

Technology Transformation Towards Industry 5.0: Human-Centric Integration, Society 5.0, and a Sustainable Digital Economy

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Abstract

Article history:

Received: July 18, 2024

Revised: August 29, 2024

Accepted: October 23, 2024

Published: December 30, 2024

Keywords:

Artificial Intelligence,
Economics 5.0,
E-business,
Industry 5.0,
Society 5.0.

Identifier:

Nawala

Page: 110-126

<https://nawala.io/index.php/ijebi>

This study aims to examine in depth the concepts of Industry 5.0, Society 5.0, and Economy 5.0 through a literature study approach involving scientific articles. Industry 5.0 emphasizes the importance of collaboration between humans and intelligent machines in technology-based production systems, including the use of artificial intelligence (AI) and the Internet of Things (IoT), to achieve greater efficiency, innovation, and long-term sustainability. Society 5.0 supports this transformation by fostering a new, inclusive, and adaptive social order where technology serves to enhance human well-being. At the same time, Economy 5.0 reflects a shift toward a digital economic model that values equity, ethics, and sustainable collaboration across various sectors. The findings indicate that synergy between advanced technology and human-centered values is essential in building resilient industrial and societal ecosystems. Furthermore, the study underlines the urgent need for integrated cross-sectoral strategies, involving government, industry, academia, and communities, to successfully manage a human-oriented digital transition while promoting social justice and inclusive economic growth.

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1. Introduction

Industrial transformation has gone through various stages ranging from mechanization in Industry 1.0 to the adoption of cyber-physical systems in Industry 4.0. Today, the world is welcoming the era of Industry 5.0, a new paradigm that emphasizes human-centric approaches, sustainability, and resilience in manufacturing systems and economies. If Industry 4.0 focuses on automation and efficiency through the integration of technologies such as the Internet of Things (IoT) and artificial intelligence (AI), then Industry 5.0 presents a collaborative dimension between humans and intelligent machines to build systems that are not only efficient but also inclusive and oriented towards human well-being. Along with these developments, the concept of Society 5.0 emerged, an intelligent society order that unites the physical and digital worlds as a whole, where technology is not only an aid, but an integral part of human life (Simonigar et al., 2023).

This concept not only covers the technological aspect, but also touches on the social and cultural side, where collaboration between humans and machines aims to address global challenges such as climate change, energy crisis, social inequality, and health crises. Along with that, the idea of Economy 5.0 also emerged, which is an evolution of Economy 4.0 which previously focused on digitalization and automation. Economics 5.0 emphasizes the balance between economic efficiency and social responsibility. In this context, digital technologies such as blockchain, big data analytics, and AI are not only used to pursue economic gains, but are also geared towards supporting the values of sustainability and social justice. This concept is

particularly relevant to the current global economic challenges, where inequality and exclusion are still major problems.

Furthermore, in the implementation of its technology, AI is one of the main foundations in supporting intelligent operations in Industry 5.0. AI is able to analyze data in real-time, provide appropriate decision recommendations, and learn from system patterns and anomalies. Meanwhile, IoT is the main link between devices and distributed systems, enabling efficient and effective data exchange in various sectors ranging from manufacturing to public services. This paradigm shift also has a big impact on the business world, especially in the e-business domain or digital business. In the context of Economy 5.0, e-business is not only aimed at profitability, but also how technology is used to strengthen human connections, expand cross-sector collaboration, and have a positive impact on the environment and society (Fachrozie et al., 2021).

Indonesia as a developing country shows great potential in adopting B2C, B2B, and C2C-based e-business models. With the support of an increasingly strong digital ecosystem and an increase in technological literacy among micro to large business actors, e-business can be the main driver of economic transformation towards Economy 5.0. However, to achieve this transformational success, a comprehensive understanding of the integration between technology, humanities, and sustainability is needed. Therefore, this literature study aims to: Analyze the concept and development of Industry 5.0 in a human-centric and sustainability context. Examining the integration of Society 5.0 and Economy 5.0 as an ecosystem that supports industrial and social transformation. Examining the role of AI and IoT

in supporting productivity and its impact on e-business in the digital era. With a literature study approach, this study compiles a synthesis of the latest research results to provide a complete picture of the direction of global economic and industrial transformation towards the 5.0 era.

