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Transitioning from Industry 4.0 to Society 5.0: Opportunities and Challenges, a Literature Review

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Abstract

Increased operational efficiency and the creation and implementation of new business models, services, and products ushered in the age of Industry 4.0, which in turn changed manufacturing and production processes. In particular, the goal for Industry 4.0 was to increase the manufacturing systems' efficiency and sustainability. Furthermore, system digitization and digitalization were prioritised, opening up possibilities for future development. The present technological progress, however, is focused more on systems and machines than on humans. Therefore, several nations have already started coordinating efforts to create Industry 5.0, which centres on creating technology, systems, and services with people in mind. Society as a whole will be affected by the changes brought about by Industry 5.0, and a new society, Society 5.0, will be born as a result. Industry 4.0 advancements will prioritise making their new tools and technology more socially and human-cantered. Consequently, the next phase of industrial development, dubbed "Industry 5.0," will place a premium on promoting environmental and human health and wellness. Human-centered, resilient, and sustainable design will be at the forefront of Industry 5.0, building on the groundwork provided by the previous iteration. Therefore, the authors of this study want to present sufficient reasons for adopting Industry 5.0 as a framework for allowing industry and rising society trends and requirements to coexist by conducting a critical literature assessment. This study is significant because it contributes a framework that may help with the evolution from Industry 4.0 to Society 5.0.

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Keywords: Industry 5.0; Society 5.0; human-centricity; resilience; sustainability

INTRODUCTION

Since the beginning of the Industrial Revolution, people have known that technology may serve as a tool for progress (Industry 1.0). Production of mechanical power from low-tech sources like water, steam, and fossil fuels marked the beginning of the First Industrial Revolution around the tail end of the eighteenth (18) century. During the second such revolution, which occurred in the 1870s, industrialists who employed assembly lines and mass manufacturing chose electrical energy (Industry 2.0). In the 1970s, during the Third Industrial Revolution (Industry 3.0), the idea of integrating automation to manufacturing industries via the use of electronics and Information Technologies was first proposed (IT). Smart Cyber-Physical Systems (CPS) in Industry 4.0 are realised with the use of IoT, cloud computing, and AI to bridge the gap between the digital and physical worlds in real time [1,2]. A decade of fast change in technology, industry, and social patterns and processes are conceptualised under the umbrella term "Industry 4.0," which is driven by technical advancements. Industry 4.0 (I4.0) is a framework that encourages increased production efficiency and better product and service quality via the development and use of foundational technologies like big data analytics, artificial intelligence (AI), and digital twins [3, 4]. The engineers behind Industry 4.0 have prioritised industrial flexibility and efficiency above industrial sustainability and worker welfare [4], thus although there have been many advancements and prospects revealed within its framework, there are also some restrictions. Therefore, a whole new age of industrial revolution is just around the corner. Engineers will be able to socialise factories and make better use of the present technology environment in this new age (see Social Factories). There are now multiple nations working towards the formation of the aforementioned human-centric period, widely known as Industry 5.0, a phrase extending to Society 5.0 as well. These countries include the European Union, Japan, and the United States. There is a common misunderstanding that Industry 5.0 will not be recognised as a separate industrial revolution since it is part of the larger technical progression known as "Industry 4.0," which is still in progress. This is a debatable but important topic that has been addressed by the current study.

The 5.0 Industrial Revolution

The Fifth Industrial Revolution, also known as Industry 5.0 (I5.0), would incorporate autonomous production with human intelligence and AI as a backbone technology, in and on

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the loop, even if Industry 4.0 has not yet been completely integrated globally [5]. (see Figure 1). In addition, it is anticipated that by 2027, there will be 5.85 billion social media users, up from 4.59 billion in 2022, as a result of the Internet's and associated technologies' explosive expansion [6].

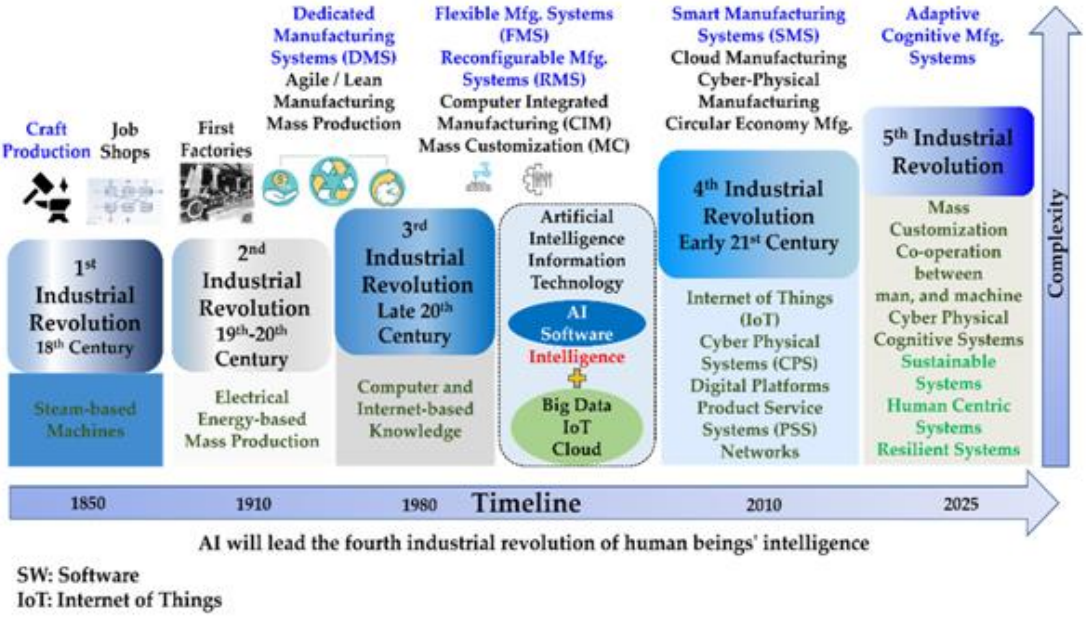

Figure 1. Industrial Revolutions with key milestones and significance of AI towards human beings' intelligence (derived from [7,8]).

Society 5.0

I5.0 [9] has steadily acquired greater attention over the last several years as a human-centric design approach that seeks to overcome the issues revealed by Industry 4.0 by having people and cobots engage in a shared working environment. In addition, a similar concept called Society 5.0 (S5.0) [10] comes into view in these years to solve the problems in current society; it is a futuristic super-smart society in which everyone can enjoy high-quality and comfortable lives through the merger of cyberspace and physical space via the optimal application of information and communication technology (Information and Communication Technology). The Japanese government formulated the strategy in response to similar initiatives in other countries, such as Made in China 2025 and I4.0 in China and Europe. When AI is taught to reason and drive organisational processes autonomously, which is expected to happen around 2030 [10], I5.0 will also occur. The CPS established in I4.0 [11] is expected to facilitate further development in the interplay between humans and machines in Society 5.0. People need to have healthy perspectives about technology [12] if we're going to see progress in all areas of

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society (including education, health, democracy, and the economy). Concerns about the potential negative effects of AI on human society (including but not limited to job loss, ethical and practical concerns about the transfer of responsibility from humans to machines, social control, and algorithmic blunders) are raised by this topic [13].

The Paper's Objective and the Key Research Questions

However, there is a lack of online literature that addresses both Industry 5.0 and Society 5.0 concurrently, despite the fact that both are developing phenomena that have been studied at a high degree of abstraction thus far. To that end, the following is a synopsis of this review paper's goals and its contributions to the body of knowledge:

Original I5.0 and S5.0 definitions are provided.

Edge computing (EC), digital twins (DT), collaborative robots (CR), Internet of Everything (IoE), big data analytics (BDaaS), blockchain, product service systems (PSS), the metaverse, and more are just some of the technologies that will allow Industry 5.0 and Smart Factory 5.0.

Applications like as supply chain management, intelligent healthcare, cloud manufacturing, manufacturing production, and many more are discussed in detail, along with their place in the future of Industry 5.0.

For the sake of obtaining I5.0 and S5.0, highlighting interesting research paths is a necessary step.

These competing paradigms might, then, be seen as two competing visions for the future of industry and society. In view of the anticipated societal changes brought about by technology progress, the following study question has been developed. Therefore, the question "which essential technical advancements allow the transition from Society 4.0 and Industry 4.0 to Society 5.0 and Industry 5.0?" arises as a topic for study. In addition, the writers of this review article make an effort to answer the following questions:

1. In order to guarantee robustness and the development of social value, which primary criteria should one concentrate on for I5.0 and S5.0?

2. What are the most important technical enablers of I5.0 and S5.0 that make it possible for humans and technology to work together effectively?

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3. Is it possible to regard Industry 5.0 and Society 5.0 as a framework for facilitating the coexistence of rising social trends and requirements with existing industrial practises?

Organizing the Paperwork

The remainder of the paper will be organised as described in the following paragraphs. In Section 2, the technique for doing the literature study is provided and explored. This is followed by a discussion of the definitions of Industry 5.0 and Society 5.0 that are considered to be the most prevalent. The discussion then moves on to Section 3, where the function of Industry 5.0 within the framework of Society 5.0 is examined. The next section, Section 4, is devoted to investigating the Factories of the Future. Following the presentation of the findings of the literature review in the parts that came before Section 5, there is a brief discussion. In addition, the study effort is brought to a close in Section 5, after which a conceptual framework is presented, and a discussion of potential future research areas is undertaken.

