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Influence of Industry 4.0 on the Service Sector: A Scoping Review

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Abstract

Industry 4.0 has the potential to transform the service sector, enhancing efficiency and quality. While its impact on manufacturing is well-studied, its implications for services remain less explored. To address this gap, we conducted a scoping literature review with two main objectives: 1) to investigate the specific ways Industry 4.0 has influenced the service sector and 2) to compare and contrast the implementation of Industry 4.0 across manufacturing and service industries. Our paper aims to analyze the applications of technologies like AI, Cloud Computing and Big Data analytics in the service industry, providing insights to develop roadmaps for leveraging Industry 4.0 concepts effectively. We reviewed articles published within the last five years from Web of Science and ScienceDirect. From a pool of 71 eligible articles, data were extracted and analyzed using descriptive and quantitative methods. The findings lay a foundation for future research on Industry 4.0's impact on the service industry, known as Service 4.0.

Keywords
Industry 4.0, Service 4.0, Service Sector, Non-Manufacturing

1. Introduction

We are witnessing an unprecedented era of technological advancement spurred by Artificial Intelligence (AI) and data-driven technologies. This convergence has ushered in Industry 4.0 – the fourth industrial revolution transforming businesses, societies, and the way we interact with technology. This revolution builds upon the first (water and steam power), the second (mass production and electricity), and the third (computers, automation, and telecommunications). Industry 4.0 further accelerates technological innovation through developments in big data, artificial intelligence, 5G communication, and cloud/edge computing.

Industry 4.0 was first announced as a German high-tech development initiative and later elaborated upon in academic literature by Schwab (2015, 2016). Schwab outlined the vast potential and interconnectedness of emerging technologies like AI, robotics, the Internet of Things (IoT), autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing.

While much research focuses on Industry 4.0's impact on manufacturing (including smart supply chains, products, factories, and manufacturing processes), its implications extend beyond production. The term "Service 4.0" describes the application of Industry 4.0 principles to the service sector. It promises enhanced service quality, customer satisfaction, and efficiency, potentially benefiting businesses and reducing costs. Service 4.0's reach is broad, with terms like Logistics 4.0, Healthcare 4.0, and Education 4.0 demonstrating its potential to transform diverse industries.

Despite extensive attention to Industry 4.0 in manufacturing, its influence on the service sector (Service 4.0) remains relatively underexplored. To address this gap, we conducted a scoping literature review with two main objectives: 1) to examine how Industry 4.0 has influenced the service sector and 2) to identify similarities and differences in implementing Industry 4.0 between manufacturing and service industries.

2. Methodology

This scoping literature review is conducted according to items defined in The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMAScR) (Tricco et al. 2009).

2.1 Eligibility Criteria

We conducted a review of recent academic articles (published after 2020) examining the implications of Industry 4.0 for the service sector. Our focus was on peer-reviewed primary research articles available in English that specifically addressed the concepts, methodologies, and applications of Industry 4.0 within service industries. We excluded the following:

- Articles published before 2020
- Articles with a narrow focus on a specific technology or algorithm (rather than broader Industry 4.0 concepts)
- Articles primarily focused on the manufacturing industry (with limited exceptions for comparative analysis)
- Research published in languages other than English or in non-academic formats

2.2 Search Strategy

To identify relevant literature on Industry 4.0, we searched two primary electronic databases: Web of Science and ScienceDirect. We used the keywords outlined in Table 1, conducting separate searches on each database. We then downloaded the titles and abstracts of identified records as individual files.

Table 1. Search Strategy

Database	Keywords	Years
Web of Science	(“Industry 4.0” OR “Fourth Industrial Revolution” OR “4IR” OR “4 IR”) AND (“Non-Manufacturing” OR “Service Industry” OR “Service Sector”)	2020 ~ 2024
ScienceDirect	(“Industry 4.0” OR “Fourth Industrial Revolution” OR “4IR” OR “4 IR”) AND (“Non-Manufacturing” OR “Service Industry” OR “Service Sector” OR “Service” OR “4.0”)	2020 ~ 2024

2.3 Study Screening and Selection

We used Covidence to streamline our selection process, following a four-stage procedure independently conducted by the reviewer. First, we identified and removed duplicate studies. Next, we screened the remaining studies' titles and abstracts against our inclusion criteria. Figure 1 (the PRISMA flow chart) details the complete screening and selection process.

