International Journal of Technology 13(7) 1373-1382 (2022)
Received September 2022 / Revised November 2022 / Accepted December 2022

International Journal of Technology

http://ijtech.eng.ui.ac.id

A Framework for Digital Development of Industrial Systems in the Strategic Drift to Industry 5.0

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Abstract. Industry 5.0 is an integral driving force for industrial development to overcome a resurgent strategic drift. This solution is a perfect tool to ensure a sustainable, human-centered, and resilient industry and encourage man-machine collaboration within intelligent cyber-social systems. A complete shift to Industry 5.0 is only feasible when industrial systems apply digital strategizing to enhance digital development. That would invite technologies and humans to facilitate all operational and customer dealings, significantly increasing the rate of innovation. This research aims to articulate a multi-perspective conceptual framework based on the premises of digital development of industrial systems in the strategic drift to Industry 5.0. The methodology implied in this research rests on an interview with industry experts, a case study of digitalization leaders in 2021, extensive and systematic literature review and scientometric analytical tools, content analysis and foresight. In this paper, the authors reframe the concept of digital strategy and consider it as a notion independent of digitalization strategy and digital transformation strategy that is traditionally based on the formation of digital thinking, implementation of digital behavior patterns, the transformation of mindset, and strategic wisdom. As a result, a brand-new perspective on Industry 5.0 is suggested – Nooindustry 5.0. This digital development framework provides grounds for a digital business strategy to advance and shapes a platform-operating model to nurture the digital maturity of industrial systems. This research identifies key strategies for the transformation of an industrial system into a bionic one to sail through the current strategic drift. Further scientific work has to be carried out in order to assess the impact and effects of digital development of industrial systems while shifting to Industry 5.0.

Keywords: Digital strategizing; Framework; Industrial system; Industry 5.0; Strategic drift

1. Introduction

The world has entered an era of revolutionary transformation. On the one hand, the current crisis opens a window of opportunity for industrial systems to develop via the implementation of digital technologies that can significantly boost their competitiveness and performance. On the flip side, industrial systems are going through a strategic drift

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doi: 10.14716/ijtech.v13i7.6193

caused by a significant number of risks that are looming above the successful shift from Industry 4.0 to Industry 5.0. Industrial systems have to deal with a whole range of undermining challenges, including destruction or reframing of international economic ties; sanctions and a subsequent lack of access to a number of technological solutions; insufficient sovereignty of some industrial sectors; higher prices for technologies and component parts; delayed implications of support measures that took place in the Covid-pandemic; transformation of global supply chains; reduction of planning horizon; high entropy between domestic and foreign agents, etc.

In their earlier research (Babkin et al., 2021a; Babkin et al., 2021b) the authors came to the conclusion that Industry 4.0 is no driver to settle entrenched social tensions because it seeks to optimize business models and economic thinking, which indeed generates the above-mentioned threats and risks. A neo-concept of Industry 5.0 is designed to supplement the digital development of industrial systems with more meaningful and efficient cooperation between people, machines, and systems in a digital environment.

2. Literature Review

2.1. Industry 5.0

The "Industry 5.0" neo-concept was coined in 2015, only four years after the advent of Industry 4.0. Since 2020, the scientific community has been showing unprecedented interest in the topic of Industry 5.0. It is often associated with extreme automation based on the Internet of Things and smart industries. However, other approaches should also be mentioned. For instance, (Özdemir & Hekim, 2018) see the democratic production of knowledge based on big data analysis and symmetric innovation as a key objective of Industry 5.0. In his turn (Nahavandi, 2019) believes that increasing productivity without removing people from production poses severe problems for the global industry. Figure 1 presents key definitions of Industry 5.0 provided by existing scientific sources.