The Current State of the Art

Review Methodology

All of the scholarly papers utilised in this bibliometric study were retrieved from the massive database Scopus. However, the same search query was also conducted to other significant databases like Web of Science and Science Direct in order to include peer-reviewed papers from those sources as well. Google Scholar and Web of Science were both queried using the same terms. In the month of July 2022, an internet search was done using the following search query: TITLE-ABS-KEY (Industry 4.0 AND Society 5.0 OR Industry 5.0 AND Society 5.0) AND PUBYEAR > 2015 AND PUBYEAR > 2015. Journals, conference proceedings, key terms, and publication years were searched for in the specialised literature. From that first query, we were able to pull up 114 publications about scientific literacy. There were 57 articles published in journals, 45 papers presented at conferences, 7 chapters in books, 3 reviews, 1 conference review, and 1 book. Not only that, but the bulk of works published on the subject may be classified as either computer science, engineering, or social science. Although newspaper articles and reports were initially included in the dataset, they were later removed in order to restrict the search query and include only high-quality research publications. Furthermore, a custom Python script was used to analyse the dataset, removing duplicates and tabulating the results. In terms of a time frame, talks and publications on Industry 5.0 and

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Society 5.0 were initially made available online to the research community in 2015, particularly from the Japanese Government. There will be no results for "Industry 5.0" or "Society 5.0" beyond the year 2015. However, some papers from the aforementioned time period (i.e., 2010-2022) were included since Industry 5.0 would substantially depend on the achievements achieved within the framework of Industry 4.0. While the year 2022 is still young, the text does feature a number of studies (over 15) that examine recent breakthroughs in the subject. The purpose of a state-of-the-art inquiry is, therefore, to keep up with the most current developments, to shed light on issues and gaps in the literature, and thus include these research works makes that possible.

After that, the dataset containing the findings was reformatted using the Comma Separated Values (CSV) format so that it could be processed further. The VOSviewer programme was used in an effort to both see the data and conduct an analysis of the bibliometric shape that they took. In a more concrete sense, VOSviewer is equipped with the functionality of creating a keyword map based on shared networks. As a result, it is capable of creating maps with multiple items, as well as publication maps, country maps, journal maps based on networks (co-citation), and maps with multiple publications. It is possible to delete keywords that are less important, and the users may adjust the total amount of keywords that are utilised. In a nutshell, the VOSviewer programme offers help for data mining, mapping, and grouping of articles that are obtained from scientific databases. These features are described further below.

In bibliometric research, topic mapping is an extremely important step [14]. The several topic areas that are relevant to the overarching themes of scientific literacy are shown in Figure 2. Figure 3 shows one of the three distinct mapping representations that may be shown by VOSviewer as part of the bibliometric study.

The diversity of the studies conducted on the topic is shown in figure 3. Figure 3 is a visualisation that, in essence, acts as a heatmap to reveal the patterns that academics are focusing their attention on more often. As a consequence of this, based on the findings of the research, one can draw the conclusion that there is a great deal of debate pertaining to topics such as the Internet of Things (IoT), applications, humans, artificial intelligence (AI), transformation, economies, educational systems, and sustainable development.

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A clustering procedure was carried out in order to better arrange the important subjects in the report. After being analysed using the VOSviewer programme, the mapping of all of the subjects resulted in the formation of four (4) clusters, which are presented in Table 1.

The clusters make it easier to see the correlations that exist between the various themes, which in turn makes it simpler to analyse the data that were obtained. The thickness of the connecting line served as an indicator of the degree to which two subject areas or keywords were related to one another. In addition to the clusters and lines, the size of the nodes also displayed the frequency of the term or subject. Economy, Education, Application, Artificial Intelligence, and Condition were found to be the most often occurring topics or keywords, as shown in Figure 2. This suggests that during the years of 2015 and 2022, scholars focused the majority of their effort on these topics. In addition, nodes or keywords that are not connected to any other keywords may evolve into new study fields.

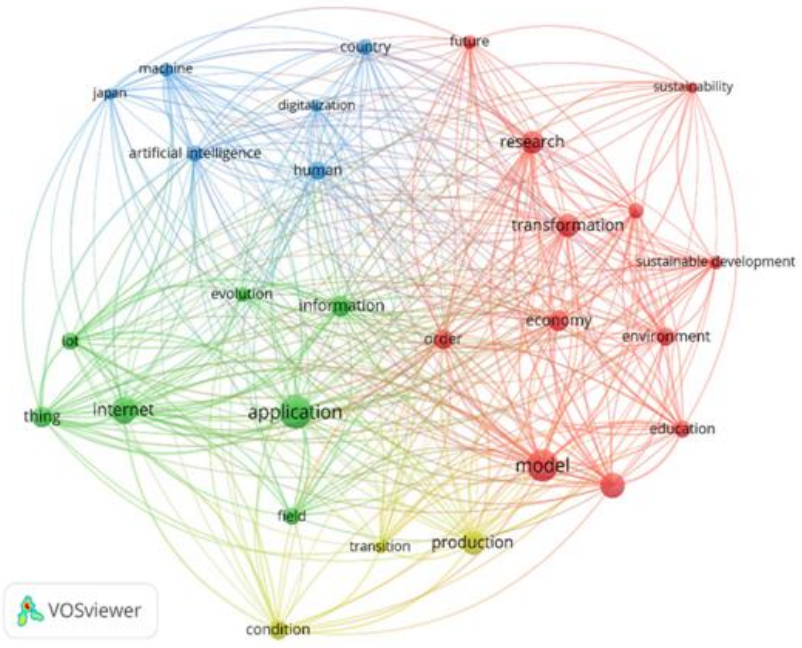

Figure 2. The Network Visualization of Literacy Topic Area.

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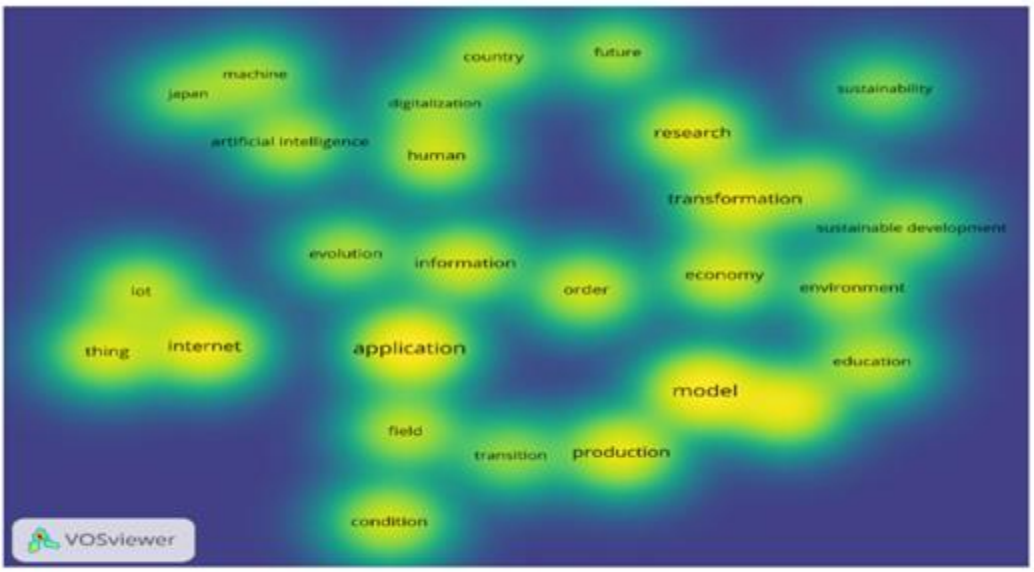

Figure 3. The density visualization of the scientific literacy topic areas.

Examine the Algorithm

The authors have constructed the technique that was used, and it is predicated on the usage of APIs (Application Programming Interface) that are given by scientific databases (including ScienceDirect, Scopus, and Web of Science). In further detail, the search algorithm makes use of three separate application programming interfaces (APIs) in order to search for publications and deliver results that are based on the search keywords that were entered by the user. An XML (eXtensible Markup Language) file is assembled and produced with the findings, which include the Title, the Year, the Abstract, and the Keywords.

The implementation of a recursive approach for excluding results took place. In further detail, the article's title was analysed using metrics derived from information theory. After that, an analysis was performed on the manuscript's Keywords, and lastly, the manuscript's Abstract was subjected to a third round of analysis. A final XML list was automatically created by the developed algorithm once the exclusion recursions were finished, and it was saved to the local storage media (such as a hard drive) so that users can locate the manuscripts and download them. This was done so that users can search for the manuscripts. At this point, it is important to emphasise that support has been added for a number of different query parameters in order to make it easier for users to refine the search queries they have entered. The method may be implemented as a self-contained programme that is designed specifically for usage on personal computers. The provision of an automatic download of papers that meet the criteria will be

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included in next versions. The application that was built is solely meant to be used for educational and research purposes. The employment of Machine Learning algorithms is the primary benefit of this search algorithm. These algorithms provide researchers the ability to expand the scope of their literature study and to raise the degree of detail when they are searching for information using the algorithm. In addition to the application programming interfaces (APIs), a web scraping module was also built in order to obtain valuable insights from websites via the usage of the internet. The capability of the web scraping algorithm to search for and extract information from non-scientific sources is one of the ways in which it adds value (e.g., think tanks, leading companies, etc.).

Table 1. Clusters as constructed by VOSviewer Software.

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Economy	Application	Artificial Intelligence	Condition
Education	Evolution	Digitalization	Production
Environment	Internet	Japan	Transition
Future	IoT	Human	
Implementation	Thing	Machine	
Innovation	Field	Country	
Sustainable Development	Information		
Sustainability			
Research			
Transformation			
Order			

The Concept of Industry 5.0 Definitions

The most essential definitions of Industry 5.0 are supplied in this part so that the discussion of Society 5.0 and its elements in the next section may take place in the appropriate environment. This discussion will take place in the following section.