2. Literature Review

2.1. Industry 5.0 and Human-Centric Transformation

Industry 5.0 is an evolution of Industry 4.0 which prioritizes the integration of advanced technology with a human-centric approach. The main focus in Industry 5.0 is no longer just automation and efficiency, but how technology can strengthen collaboration between humans and machines to achieve common prosperity. Tóth et al. (2023) emphasizes that Industry 5.0 combines the values of sustainability, resilience, and inclusivity in the manufacturing process through a human-first approach. The shift from automated machines to collaborative systems requires a redefinition of the role of humans as co-creators in the production line.

This is reinforced by Nguyen and Tran (2023) who explain that the manufacturing systems of the future require not only technical efficiency, but also trust in artificial intelligence that can be adapted to human values. Digital twins and AI are the backbone of the implementation of Industry 5.0. Asad et al. (2023) stated that digital twins enable prediction and optimization of production processes with a data-driven real-time approach, while AI technology supports fast and precise decision-making. Industry 5.0-based manufacturing systems are more adaptive to social and environmental needs. Thus, Industry 5.0 is a strategic movement in

answering today's industrial challenges, namely how to integrate technological efficiency with concern for social, environmental, and human welfare values as a whole.

2.2. Society 5.0 and Social-Digital Integration

The concept of Society 5.0 was first introduced by the Japanese government as a vision of a future society that integrates digital technology with human life to improve the quality of life (Simonigar et al., 2023). Unlike previous technology-focused revolutions for industry, Society 5.0 puts humans at the heart of technological development, enabling intelligent solutions to the complex problems of modern society. Carayannis et al. (2022) explain that Society 5.0 emphasizes borderless connectivity between humans, machines, and data that creates a new social order based on inclusivity and collective intelligence. In this context, the presence of AI and IoT is no longer dominant, but instead strengthens the ability of humans to adapt and innovate. The integration of Society 5.0 with Industry 5.0 creates a new space for dynamic collaborative work between communities and industry sectors.

Marinagi et al. (2023) added that Society 5.0 is a form of social system evolution towards a balance between digital efficiency and cultural values. This supports the creation of a society that is responsive to climate change, natural disasters, and energy crises. This concept also inspires the emergence of a smart city ecosystem that is not only based on digital infrastructure, but also inclusive social design. Thus, Society 5.0 is not just a digital transformation, but a profound social

paradigm shift. He places technology as a tool to empower people towards a smarter, inclusive, and sustainable life.

2.3. Economy 5.0 and the Role of Technology in E-Business

Economy 5.0 is the result of a synthesis of the development of Economy 4.0 which focuses on digital transformation. However, unlike previous approaches that tended to pursue production efficiency and profit optimization, Economy 5.0 adds a humanist, collaborative, and sustainable dimension to economic activity. The main characteristics of Economy 5.0 include social justice, equitable economic distribution, and the use of technology to address inequality. Technologies such as AI, blockchain, and IoT are used to strengthen transparency and efficiency, while also driving social accountability. Furthermore, Nguyen and Tran (2023) underscore the important role of AI in generating predictive data and personalizing consumer services, especially in the e-business sector.

Fachrozie et al. (2021) and Nizar et al. (2023) stated that e-business in Economy 5.0 does not only function as a trade channel, but also as a forum for cross-sector collaboration to create shared value. In Indonesia, B2B, B2C, and C2C e-business models have proven to be successful in expanding the market and empowering MSME players. In addition, Tallat et al. (2023) stated that e-business in Economy 5.0 serves as a bridge between digital transformation and social responsibility, as it opens up wider access to economic services, education, and information to the public. With a more inclusive approach and increasingly affordable technology, Economy 5.0 is able to create a business model that is not

only profitable but also humane. This is where technology and sustainability meet in the business world.

