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THE DEFINITION OF SMART ECONOMY AND DIGITAL TRANSFORMATION OF BUSINESS IN THE CONCEPTS INDUSTRY 4.0 AND 5.0

The object of the study is the relationship between economic entities in the smart economy and their digital transformation in the conditions of Industry 4.0 and 5.0. One of the most problematic areas is the definition and structuring of the smart economy and establishing the effects of digital business transformations in the conditions of Industry 4.0 and 5.0.

The research used methods of grouping, system analysis, historical approaches to scientific research, synthesis and analysis, forecasting, etc. A qualitatively new definition and structuring of the smart economy was obtained, which is connected with the use of new business technologies in the conditions of total digital transformation in the concepts of Industry 4.0 and 5.0. In particular, new classification approaches to the structuring of the smart economy and digital transformation of business in the concept of Industry 4.0 and 5.0 are singled out.

The conducted study of the state of the smart economy and digital transformation of business according to the concepts of Industry 4.0 and 5.0 indicate a significant potential for the use of digital technologies in business and a significant economic effect of their use, which requires further improvements. This puts the potential for investment in robotic manufacturing to reach 120.6 billion USD in 2025, followed by autonomous operations and 360-degree customer management at 90.9 and 74.7 billion USD, respectively. The industries that will have the highest spending on digital business transformation in the smart economy throughout the forecast period are discrete and technology manufacturing, followed by professional services and retail. The economic sectors that will experience the fastest growth in spending on digital business transformation in the smart economy, according to the forecast for 2020–2025, are construction (21.0 %), securities and investment services (19.2 %), and banking (19.0 %). Compared to similar well-known developments, all 19 industries considered in the digital transformation of business in the smart economy are predicted to provide double-digit growth over the five-year forecast. This provides significant economic advantages in the adaptation of economic agents to the conditions of introducing digital business transformation in the context of Industry 4.0 and 5.0.

Keywords: *digital economy, business technologies, information economy, digitalization of business processes, Industry 4.0, Industry 5.0.*

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1. Introduction

The use of Industry 4.0 and 5.0 in the context of the formation of the smart economy and digital transformation of business and their prospective development is a very urgent task of today. To this day, the economic science of financing the prospective development of digital business transformation in the smart economy is dominated by the practice of assessing the economic result from the introduction of digital business technologies using the net present value method. This method is the difference in income and expenses from an investment project into a digitalized economic system brought to their value today. The main reason why it is difficult to introduce innovations in the smart economy and carry out digital transformation of business in accordance with the elements of using the concepts Industry 4.0 and 5.0 is the use of high discount rates. This is not providing an opportunity to solve many economic problems, including problems with rising income inequality, the state of the environment, etc. In many countries of the world, the situation is becoming so alarming that they are already actively investigating financiers and economists and specialists in various fields of knowledge. Instead, the world community ambiguously perceives these problems, which is why the issue of research and empirical measurement of the state of the smart economy and digital transformation of business in the world, as well as the prospects for the development of digital business technologies and systems, subject to the introduction of Industry 4.0 and Industry 5.0, is extremely relevant. In recent years, the developed countries of the world, in particular the USA, Canada, Japan, China, Australia, South Korea, India, have begun to actively implement models of digital business transformation and building their own smart economies with the identification of components of the information economy models. Using the transition to Industry 5.0 economic development ahead of the scientific justification of such components of financial or economic modules in their development. This especially actualizes the application of Industry 4.0. and 5.0, technology in the context of the prospective development of the smart economy and digital transformation of business, as well as the assessment of their economic effect.

There is no well-established interpretation of the concepts of «Fourth Industrial Revolution (Industry 4.0)» and «The Fifth Industrial Revolution (Industry 5.0)» as well as the peculiarities of applying them as separate technologies and for a certain type of economic activity and with the general digital transformation of business during the transition of national economic systems into a smart economy.

«Smart-economy», «inclusive», adaptive economy, digital economy, information economy, behaviourist economics, etc. is necessary to classify for the adequate use of concepts Industry 4.0 and 5.0. In the research of representatives of the German scientific school and their analytical materials and various interviews, Industry 4.0 is associated with the industrial production of the future, based on nine innovative technological developments [1]. The most complete components of Industry 4.0 were described in the so-called White Report, which was prepared by representatives of the board of directors of WEF [2]. They systematized the following components of revolution 4.0:

– Big Data;
– Cyber systems (Smart Factory, Autonomous Robots);
– Cybermodeling (Simulation);
– Horizontal and Vertical System Integration;
– The Industrial Internet Things;
– Cloud technologies (The Could);
– Additive Manufacturing and Cybersecurity.

