Business Challenges and Opportunities in the Era of Industry 5.0

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Emerald Studies in Finance, Insurance, and Risk Management: Business Challenges and Opportunities in the Era of Industry 5.0

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Emerald Publishing Limited
Emerald Publishing, Floor 5, Northspring, 21-23 Wellington Street, Leeds LS1 4DL.

First edition 2025

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-83549-677-0 (Print)
ISBN: 978-1-83549-676-3 (Online)
ISBN: 978-1-83549-678-7 (Epub)

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Foreword

The shift from Industry 4.0 to Industry 5.0 marks a pivotal moment in the transformation of industrial and urban systems. This new era is defined by the deep integration of human intelligence and advanced technologies, fostering unprecedented collaboration between humans and machines. This book provides a thorough examination of the key concepts, technologies, and challenges that define Industry 5.0, offering a roadmap for navigating this complex and rapidly evolving landscape.

Industry 5.0 represents a fundamental shift towards systems that prioritise human wellbeing, sustainability, and resilience. This book begins with an exploration of the transition from monolithic to micro-service-oriented architectures, a critical change for organisations aiming to stay competitive. This transition, supported by various decomposition techniques, including artificial intelligence (AI)-driven methods, is essential for organisations that require flexibility, scalability, and fault tolerance in a fast-paced environment.

A central theme of this book is the application of digital twins, which enable real-time monitoring, simulation, and optimisation of systems. These digital replicas are indispensable tools in managing urban environments and industrial processes. It discusses how digital twins are used in urban planning to anticipate and mitigate the impacts of natural disasters, particularly within smart cities, where they help optimise infrastructure and enhance system resilience.

The impact of Industry 5.0 extends far beyond industrial and urban systems, significantly affecting the insurance sector. This book explores how technologies such as AI, blockchain, and cyber–physical systems are transforming internal controls and risk management in insurance. As these companies face new risks, they must adapt their internal controls to ensure financial integrity and regulatory compliance. It provides valuable insights into leveraging these technologies to enhance operations and develop innovative insurance products that meet evolving customer needs.

Additionally, this book addresses the ethical and regulatory challenges that come with Industry 5.0. The increased reliance on AI and other technologies raises important questions about transparency, accountability, and fairness. It offers guidance on how companies can navigate these challenges while maintaining ethical practices and regulatory compliance.

This book is a timely resource for anyone involved in the transformation of industry and urban systems. It provides a comprehensive overview of the technologies, methodologies, and strategies driving Industry 5.0, along with practical recommendations for addressing the associated challenges and opportunities.

Whether you are a researcher, industry professional, or policymaker, this book equips you with the knowledge and insights needed to thrive in this new era.

As we advance into this new industrial revolution, understanding the forces shaping our world and preparing for the challenges and opportunities ahead is vital. This book is not only a guide to the technologies and methodologies of Industry 5.0 but also a call to action for those who wish to lead in this transformative era. By embracing the innovations and strategies discussed here, readers can contribute to the development of systems that are more efficient, resilient, and human centred.

Industry 5.0 offers a bold vision for the future – one where technology and human intelligence converge to create systems that are not only efficient and flexible but also sustainable. This book is an invaluable resource for those who want to be part of this transformation, providing a comprehensive analysis of the key components of Industry 5.0 and their implications for the future of industry and urban life.

This book's exploration of the transition to Industry 5.0, focussing on microservice architectures, digital twins, and their impact on industries like insurance, carries significant implications for society and the economy. Through its detailed analysis, this book can shape how businesses, governments, and individuals navigate the evolving industrial landscape. By promoting the adoption of microservices and digital twins, it plays a crucial role in economic transformation, fostering the creation of agile and resilient industries essential for sustaining growth in a rapidly changing technological environment.

This book also addresses the transformation of the job market, highlighting the importance of reskilling and upskilling to prepare the workforce for new roles emerging from AI, Internet of Things (IoT), and robotics. In urban development and infrastructure resilience, its advocacy for digital twins is particularly impactful, enhancing disaster preparedness and reducing the economic and human costs associated with natural disasters. Furthermore, its insights into the financial and insurance sectors underscore its economic significance, showing how AI and blockchain can improve transparency, reduce fraud, and strengthen the resilience of financial institutions.