Industry 5.0 is designed to establish solid cooperation, not competition, between humans and machines. (Doyle-Kent & Kopacek, 2019) believe that Industry 5.0 contributes to a paradigm shift in industrial development in a way similar to the Fourth Industrial Revolution. On the contrary, (Rada, 2018) and (Babkin et al., 2022b) emphasize that Industry 5.0 does not operate as another industrial revolution. But is indeed an evolutionary addition to Industry 4.0 technologies, aimed at strengthening cooperation between humans and robots. In their turn, the works of (Fedorov et al., 2021a; Fedorov et al., 2021b) consider Industry 5.0 as a fundamental requirement for the design of neuro-digital ecosystems. The study by (Breque et al., 2021) presents Industry 5.0 as a tool for ensuring a sustainable, human-centered, and resilient industry. The main problem is that the management of many industrial systems does realize the potential value and prospects of Industry 5.0 but is still not ready to implement digital strategizing. That contradiction reveals a significant gap between mere awareness and implementation of Industry 5.0 solutions.

Industry 5.0 brings back the human workforce to the factory, where human and machine are paired to increase the process efficiency by utilizing the human brainpower and creativity through the integration of workflows with intelligent systems (Nahavandi, 2019)
Industry 5.0 compels the various industry practitioners, information technologists and philosophers to focus on the consideration of human factors with the technologies in the industrial systems (Chanias et al., 2019)
Industry 5.0 is a first industrial evolution led by the human based on the 6R principles of industrial upcycling, a systematic waste prevention technique and logistics efficiency design to valuate life standard, innovative creations and produce high-quality custom products (Rada, 2020)
The new revolutionary wave, Industry 5.0, integrates the swerving strengths of cyber–physical production systems (CPPS) and human intelligence to create synergetic factories (Longo et al., 2020)
Industry 5.0 – cyber-social system; consists of a set of interacting actors-ecosystems, that operate and self-organize in a special "neurosphere", formed by collective intelligence, which allows combining human and machine intelligence to create a collective superintelligence. The latter can evolve into a source of harmonious technological development of humankind. (Babkin et al., 2021a)

Figure 1 Industry 5.0. Key Definitions

2.2. Digital strategizing

Adaptability to strategic drift that takes place in the transition to Industry 5.0 requires new digital solutions and tools for digital strategizing of industrial systems. That's why another aspect that is vastly covered in scientific research is the development of digital strategies. For instance, the works of (Zhuravlev & Glukhov, 2021; Koroleva & Kuratova, 2020; Albukhitan, 2020; Hess et al., 2016; Matt et al., 2015) deal with strategizing of digital transformation within economic systems. It is worth noting that the works of (Sasev, 2021; Ludwig & Stegmann, 2021; García-Esteban et al., 2021) consider the strategy of digitalization of various processes in general. At the same time, specific digital tools and technologies of strategizing – digital twins and artificial intelligence – are considered in the works of (Surovitskaya, 2021; Simchenko et al., 2021). Scientists who are directly engaged in digital strategizing research are represented primarily by (Morton et al., 2022; Glukhov et al., 2022; Babkin et al., 2022a; Kalinin, 2021; Morton et al., 2020; Ruel et al., 2020; Chanias et al., 2019). Figure 2 presents key definitions of digital strategizing. The main conceptual disadvantage of many scientific works dedicated to strategizing digital development is that they generate and exploit confusing terminology. For example, such notions as digital strategy, the strategy of information systems, digitalization strategy, and the strategy of digital transformation, are used interchangeably.

Digital strategizing is considered as the third (highest) level of digital maturity following IT strategizing (the lowest level of maturity), and Aligned strategizing (medium level of maturity) (Chanias et al., 2019)
A domain focused on the interplay between digital technologies and people at different levels of organisations in processes that form, transmit, implement, host, and support strategy (Morton et al., 2022)
Digital strategizing necessarily covers a range of areas including the use of IS for strategy and strategizing, the mobilisation of strategic IS, and the formulation and implementation of specific (digital) strategies (Morton et al., 2022)

Figure 2 Digital Strategizing. Key Definitions

A number of scientists observe digital strategy from a rather narrow perspective, defining it as a business strategy of an enterprise based on the use of digital technologies and information systems. For instance, the United Nations Development Program of Digital Strategy, 2022-2025 applies a broader approach, where the term "digital" is applied both

to the constantly evolving range of technologies and to the transformation of the work environment that allows people and organizations to innovate and progress using technology. Thus, digital strategizing should be considered beyond the simple introduction of digital technologies into the operations of decision-makers in industrial systems.