The first definition is based on the findings of the study conducted by Breque and colleagues (20210. The authors believe that Industry 5.0 is a forward-thinking idea that looks to the future of industry in the direction of a manufacturing system that prioritises people, is sustainable, and is highly resilient (Breque et al., 2021). I5.0 is fast to act, robust, and respects the boundaries of the world while simultaneously cultivating talent, diversity, and empowerment [15]. This is made possible by technologies that are adaptive and agile.

According to the third definition supplied by [8], human and machine collaboration in the manufacturing improves process efficiency via the use of human ingenuity and the harnessing of automated technology.

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To apply new technology in industrial systems, business professionals, IT specialists, and philosophers will have to pay more attention to human issues, say Friedman and Hendry [17].

In the socially intelligent factory of the Fifth Industrial Revolution (Industry 5.0), cobots interact with humans using natural language. The Social Smart Factory [18] uses enterprise social networks to ensure that humans and CPPS parts can communicate effectively.

When taken together, the aforementioned concepts highlight the need of human-centered design, system resilience, and long-term sustainability. The bulk of the definitions of Industry 5.0 include a whole age of technology and sociological advancements, while the remainder of them concentrate more on the industrial transition, which is revealed upon deeper examination of the definitions.

Discourse Defined, Fifth Edition

To continue with the theme from before, this part will examine the most important definitions for Society 5.0. Figure 4 summarises the social revolutions based on the most salient features before defining Society 5.0. Evolution in both society and industry may be seen. When one considers the revolutions that have occurred inside business (as covered in Section 1), parallels to societal development become readily apparent. Thus, everything has been learned and imagined up to this point in Industry 4.0 forms the basis for the notion of Society 5.0.

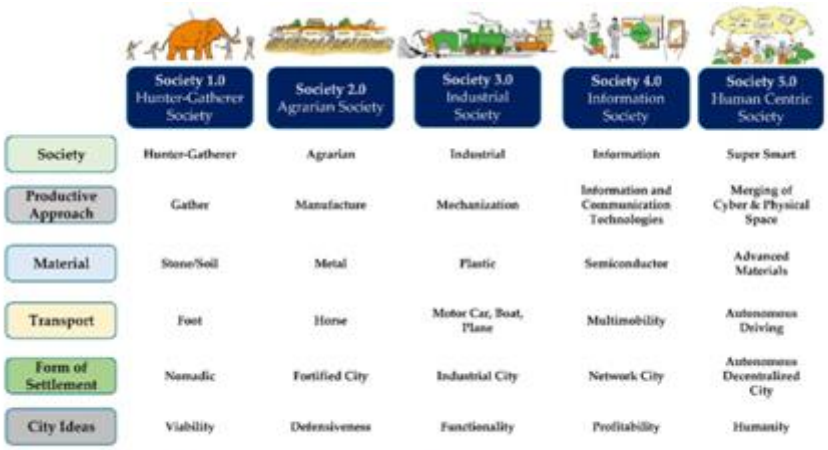

Figure 4. Societal evolutions categorized in key aspects.

As a response to the challenges facing the Japanese economy [19], the Japanese government first mentioned their vision of a human-centered society, "Society 5.0," in 2015. This society is characterised by a high degree of integration between cyberspace and physical space, which

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they believe will lead to economic growth and the solution of social problems. Natural catastrophes, terrorism, environmental concerns, a depleting natural resource base, and an increasingly elderly and smaller labour force are among the most pressing problems confronting modern civilization. Granrath's studies on Japan's Society 5.0 and beyond Industry 4.0 from 2017 [20] employ this technique.

The notion of Society 5.0, as put out by Serpa (in the MDPI encyclopaedia) [21], may be realised as a guide for social evolution and has the potential to have far-reaching effects on the existing social order at a variety of levels. Adopting the Smart Society paradigm will be crucial to social progress because of the positive effects it will have on people's standard of living and the health of the planet.

Society 5.0 is defined by authors Deguchi et al. in their book [22] as a highly intelligent society based on the creation, processing, and sharing of data and information through the linking of the physical world with cyberspace.

Similarly, Rojas et al. [23] of the year 2021 describe Society 5.0 as a "Superintelligent Society," using the technical gains made during Industry 4.0 for the benefit of society as a whole and the environment.

Progress from the Old Order to the New Order: Industry 4.0 and Society 4.0

The invention of the transistor and the microprocessor laid the groundwork for the third and most recent phase of the industrial revolution (1960). Because of these advancements, the acceleration of technological progress in areas such as computing and communications was made feasible, and the beginnings of process automation were established. As a consequence of this, society began the process of transitioning from an industrial society centred on the production of products and profits to a post-industrial society based on the creation of knowledge and the rise of service sectors. The post-industrial or information society, which places an emphasis on the organisation of knowledge and functions as a social control mechanism, thereby guiding innovation and change, went through a transition in the 1980s as a result of the advent of digitalization [24]. This society places an emphasis on the management of information and acts as a social control mechanism. As a direct consequence of the growth of the Internet, a global information society has emerged with the objective of providing access to the Internet, improved education, assistance for businesses, and the opportunity for

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networking. In light of the fact that the contemporary information societies are built on a capitalist system, it is also essential to emphasise the institutional and cultural diversity of information systems (such as the distinctions between various countries and nations). In addition, the contemporary information society is founded on the most advanced technical breakthroughs for the processing of data and the generation of new knowledge. The advent of the information age has placed a significant focus on the collection and processing of data at a variety of different stages. As shown in Figure 5, the conventional society is now going through a period of significant structural transformation as a direct consequence of the Fourth Industrial Revolution. An sophisticated artificial intelligence system will be utilised to collect and evaluate the massive volumes of data that are acquired by devices and sensors that are spread all over the physical world. The results of the investigation have a considerable bearing on the interactions that take place between humans and machines in the real world. The virtual world and the physical world are getting more and more intertwined. As a consequence of this, educational institutions need to place an emphasis on contemporary professional development, the growth of talents, and collaborative connections [25]. As a result, it is important to emphasise that society is a particular kind of social structure in which the gathering, processing, and dissemination of knowledge are the primary sources of power and production.

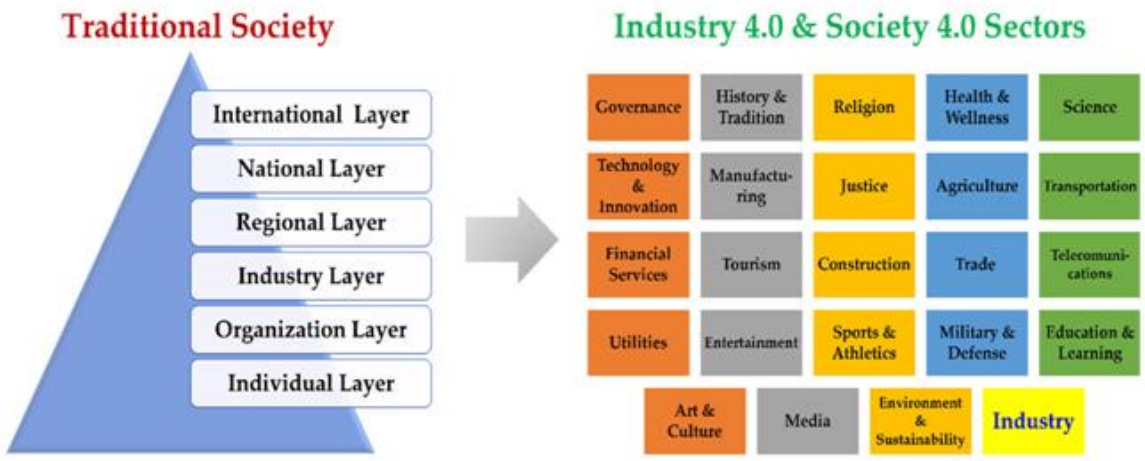

Figure 5. From Traditional Society to Society 4.0.

5.0 Version of the Sustainable Concept of Society

Even though the Society 5.0 model was created for Japan, its components are applicable to every country. Society 5.0 is a paradigm for sustainable development at all sizes. Therefore, it's crucial to focus on the concept's adaptability features that are related to industrial

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development. Europeans have long been in the forefront of adopting the production-centric Industry 4.0 approach. Society 5.0, on the other hand, is equally concerned with the social realm. Therefore, we may adopt just the parts of the Japanese idea that are meant to update non-industrial social processes [26].

Society 5.0's goal is to leverage the potential of the digital transition to foster both economic development and social progress, allowing people and environment to live in harmony. With its help, we can complete the UN's Sustainable Development Goals (SDGs) [27]. Figure 6 presents this distinct societal vision, which we call "Society 5.0 for SDGs."