To facilitate reference management, we directly imported RIS files generated by Web of Science and ScienceDirect into Covidence. This aided in duplicate removal and will simplify citation generation for selected papers.

Our initial search yielded 433 articles from Scopus and 44 from Web of Science. After Covidence removed 6 duplicates, we screened the abstracts of 471 articles. Of these, we excluded 356 studies for a focus on either

manufacturing or specific technological applications. We then assessed the full text of the remaining 115 studies, further excluding 44. This resulted in a final selection of 71 articles for examination in this paper.

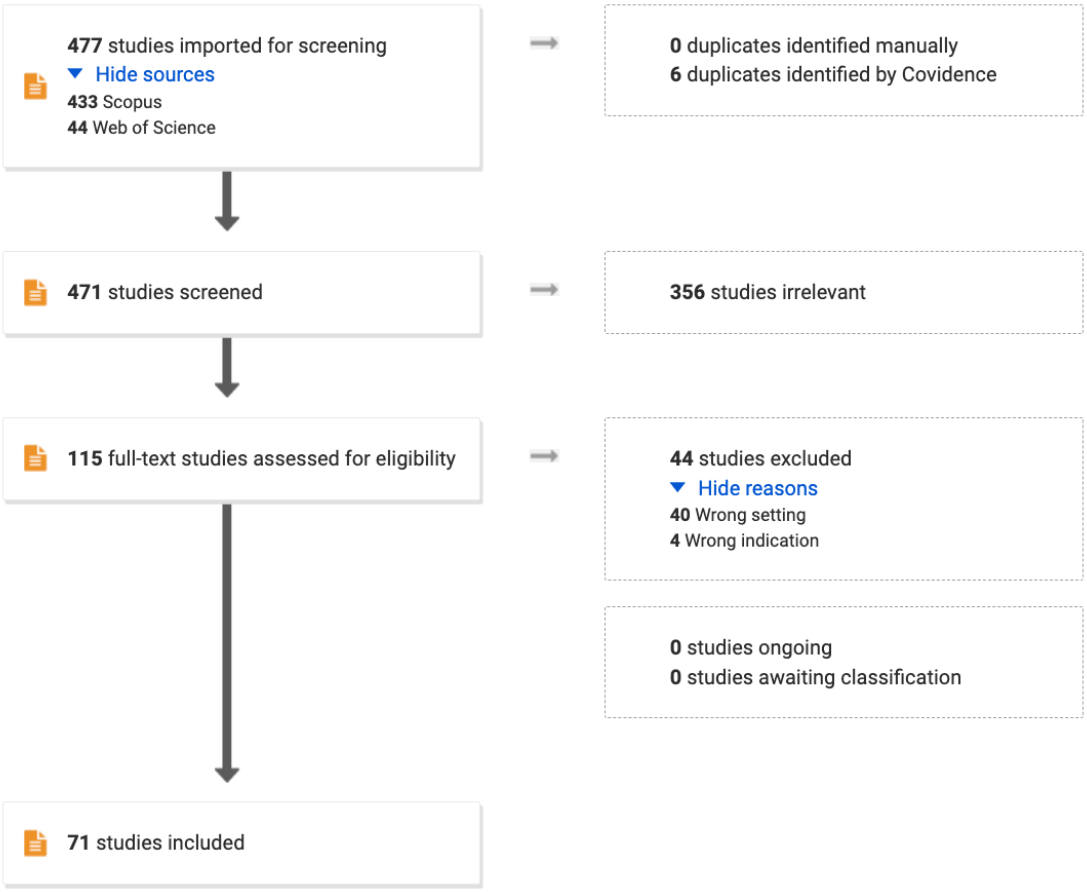

Figure 1. PRISMA Diagram of Study Selection and Screening

3. Results

Our analysis results are presented across four dimensions:

- Section 3.1: Explores synonyms of Industry 4.0 and clarifies their definitions (Table 2).
- Section 3.2: Outlines the various applications of Industry 4.0 within different service industries (Table 3).
- Section 3.3: Focuses on the specific research areas addressed by Industry 4.0 research in the service sector (Table 4).
- Section 3.4: Provides a list of the key technologies or methodologies underpinning Industry 4.0's implementation in the service sector (Table 5).