3. Methods

This research *aims* to define a multi-perspective conceptual framework based on the premises of digital development of industrial systems that takes place under strategic drift on the way to Industry 5.0. This research primarily focuses on industrial systems that operate in conditions of adaptation to an advancing digital environment, and apply the advantages of digital solutions and digital behavior patterns in order to increase their competitiveness and overall efficiency. It is important to address the following *issues* in a comprehensive manner:

1. What is the research gap in the neo-concepts of Industry 5.0 and digital strategizing?

2. What are the basic constructs of digital development of industrial systems in the conditions of strategic drift?

3. What does the framework for the digital development of industrial systems in strategic drift include in the transition to Industry 5.0?

4. Can Industry 5.0 be viewed as a cybersocial framework for the digital development of industrial systems in the conditions of strategic drift?

5. What is the comprehensive approach on how to define the concepts of digital strategy and digital strategizing that does not avoid ambiguity between these notions and other terms, such as digitalization strategies or digital transformation?

6. What are the strategies for transforming the industrial system into a bionic industrial system?

To address the first two issues, a systematic literature review was conducted based on scientific cognition analysis and synthesis. It included assessment and combining scientific data carried out with appropriate techniques and instruments, including quantitative and qualitative ones. Th authors employed a standardized eight-step methodology for an independent systematic literature review developed (Okoli, 2015) (Figure 3).

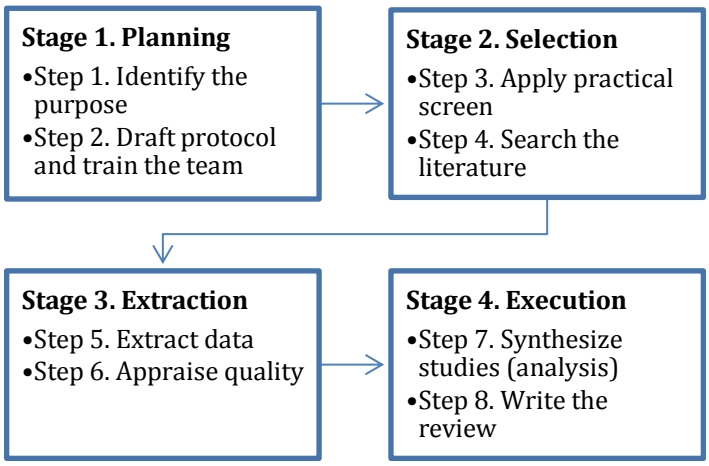

Figure 3 Standardized methodology for the systematic literature review (also called systematic review)

As for the methods of a quantitative assessment of digital development, the authors used clustering and scientometric tools (Figure 4). The Elsevier Research Intelligence

(Scopus), and the VOSviewer (Visualizing scientific landscapes) – version 1.6.18, released on January 24, 2022 – were used as analytical tools. Of the total number of all search results received, 76 publications were deemed relevant and were further analyzed.

