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THE CONTRIBUTION OF INDUSTRY 4.0 TECHNOLOGIES TO THE SUSTAINABLE DEVELOPMENT GOALS ACHIEVEMENT

Abstract*: the creation of added value in early industrialized countries is currently defined by the transition to the fourth stage of industrialization, known as Industry 4.0. This development follows the third industrial revolution, which began in the early 1970s and relied on electronics and information technologies to achieve a high level of production automation. If information was the main element in the production function of post-industrial economies, then data is the key element in Industry 4.0. Industry 4.0 is characterized by the use of digital technologies, 'smart' concepts, ensuring continuous connectivity among all process participants, efficiency, and adherence to principles of sustainable development.*

Keywords*: Industry 4, enabling technologies, sustainable development, sustainable development goals.*

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ВКЛАД ТЕХНОЛОГИЙ ИНДУСТРИИ 4.0 В ДОСТИЖЕНИЕ ЦЕЛЕЙ УСТОЙЧИВОГО РАЗВИТИЯ

Аннотация*: создание добавленной стоимости в странах с ранней индустриализацией в настоящее время определяется переходом к четвертой стадии индустриализации, известной как Индустрия 4.0. Это развитие*

следует за третьей промышленной революцией, которая началась в начале 1970-х годов и опиралась на электронику и информационные технологии для достижения высокого уровня автоматизации производства. Если информация была основным элементом производственной функции постиндустриальных экономик, то данные являются ключевым элементом в Индустрии 4.0. Индустрия 4.0 характеризуется использованием цифровых технологий, «умных концепций, обеспечивающих непрерывную связь между всеми участниками процесса, эффективность и приверженность принципам устойчивого развития.

***Ключевые слова**: Индустрия 4.0, стимулирующие технологии, устойчивое развитие, цели устойчивого развития.*

Introduction

Industry 4.0 is founded on the use of digital representation of information across all management levels and types and represents a new level of production organization and value chain management throughout the product lifecycle. The development of Industry 4.0, based on the creation of smart cities, product factories, and services integrated into the Internet of Things, has a significant impact on sustainable production and achieving sustainable development goals.

However, while the development of Industry 4.0 provides new opportunities for sustainable development practices across economic, social, and environmental aspects [2], contemporary research primarily focuses on Industry 4.0's contribution to the development of circular economy practices and reducing environmental impact.

Industry 4.0 enabling technologies and sustainability

Researchers and practitioners are increasingly considering sustainability in technological innovations during Industry 4.0 in general [1]. Related to sustainability, numerous contributions in the literature aim to define the link and impact of Industry 4.0 in defining processes, with firms increasingly oriented towards sustainable development. Hence, the literature at the intersection of Industry 4.0 and sustainability is rapidly evolving and growing to cover different areas [1, 2, 4]. Simultaneously, the

rapid, progressive development of the digital revolution contributed to the establishment of specific tools of Industry 4.0, known as «enabling technologies», widely used by firms. These technologies are often classified as the «nine enabling technologies of Industry 4.0»: additive manufacturing, augmented reality (AR), autonomous robot, Big Data, cloud computing, cybersecurity, horizontal and vertical system integration, the industrial Internet of Things (IoT) and simulation. Scholars started to investigate the link between Industry 4.0 and sustainability from the perspective of its enabling technologies. New technologies directly or indirectly contribute to sustainability [1].

It is also pointed out that very few studies investigate enabling technologies and their contribution to sustainability. Moreover, it is not only important that firms implement sustainable practices but also communicate them to stakeholders to gain economic, competitive, and corporate image benefits. Although the disclosure of sustainable information and practices is not mandatory, its dissemination can enhance a firm’s reputation and brand, as well as increase credibility in the eyes of stakeholders. In this domain, no existing study in the literature looks at the role of enabling technologies in sustainability under the lens of communication.

The implementation of sustainable business models in Industry 4.0 is ensured at all levels of the economy. Different principles of Industry 4.0 necessary for implementing its 'scenarios' can be identified. For example, functional compatibility (interoperability) implies direct interaction or the ability of machines, devices (robots), sensors, and humans to exchange information using Internet of Things.