Ethical considerations and regulatory compliance are key themes, reflecting the growing importance of these issues as advanced technologies become more integrated into society. This book offers guidance on implementing these technologies transparently and fairly, ensuring public trust and preventing misuse. It also provides valuable insights for policymakers and regulators, influencing the development of regulations that balance innovation with the protection of public interests.

This book is among the first to deeply explore Industry 5.0, focussing on the human–machine collaboration that defines this new era. It uniquely combines technical guidance with strategic insights, particularly in its analysis of the transition from monolithic to microservice-oriented architectures. Its exploration of digital twins in urban and industrial contexts, especially within smart cities and disaster management, offers new solutions to persistent challenges in urbanisation and sustainability.

The focus on the insurance industry's transformation under Industry 5.0 addresses a gap in the literature, examining the implications of AI, blockchain, and cyber–physical systems. This focus is crucial for understanding how these technologies reshape the financial sector and maintain its stability. This book also distinguishes itself through its forward-looking ethical analysis, providing practical recommendations for navigating the regulatory challenges posed by Industry 5.0 technologies.

Finally, the inclusion of practical implications and case studies offers readers actionable insights that set this book apart from others in the field. By combining theoretical depth with practical applications, it provides a holistic view essential for understanding and navigating the complexities of the future industrial landscape, making it a valuable resource for researchers, industry professionals, and policymakers alike.

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Preface

Industry 5.0 ushers in a transformative era where the fusion of human creativity and advanced technologies form systems that are highly efficient, adaptable, and attuned to human and environmental needs. This book delves into the broad implications of this new industrial revolution, providing in-depth analyses of the evolving landscape of industrial and urban development.

Central to Industry 5.0 is the seamless integration of artificial intelligence (AI), machine learning, robotics, and the Internet of Things, which collectively drive the shift from traditional systems to more agile frameworks. This book begins by examining the critical transition from monolithic to micro-service-oriented architectures – a shift that is essential for organisations seeking to excel in this dynamic environment. This move allows companies to better respond to the demands of the modern industrial world by enhancing flexibility, scalability, and fault tolerance.

Further, this book introduces the concept of digital twins – digital replicas of physical entities that enable real-time monitoring, simulation, and optimisation. These digital twins are increasingly pivotal in urban planning and disaster management, equipping planners and decision-makers with the tools needed to anticipate and mitigate the impacts of natural disasters. Beyond urban applications, digital twins play a crucial role in the construction industry by streamlining project management, boosting sustainability, and improving overall efficiency.

The exploration of Industry 5.0's impact extends to critical sectors such as insurance. This book delves into how this revolution is reshaping the insurance industry, particularly in internal controls and risk management. As these companies face challenges posed by emerging technologies like AI, blockchain, and cyber–physical systems, the need for robust internal controls becomes evident. These controls are essential for maintaining financial integrity, ensuring compliance, and safeguarding policyholder interests in an increasingly complex world.

In addition to these technological advancements, this book underscores the importance of ethical considerations and regulatory compliance. As AI and other technologies become more integral to business processes, the potential for ethical dilemmas and regulatory challenges grows. It provides practical guidance on navigating these challenges while upholding ethical standards and regulatory requirements.

All in all, this book serves as a comprehensive resource for understanding the profound changes brought about by Industry 5.0. It offers a detailed examination of the technologies, methodologies, and strategies shaping the future of industry

and urban development. By presenting a balanced view of both opportunities and challenges, this book equips readers with the insights necessary to thrive in this new era.

Whether you are a researcher, industry professional, or policymaker, this book offers the tools and perspectives needed to navigate the complexities of Industry 5.0. As we stand at the brink of a new industrial revolution, understanding the driving forces and preparing to embrace the future with confidence is crucial.

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Brief Summary

Industry 5.0, also known as the fifth industrial revolution, is characterised by the use of advanced technologies such as artificial intelligence (AI), the Internet of Things (IoT), and robotics in manufacturing and other industries. These technologies have the potential to improve a wide range of business operations, from production and logistics to supply chain management and customer service. Some potential benefits of Industry 5.0 technologies for businesses include increased efficiency and productivity, improved product quality, and the ability to create new products and services. In addition, these technologies help businesses to reduce their environmental impact and operate more sustainably. Ultimately, the adoption of Industry 5.0 technologies gives businesses a competitive edge and helps them to remain relevant in a rapidly changing business landscape. The use of innovative technologies in Industry 5.0 can bring several benefits to companies and the industrial sector as a whole.