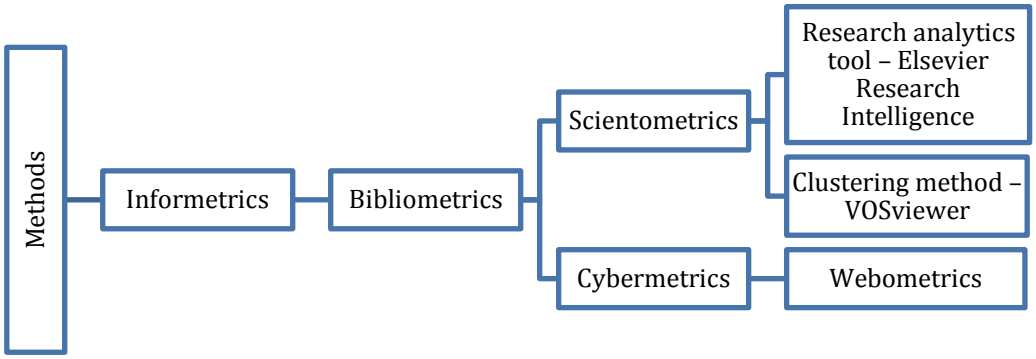

Figure 4 Methodological research tools

The address to the third research issue was obtained through an interview with industry experts. The current state of digital strategizing in 20 industrial systems was analyzed (Almaz Group, Vyksa Steel Works, Tactical Missiles Corporation, 3B-System Cooling, CHEAZ Group, UEC Saturn, Tonar Machine–Building Plant, Cable factory "Expert cable", United Engine Corporation, etc.), and the problems of their digital transformation in the conditions of strategic drift in the transition to Industry 5.0 were investigated. Based on the of case study of digitalization leaders in 2021, the fourth issue was solved. In order to gain insight into the concepts of digital strategy and digital strategizing, content analysis was applied. The address to the last research issue was obtained on the basis of the foresight, which also allows us to identify areas for further research.

4. Results and Discussion

The scientometric analysis of the Scopus database from 30/09/22 revealed 76 documents based on the keywords "digital" and "strategizing". The initial signs of interest to the problems of digital strategizing date back to 2005, followed by a significant increase in the number of works on the topic. Logically enough, such dynamics go hand in hand with a growing interest in Industry 5.0. The obtained information included citation data, bibliographic information, a brief description and keywords, information on funding, etc. Later on, all these findings were uploaded to VOSviewer, which allowed the designing of an entire map based on bibliographic data (Figure 5).

As a result of scientometric analysis, 129 keywords were identified and divided into 16 clusters. The main constructs of digital development of industrial systems in conditions of strategic drift (keywords with occurrences more than 1 (from 2 to 8)) include: strategizing, strategy formation, strategy practice, IS strategizing, digital strategy, digital transformation strategy; digitalization, digital transformation; digital innovation; digital technologies, big data, robotics, artificial intelligence, etc. Based on the results of clustering and defining key constructs, the authors have developed a framework for the digital development of industrial systems that face a strategic drift in their transition to Industry 5.0 (Figure 6). The developed framework for the digital development of industrial systems in the strategic drift of the Industry 5.0 shift allows to correlate the stages of digital strategizing with the stages of digital development, milestones of industrial revolutions and their corresponding objects and tools.

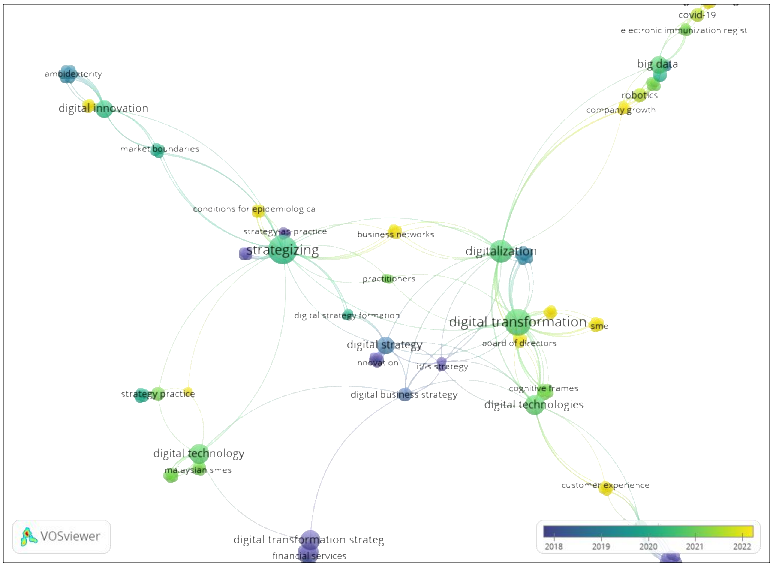

Figure 5 Map based on bibliographic data from 76 Scopus documents (by keywords "digital" and "strategizing")