Informational transparency, or the ability of systems to create virtual (digital) copies of real systems, emerges based on interoperability and results from direct interaction. It is achieved by supplementing information models with data coming from various sensors in real-time. To achieve informational transparency, it's necessary to collect data from sensors and detectors within the content they generate. As a result, digital copies of real objects, systems, and functions are created in the virtual world, accurately replicating everything happening with their physical clones. These digital

twins accumulate information about all processes occurring with smart equipment, production, and products.

Technical support and decentralization of managerial decisions (machine assistance to humans) denote the ability of cyber-physical systems to participate in decision-making by collecting, analyzing, and visualizing information. This leads to the decentralization of decision-making and even the delegation of some to cyber-physical systems. Technical support also involves replacing humans in performing routine or hazardous operations. The final stage of the process is automation where cyber-physical systems efficiently function without human intervention or human replacement. Humans act as controllers, intervening only in emergency and non-standard situations.

The implementation of Industry 4.0 principles also has a significant impact on the level of global value chains. For instance, factory robotization enables automobile manufacturers to establish domestic production instead of relying on cost-effective labor from other countries. In this context, Industry 4.0 principles serve as an alternative to political instruments for regulating the macroeconomic situation.

The most significant value, both from a scientific and practical standpoint, lies in researching the contribution of Industry 4.0 to addressing global human challenges and achieving sustainable development goals

Conclusions

With the emergence of Industry 4.0 the concept of sustainable development has acquired new dimensions. This can be explained by several reasons. Firstly, initially, in the early policy documents of the Ministry of Education and Research of Germany, dedicated to the development of Industry 4.0, it was viewed as a strategy for creating sustainable production. In other words, Industry 4.0 was portrayed as a production concept free from the shortcomings of its predecessor, accompanied by the depletion of natural resources, climate change, and a decline in workforce quality [3]. It's important to underline that Industry 4.0 consists of sustainable development practices, where sustainability acted as a premise for the development of Industry 4.0.

Secondly, subsequently, around the elements of Industry 4.0, disruptive, «revolutionary» business models began to evolve, presenting new opportunities for implementing the concept of sustainable development – primarily through the use of digital infrastructure and information-communication technologies. These are business models of sustainable production, consumption, waste management, and changes in global value creation chains. Among them, particular attention should be paid to the platform economy, sharing economy, and app economy.

Key trends in the development of the digital economy include globalization, mindful consumption, constant changes, digitalization of communications, social transformation, technology, and innovation.

Thirdly, the development of Industry 4.0 not only fit into the broad discussion on industrial sustainability but also raised new questions. Do the technologies of Industry 4.0 genuinely contribute to sustainable development? On the contrary, do the key components of Industry 4.0 (robotization and digitalization) pose additional threats and place humanity in front of new global challenges?

Addressing the challenges posed by Industry 4.0 represents the most complex and debatable aspect. Besides, the concept of Industry 5.0 as a subsequent phase of Industry 4.0 is centred around values, such as human-centricity, ecological or social benefits. This paradigm shift is based on the idea that technologies can be shaped towards supporting values. This is especially important as ongoing societal developments in the fourth industrial revolution change the way value is created, exchanged and distributed. The technologies at the core of Industry 5.0 are largely congruent with Industry 4.0, while a stronger focus on human-centred technologies and, hence, cooperation problems forms the basis for Industry 5.0.

Reference

1. Piccarozzi M., Stefanoni A., Silvestri C., and Ioppolo G. (2023). Industry 4.0 technologies as a lever for sustainability in the communication of large companies to stakeholders, European Journal of Innovation Management, ISSN: 1460-1060, https://doi.org/10.1108/EJIM-11-2022-0641.

2. Papetti A., Pandolfi M., Peruzzini M., and Germani M. (2020). A frame-work to promote social sustainability in industry 4.0, International Journal of Agile Systems and Management, Vol. 13 No. 3,

3. Schwab K. (2016). The Fourth Industrial Revolution. World Economic Forum.

4. Xu X., Lu Y., Vogel-Heuser B., and Wang L. (2021). Industry 4.0 and Industry 5.0 – Inception, conception and perception, Journal of Manufacturing Sys-tems, Vol. 61.

5. Saniuk S., Grabowska S., Straka M. (2022). Identification of social and economic expectations: contextual reasons for the transformation process of industry 4.0 into the industry 5.0 concept. Sustainability, 14 (3), 2022. DOI 10.3390/su14031391. EDN HOOEBU