Some of these benefits include:

Improved efficiency and productivity: The automation of production processes and the use of advanced technologies such as AI and machine learning (ML) help companies improve their operations and increase their productivity.

Increased competitiveness: The use of new technologies can help companies stay competitive in an increasingly global market. By adopting Industry 5.0 technologies, companies can improve their operations and offer more advanced and high-quality products and services.

Enhanced worker safety: The use of robotics and other advanced technologies can help reduce the risks of accidents and injuries in the workplace, making it safer for workers.

Improved decision-making: The use of big data analytics and other technologies can help companies collect and analyse large amounts of data, allowing them to make more informed and data-driven decisions.

Overall, the use of Industry 5.0 technologies helps companies improve their operations and remain competitive in a rapidly changing global market. This book brings together experts from different disciplines and shows how, where, and

in which ways these disciplines can be applied with a focus on Industry 5.0. In this context, ML, blockchain and smart contracts, robotic applications, autonomous control units and systems, smart finance applications, smart cities and control systems, smart healthcare, supply chain management systems, business analytics, digital society, cloud systems, smart agriculture applications, manufacturing process optimisation, mass customisation, cyber–physical systems, Industry 5.0 applications in higher education, and digital twins are discussed.

Overview of This Book

This book first introduces the concept of Industry 5.0. In addition, it describes the development of Industry 5.0 and the current technologies within this concept. Second, it introduces technologies that will provide sustainable competitive advantage to businesses in different sectors with a focus on Industry 5.0. Finally, this book discusses current technologies that can be used within the scope of Industry 5.0 and their applications in different disciplines. For this, it discusses concepts such as ML, blockchain and smart contracts, robotic applications, autonomous control units and systems, smart finance applications, smart cities and control systems, smart healthcare, supply chain management systems, business analytics, digital society, cloud systems, smart agriculture applications, manufacturing process optimisation, mass customisation, cyber–physical systems, Industry 5.0 applications in higher education, and digital twins.

Overview of the Chapters

This book on Industry 5.0 covers various aspects of the emerging industrial paradigm through 12 insightful chapters.

Chapter 1 introduces Industry 5.0, emphasising its human-centric and sustainable approach, contrasting it with Industry 4.0.

Chapter 2 explores the role of blockchain and distributed ledger technologies in enabling mass customisation, hyper-personalisation, and secure processes in Industry 5.0.

Chapter 3 discusses the application of digital twins in predicting and mitigating natural disaster impacts, using the Bolu Province Health Building as a case study.

Chapter 4 examines the transformative potential of AI in healthcare, emphasising personalised medicine and intelligent diagnostics under Industry 5.0.

Chapter 5 analyses the impact of Industry 5.0 technologies on distance learning, highlighting the need for personalised, interactive, and effective educational environments.

Chapter 6 outlines the development of advanced automation systems, focussing on enhancing human–machine cooperation and intelligent manufacturing within Industry 5.0.

Chapter 7 evaluates methods for transitioning from legacy monolithic architectures to microservice-oriented architectures, essential for Industry 5.0's complex demands.

Chapter 8 explores AI-assisted forecasting and modelling approaches in finance, particularly in bankruptcy prediction models for the banking industry.

Chapter 9 examines the integration of smart agriculture and supply chain management systems in Turkey's agricultural sector under Industry 5.0.

Chapter 10 discusses the hotel industry's transition from digital production to a digital society, emphasising the need for cybersecurity, ethical AI, and a skilled digital workforce.

Chapter 11 analyses the challenges and opportunities for developing internal controls in the insurance industry within the context of Industry 5.0.

Chapter 12 investigates Nvidia's contributions to Industry 5.0, focussing on their key technologies like graphics processing units, the Omniverse platform, and humanoid robot technology.

Chapter 1

Introduction of Industry 5.0

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Abstract

Purpose: Industry 5.0 is a revolution building on the fourth industrial revolution, adopting human-centred production. It aims for a future that enables people to live with high welfare power by combining the power of the technologies it supports and uses with human creativity and skill. The study explores how Industry 5.0 differs from the industrial revolutions that preceded it, highlighting the challenges, benefits, and possible future trends of Industry 5.0 systems.

Need for the study: Industry 5.0 differs from Industry 4.0 – it represents a human-centred and sustainable approach along with the innovations it brings. Examination of the still emerging concept of Industry 5.0 and to investigate the driving forces behind the emergence is needed.