3. Method

This study uses a descriptive qualitative approach with the literature study method as the main basis in the preparation and analysis. The literature study was chosen because it is able to provide a deep and comprehensive understanding of the development of the interrelated concepts of Industry 5.0, Society 5.0, and Economy 5.0 and their influence on e-business practices in the current digital era. This approach is considered relevant considering that the topics discussed are multidisciplinary and require studies from various reliable scientific sources. The data collection process is carried out by searching scientific articles through academic databases, especially Google Scholar. Keywords used in searches include "Industry 5.0", "human-centric manufacturing", "Society 5.0", "Economy 5.0", "Artificial Intelligence (AI)", "Internet of Things (IoT)", and "e-business in digital economy".

The inclusion criteria set are articles that explicitly discuss these concepts, have open access or are available in full PDF/HTML format, and have gone through a peer-review process. From the results of the initial search and screening, around 12 scientific articles were obtained which were then analyzed qualitatively. Each article is read thoroughly to extract key ideas, methodological approaches, outcomes, as well as relevance to the research theme. The analysis was carried out thematically with a focus on three main dimensions: (1) technological and human-centric transformation in Industry 5.0; (2) social-digital integration through Society 5.0; and

(3) the evolution of the economic system through Economy 5.0 and its implications for digital business.

To maintain the quality and validity of the data, a source triangulation process is carried out, which is comparing the findings of one article with another that has a similar focus. This technique helps to strengthen conclusions and avoid interpretive bias. In addition, direct quotes from the main authors are used to strengthen the argument as well as show the fit between the theory and the context being studied. Using a systematic literature approach, this study aims to form a comprehensive understanding of how the Industrial 5.0 revolution and Society 5.0 are shaping the new face of Economy 5.0, as well as the role of technologies such as AI and IoT in strengthening future e-business models oriented towards collaboration, inclusion, and sustainability. This approach not only provides a theoretical basis, but also offers a critical reflection on the current direction of industrial policy and practice.

4. Results

Based on the results of a literature study conducted on various scientific publications from last five years, it was found that Industry 5.0 marks an advanced phase of industrial evolution that places humans at the core of an intelligent technology-based production system. Unlike Industry 4.0 which emphasizes automation and integration of cyber-physical-based systems, Industry 5.0 actually reintroduces the role of humans as co-creators who collaborate with smart machines in the manufacturing process. This approach aims to create a more adaptive, ethical, and sustainable production system. Research by Tóth et al. (2023) underlines that

the human-centric approach in Industry 5.0 is a response to the limitations of Industry 4.0 which tends to negate the role of humans in industrial processes. Collaboration between humans and intelligent machines, as applied in the concept of smart manufacturing, allows for the creation of new added value through the integration of machine analysis capabilities with human intuition and creativity. Lu et al. (2021) stated that this kind of interaction not only improves production efficiency, but also the quality of work results and job satisfaction of human workers themselves.

Research by Asad et al. (2023) shows that the use of digital technologies such as digital twins and artificial intelligence (AI) is bringing the industry closer to real-time data-based production efficiency. However, the use of this technology also brings ethical and social challenges, such as data privacy issues, excessive surveillance, and workforce anxiety due to technological disruption. Therefore, the success of the implementation of Industry 5.0 is highly dependent on the design of systems that are inclusive and adaptive to the diversity of human needs. One of the widely used strategies is the strengthening of the Human-Machine Interface (HMI) which is more intuitive and adaptive, so that users from various backgrounds can use advanced technology easily and conveniently. With this approach, the industry pursues not only efficiency, but also human values such as participation, empathy, and occupational safety.