3.1 Synonyms of Industry 4.0

Concepts and Applications

- Garcia-Loro et al. (2021) introduced the concept of Laboratories 4.0, exploring how Industry 4.0 principles reshape web-based educational laboratories.
- Yigitcanlar et al. (2023) delve into City 4.0, which merges Industry 4.0 and Society 4.0 within smart cities. They examine City 4.0 through societal, environmental, and economic perspectives, emphasizing themes like circularity, adaptability, livability, accessibility, authenticity, and responsibility.

Specific Research Areas

- Gowripeddi et al. (2021) present case studies on Education 4.0, covering Remote Labs and student development in Remote Engineering Frameworks.

- Haderer et al. (2022) introduce an AI-assisted task and planning system for students, including mobile operating system analysis, concepts, and smartphone user interfaces.
- Goldin et al. (2022) propose a reference architecture to help instructors and engineering educators integrate digital tools synergistically in a post-pandemic landscape.
- Efimova et al. (2021) explore the impact of Industry 4.0 technologies on Quality 4.0, focusing on quality management and customer satisfaction.
- Dovleac et al. (2021) outline an agile development approach for Quality 4.0 tools using a Knowledge Management lifecycle. They emphasize the characteristics of Quality 4.0 and its connection to Industry 4.0, highlighting Knowledge Management's role.
- Har et al. (2022) examine Retail 4.0 applications, discussing the retail sector's transformation and the extent of Retail 4.0 technology adoption across countries.
- Silva et al. (2022) address Human Resource Management 4.0, creating an HRM framework within Industry 4.0 to guide professionals and organizations in addressing Industry 4.0 challenges.

Table 2. Synonyms of Industry 4.0

Synonyms	**Articles**
Laboratories 4.0	Garcia-Loro 2021
City 4.0	Yigitcanlar 2023
Education 4.0	Gowripeddi 2021 Haderer 2022 Goldin 2022
Quality 4.0	Efimova 2021 Dovleac 2021
Retail 4.0	Har 2022
Human resources management 4.0	Silva 2022

3.2 Service Industry Adopted with Industry 4.0

High-Tech Companies: Marcon et al. (2022) analyzed how Industry 4.0 influences business models for technology providers within high-tech companies. Hizam-Hanafiah et al. (2021) guided companies seeking to understand open innovation and adopt Industry 4.0 technologies. Jiao et al. (2021) assessed fintech success across countries and cities, proposing policies to accelerate Industry 4.0 adoption.

Healthcare: Inuwa et al. (2022) conducted a comparative analysis of Industry 4.0 technologies as applied to healthcare. Papadopoulos et al. (2022) developed a framework for culturally competent Socially Assistive Robots (SARs). Rayan et al. (2023) explored key ICTs, cloud computing, and big data applications within Health 4.0, including health monitoring, disease prevention, smart medication, personalized health, and telemedicine.

Education: Yoo et al. (2021) focused on helping students develop essential Industry 4.0 competencies. Chigbu et al. (2023) investigated new pedagogies for Higher Education Institutions transitioning to HE4.0. Ahaidous et al. (2023) explored the use of Big Data analytics in education, proposing a new architecture based on emerging technologies.

Tourism: Calero-Sanz et al. (2022) developed a methodology using Machine Learning to analyze online reviews of service robots in hotels. Bilotta et al. (2021) outlined skills crucial for Tourism Science students to thrive within a Tourism 4.0 context.

Retail and Service: Noble et al. (2022) provided a roadmap for Industry 4.0 advancement within the retail and service sector.

