of job losses resulting from human–machine collaboration, reskilling, and upskilling (digital skills, decision-making, and cognitive skills) in the present workforce (Jaiswal et al. 2022; Tschang and Almirall 2021). In contrast, Srivastava (2018) concluded that there is a possibility of job losses during the next 10–20 years, estimated to be 47% in the US, 35% in the UK, 49% in Japan, 40% in Australia, and 54% in the European Union. Ultimately, no country can isolate itself from the side effects of I4.0 technologies in the future. Among South Asian nations, India can have significant impacts on healthcare, agriculture, education, and the manufacturing sectors. Developed countries can expect annual economic growth rate to double by 2030. As a result, Industry 4.0 technologies bring with it a spectrum of opportunities as well as challenges such as data quality, privacy, and a lack of a skilled

workforce, which are the major concerns for emerging economies (Sharma et al. 2022). In Bangladesh, artificial intelligence, IoT, big data, and blockchain have become very popular due to automation and control technology in the manufacturing and service sectors (Babu 2021). In the research of Iqbal et al. (2021), Bangladesh has been positively and negatively affected by artificial intelligence. Since the digital economy of Bangladesh is emerging, existing jobs are replaced with new opportunities. Such technology allows machines to detect, understand, act, and learn either on their own or to augment human activities (Ehsan 2021). However, India, Pakistan, Bangladesh, Nepal, and Sri Lanka may continue to face technological and economic barriers in the coming years. The current study suggests that far-reaching initiatives from the top management, a focus of government decision-makers on technical and vocational education, and more training are critical. Proper I4.0 technology adoption, industry ecosystem, and infrastructure can drive significant growth in the labor market. The study also suggests grabbing the high potential benefits shown in the Pareto chart, for example, high driving power, competitive advantages, technology proficiency, quality and cost advantages, very high-capacity networks, capital accumulation, and human and collaborative robots that may come from disruptive technologies (Bhuiyan et al. 2020). Overall, the impact of these technologies can be useful for industries to boost their efficiency and productivity (Pathak and Sharma 2022).

RQ2: What challenges exist regarding the adoption of I4.0 technologies in the region, and how do they impact the labor market and workforce skills?

Regarding the second research question stated in the introduction, this review further explored the challenges and obstacles of I4.0 technologies on employment and skills. The authors identified 33 challenges and categorized them into six types (Table 2) on the basis of the frequency of occurrence. The categories are (1) training and development, (2) skills and workforces, (3) financial, (4) regulatory, (5) technology, and (6) social and psychological challenges. Previous research also found myriad challenges and impacts on the labor market regarding the adoption and implementation of Industry 4.0 technologies in that region. For instance, Raj et al. (2020) highlighted the absence of digital strategy and resource scarcity as significant barriers in both developed and developing economies. In Nepal, the lack of critical infrastructure, shortage of skilled manpower, capital constraints, and policy implementation are the main challenges in industries (Devkota et al. 2022). Rehman et al. (2021) underscored challenges such as workforce availability, infrastructure limitations, management-related concerns, data management, knowledge-driven processes, security, capital constraints, workforce readiness, and education that hinder the process of adopting smart technologies. All these challenges impact the I4.0 ecosystem in developing economies, fueled by automation and digital technologies.

Overall, the findings demonstrated the distribution of barriers in which financial challenges (18%) played a decisive role, affecting technological, regulatory, and organizational workforces (Sayem et al. 2022). Particularly, the skill and workforce challenges (21%), such as lack of specialized workforce, training, and skills require a new set of skills and knowledge for the industries. Training and development challenges (28%) are the most significant barrier to I4.0 in Bangladesh, India, Pakistan, Nepal, and Sri Lanka. There is a need for robust technical and vocational training to equip employees and workers for emerging jobs and the gig economy (Spoettl and Tūtlys 2020). Necessary infrastructure for digital learning, training, and the need for skilled human resources also present significant challenges for the future of work (Rodrigues et al. 2017). Thus, the government and employers should focus on life-long learning by reskilling and upskilling the workforce to be ready for the future job market (Li 2022). I4.0 also demands reformation of the education sector by initiating digital learning, accessing remote learning, and building modern infrastructure. Education has a big role in the transformation of society and the development of human resources (Manda and Ben Dhaou 2019). Besides, organizations must focus on flexible and cross-domain communication for global talent (Oesterreich and Teuteberg 2016). The analysis concludes that the financial, institutional, social, psychological, technological, workplace, and government regulatory challenges pose significant threats to the pace of

adoption and implementation of Industry 4.0 technologies in developing countries (Wu and Kao 2022).