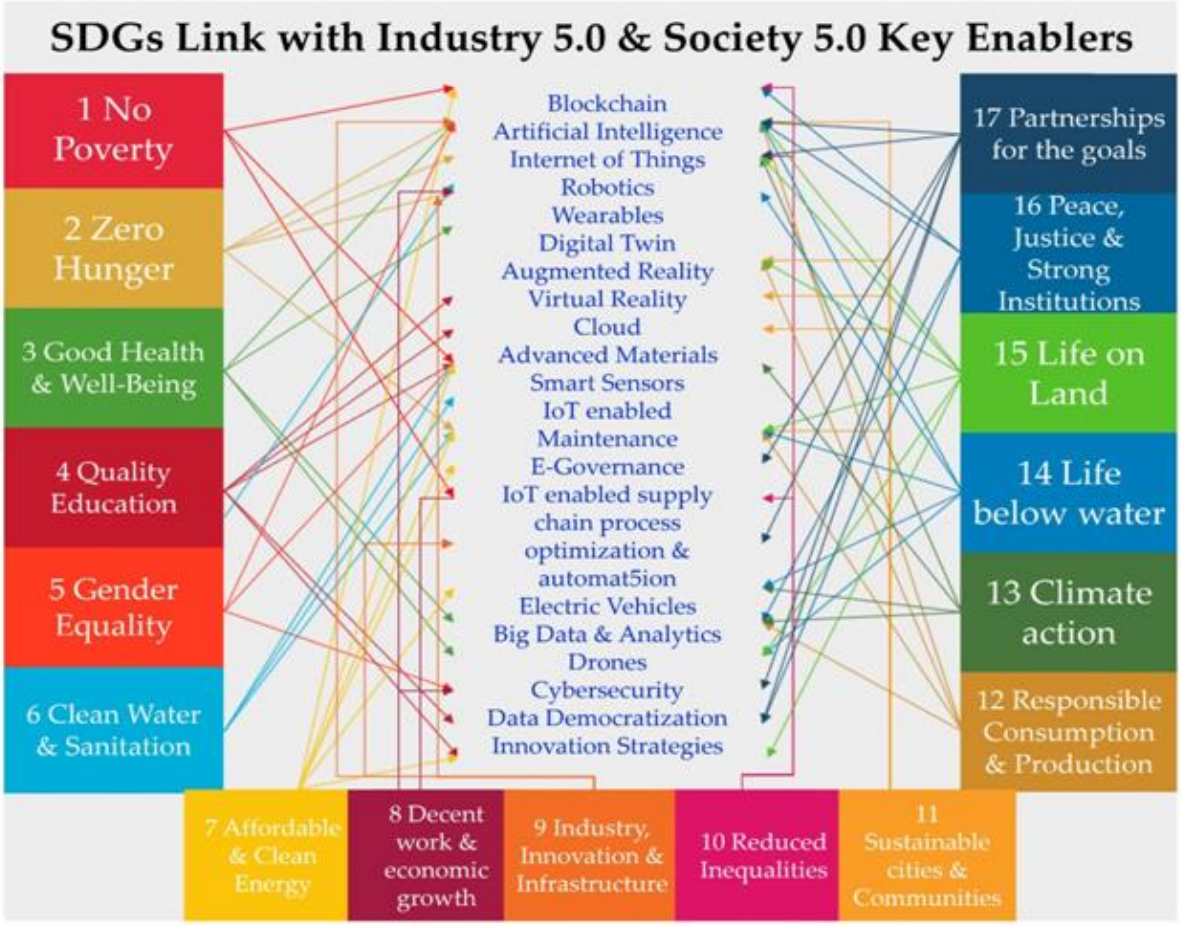

Figure 6. Society 5.0 for Sustainable Development Goals.

The Keidanren has already taken the initiative to begin implementing this notion, which will have far-reaching effects on the Japanese economy and society [28]. Societal and commercial conventions will undergo radical shifts in the Society 5.0 era. Close relationships across borders and sectors, as well as the change of current industries, will allow people to pursue a wide range of lifestyles. S5.0 aspires to resolve societal challenges in a way that allows everyone to pursue

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their own pleasure and way of life while simultaneously contributing to environmentally friendly, economically stable, and culturally vibrant progress. That lines up with the UN's Sustainable Development Goals, which were established to fix the world and create lasting communities. While S5.0 is necessary to accomplish several of the SDGs, it cannot do so alone. While developing S5.0 will help accomplish certain goals directly, it will also pave the way for a number of useful solutions to be built upon. As S5.0 promotes creative problem-solving from a range of viewpoints and backs up these ideas with digital transformation, the notion of S5.0 for SDGs will come to fruition. Here we outline the path toward S5.0 via sector-specific reforms, with an emphasis on how these initiatives will help us reach the Sustainable Development Goals.

This Era of Digital Disruption

Society 5.0 (Creative Society) is a society that we shall develop ourselves by integrating Digital Transformation (DX) with the imagination and creativity of a broad variety of individuals to create values and discover answers to issues. Future-proofing our societies with DX is a vital concept. The ongoing DX, which refers to the fundamental transformation of society as a result of advances in digital technology and data use, is driving the development of S5.0. This DX is causing significant shifts in people's daily routines, the way governments function, the makeup of economies, and the job market.

Low-cost data gathering, transmission, storage, and analysis stimulates a variety of industrial innovations [29]. When issues are revealed by data, solutions may be explored. The world's management and societal issues may be handled with the rapid worldwide sharing of such knowledge and ideas. Data eXchange (DX) employs data-based technologies including the Internet of Things (IoT), artificial intelligence (AI), 5G, robots, and blockchains to effect societal transformation [30,31].

DX's disruption is not limited to technology means of transformation. In the most fundamental sense, it exemplifies a seismic upheaval in the cultural underpinnings of our society. Beyond simple "kaizen" labour savings, automation, better productivity, and digital technology-based optimization, DX enables whole new ways of thinking. DX is reform that seeks to develop new values in reaction to substantial societal changes, sometimes at the price of old values. Thus, it can be emphasised that DX is a transformation that goes beyond just modifying IT systems and instead affects the whole fabric of society and business. In light of this, DX should be a

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company's number one management goal, and employees should work on it proactively and willingly [32]. DX is defined as follows in the Keidanren proposal:

"Fundamental and revolutionary changes in society, industry, and life as a result of advances in the use of digital technology and data; and radical changes implemented by industries, organizations, and individuals toward such transformation."

Version 5.0 of "The Nature of Society"

Even while digital transformation ushers in a new era in society, it is important that digital technology and data be used to build a world where individuals may seek diverse lifestyles and forms of happiness in their own ways. Although the 5th Science and Technology Basic Plan first labelled Society 5.0 as a "super smart society," this is merely one facet of the future society [33,34]. As indicated in Section 2.6, the digital transformation has made it possible for anybody to get access to sophisticated "abilities." With enough drive and vision, individuals may launch ventures with far-reaching consequences for the world at large.

Society 5.0 will require vivid imaginations in order to identify the wide range of societal requirements and challenges, and to generate scenarios for resolving them through the innovative use of digital technology and data. Problems may be solved and value can be created more quickly and easily when digital transformation is combined with the imagination and creativity of many individuals.

Society 5.0 will be a Creative Society, a place where digital revolution mixes with the imagination and creativity of individuals from all walks of life to find solutions to societal problems and create new value. Figure 7 depicts how humans in Society 5.0 would utilise their creativity to create methods to live in harmony not just with each other but also with environment and technology.

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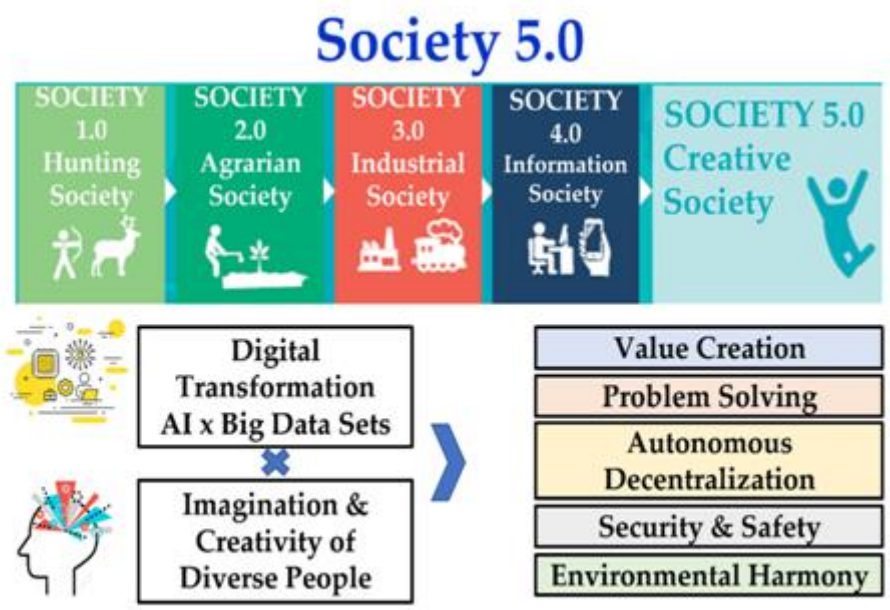

Figure 7. Evolution of society—Co-creating the future (adapted from [35]).

Society 5.0: The Next Step Forward

Value creation and issue resolution, variety, decentralisation, resilience, sustainability, and environmental harmony are some of the hallmarks of Society 5.0 as opposed to Society 4.0 (Figure 8). Society 5.0 may be thought of as an Industry 4.0 that puts people first. "a human-centered society that balances economic growth with the settlement of social issues through a system that closely combines cyberspace and physical space," as defined by the Cabinet Office of Japan, is the essence of Society 5.0. People should be encouraged to pursue their own versions of happiness using digital technology and data [35]. Furthermore, people in Society 5.0 will be able to follow a wide range of lives and ideals because to the removal of barriers that have previously prevented them from doing so. In particular, the burden of maximising productivity will be lifted from the shoulders of the populace. Instead, we shall be concerned with the needs of particular people, as well as the resolution of specific issues and the generation of tangible value. Freedom from oppressive effects on individuality, such as gender, colour, nationality, and isolation due to one's ideals and worldview, will allow people to thrive in all aspects of life, including living, learning, and working. Furthermore, everyone will have equal access to resources and information at any time and from any location, eliminating inequalities brought on by wealth and data concentration. With improved safeguards against joblessness and poverty, one of the goals of the shift from Society 4.0 to Society 5.0 will be the end of people's dread of terrorist attacks, natural catastrophes, and cyberattacks. Finally,

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according to the WEF Annual conference in 2019, the objective is to establish a society where anybody, at any time and from any location, may generate value without interference, in complete safety and harmony with nature [36].