Table 3. Service Industries Adopted with Industry 4.0

Service Industry	Articles
High Tech	Marcon 2022 Hizam-Hanafiah 2021 Jiao 2021
Healthcare	Inuwa 2022 Papadopoulos 2022 Rayan 2023
Education	Yoo 2021 Chigbu 2023 Ahaidous 2023
Tourism	Calero-Sanz 2022 Bilotta 2021
Retail and Service	Noble 2022

3.3 Broad Industry 4.0 Research

Conceptual and Empirical Studies: Capello et al. (2021) defined 4.0 transformations and mapped them across Europe. Khan et al. (2023) developed an AI adoption framework for conservative industries. Cirillo et al. (2023) explored the relationship between technology, skills, and work organization, providing evidence on the value of education and training within the Industry 4.0 context.

Digital Transformation and Maturity: Soellner et al. (2024) investigated successful PSS implementation and digital servitization processes. Tutak et al. (2022) analyzed variations in digital business maturity across EU countries due to Industry 4.0 implementation.

Human Factors, Frameworks, and Models: Angelopoulou et al. (2020) emphasized an anthropocentric approach to Industry 4.0, prioritizing human decision-making supported by technology. Aguilar-Rodríguez et al. (2023) provided empirical evidence on the impact of technologies on circular processes in emerging economies. Kiraz et al. (2020) used a structural equation model to analyze factors influencing the adoption of Industry 4.0.

Tools and Methodologies: Salini et al. (2023) introduced a conceptual AI-enhanced Digital Twin Stores framework. Weking et al. (2020) presented a framework for analyzing Business Models within Industry 4.0. Koldewey et al. (2020) developed a smart service ideation canvas and supporting tools. Sakurada et al. (2022) explored an agent-based approach to asset digitization. Meyer et al. (2020) outlined a methodology for data-driven product development.

Table 4. Research Fields of Industry 4.0 on the Service Sector

Research Fields	Articles
AI/Digital Transformation	Capello 2021 Khan 2023 Cirillo 2023 Soellner 2024
Business Model Innovation	Marcon 2022 Hajipour 2023 Inuwa 2022
Status of industry 4.0 application	Vacek 2022 Tutak 2022
Factors on the adoption of Industry 4.0	Noble 2022 Pathak 2023 Muhamad 2023 Hizam-Hanafiah 2021 Caliskan 2021 Sony 2021

	Chung 2022 Angelopoulou 2020 Jiao 2021 Aguilar-Rodríguez 2023 Sarbu 2022 Sahoo 2024 Kiraz 2020 Marciniak 2020
Application Framework	Papadopoulos 2022 Salini 2023 Weking 2020 Zhong 2023 Koldewey 2020 Calero-Sanz 2022 Sakurada 2022 Rahman 2022 Meyer 2020

3.4 Technologies of Industry 4.0

Our research pinpoints AI/Machine Learning, Big Data, Blockchain, and Cloud Computing as pivotal drivers of Industry 4.0 within the service sector (Table 5). To illustrate, Khan et al. (2023) developed a value-based theoretical framework for AI adoption, streamlining AI transformation in Industry 4.0 while offering a tool for AI proposal evaluation. Similarly, Hajipour et al. (2023) presented a business model based on AI-as-a-Service (AIaaS), enabling companies to access a bundle of AI products and services.

To demonstrate Industry 4.0 application in the travel industry, Calero-Sanz et al. (2022) proposed a methodology that collects data from TripAdvisor, using Machine Learning techniques to analyze online hotel reviews. Sakurada et al. (2022) developed an agent-based Asset Administration Shell (AAS) approach, integrating artificial intelligence technologies to boost asset digitization for Industry 4.0.

Ahaidous et al. (2023) explored the use of big data analytics in the education industry, while Rayan et al. (2023) highlighted its application within the healthcare sector. Lobo et al. (2022) examined the impact of applying blockchain technology to support last-mile delivery of goods, focusing on process efficiency and cost reduction.

Table 5. Technologies of Industry 4.0 Applied in the Service Sector

Technologies	**Articles**
AI/Machine Learning	Khan 2023 Hajipour 2023 Muhamad 2023 Weking 2020 Calero-Sanz 2022 Sakurada 2022 Rahman 2022 Belk 2023
Big Data	Ahaidous 2023 Rayan 2023
Blockchain	Lobo 2022 Kimani 2020
Cloud Computing	Chauhan 2022 Inuwa 2022

Kimani et al. (2020) detailed how organizations and regulators can leverage blockchain to enhance operations and reduce costs. Both Chauhan et al. (2022) and Inuwa et al. (2022) discussed the technology of cloud computing and its transformative potential within the healthcare industry.