In parallel, the concept of Society 5.0 is developing as a future social model that is in line with the technological transformation. Society 5.0 was first introduced by the Japanese government in response to social challenges such as population

aging, natural disasters, and social inequality. In Society 5.0, digital technologies such as AI, IoT, and big data are developed to address social problems in a systemic and humane manner. Simonigar et al. (2023) explained that Society 5.0 is not only the adoption of technology in people's lives, but also an ideal form of social order that prioritizes digital integration in all aspects of life, including education, public services, the economy, and governance. In this context, technology is not seen as a foreign entity that controls humans, but rather as a tool for human empowerment. This opens up space for the emergence of new forms of technology-based social interaction, such as smart cities, digital-based health services, and smart logistics systems that are integrated with the needs of local communities.

Carayannis et al. (2022) show that Society 5.0 creates a deeper connection between humans, machines, and the environment. In this model, society is not only a consumer of technology, but also a producer and manager of data-based values and digital collaboration. This approach also allows societies to adapt quickly to global changes and unexpected disasters. In a study by Marinagi et al. (2023), it was explained that Society 5.0 enables collective data-driven social decision-making, encourages equitable distribution of resources, and increases community participation in the development process through an inclusive digital ecosystem.

This transformation also has a direct impact on the economic system, which developed into the concept of Economy 5.0. Economy 5.0 is a synthesis of the technological approach in Economy 4.0 with a humanitarian and sustainability dimension. If Economy 4.0 emphasizes digitalization and efficiency, then Economy 5.0 prioritizes ethical values, social responsibility, and ecological sustainability in

economic processes. According to Waheed et al. (2022), Economy 5.0 requires business actors to not only pursue profits alone, but also consider the social and environmental impacts of every business activity. In this context, technologies such as blockchain are used to strengthen transparency, while AI and big data are used to analyze consumer needs ethically and holistically.

The implementation of Economy 5.0 is clearly reflected in the growing e-business practices. Fachrozie et al. (2021) and Nizar et al. (2023) stated that digital business models that are developing in Indonesia such as B2B, B2C, and C2C are the main foundation for building an economy based on collaboration and participation. E-business is now not only a means of buying and selling, but also a space for empowering small business actors, increasing digital literacy, and distributing value fairly. The Economy 5.0, digital platforms must be designed to be able to support openness, security, and accountability and facilitate collaboration between stakeholders from various sectors.

Artificial intelligence (AI) plays a very important role in all of these transformations. AI is used to support business decision-making, production process automation, consumer behavior analysis, and data-driven strategic planning. Nguyen and Tran (2023) explain that AI can increase productivity while supporting sustainability through predictive and adaptive systems. Trust in AI systems must be built through algorithm transparency, data protection, and independent audit mechanisms. AI should not be used carelessly as its impact can create inequality and algorithmic bias if not strictly supervised.

Along with AI, Internet of Things (IoT) technology is the main infrastructure in building data connectivity across sectors. Nahdi and Dhika (2021) say that IoT is able to create industrial and social systems that are more efficient, safe, and responsive. In the context of manufacturing, IoT supports predictive maintenance systems and real-time optimization of production processes. While in everyday life, IoT allows the integration of transportation, energy, and security systems that are directly connected to user preferences and needs. The potential use of IoT in rural contexts through drones and cloud-based distribution systems, which are particularly beneficial for remote areas in Indonesia.

The application of AI and IoT also strengthens e-business performance. Digital systems that integrate AI and IoT can provide automated personalization services, better user experiences, and data-driven decision-making. Tallat et al. (2023) explain that this integration allows e-business to be more adaptive to market dynamics while paying attention to environmental and social sustainability. For example, AI can be used to calculate the carbon footprint of digital logistics activities and provide consumers with eco-friendly options.

Overall, the results of the study show that the successful transformation towards Industry 5.0, Society 5.0, and Economy 5.0 requires synergy between technology, regulations, organizational culture, and community literacy. Without this holistic approach, advanced technology will fail to address increasingly complex social and economic problems. Therefore, it is important for all stakeholders, both from government, industry, academia, and civil society to be actively involved in this transition process in a collaborative and responsible manner.