Society and Sustainable Development Objectives 5.0

S5.0 will have far-reaching effects on everyday life and commercial enterprise. This social revolution will help achieve the SDGs by seeking solutions to societal problems that don't compromise with nature. Table 2 summarises the Sustainable Development Goals to which each number refers.

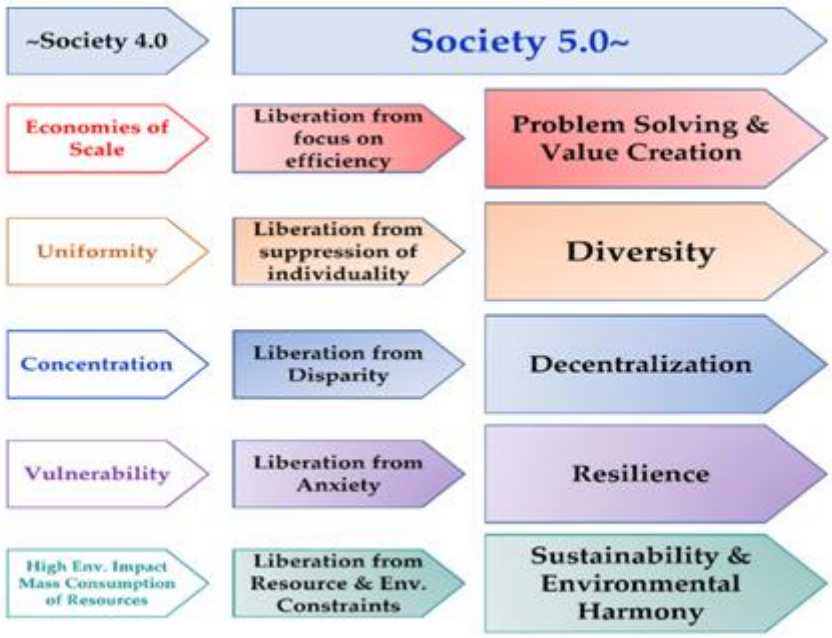

Figure 8. Changes from Society 4.0 to 5.0.

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Table 2. The 17 sustainable development goals (SDGs) to transform our world, derived from [37].

The 17 Sustainable Development Goals (SDGs)	
GOAL 1	No Poverty
GOAL 2	Zero Hunger
GOAL 3	Good Health and Well-being
GOAL 4	Quality Education
GOAL 5	Gender Equality
GOAL 6	Clean Water and Sanitation
GOAL 7	Affordable and Clean Energy
GOAL 8	Decent Work and Economic Growth
GOAL 9	Industry, Innovation, and Infrastructure
GOAL 10	Reduced Inequality
GOAL 11	Sustainable Cities and Communities
GOAL 12	Responsible Consumption and Production
GOAL 13	Climate Action
GOAL 14	Life Below Water
GOAL 15	Life on Land
GOAL 16	Peace and Justice Strong Institutions
GOAL 17	Partnerships to achieve the Goal

The following is a synopsis of the sector-by-sector changes and action plans:

Priority Areas: Goals 3, 4, 5, 6, 8, 11, 12, and 13 for Cities and Regions

In addition to facilitating a wider range of lifestyles with far less adverse environmental impacts, the widespread adoption of autonomous technologies like automated driving and sharing economies would be a boon to the economy. Sustainable, decentralised communities will be developed in the suburbs and rural areas to create autonomous, prosperous regions where people live in harmony with nature by utilising the distinctive qualities of their respective regions; this will occur while continuing to work to improve the competitiveness of large cities. You may access top-notch medical care and academic resources from any location in the world. In order to build a sustainable society and save costs, we must use autonomous, decentralised social infrastructure technologies like off-grid electricity.

Seniors who live in places without a reliable public transit system will have access to autonomous cars to help them get to and from important destinations like grocery stores and medical facilities. High-quality, pleasant lives can be had anywhere, regardless of the quality of the underlying infrastructure.

energy-related SDGs: 7, 9, and 13

To attain sustainable lifestyles in every setting, data will be utilised to design efficient energy networks, and this includes smart cities and decentralised communities. Energy development will be coordinated with local needs and incorporate decentralised microgrids that use demand-

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side controls, power storage, and renewable energy sources. Off-grid energy systems, which do not rely on the grid to function, will be an alternative. Most of the world's population, if not all of it, will have access to cheap, reliable energy, and other sectors will follow suit by employing decentralised systems. This will ensure that the vast majority of people on Earth may live a wide variety of lives without compromising their environment.

Reducing the Impact of Disasters: Sustainable Development Goals 3, 6, 11, and 13

The frequency and severity of natural catastrophes are rising worldwide, calling for swift action and greater resilience. Disaster information collaboration tools will be developed to allow rapid responses by collecting data on damage and rescue supplies from evacuation centres, IoT devices, and social media and sharing it across geographies and organisational barriers in the public and commercial sectors. Daily upkeep and effective safeguards against infrastructure deterioration will be accomplished with the help of digital technology. Emergency situations don't have to interrupt water service, thanks to preventative measures and rapid repairs to water and sewage systems. We will be encouraging robust infrastructure built on decentralised energy systems.

Personalized Healthcare

We will be able to provide everyone the care they need, when they need it, thanks to developments in technology like the digitization of people's physical traits and behaviours and the biotechnological study of life's systems. To postpone the beginning and progression of sickness and increase healthy life expectancy, new techniques will give therapy that is tailored to each patient's health at the preventative stage, whereas traditional medicine has supplied standard treatments for average people or symptoms.

Next-generation high-speed communication networks, artificial intelligence-based medical, agricultural, and nutritional wellness support services, telemedicine, and the creation of systems allowing individuals to actively use and manage their own life-stage data will all contribute to universal access to high-quality healthcare services. As a consequence, we may all enjoy long, healthy lives. For instance, older individuals in rural areas would have access to telemedicine for health monitoring, and in the case of an unexpected sickness, they will be brought to a hospital that is suited to their needs, as assessed with the use of artificial

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intelligence. These technology, operational knowledge, and systems will enhance healthcare throughout the world if they are deployed in underserved areas of poor countries.

Goals 2, 12, 14, and 15 all pertain to agriculture and food.

Production of food and agriculture will be revolutionised into dynamic, self-sustaining fields where individuals can freely exercise their originality. Robotic farming, AI-powered remote monitoring and control, and autonomous drones for on-site agricultural labour will all be put to good use. Work hours will be cut down substantially, efficiency will be increased drastically, and production will increase exponentially with the help of many different stakeholders, such as private enterprises, young people, and agritech startups. Strategies to increase biodiversity and lessen environmental impact will be promoted to help preserve the vast marine and terrestrial ecosystems. Information on changing customer preferences will be rapidly incorporated into the food supply chain. The coordination of delivery dates, volume, and routes may help prevent food waste, and the integration of data from production, logistics, and export can facilitate the real-time exchange of stock and sales information. Customers will have free access to manufacturing history and product information, as well as interactive communication features.

Logistics—SDGs 11 and 12

Logistics contribute to economic growth and play an important role in the social infrastructure that supports everyday living and commercial operations because they facilitate the movement of products. Logistics in Society 5.0 will be much more complicated and diversified due to the fast growth of e-commerce and the globalisation of supply chains, and the deployment of cutting-edge technology will alter logistics. For instance, Internet of Things (IoT) technology like Radio Frequency Identification (RFID) will be utilised to link goods and transportation systems to networks, allowing for real-time logistical tracking and management.

Goals 5, 8, and 9 for Industrial Production and Services

Artificial intelligence's ability to disperse skills will provide industry and service delivery with potent new resources. Until recently, data analysis and the creation of valuable goods and services needed a sizable financial investment and specialised skills. With the help of digitalization, these abilities will be shared and made available as AI modules and services. By bringing them together, quicker, higher-quality production of goods and services will be

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feasible. Future company models will be based on services, rather than physical products. In the age of digitization, production and services will not mirror those of the twentieth century in any significant way. Increased opportunities for participation in production and service provision will arise from a DX that creates several types of value.

SDGs 1-5, 8 and 9 in terms of finance

To add to this, the evolution of financial services has paved the way for solo entrepreneurs and small firms to provide a wide range of products and services. DX will increase access to a variety of financial services, including asset creation, financing, settlement, and insurance. Because of cheap, useful, rapid, secure, and varying means of settlement, individuals will be able to live everywhere without currency. Apps that facilitate communication between various services and smart contracts will streamline the process of creating brand new services. Financing, asset formation, insurance, settlement, and transfer will become easier with the help of digital devices and technologies, allowing individuals in developing nations to enjoy greater economic security, freedom from economic dependence, improved quality of life, and greater income equality.

New methods of exchanging wealth will emerge as a byproduct of the emergence of cryptocurrencies and token economies based on blockchain technology and other developments. Establishing safe, smart, and trackable worldwide contracting and settlement mechanisms will pave the way for a wider variety of individuals to participate in the global manufacturing and service provisioning economies.

SDGs 1, 3, 4, 10, and 16: Public Services

Public services will also be undergoing major modification to accommodate the aforementioned people and businesses. All levels of government will begin with updating their digital infrastructure. Through digitising numerous processes and rapidly disseminating data among diverse players, they will provide more creative public services. For instance, governmental authorities may better meet the needs of their citizens by using precise demographic and other data analysis to foresee the need for nurseries, schools, hospitals, and nursing homes. Once governments have put in place sufficient safety nets, any individual may tackle a wide range of security issues with confidence.

Enterprise in the Post-Present World

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The study given thus far classifies industries according to their nature and the goods they create. However, they are separated into subheadings in the following section based on the importance of the user experience and the issues they tackle. The current industrial structure, known as 5C Architecture [38], which places huge businesses at the top, will be replaced with a flatter co-creation framework. Table 3 displays the industrial evolution from the 4.0 Society to the 5.0 Society and beyond.