Methodology: The characteristics that distinguish the Industry 5.0 system from the fourth industrial revolution are explored in detail. The areas in which the technologies used in Industry 5.0 provide benefits and the challenges in implementing the system are analysed. The measures to be taken to overcome these difficulties and the deficiencies were investigated.

Findings: The most important principle of Industry 5.0 is human-centred production and technology. In addition, sustainability, personalised production, new business opportunities, more environmentally friendly and renewable energy use, and bioeconomy are shown as innovations brought by Industry 5.0.

Business Challenges and Opportunities in the Era of Industry 5.0
Emerald Studies in Finance, Insurance, and Risk Management, 1–18

doi:10.1108/978-1-83549-676-320251001

Practical implications: The adoption of Industry 5.0 appears to be a mandatory change. In addition, the study emphasises the measures that businesses should take in terms of sustainability, sustainable economy, the importance of the use of renewable energy sources, and much more environmentally friendly and waste-free production.

Keywords: Industry 5.0; sustainability; internet of things; human–machine collaboration; big data analytics

JEL classifications: O30; O31; O32; O36; Q55; Q56

1. Introduction

In our constantly changing and developing world, mankind has always been in constant search for new things since the formation of various civilisations. In these searches, it has undoubtedly pushed mankind to new technological inventions that facilitate the daily work of mankind, always thinking one step ahead. In the old societies, especially in the process that started with the replacement of ignorance by science, technological innovations developed with conceptual differences, and in the following years, especially in the 1860s, the concept of industrial industrialisation emerged in the 1860s, the technology began to enter human life and spread as a wave over the past centuries. This wave, which started with Industrial Revolution 1.0, has started industrial revolutions that are now divided into different categories with production and continuously developing technological processes.

Before moving on to the Industry 5.0 revolution, it is necessary to look at what innovations came in the industrial revolutions before this period. The stages of the industrial revolution are given in Fig. 1.1. In the Industry 1.0 era, which emerged at the end of the 18th century, industrial production began to change significantly and drastically with the introduction of water and steam technology into people's lives. This period, also known as the first industrial revolution, was the era of transition from mechanically obtained agricultural economies to production using machines. In this period, significant innovations in industrial development occurred with the invention of steam-powered engines. The availability

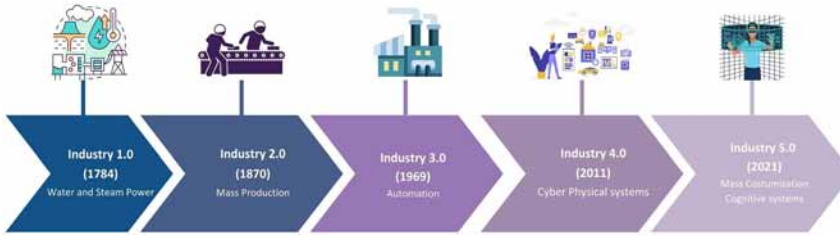

Fig. 1.1. Evolution of Industry. *Source*: Adapted from Gomathi et al. (2023).

of water and steam power technology has greatly changed the industrial fields such as mining, textile, agriculture, etc. (Demir & Cicibaş, 2019). In the Industry 2.0 era that emerged in the following periods, machines started to take over the human power, and this period appeared as economic growth for countries. Especially in this period, technological developments such as internal combustion engine, production and assembly line, and electricity have led to major changes in production processes (Nahavandi, 2019).

The Industry 3.0 era, also known as the third industrial revolution, started towards the end of the 20th century with the inclusion of computer and automation systems in production, where technology has become much more prominent. In this period, digital systems have assumed a central role in managing and controlling production and in the decision-making of managers. From this point of view, this period can actually be defined as a revolution in which the digital age began because in this era, the use of integrated circuit chips in mass production in factories, programmable circuit systems with the widespread use of the internet, and computer automation systems of programmable circuit systems and controls have been the beginning of the era of smart factories (Khan et al., 2023).