Table 2. Challenges of Industry 4.0 Technology Adoption in South Asia.

	Challenges of Industry 4.0 Technology Adoption in South Asia	Occurrences	Percentages (%)	Cumulative (%)
1.	**Training and development** (training and retraining of people, digital learning, crisis of human resources, learning strategy, lack of professional skills, digital learning, remote learning, education reform, lack of basic infrastructures)	9	27	27
2.	**Skills and workforces** (skill gap, reluctant to implement industry 4.0, institutional pressure on workforce, adaptability of workers, lack of qualified employees, employee resistance, insufficient maintenance support system)	7	21	48
3.	**Financial challenges** (investment cost, lack of international supports, cost of employment, capital accumulation, lack of funds uncertainty of investment)	6	18	66
4.	**Regulatory challenges** (resistance to change, co-ordination and collaboration, government initiatives and policy, environmental regulation)	4	12	79
5.	**Technology challenges** (data security, lack of autonomous system, data access option, readiness to operate technologies)	4	12	91
6.	**Social and psychological challenges** (social influence, anxiety, long term consequences of job loss)	3	9	100

RQ3: What are the key skill requirements and gaps resulting from the integration of I4.0 technologies?
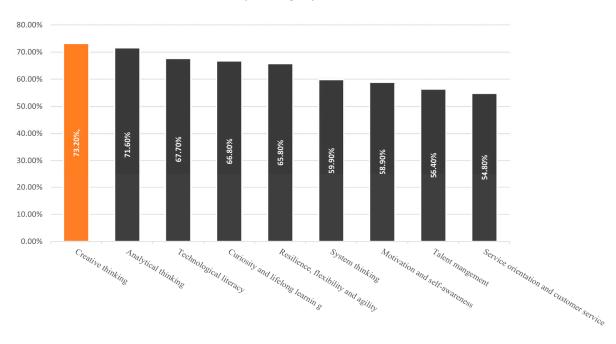
Our third research question focuses on skill requirements and gaps arising from the integration of I4.0 technologies. The changing skill demand for the industry is just the newest case of a fairly old debate. Digitalization, new sets of skills, and diverse knowledge constitute new challenges for today's industries. By 2030, there will likely be a competence gap in the youth of today, which raises the possibility of robotic replacement of humans (Alhloul and Kiss 2022; Saniuk et al. 2021). To delve into this question comprehensively, the authors categorized all the summarized skills into five types (Table 3). They are: (1) technical and information technology skills, (2) communication and interpersonal skills; (3) digital skills; (4) entrepreneurship and leadership skills; and (5) problem-solving and relationship skills. Our findings aim to assess the impact of these skills to overcome the challenges and drive the benefits to different industries, e.g., manufacturing firms, software firms in India, apparel and service industries in Bangladesh, education sectors in Pakistan, and Nepal. Most South Asian countries have gaps in these skill sets, which require timely actions to produce a skilled workforce.

However, in our analysis, the authors found technical skills (26%) consisting of information technology, specialized manufacturing skills, data analytical skills, data management skills, communication and interpersonal skills, and problem-solving skills to be highly demanded and influential in Bangladesh, India, and Pakistan, Nepal, and Sri Lanka. The dominant skills are new and a significant contribution to our study. The current study shows skill gaps in these areas and suggests reskilling and upskilling with the collaboration of industry, academia, and government initiatives. Moreover, several previous studies also corroborate our research findings regarding the assessment of required skills. For instance, Woschank et al. (2020) compared skill requirements in Central European and Southeast Asian industries, uncovering significant disparities. Maisiri et al. (2019) concentrated on engineering profession skills, underscoring the imperative for capability development to align with I4.0 needs. In Malaysia, Indonesia, and Brunei, the critical skills and career readiness of tertiary students lack awareness about I4.0's skill prerequisites (Adnan et al. 2021). As a

result, Bongomin et al. (2020) suggest disruptive technologies such as the Internet of Things, big data, and artificial intelligence be integrated to the education sector and stress the importance of their implementation. In order to overcome the challenges and boost the economy, Thailand took initiatives to implement the I4.0 concept—the "Thailand 4.0" policy. Such policies are considered the main tool for integrating innovation, knowledge, technology, and creativity for economic and social development (Puriwat and Tripopsakul 2020).