But all these components of Industry 4.0 and 5.0 cannot be fully applied without adapting to the conditions for financing renewable energy systems, up to a complete transition to a carbon-free method of extracting and producing energy in the world [3, 4].

Given the novelty of the concept of Industry 4.0 and 5.0, there are practically no or very few works that would reflect the results of thorough research and the risks of introducing its technologies in renewable energy systems and they are not completely tangential to the issues that will be investigated in this article.

Given that this aspect of the prospective application of technologies Industry 4.0 and 5.0 in the digital transformation of business into a common smart economy in economy science was not studied enough, and some scientific schools described only the general ideas, paradigms and concepts of Industry 4.0 and 5.0, the unresolved nature of this issue and its urgent need became the reason for choosing the topic of this article.

Given the relevance of the studied issues, *the object of the research* study is the relationship between economic entities in the smart economy and their digital transformation in the conditions of Industry 4.0 and 5.0. *The aim of this article* is a theoretical and empirical study of the state of digital business transformation and the application of digital business technologies of the smart economy in the concepts of Industry 4.0 and 5.0.

2. Research methodology

The research used methods of grouping, system analysis, historical approaches to scientific research, synthesis and analysis, forecasting, etc.

A qualitatively new definition and structuring of the smart economy was obtained, which is connected with the use of new business technologies in the conditions of total digital transformation in the concepts of Industry 4.0 and 5.0. In particular, new classification approaches to the structuring of the smart economy and digital transformation of business in the concept of Industry 4.0 and 5.0 are singled out.

3. Research results and discussion

Industry 4.0 is the updated concept of «smart production», identified with the «Fourth Industrial Revolution» and the emergence of cyberphysical systems. In other words, it's the next stage of business digitalization and the construction of national smart economies, in which the main role is played by technologies and concepts such as the Internet of Things, «big data», «predictive analytics», cloud computing, «machine learning», machine interaction, artificial intelligence, robotics, 3D printing, supplemented reality [3]. Within the framework of the concept of Industry 4.0 and socially oriented Industry 5.0 (Fig. 1) the construction of national smart economies in the world is in the zone of total digital transformation of business, going beyond the use of exclusively information technologies and automation of production. The use of digital business technologies that are inherent in the smart economy compared to the base year of 1990, in which Industry 4.0 has not yet existed.

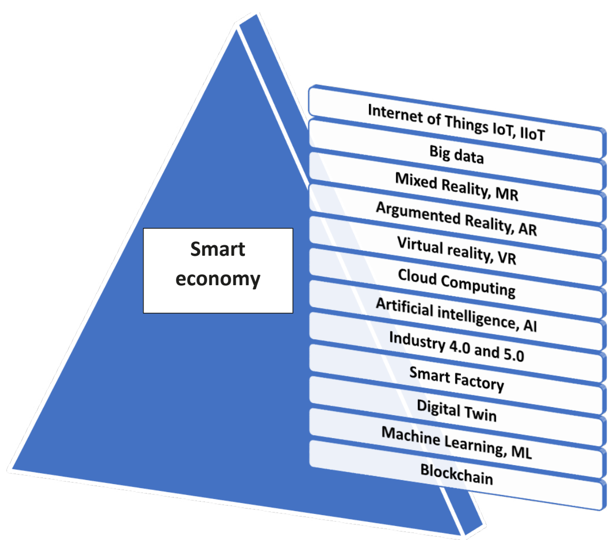

Fig. 1. Digital transformation of business by its types in the smart economy

The main technology in the concepts Industry 4.0 and 5.0 is considered to be the Internet of Things (IoT). IoT is the driving force of which is the Industrial Internet of Things (IIoT), by which let's understand a system of integrated computer networks and production facilities

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with built-in sensors and single software for collecting and exchanging data with the ability to remotely control and control in an automated mode without human intervention. As well as the Industrial Internet of Things allow to create automated productions that require significant initial investments, but are significantly economical in further operation, since it is not necessary to form wage funds and their derivative funds, which, in turn, reduces the average cost of all goods or works performed by such automated production.

This gives reason to believe that IIoT can significantly increase efficiency, in some cases even several dozen times, and the payback period of such investment projects based on IIOT does not exceed several months. This means of production is equipped with appropriate radio marks that uniquely verify all stages of production element-by-element, and all of them are integrated into a single system (platform) of data processing.