In the Industry 4.0 era, a transition to cyber–physical systems has been made with the use of digital technologies, data analytics, business intelligence, and artificial intelligence in industrial production, and the era of decision-making based on data science has begun thanks to these systems. Especially in this era, technological developments such as the internet of things (IoT), artificial intelligence, machine learning, deep learning, robotics, and cloud computing have been integrated into smart and autonomous systems, enabling much higher levels of efficiency and autonomous decision-making in the production value chain. In addition, Industry 4.0 has enabled the interconnection of computers and related autonomous systems, machines, and materials with artificial intelligence by requiring minimum human power in decision-making (Huang et al., 2022). Today, the 21st-century era can now be considered as the Industry 5.0 era. This age is now the age of human-centred automation. Artificial intelligence, which replaces humans with Industry 4.0, now refers to the harmonious coexistence and cooperation between humans and advanced technological data in today's age. While automation has become a part of our lives, Industry 5.0 has recognised that human creativity, intuition, problem-solving, and decision-making ability are indispensable. Especially in this age, with the use of human and robot (collaborative robot) technology, especially in smart factories, production has become much more technological, much more sustainable, and much more human centred (Adel, 2022; Grabowska et al., 2022).

In this study, the current status, future, implementation challenges, and benefits of Industry 5.0 are explained in detail. In the first part of this study, basic concepts related to Industry 5.0 are given. In this section, the events that occurred in the other industrial revolutions are given in detail. In the second part of this study, especially the literature review on Industry 5.0 is given. In the third part, Industry 5.0 is explained in more detail, and its differences from previous Industry 4.0 are explained. In the same section, the benefits of the system for the enterprises

that will use Industry 5.0 technologies and the difficulties in implementation are given in items. In the fourth part of this study, the technologies supported by Industry 5.0 and the technologies to be used in this revolution are explained separately. In the final part of this study, the current status of Industry 5.0, which is the last stage of the industrial revolution, is discussed, and suggestions are made regarding the possible future challenges and their solutions.

2. Literature Review

Industry 5.0 is a concept that enables human-oriented production in industries and facilitates the integration of sustainable and more powerful technological systems into production. The concept of Industry 5.0 was introduced a few years ago, and a lot of research has been done on it. In particular, researchers are still conducting extensive studies on the future of this new industrial revolution, the difficulties in passing through other industrial revolutions, and the innovative technologies used in this revolution.

In one of these studies (Kasinathan et al., 2022), Industry 5.0 and Society 5.0 concepts were compared, and the role of Industry 5.0 in achieving sustainable development goals was investigated. The study describes a scenario of smart cities and villages where the possibility of achieving sustainability goals is more meaningful and draws a framework in which new technologies are used to fully embed the concepts of Industry 5.0 and Society 5.0 in smart cities and villages. In addition, this study analysed the result of using disruptive technologies through product development, transformation in health services, smart cities and villages. It is stated that the data obtained as a result of the study will help industrialists, politicians, and researchers. Another study (Javaid et al., 2020) focussed on the improvement created by Industry 5.0 technologies in the health sector. It was stated that Industry 5.0 technologies used in the recovery processes of Covid-19 patients, especially during the pandemic period, gave positive results in personalised therapy and treatment processes. In addition, it was concluded that patient demands were responded much faster with these new technologies used as a result of the study, and the Covid-19 virus was followed in crowded places where face-to-face communication is high. Gagnidze (2023), on the other hand, created various prediction scenarios regarding the challenges of Industry 5.0 and 4.0 and stated that clusters can cope with these challenges and can be a driving force in the development of the economy. For this purpose, the author graphically presented the developmental aspect of digitalisation within clusters and examined it with the approach developed by him. Dwivedi et al. (2023) drew attention to the gap in this field by addressing the circular supply chain and Industry 5.0 drivers together. In the study, it is stated that the approaches of these two concepts are effective in the adoption of technologies used in Industry 5.0 and circular supply chain management and in achieving sustainability goals in a highly competitive and sustainable environment. As a result of the study, a mixed model was created using the interpretive model and the cross-effect matrix product applied to the classification and the importance of this proposed new model was explained. In another study (Rane, 2023), various applications provided

by Vision Transformers (ViTs) in Industry 5.0, Industry 4.0, and Society 5.0 and the challenges in these applications were investigated. In the study, the challenges encountered in areas such as production, health, education, retail, retail, building industry, transport and agriculture and the role of ViTs in these situations; Industry 5.0, Industry 5.0 and Industry 4.0 were examined separately under the headings Industry 5.0, Industry 4.0 and Industry 4.0 and various results were obtained. According to these results, the understanding of complex image information is provided by Industry 4.0 technologies. Thanks to the human–machine collaboration in the Industry 5.0 era, images can safely benefit from ViTs, and finally, the models obtained in Society 5.0 help to create inclusive and sustainable smart communities such as health, education, and urban planning.