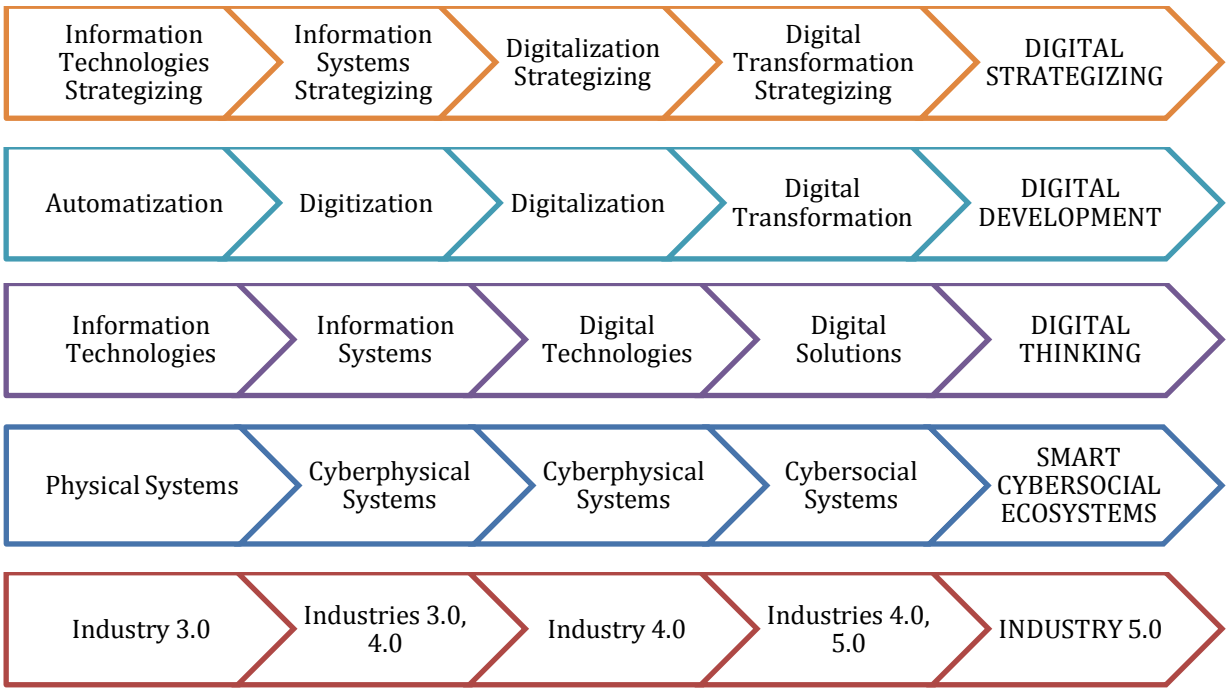

Figure 6 Framework for the digital development of industrial systems in the strategic drift of the Industry 5.0 shift

The framework is expected to serve as a basis for a multi-perspective concept of digital strategizing in industrial systems, which will allow industrial systems management and decision-makers to design a digital development strategy, as well as to form a platform-operating model to increase the level of digital maturity (Kvint et al., 2022; Agus et al., 2021; Bencsik, 2020; Lyukevich et al., 2020). Based on the framework (Figure 6), the authors present Industry 5.0 as a Nooindustry 5.0, with reference to the terms “noosphere” (Jaseckova et al., 2022), and “nooeconomics” (Bodrunov, 2019). This industry rests on the principles of justice and reason based on a new type of cooperation – noo-cooperation (Babkin et al., 2022b). Industry 5.0 is centered around intelligent cybersocial ecosystems –

"ecosystems of a new meta-level, evolving in the transition from Industry 4.0 to Industry 5.0. They incorporate cybersocial values of human-centricity, sustainability, and resilience; and are characterized by a high level of hyperconvergence of cybernetic, socio-ecosystem, technological and cognitive modalities aimed at the achievement of ethical social goals, sustainable well-being of humanity and each individual" (Babkin et al., 2022a).