Table 3. Industrial Focus of Societies.

	Society 1.0 to Society 4.0	Society 5.0 and Thereafter
Industrial Focus	Product and Business Types	Values realized and issues solved
Areas of application	Electricity, mobility, infrastructure, construction, medical equipment, logistics, and financial services	Comfortable mobility, environmentally friendly energy, and realization of health
Common Goal	Transition to an autonomous, decentralized co-creation framework where businesses construct an industrial structure based on the values of the consumers and combine technologies and channels in their areas of specialization to realize these values	

Sharing the Creative Load in the Post-Industrial Age

Beyond traditional commercial or corporate partnerships, "co-creation" is a new kind of cooperation based on providing value to customers and solving social problems from their point of view. It is predicated on introducing novel business models and ecosystems in which diverse organisations may generate revenue via a variety of techniques that combine their strengths and compensate for one other.

Co-Creation Techniques

The following is not an exhaustive list of the ways in which businesses might collaborate to generate new revenue streams. The success of any co-creation effort hinges on the establishment of appropriate governance systems, as well as venues and mechanisms for participation from a wide range of entities, in order to define the desired outcomes and values of the target audience, ensure effective multi-level communication, and realise those outcomes.

1. collaboratively developing products and services.

secondly, sharing data for collaborative production.

The third way is to pool resources in the form of human creativity.

Management

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The following is a list of the essential competencies of managers in order to prepare for Society 5.0:

1. An understanding of DX and the determination to put it into practise

2. A transparent management and leadership vision for the co-creation process.

3. Knowledge of emerging industries and technological advancements

4. Refocusing.

5. the ability to make judgements and take action on time.

Personnel Novel ideas, ideation, and the development and execution of business plans are only some of the many talents and experiences necessary for marketing DX.

Organization

Embracing diversity as a means to inspire innovation and drive change is crucial to the success of any company.

Technology

Maintaining customer-facing infrastructure and services while also becoming DX-ready necessitates a rapid embrace of digital technology. The ability to consistently apply DX while keeping an eye on emerging tech developments is essential for these tasks. Maintaining customer-facing infrastructure and services while also becoming DX-ready necessitates a rapid embrace of digital technology. The ability to consistently apply DX while keeping an eye on emerging tech developments is essential for these tasks.

Informational Synergy

In order to move forward with co-creation, it is necessary to construct a communicable yet autonomous and decent- trailed architecture as the shared backbone. Next, to minimise issues hindering data sharing, it is vital to specify quality requirements for transmitted and connected data.

Technological Foundations for Industry 5.0

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To put it simply, "Industry 5.0" is the idea of a competitive industry that is also inventive, resilient, socio-cantered, and conscious of planetary limitations. It raises several fresh issues in technical, socioeconomic, regulatory, and administrative spheres. Given this, on July 2 and 9, 2020, participants from European funding agencies and RTOs explored the concept of Industry 5.0 in two online seminars. The goal was to have a conversation about the necessary technology, possible roadblocks, and get people's thoughts on the concept as a whole. All participants felt that technological innovation should take more consideration of societal and environmental concerns. Participants also agreed that a comprehensive approach was required to handle the complexity of the difficulties, rather than depending exclusively on particular technologies [39].

Human-centric solutions and human-machine interaction technologies that integrate and combine the strengths of humans and machines are among the Key Enabling Technologies (KET) that are facilitating the shift from Industry 4.0 to the idea of Industry 5.0.

Intelligent materials and bio-inspired technologies make it possible for recyclable materials to have integrated sensors and have enhanced functionalities.

Modelling whole systems through simulation and real-time digital twins.

Tools for managing system and data interoperability that include cybersecure data analysis, transfer, and storage.

In artificial intelligence, the capacity to discover causal linkages in intricate, dynamic systems and provide usable knowledge is a key capability.

Since the KET consumes so much power, it is imperative that we develop dependable and efficient autonomous technology.

Edge Computing (EC), Digital Twin (DT), Internet of Everything (IoE), Big Data Analytics (BDA), Cobots, 5G, and blockchain are all examples of enabling technological trends that can help industries boost production and speed up the delivery of individualised products through the integration of cognitive abilities and innovation. Industry 5.0, made possible by these enablers, is a cutting-edge manufacturing paradigm that prioritises communication between machines and people. There is an emphasis on the technologies that will allow Industry 5.0 to flourish.

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Through the use of "Edge Computing," data may be processed close to the network's perimeter. In response to the rapid expansion of the Internet of Things (IoT) and the proliferation of cloud services, EC was developed. The needs for latency costs, battery life limits, reaction time limitations, and data privacy and security may all be met by EC [41]. Also, it assures that applications continue to function properly even when deployed to far-flung locales, while simultaneously lowering communication costs. Important Industry 5.0 events may be processed with minimal security risks because to EC's ability to process data locally without transferring it to a public cloud [42].

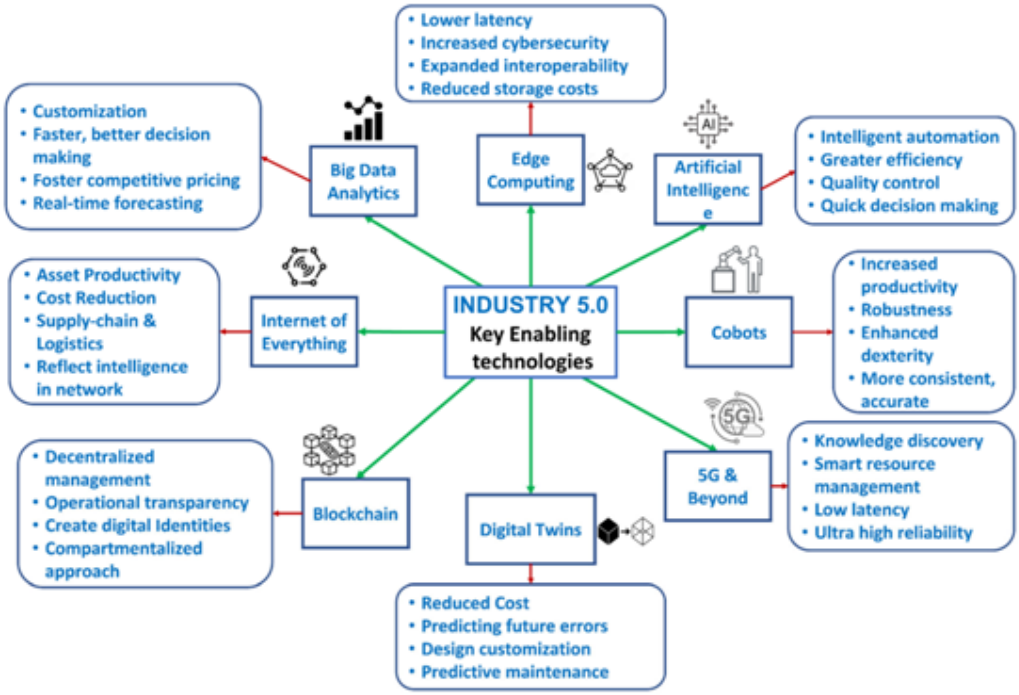

Figure 11. Key Enabling Technologies in the transition from Industry 4.0 to Industry 5.0 (derived from [40]).

With the help of Internet of Things (IoT) gadgets, real-world things may be simulated in real time, a concept known as "digital twins." Thanks to DT's digital mapping of real-time objects and systems, problems may be analysed, monitored, and prevented before they ever occur in the physical world. Rapid progress in AI, ML, and BDA has allowed DT to reduce maintenance costs and increase system performance [43,44]. DT is used in Industry 5.0 to tailor products to individual needs, improving the whole customer service experience.

The Internet of Everything (IoE) refers to the worldwide web of interconnected computers, devices, people, and other entities. The Internet of Everything (IoE) has the potential to be incredibly useful in opening up new avenues for Industry 5.0 uses. New features, an improved

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user interface, and widespread economic and societal advantages are all possible thanks to a few of the most promising applications. Increased consumer happiness and loyalty, as well as the development of unique, data-driven experiences, are central to the Internet of Everything's (IoE) function in the fifth industrial revolution [45,46].

The influence of Big Data Analytics, or BDA, on Industry 5.0 will be substantial. To optimise product pricing, focus on boosting production efficiency, and help minimise overhead costs, most enterprises in Industry 5.0 can utilise BDA to better understand customer behaviour [47]. Understanding user behaviour, social ties, and human behaviour standards is a substantial difficulty. Because of the availability of real-time analytical shared data with smart systems and data centres, manufacturers can create and handle massive amounts of data. Constantly improving processes is another major obstacle for Industry 5.0, as doing so typically requires collecting extensive data about the whole production procedure [48].

Recent developments in automation and robotics have made cooperative robots (or "cobots") increasingly important in the workplace. Due to the rapid advancements in artificial intelligence and other forms of smart technology, it is clear that all gadgets with computing capabilities are now more intelligent, and a new technology known as cobots has been launched as a result. Collaborative robots are those designed to work side by side with humans.

Together, these advancements make it less complicated than ever for solo entrepreneurs and startups to automate human capabilities, while also increasing productivity. Though they can't compare to humans in terms of critical thinking, robots excel above humans in terms of tolerance during high-volume product production. Products that are personalised or customised may be difficult to manufacture with robots. As a result, it is critical to maintain order among workers throughout manufacturing procedures. Cobots in Industry 5.0 are capable of completing their intended tasks, allowing for the rapid and precise delivery of products with extensive customization options to clients [50].