5. Discussion

The findings of this literature study show that the shift towards Industry 5.0 involves not only technological changes, but also fundamental changes in social, economic, and human paradigms. Industry 5.0 with a human-centric approach puts humans back at the center of industrial processes, not just objects of automation. This transformation gives rise to the need to design a work system that allows for synergistic collaboration between humans and intelligent machines. This means that companies are not only adopting technology, but also having to make organizational culture adjustments, human resource training, as well as system redesigns oriented towards worker comfort and safety. In this context, the relationship between technology and humans is complementary, not replaceable.

Further discussions need to be directed at how the integration of technologies such as AI and IoT can support sustainability and social inclusivity. Although both technologies have been shown to increase efficiency and productivity, the literature emphasizes that their use should be ethical, privacy, and transparent. AI, for example, can provide big data-driven automated decisions, but it can also potentially lead to bias or discrimination if left unsupervised. Likewise, IoT, which opens up opportunities for real-time monitoring of systems, but holds cybersecurity risks and reliance on vulnerable network infrastructure. Therefore, technological transformation must be balanced with strong and adaptive regulations and public policies.

The concept of Society 5.0 provides an ideal social framework to support the transition to an inclusive and equitable technology system. Through Society 5.0,

collaborative and humanitarian values are emphasized as the core of digital-based development. The community is no longer positioned as passive users of technology, but as actors involved in the creation and management of technology-based data, information, and public services. In the context of developing countries such as Indonesia, this approach is very strategic because it opens up opportunities for the participation of the wider community in the development process, including in remote or underdeveloped areas. However, the gap in access to technology and digital literacy is still a major challenge that needs to be systematically addressed through digital inclusion policies, education, and basic infrastructure.

Economy 5.0 as a pillar of the new economy also shows a more ethical and sustainable development direction. This model emphasizes the active role of businesses in addressing social and environmental challenges through technological innovation. In practice, the transformation towards Economy 5.0 can be seen from the development of e-business as a collaborative platform between manufacturers, consumers, and service providers. However, for this model to be effective, digital platforms must be designed in an open, transparent manner and uphold the value of justice. This requires collaboration between the public, private, and community sectors to design a digital architecture that facilitates inclusive participation.

Finally, the discussion of the results of this study confirms that Industry 5.0, Society 5.0, and Economy 5.0 are three interrelated and inseparable entities. All three represent a new phase in global development that integrates technology with social and sustainability values. Indonesia as a developing country has a great opportunity to be part of this revolution, as long as it is able to build a national strategy oriented

towards innovation, social justice, and smart and ethical technological adaptation. Success in facing future challenges will be largely determined by the extent to which this synergy can be built and implemented collectively.

6. Conclusion

Based on the results of the literature review that has been conducted, it can be concluded that the transformation towards Industry 5.0, Society 5.0, and Economics 5.0 marks a major paradigm shift in the way humans, technology, and social systems interact. Industry 5.0 emphasizes the importance of a human-centric approach in the design and management of production systems, where humans are not only users, but also controllers who cooperate with intelligent machines within the framework of sustainability- and ethical-based manufacturing. Society 5.0, as the social foundation of this revolution, enables the creation of an adaptive and responsive community ecosystem to global challenges through the use of digital technologies such as AI, IoT, and big data that are inclusive and empowering. Meanwhile, Economy 5.0 is a representation of an economy that not only pursues efficiency, but also social justice and long-term sustainability.

The application of technologies such as AI and IoT has been proven to be able to drive efficiency and productivity, but it must still be balanced with ethical, security, and regulatory aspects. E-business as the real face of digital economy transformation in the 5.0 era, shows that technological advances can be aligned with community empowerment if managed collaboratively. Therefore, to achieve maximum benefits from the 5.0 revolution, an integrative strategy is needed that

involves collaboration between government, industry, society, and academia to build an inclusive, secure, and sustainable digital ecosystem.

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