While shifting to Industry 5.0, industrial systems need to form a digital strategizing system. By one, the authors consider a range of interconnected elements that shape a certain unity focused on the interaction between digital solutions and people with digital thinking. Such interaction occurs at different levels of industrial systems in the processes that form, transmit, implement, host, and support a digital strategy. The *digital strategy* is considered as the utilization of digital solutions in strategizing based on digital thinking combined with the activities of decision-makers. Such an incorporating approach leads to the overall transformation of how work processes are organized and allows industrial systems to innovate using technologies that create differentiated value and effective competition through the use of new business models.

It is extremely important to terminologically distinguish the concepts of digital strategy, digitalization strategy, and digital transformation strategy. As Figure 6 shows, digital strategy is a concept of a higher "rank", along with such fundamental concepts, as "digital development" and "digital thinking". It is digital thinking precisely – based on the transformation of perspective on preparation, adoption, and implementation of solutions – that distinguishes the digital strategy from the "strategy of digital transformation", and "digitalization strategy". Digital thinking should be based on strategic wisdom (Kvint et al., 2021) and digital behavior patterns. The authors suggest considering industrial systems with a high level of digital development in the strategic drift of the Industry 5.0 shift as bionic. Bionic industrial systems based on digital strategizing combine digital technologies with human capabilities within Industry 5.0. The goal of it all is to transform operations that develop experience, customer relationships, and efficiency by significantly increasing the pace of innovation (Kvint et al., 2022). Transformation of an industrial system into a bionic one is possible when it rests on four strategies: significant investment in digital technologies, data, and human potential; use of artificial intelligence as the basis for digital transformation; introduction of a platform-operating model; convergence of technologies and human capabilities based on the principles of justice and reason within the framework of the Nooindustry 5.0 (Panteleeva & Petrov, 2022; Geliskhanov et al., 2018).

5. Conclusions

As a result of this research, the authors clarify the current condition of digital development in industrial systems that find themselves in a strategic drift on the way from Industry 4.0 to Industry 5.0. Systematization of the existing pool of definitions for "Industry 5.0" and "digital strategizing" allowed identifying a research gap and the spotting a terminological confusion and a narrow approach to the definition of digital development strategies. The study reveals the integral constructs of digital development of industrial systems in the conditions of strategic drift, including: digital strategizing, digital transformation, digitalization, digital technologies, digital transformation strategy, digital strategy, etc. The authors developed a structural framework for the digital development of industrial systems in the strategic drift of the Industry 5.0 shift. On the basis of bionic industrial systems with a high level of digital development, the author's interpretation of Industry 5.0 boils down to the concept of Nooindustry 5.0, shaped. The concept of digital strategy is terminologically separated from the concepts of digitalization strategy and digital transformation strategy, based on the inclusion of such fundamentals as digital

thinking, mindset transformation, digital behavior patterns, and strategic wisdom. Strategies for an industrial system to transform into a bionic one were also proposed. The limitations of the study are related to the sample size of the survey of 20 industry experts, as well as the longevity of the analyzed cases of digitalization leaders in 2021. Further research on the topic requires a careful consideration of such issues as the impact and effects of digital development under the strategic drift in the shift to Industry 5.0.

Acknowledgments

The research was carried out within the framework of project No. 20-010-00942A of the Russian Foundation for Basic Research (2020-2022).

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