The value of future Industry 5.0 services may be greatly boosted by 5G and 6G technology. With hundreds, if not millions, of sensors, hardware components, and robots, it might be challenging to construct radio infrastructure. Strong expansion of smart infrastructure and prospective applications will result in soaring demands for network bandwidth that cannot be met by existing infrastructure (such as 4G and 5G networks). Lower latency, support for high-quality services, comprehensive IoT infrastructure, and integrated artificial intelligence (AI)

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capabilities are just some of the benefits that 5G and beyond will bring to the table in the Industry 5.0 revolution.

Ethereum: Ethereum's distributed ledger technology has the potential to greatly improve Industry 5.0. One of the biggest obstacles to achieving Industry 5.0 is the lack of a unified system for controlling the vast array of connected, heterogeneous devices. As a result of blockchain's ability to facilitate distributed trust, it may be included into the planning and development of distributed systems for administration and instruction [52,53]. Blockchain technology, which allows for secure peer-to-peer communication, provides an immutable ledger that may be used to keep track of transactions and other data in a trustworthy manner. As an added bonus, the immutable ledger underpins operational responsibility and transparency for major events in Industry 5.0 applications [54].

A Different Enabling Technology—eXtended Reality (XR): There are many different fields where the cutting-edge technology known as XR may be used. Improved human-machine interactions are one of the many benefits of XR's merging of the real and virtual worlds. For convenience, we will refer to VR, AR, and MR together as "XR" [55]. To a large extent, XR technologies will facilitate a variety of Industry 5.0 applications. XR technologies are already being used in a variety of applications related to Industry 5.0, including remote assistance [56], assembly line monitoring [57], remote healthcare [58], health education [59] and training [60], indoor and localised outdoor navigation [61], driver and pilot training, maintenance [62], and education and training for operating drones and unmanned aerial vehicles [63]. The development of zero-touch networking, edge computing, highly competent devices, enhanced communication technologies, and high-precision calculation capabilities will be essential for the advancement of XR technologies toward Industry 5.0 applications.

Ultra-Customized Production in Industry 5.0: What Technology Is Needed? Adapting to a more fluid supply chain and production method [66] is the first step toward mass personalisation. The human touch, in the form of feedback from the production staff and the consumers, will be required to keep these processes individualised. Furthermore, cost-effectiveness is crucial to the long-term success of Mass Personalization. As a result, the writers in [64] have developed a technological road map for Industry 5.0 projects, which includes the following:

Platform for managing data and data governance procedures.

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Modelling and simulating multi-scale dynamic systems.

Third, self-driving intelligent systems.

Fourth, innovative approaches to the interface between humans and machines, including cognitive systems.

The fifth is the process of additive manufacturing.

Sixth, a personal touch.

Ability Sets Crucial to the Business and Social World 5.0

Tools and manufacturing procedures are only one area that can benefit from the AI-driven industrial revolution. The long-term viability of your business depends much more on your investment in human capital to back up those innovative ideas. For 36% of firms, the inability to find qualified workers is the biggest obstacle to getting the most out of their smart factory investments [67]. In addition, 57% of business executives feel they are lacking the AI talent that is essential to developing the autonomous and intelligent solutions that will eventually take over the 3D activities. Table 5 details the top five critical abilities for now and the future.

Table 5. Top five critical skills for today and the future [25].

Skills of Today	Skills of the Future
Basics of modern programming or software engineering	Deep understanding of modern programming or software engineering techniques
Manufacturing skills	Digital dexterity, or the ability to leverage existing and emerging technologies for practical business outcomes
Great communication skills	Data science
Innovation skills (e.g., brainstorming, design thinking)	Connectivity
Traditional IT skills	Cybersecurity Manufacturing Skills

Discussion and Future Prospects

Future Manufacturing Facilities

Industry 4.0 is being pushed to its limits in the "Factory of the Future," which is revolutionising R&D, the plant, the supply chain, product delivery, and customer service throughout the whole linked ecosystem. Figure 12 shows the progression from the traditional factory to the smart factory of today and on to Shop Floor 5.0. Here are some of the expected gains from using Shop Floor 5.0:

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Give attention to the satisfaction of your clients.

With a focus on extreme personalization.

• A flexible and decentralised distribution system.

• Products that can only be enabled by a user's experience.

The repopulation of manufacturing centres.

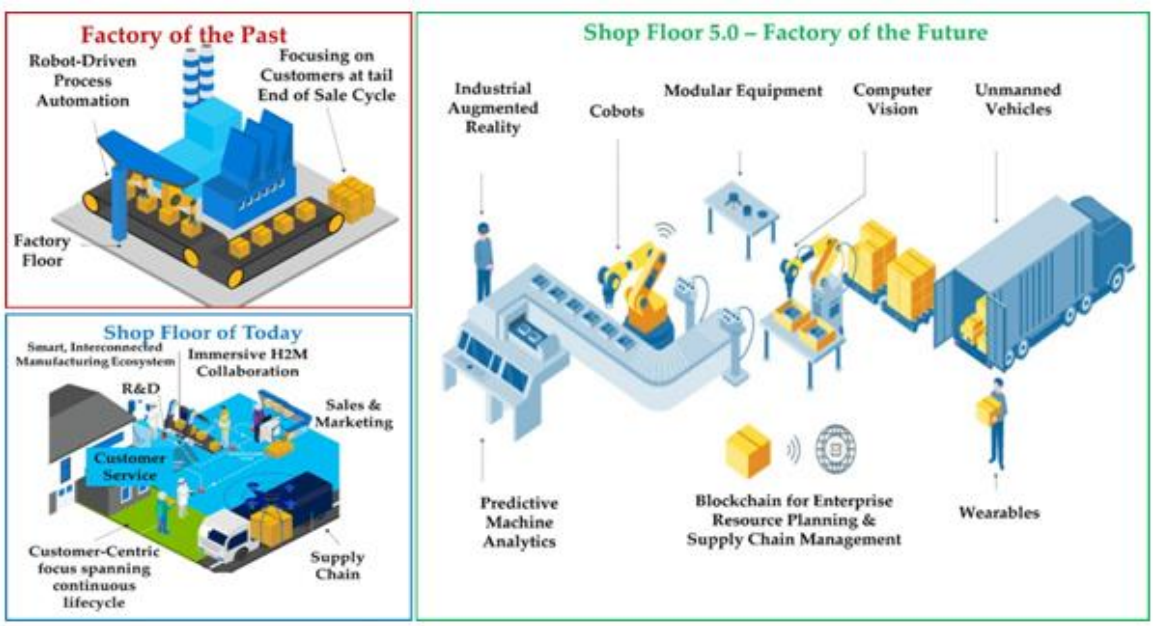

Figure 12. Towards Shop Floor 5.0 (derived from [68]).

Industry 5.0 is seen as a development, appropriately merging essential components of Industry 4.0 into a bigger vision that benefits a wider group of stakeholders, in light of the European Union's and others' commitment to a more sustainable future. The goal is to move away from traditional value production models that are dependent on extracting value from the economy and instead adopt new types that allow for a more even distribution of economic well-being. The objective is broader than simply increasing profits for shareholders; it is motivated by ideas like regenerative purpose and the modernization of manufacturing. Table 6 below outlines some of the main differences.

New objectives for DX, new business models, value chains, and supply chains, new economic priorities for measuring industry performance, new approaches to policymaking that better align the interests of business and industry, new ways to drive innovation and research capabilities, and new ways for businesses to better align their interests with the public will all

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be necessary for Industry 5.0 to be a success. Therefore, the pandemic has taught us that we must immediately take measures to increase the resilience of our value chains if we are to maintain economic growth and security.

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Table 6. Comparison of Industry 4.0 versus Industry 5.0 [69].

Industry 4.0	Industry 5.0
• Centered around enhanced system and process efficiency through digital connectivity and AI • Technology-centered based on the implementation of CPS • Aligned with optimization of business models within existing capital market dynamics and economic models—i.e., directed towards the minimization of costs and maximization of profit for shareholders • No focus on design and performance dimensions essential for systemic transformation and decoupling of resource and material use from negative environmental, climate, and social impacts	• Ensures a framework for industry that combines competitiveness and sustainability, allowing industry to realize its potential as one of the pillars of transformation. • Emphasizes impact of alternative modes of (technology) governance for sustainability and resilience. • Empowers workers using digital devices, endorsing a human-centric approach to technology. • Builds transition pathways towards environmentally sustainable uses of technology. • Expands the remit of corporation's responsibility to their whole value chains. • Introduces indicators that show, for each industrial ecosystem, the progress achieved on the path to well-being, resilience, and overall sustainability.

Abilities for Realizing Society 5.0

The goal for Industry 5.0 builds on the technological and economic principles of Industry 4.0 by putting an emphasis on three pillars like Human Centricity, Resilience, and Sustainability. Given the widespread dedication of companies to introducing tech-enhanced processes and systems, now is the ideal moment to anticipate the next wave of innovation. Ten (10) essential talents have been pinpointed by the World Manufacturing Forum (WMF) [70] as being necessary for the manufacturing industry going forward. Figure 13 shows how important it is for this combination of talents to incorporate digital and technological abilities in addition to cross-functional ones like creativity, adaptability, and open-minded thinking. Everyone in an organisation, from executives to middle managers to frontline workers, will need to evolve and improve in order to keep up with the requirements of Industry 5.0.