In another study (George & Hovan George, 2023), the effects of the promises and challenges of Industry 5.0 on the manufacturing industry and society were investigated. In the study, the future innovation expectations of Industry 5.0 are explained such as efficiency, productivity, reliability, sustainability, and the use of renewable energy sources. The difficulties that Industry 5.0 will bring, difficulties such as the integration of different technological systems, investment for the technical infrastructure required for hardware and software, and difficulties in finding highly skilled labour force, were discussed, and case studies were made by giving examples from companies that implemented Industry 5.0. Gomathi et al. (2023) examined potential Industry 5.0 technologies in the healthcare sector. In the study, it is stated that personalised medicine, more advanced diagnostics, telemedicine, and patient-oriented care are realised with advanced technological applications such as artificial intelligence, big data analytics, and robotics, while they concluded that problems such as data security, interoperability, ethical considerations, workforce characteristics, cost, and infrastructure need to be solved. In another study (Sharma et al., 2022), the obstacles encountered in the use of Industry 5.0 technologies in the pharmaceutical manufacturing sector in Germany and related solutions were explained. In the research, sustainable supply chain management and Industry 5.0 applications are discussed in line with the views of German industry experts in the pharmaceutical sector. According to the study, the most critical challenge in the transition to Industry 5.0 is the confusion between real and virtual reality. The study also concludes that the lack of standardisation and fair benchmarking policy regarding Industry 5.0 are barriers to the use of new technologies.

Adel (2022) investigated the opportunities, possible future technologies, and research expectations in the transition from Industry 4.0 to Industry 5.0. The study provides information about the applications in Industry 5.0 and the technologies required by this revolution. In particular, technologies used in this period include big data analytics, digital twins, blockchain technology, collaborative robots, 6G systems, and technologies such as health services and supply chain cloud production. The research also includes challenges and issues in organisations in human–robot interaction.

In a study describing the importance of Industry 5.0 to human beings (Orlova, 2021), the personalisation feature of Industry 5.0 is explained through human–machine cooperation. The study applied the corporate human capital assessment

(CHCM) in the focus of Industry 5.0 technologies thanks to the new opportunities that come with digital transformation. As a result of the research, the innovations brought by CHCM were explained as the emergence of new human-centred professions, the use of employee evaluation both quantitatively and qualitatively, and the creation of professional development of employees.

3. What Is Industry 5.0? What Are the Differences from Industry 4.0?

Industry 5.0 is mainly driven by changes in the relationships between people and intelligent systems (Nahavandi, 2019). This new industrial age consists of basic principles such as human-centred production, system flexibility, sustainability, and collaborative intelligence. Human-centred manufacturing refers to the idea that industrial systems should be designed based on human needs and capabilities (Leng et al., 2022). System resilience and sustainability ensure that industrial systems are resilient to technological challenges while minimising environmental impact and contributing to the sustainable development goals of a super-smart society. Collaborative intelligence refers to the ability of workflows to work together with intelligent systems and support decision-makers in intensive production (Grabowska et al., 2022). Thanks to this cooperation, human creativity and brainpower work together with the capabilities of intelligent systems, resulting in much more efficient production. Industry 5.0 is based on factors such as the harmonisation of knowledge and skills supported by the interaction of machines, people, work, and tasks. This harmony facilitates the emergence of personalised products and services to meet the different needs of each customer, facilitating the transition to a much happier and more spacious social order (Barata & Kayser, 2023).

The focus of Industry 5.0 is to place the well-being of workers at the centre of the production process and aims to achieve societal goals beyond employment and economic growth, including the creation of a robust and resilient welfare provider in the industrial community of the future. This is not only an industrial improvement but also a vision that goes beyond technological progress and aims to increase the thinking and production capacity of people and to achieve balance in the economic context (Xu et al., 2021).

Industry 4.0 aims to provide various services and production using super-intelligent computers to automate processes. The focus is to increase process efficiency in work and workflow charts by ignoring manpower and costs. With the full implementation of Industry 4.0 in all processes, this will be a serious problem in the next few years (Akundi et al., 2022). The benefits of the Industry 5.0 era to the industrial society can be listed as follows (Müller, 2020):

- The constant disregard of human labour and its cost will attract the attention of labour unions, and all the features of Industry 4.0 will not be used efficiently. The solution to this situation is assumed to be the Industry 5.0 era and the innovations it brings, which are expected to be used much more in

the coming years. The fifth industrial revolution brings back manpower to factories and production centres and increases productivity and creativity by ensuring human–machine cooperation.