4. Discussion

We examine the findings and address the two questions posited in this paper: 1) How Industry 4.0 has influenced the service sector? 2) What are the similarities and differences in implementing Industry 4.0 between manufacturing and service industries.

4.1 Influence of Industry 4.0 on the Service Sector

Kenessey (1987) established a three-sector model for economic activity: primary industries (raw material production), secondary industries (manufacturing and transformation), and tertiary industries (service provision to consumers and businesses). This paper focuses on the tertiary sector, comprising industries such as Hospitality, Tourism, Consulting, Gambling, Retail, Franchising, Financial Services, Professional Services, Transportation, Information Technology, Education, and others dedicated to customer service.

Our research reveals that Industry 4.0 remains under-explored within the service sector. In our literature review, relevant studies were primarily located within the high technology, healthcare, education, tourism, and retail industries. This suggests a significant gap exists regarding the application of Industry 4.0 across the broader service sector. We believe technologies and practices successfully implemented in other industries hold transformative potential, offering opportunities to enhance efficiency, service quality, and production within the service sector.

4.2 Industry 4.0 on Manufacturing and Service Sector

Frank et al. (2019) analyzed Industry 4.0 adoption patterns in manufacturing, identifying core technologies like the Internet of Things (IoT), Cloud Computing, and Big Data/Analytics (often utilizing Artificial Intelligence). Our research aligns with these findings for the service sector, especially regarding Cloud Computing, Big Data, and AI/Machine Learning as key drivers. However, we observe a significant lack of studies focusing on IoT implementation within services (Table 6). This likely stems from the sector's different data collection methods; services typically don't rely on field devices and sensors in the same way that manufacturing processes do.

Comparing Frank et al.'s findings (Table 7), we see manufacturing heavily prioritizes supply-chain management, product enhancement, and production processes. In contrast, the service sector's Industry 4.0 implementation centers around customer experience. Improving service quality and customer satisfaction emerge as the primary goals within the service industry.

Table 6. Base Technologies of Industry 4.0

	Manufacturing Industry	**Service Industry**
Internet of Things (IoT)	Yes	No
Cloud Computing	Yes	Chauhan 2022 Inuwa 2022
Big Data	Yes	Ahaidous 2023 Rayan 2023
Analytics	Yes	Khan 2023 Hajipour 2023 Muhamad 2023 Weking 2020 Calero-Sanz 2022 Sakurada 2022 Rahman 2022 Belk 2023

Table 7. Applications of Industry 4.0

	Manufacturing Industry	**Service Industry**
Smart Service	No	Calero-Sanz et al. (2022) Bilotta et al. (2021) Sakurada et al. (2022) Efimova et al. (2021)
Smart Manufacturing	Yes	No
Smart Product	Yes	No
Smart Working	Yes	No
Smart Supply-Chain	Yes	No

5. Conclusions

This scoping literature review explored the influence of Industry 4.0 on the service sector, seeking to illuminate similarities and differences in implementation compared to the manufacturing industry. We analyzed 71 peer-reviewed articles published after 2020, scrutinizing them across four dimensions: Industry 4.0 terminology, service industry applications, relevant research fields, and core technologies. A detailed comparison was drawn between the foundational technologies and use cases for Industry 4.0 in both manufacturing and service sectors.

Our findings confirm a relatively unexplored landscape regarding Industry 4.0's application within the service industry. A key distinction lies in the focus: service sector implementation ("Service 4.0") prioritizes customer satisfaction, while manufacturing emphasizes production and processes. Technologically, manufacturing's Industry 4.0 hinges on data infrastructure and communication alongside analytics, whereas Service 4.0 centers primarily on data analytics.

This review establishes a strong foundation for future research. It highlights the transformative potential of applying Industry 4.0 technologies and practices across the diverse range of service industries.

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