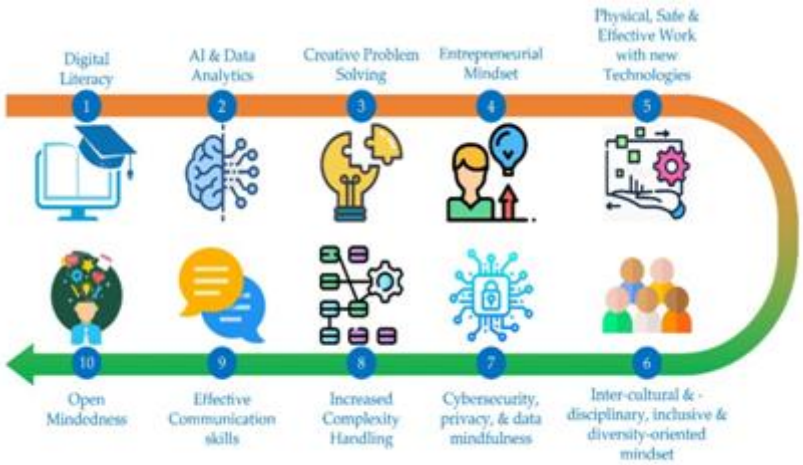

Figure 13. Ten Critical Skills facilitating the realization of Society 5.0, derived from [70]).

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There has been a lot of study on the theoretical underpinnings of digital transformation. The majority of top-level executives nowadays are computer savvy and able to do business online. After establishing these ground rules, it is prudent to shift focus to integrating the values of Human Centricity, Resilience, and Sustainability. The following are some important ideas to keep in mind throughout the next several years:

Refocusing on people.

Helping people be resilient.

The value of a long-term perspective on things.

Despite the significance of being ready for Industry 5.0, there are other external pressures that will ultimately push businesses to embrace human-centricity, resilience, and sustainability. It's far preferable to take advantage of the possibility to prepare in advance than than to respond to an unanticipated disruption in the system. In this way, beyond the standard "better, cheaper, and quicker," Industry 5.0 aims to steer the next generation toward a set of decisions that will result in industries that are smarter, cleaner, and more resilient.

Observations with Respect to Future Studies, Clinical Work, and Social Policy

Lack of a universal rate of technological development is one of the most important consequences that has been uncovered so far [60]. For the sake of this article, this observation pertains especially to the implications of Industry 4.0. But it hasn't been dealt with properly yet. That's why it's so important for government, schools, and businesses to work together to bridge the technology gap, which is most pronounced between industrialised and poor nations [71]. It also has significant ramifications for the evolution of academic institutions. Universities are expected to provide insights that may inform both technological and societal progress. There isn't just one path to a universal technology standard; there are several. The UN's Sustainable Development Goals (SDGs) provide a framework for tackling and ultimately solving major social problems. Alternatively, the community should welcome and encourage more investment in R&D initiatives in poor nations. Finally, a third option is for more wealthy nations to lend their technological know-how and other solutions to help less developed nations advance more rapidly.

Threats and Prospects

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To guarantee that individuals maintain their capacity for purposeful and creative living, Industry 5.0 and Society 5.0 prioritise ecological and digital changes. Thereby, institutions like universities and corporations will play a more pivotal role in accomplishing this objective. As we strive for a more people-centered way of living, it is essential that we pair advances in IT with programmes that train the next generation of industrial innovators and increase everyone's ability to use and understand data. Universities, in addition to improving technology as they have in the past, are now responsible for encouraging information literacy among the public by shifting their general curriculum toward a more individualised approach to learning and perception [60].

In conclusion, it should be emphasised that Industry 5.0 is a crucial aspect of the larger Society 5.0 movement. The forthcoming 5th industrial revolution will hasten the advancement of society. The growth of civilization will also help pave the way for the next industrial revolution. Table 7 summarises the common challenges and opportunities between Industry 5.0 and Society 5.0.

Table 7. Summary of challenges and opportunities.

Similarities between Industry 5.0 and Society 5.0	
Challenges	**Opportunities**
1. Aging population	1. Human–Cyber Physical Systems (HCPS)
2. Resource shortage	2. Green Intelligent Manufacturing (GIM)
3. Environmental pollution	3. Human–Robot Collaboration (HRC)
4. Complex international situations	4. Future Jobs and Operators 5.0
	5. Human Digital Twin (HDT)

Industry 5.0 and Society 5.0: A Proposed Framework for Implementation

Compatibility of technology, activities, and changes with the SDGs as set by the UN is an integral part of Industry 5.0 and, by extension, Society 5.0. To properly grasp the concept of Society 5.0, it is crucial for academics, industry, and other interested groups to come together and enhance their partnership. Future research will aim to design, develop, and deploy frameworks that combine the technologies outlined in the preceding paragraphs in an effort to bridge the gap between the public, private, and academic sectors, as depicted in Figure 14. The conceptual framework in the preceding graphic makes a direct relationship between Industry 4.0 and Society 5.0. As a corollary, it is emphasised that the technical progress made thus far is not squandered, but rather is redirected toward the development of the "super intelligent society" referred to in the preceding paragraphs. Two important reference architectures are also

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presented at the framework's lower portion: I the RAMI 4.0 and (ii) the Society 5.0 Reference Architecture (S5RA), which was first announced by the Cabinet Office in 2018 in the "Policy for the Development of a Data Exchange Platform" and has been under development since then. The two reference architectural models, RAMI4.0 and S5RA, focus on various things; RAMI4.0 emphasises the technological and organisational structure of businesses, while S5RA is broader and includes societal considerations. As a result, the two reference designs do not compete but rather reinforce one another. In this way, we can see how academic institutions, non-profit organisations, and businesses all depend on one another. Furthermore, the S5RA has been refined over the past few years after multiple proof-of-concept testing under the Cross-ministerial Strategic Innovation Promotion Program (SIP). Although the S5RA is a whole new reference design, it draws inspiration from RAMI4.0, and its layered structure, seen in the lower right section of Figure 14, is based on the EA3 cube framework. These are the three dimensions: Time and space are on the x-axis, while the y-axis represents the topic at hand, and the z-axis represents the underlying meaning. Using data and information effectively is emphasised. Even more explicitly, the design has two layers whose sole purpose is to deal with data and data federation. Each layer of the design has its own security and authentication mechanisms, which work together to keep everything safe.

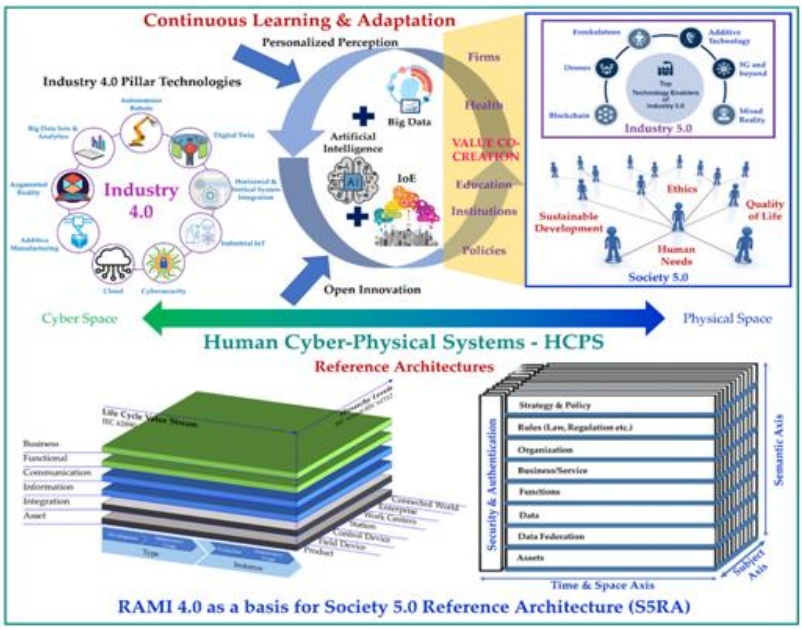

Figure 14. Industry 5.0 and Society 5.0 conceptual framework based on the integration of Industry 4.0 reference architecture model and technologies.

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Two paradigms, namely I Personalized Perception [60] and (ii) Open Innovation [71], are also provided in addition to the technical details of the reference architectures. Although the authors in [60] emphasise Education for analysing the unique requirements and abilities of each student through the application of key technologies of I4.0, the framework of the paradigm may be further extended to encompass individualised perception at the societal level. Value co-creation, in which several parties work together to accomplish a similar objective, is also discussed by the authors of [71], who highlight the contribution of Open Innovation to the movement towards Society 5.0.

Future Prospects and Conclusions

An extensive literature survey was conducted for this study, with a primary focus on the impending Industry 5.0 and Society 5.0. By advancing a conceptual model in a field that has not yet been thoroughly studied in the literature, this study aimed to compile a comprehensive literature review and provide a snapshot of the most helpful components and technologies for the transition from Industry 4.0 to Industry 5.0 and Society 5.0.

The investigation of scientific published works and the documentation from governments and organisations working on such initiatives has led to the safe conclusion that Industry 5.0 is more than a trend and that Society 5.0 will therefore open up unprecedented opportunities towards the creation of a highly intelligent global society. The technical context was provided and discussed as part of the literature study offered in order to provide a clear understanding of the current technology readiness level and the predicted trends over the next few years. All goals within the paper's scope have been accomplished, and all research questions that were posed have been answered. The first part of our objective was reached when we learned about the study findings related to Industry 4.0 and Society 5.0. To guarantee the sustainable development of a human-centered society, it is essential to construct a physical-to-digital-to-physical loop, as shown in the insights. Three concerns, including (1) human-oriented action, (2) sustainable development, and (3) the physical-to-digital-to-physical loop, emerged from our research as crucial for bridging Society 5.0 and Industry 4.0. At the literature and bibliometric analysis stage, we additionally clustered word sets for the core keywords "Industry 5.0" and "Society 5.0." This showed that throughout the time period analysed, besides society and the economy, the dominant sectors were education, IoT and Applications, artificial intelligence and digitization, and the environment.

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