- While the main concern of Industry 4.0 is automation systems, the aim of Industry 5.0 is for collaborative systems between humans and machines to work together properly. This situation accelerates the transition to an efficient and high value-added production process that reduces costs, especially when manpower and robots work side by side with each other.
- With Industry 5.0, the definition of the word 'robot' has changed. Robots have gone beyond being a programmable machine that can perform continuously renewable tasks and have become the companion of the human figure for some situations. In this revolution, humans are no longer replaced by robots but by collaborative robots that work efficiently with each other. These collaborative robots will be aware of humans, observe how humans perform tasks, and benefit from human experience.
- One of the most important benefits of Industry 5.0 is the issue of environmental pollution, which is ignored in Industry 4.0. When Industry 5.0 is compared to other existing industrial revolutions, its purpose is to offer much greener ecological solutions than other industrial revolutions. From this point of view, wastes in the society and industrial field can be categorised under four headings. These are physical waste, urban waste, process waste, and social waste consisting of unwilling people who do not want to work but only occupy space in the company. Industry 5.0 is of great importance in terms of developing a perspective to prevent these four types of waste and reducing manufacturing-related expenditures and costs.
- Thanks to predictive data analytics and business intelligence used in this era, more stable decisions are made.
- When looking at all processes that are ready for change with Industry 5.0, it is ensured that productivity and profitability increase, providing a much more sensitive working environment and reducing overall costs.
- Again, when the main centre of Industry 5.0 is human and society-oriented business processes, people spare time for themselves by supporting technological developments without fear of losing their jobs. In this period, more open-minded and forward-thinking employees are trained with new human-centred business models.
- The four types of waste prevention activities described above to ensure sustainable production, reduce costs, and better communicate with the society by protecting the environment are more prominent with Industry 5.0.

Industry 5.0 is defined as a significant change in the field of service and production. In this new era, unlike other revolutions, automation and efficiency have begun with the arrival and integration of collaborative robots into advanced production lines, largely with the human touch. These robots are designed to work together with humans and take their capabilities and bring a much more productive, sustainable, and human-oriented industry. From this point of view, it can be

said that Industry 5.0 plays a complementary role in Industry 4.0. However, the basic tendency of Industry 5.0 is to provide a common working environment for the human–robot–machine trio, and as a result, it is seen that it strives to create a much smarter society (Demir & Cicibaş, 2019). In Table 1.1, the systematic differences between Industry 4.0 and 5.0, objectives, environmental factors, and technologies used and likely to be used are given in a comparative manner.

As can be seen in Table 1.1, the main purpose of Industry 4.0 is to invest in the future with smart production. In this context, it is to switch to mass production in order to increase productivity in production with innovative technologies. In fact, for this purpose, it is similar to the revolutions that came before it. In this period, especially the IoT, cloud computing, robotics, big data, and artificial intelligence technologies are trending technologies used in Industry 4.0 but not only in this period. As for Industry 5.0, the main goal of this revolution is to ensure human–robot cooperation. With Industry 4.0, the phenomenon of decreasing manpower has been replaced by manpower in this period. Robots will take into account the manpower and will benefit from their abilities and help people in decision-making. The basis is to develop a smart and sustainable

Table 1.1. Comparison of Industry 5.0 and Industry 4.0.

Industry 4.0	**Industry 5.0**
– Smart factories – smart production – System optimisation	– Human–robot cooperation – bioeconomy – Social benefit
– Mass production	– Smart society – sustainability
– Electric power – Fossil fuels – Renewable energy	– Electrical power – Renewable energy sources
– IoT – Cloud computing – Big data analysis – Artificial intelligence – Automation – Machine-to-machine communication	– Human–robot collaboration – Renewable resources – Human–machine interaction – Technologies that can detect physical and mental fatigue – Intelligent decision support systems
– Research areas ❍ Organisational research ❍ Developing and improving business processes ❍ Business administration	– Research areas ❍ Agriculture ❍ Biology ❍ Waste prevention ❍ Organisational research ❍ Improvement and development of processes ❍ Business administration

Source: Adapted from Akundi et al. (2022).