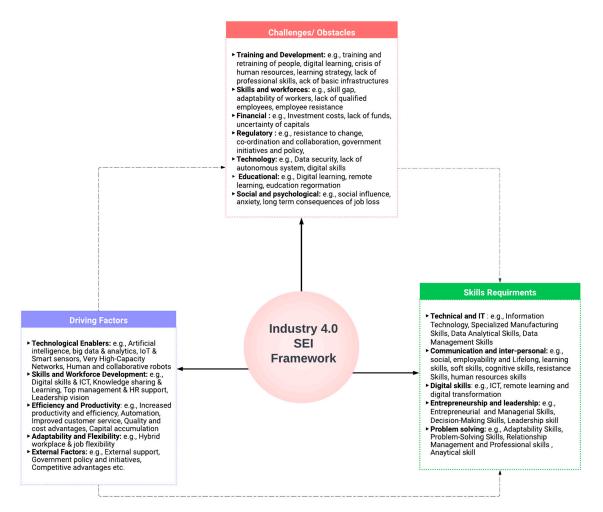**Table 3.** Skill requirements and gaps in South Asian countries.

	Skills Requirements and Gaps in South Asia	Occurrences	Percentages (%)	Cumulative (%)
1.	**Technical and ICT** (Technical Skills, Information Technology, Specialized Manufacturing Skills, Information Technology, Data Analytical Skills, Data Management Skills, Conceptual Skills)	10	26	26
2.	**Communication and Interpersonal** (Social Skills, Employability and Lifelong Learning Skills, Soft Skills, Cognitive Skills, Resistance Skills, Human Resources Skills)	6	26	52
3.	**Problem-Solving and Relationship** (Adaptability Skills, Problem-Solving Skills, Stakeholder/Relationship Management Skills, Professional Skills, Analytical Skills)	5	19	91
4.	**Digital** (ICT Skills, Digital Skills, Digital Transformation Skills, Remote Learning Capacity)	4	15	66
5.	**Entrepreneurial and Leadership Skills** (Entrepreneurial Skills, Managerial Skills, Decision-Making Skills, Leadership Skills)	2	15	79

Conversely, the current study aligns with the findings of the World Economic Forum's report, which indicates that the top skills and skill sets expected to be increasingly in demand from 2023 to 2027 are illustrated in Figure 9. It shows that creative thinking will grow faster in the next five years than demand for analytical thinking. Technology literacy (68.70%) is the third fastest growing category, ahead of curiosity and lifelong learning, resilience, flexibility and agility, and motivation and self-awareness.

Figure 9. Top 10 skills in demand according to the World Economic Forum. Source: Battista et al. (2023).

Moreover, the findings suggest strategies for adopting new skills in developing countries, especially in South Asia. Creating a learning environment, industry–academic collaboration, infrastructure development, sharing and transferring of knowledge internally and externally, and reforming education with enhanced training curricula can help in making skilled and efficient workforces (Artifice et al. 2019; Sallati et al. 2019). Based on the analyses and syntheses of the systematic review, the authors propose a framework (Figure 10), "Industry 4.0 SEI Framework", that depicts the driving factors, challenges, and required skills for the future labor market. Through this framework, the current study also significantly contributes to the existing field of knowledge in the ongoing debate regarding the fourth industrial revolution. Previous studies by Horváth and Szabó (2019) and Vuksanović Herceg et al. (2020) also support our findings. They explored human factors, efficiency factors, and technological factors as the major forces in the pace of digital transformation. However, the driving forces are the key elements and enablers that strengthen the adoption and implementation of Industry 4.0 technologies. For example, technological enablers, skill and workforce development, efficiency and productivity, adaptability and flexibility, and external enablers can transform management functions. The authors also address the challenges that industry might encounter when transitioning to the integration of technologies, such as investment costs, a lack of funds, data security, and a lack of qualified workforce. Therefore, the conceptual framework also suggests specific abilities and skills, which include technical skills, digital skills, cognitive skills, analytical skills, and many more. The authors suggest these skills for the future workforce and individuals who need to effectively operate and manage their operations.

Figure 10. Industry 4.0 SEI Framework (Source: Authors). Notes: SEI stands for Skills and Employability Framework for Industry 4.0.

4.3. Theoretical and Practical Implications

The current systematic review has a set of potential theoretical and practical implications. In theoretical terms, our study offers insights about the impact of 4IR technology on employment and skills in South Asian countries in several ways using the current body of knowledge. Firstly, the study identifies the key drivers or success factors, including artificial intelligence, digital skills, and big data analytics, which organizations and governments should prioritize for enhanced productivity and efficiency. These driving factors of I4.0 have direct or indirect effects on the labor market, opening a wide range of opportunities, and reducing costs economically (Szabó-Szentgróti et al. 2021). Most of the previous studies conducted research on the integration of human factors and ergonomics, the effects of Industry 4.0 technologies on supply chain management, and digitizing some of the manufacturing, retailing, warehousing, transportation, and industrial procedures of the logistics industry. Overall, these studies explained impact and behavior, with less focus on the critical success factors that can emerge from FIR. The nine most important driving factors can significantly improve the technology readiness and strengthen the digital transformation of manufacturing firms, SMEs, service sectors, and sustainable growth industries (Hizam-Hanafiah et al. 2020; Madhavan et al. 2022). Secondly, the study extracted different challenges of I4.0 technologies that can provide a significant contribution in developing countries to be prepared for the future of work. These findings significantly contribute to the understanding of the complex technological effects and obstacles of I4.0. Thirdly, the authors found skill requirements and gaps in South Asian countries, which can open the eyes of industries, governments, managers, and other practitioners. This finding contributes to preparing a skilled workforce and increasing the employability in that region. Previous studies by Iram Javeed (2023) and Husin et al. (2022) also corroborate the notion that the current labor market needs highly skilled labor because 4IR will create more jobs for people along with replacing existing jobs. Therefore, human capital will undergo major changes due to skill deficiencies, particularly in India, Bangladesh, and Pakistan. Such skills, for example, technical skills, digital skills, creativity, analytical skill, and problem-solving skills, will be required by the labor market and individuals to possess a combination of technical and soft skills to thrive in the future.

In terms of practical implications, our research can assist managers from a variety of industries, government policymakers, and other practitioners in updating their understanding of the surrounding technologies and the effects of I4.0 on the current labor market. It could also assist aspiring entrepreneurs in better comprehending and adopting new workplace technologies (Piccarozzi et al. 2018). Managers can gain insight into the future of digital transformation and the capabilities of Industry 4.0 concepts by utilizing our proposed Industry 4.0 SEI Framework. The driving factors, challenges, and skill requirements can assist human resource managers in identifying their strengths and weaknesses when it comes to locating the best talent.

5. Conclusions

This systematic review and Pareto analysis on the impact of I4.0 technologies on employability and skills has provided South Asian regions with valuable insights. The paper investigated 48 articles from the Web of Science database that have been peer-reviewed. The findings of the study significantly elucidate the regional I4.0 trends, driving factors, challenges, and required skills. India, followed by Pakistan and Bangladesh, has emerged as a leading contributor of research articles in recent years, as research activity as a whole has increased significantly over the past decade. Artificial intelligence, digital skills, and information technology have been identified as the primary factors driving the adoption of Industry 4.0 technologies, including the need for reskilling and upskilling. Adoption challenges include training and development, financial constraints, regulatory issues, and technological obstacles. In South Asian industries, technical and ICT skills, communication, problem-solving, digital literacy, and leadership skills are essential. The study also suggests a comprehensive strategy to address these challenges,

emphasizing industry, academic, and government collaboration. The proposed "Industry 4.0 SEI Framework" provides stakeholders with guidance for understanding the dynamics of Industry 4.0 in South Asia, allowing the region to capitalize on the potential benefits of this technological revolution while mitigating its risks.

6. Limitation and Future Research Agenda

This study has several limitations, primarily stemming from the choice of the database. In our source selection, the authors exclusively used the Web of Science database, and no other databases were taken into account. Additionally, our study employed a search strategy reliant on research strings to determine the documents for analysis, restricting the search to specific keywords. Subsequent research might contemplate employing alternative combinations of terms to yield more comprehensive results.

The analysis in this study is founded on a sample of 48 articles, which might not adequately represent the full spectrum of research in the field. It is important to note that there could be pertinent studies excluded from our sample, particularly since the authors excluded books, book chapters, and conference proceedings. The analysis is confined to articles published up to December 2022, and it is conceivable that research trends and influential papers may have evolved beyond this timeframe, leaving newer developments unaccounted for due to our omission of a complete calendar year. The findings from this study may not be generalizable to all regions and contexts, as the concepts related to I4.0 are continually evolving. Despite these constraints, our research provides a valuable overview of the driving forces, potential challenges, and skill gaps, which lays the groundwork for further exploration and research in the domain of the labor market. More research, preferably empirical research, should look into how Industry 4.0 technologies are used and how they affect the growth of human capital in this digital age. The goal is to create a skilled workforce for the current job market. These insights can serve as valuable resources for both researchers and practitioners, enabling them to inform their work and contribute to the ongoing discourse and advancements in this field.

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