In [2], which based on a survey of 1400 senior executives in many countries of the world (of which 736 are company executives), indicates the contribution of IIOT to global production in 2030 could be about 14.2 trillion USD. Whether it will be at the expense of the Ukrainian economy is not a definite question, because the potential increase due to the digitalization of financial and business processes in Ukraine is under threat, since neither companies nor the state take sufficient measures to create conditions for this. As indicated in this report, by 2030, the results of the implementation of IIoT could be as follows:

– in the United States, total GDP could increase by 6.1 trillion USD;
– Germany can increase total GDP by 700 billion USD, or 1.7 %;
– the UK can increase total GDP by 531 million USD, or 1.8 %;
– and the greatest benefits from the effective introduction of IIOT technologies in business structures in China, which can grow its total GDP by 1.8 trillion USD, or 1.3 % in 2030.

IIoT helps to develop augmented and virtual reality (AR/VR) technologies based on the MQTT messaging protocol (Message Queue Telemetry Transport), which is a simplified data exchange protocol and works on TCP/P) and provides increased cybersecurity of such production digitalized systems, and allows them to significantly increase their economic efficiency due to the significant duration of the production cycle. For example, the introduction of IIOT at Harley Davidson managed to reduce the production cycle from 21days to 6 hours, that is, almost tenfold. The implementation of end-to-end management of production and sales throughout the life cycle, reducing the cost of forming a wage fund and its derivatives, etc [5, 6].

The use of Big data processing technology in business also increases the cost-effectiveness of managing business structures and processes, because the Big Data technology itself allows to designate structured and unstructured data, including text and graphics, of huge volumes and significant diversity. That can be efficiently processed using software tools that are horizontally and vertically scalable and are a fairly powerful alternative, application of such business methods of management and management, which were and are database management systems of the Business Intelligence solution class.

Significant characteristics of Big Data, which increase the economic efficiency of business process management, of course, are the implemented principle of seven «V», or the VVVVVVV dataset (veracity, volume, velocity, variety, viability, value, visualization – reliability, physical volume, data growth rate and the need for their fast processing, the ability to process data of various types, viability, value, visualization). And this is achieved largely due to the basic principles of working with Big Data [7]:

– horizontal and vertical scalability, the basic principle, which, by increasing the number of computational nodes by which data is distributed, increases productivity;
– fault tolerance, as well, due to the introduction of preventive measures regarding the likelihood of machine failure due to an increase in hundreds of thousands of cluster computing systems – allows to make more effective management decisions about competitors or the life cycle of your own product in the business environment;
– the locality of the data allows to select the data isolated from big data, which is needed exclusively for a given business environment or a certain management decision in business.

The application of Big Data distribution technologies in the smart economy and in the business of digital technologies is manifested in the following trends:

– MapReduce (Google's distributed computing model);
– NoSQL (various non-core databases and storages);
– Hadoop (sets of utilities, libraries, free code frames for the development of distributed cluster programs that can work simultaneously on clusters of hundreds of millions of nodes);
– R (programming language for mining and big data processing);
– hardware solutions (hardware and software complexes based on free or paid software code for intelligent processing (mining) of Big Data.

Each of the mentioned digital technologies for working with Big Data, which have a certain partial or full implementation in economic processes, allow significantly reduce the production cycle, accelerate the turnover of funds, reduce the time spent by management personnel in business structures, and thereby significantly reduce the cost of goods, works and services while improving product quality.

At the same time, to achieve the goal of improving the economic efficiency of business with the help of digital Big Data technology, which are usually used by 11 McKinsey methods:

1) Data Mining methods (data mining, data mining, in-depth data analysis);

2) Crowdsourcing – classification and enrichment of data by a wide, undefined circle of individuals performing this work without entering into labor relations, data fusion and integration;

3) Machine learning, including learning with and without a teacher;

4) Artificial neural networks, network analysis, optimization, including genetic algorithms;

5) Pattern recognition;

6) Predictive analytics;

7) Simulation;

8) Spatial analysis;

9) Statistical analysis – time series analysis;

10) A/B testing (A/B testing, split testing – marketing research method);

11) Visualization of analytical data [8].

In 1994, authors of [9] defined mixed reality (MR) as «… all between the extremes of the virtual continuum (VC), where the virtual continuum extends from full reality to a fully virtual environment with augmented reality and virtuality within it». Later, in business circles, it begins to be called hybrid reality, or computer-mediated reality, reduced reality, modulated reality or modified reality, and the meanings of these terms partially change depending on the business environment where they are put into practice. «Things» are convenient labels for different points of the spectrum [10]. Mixed realities used as digital business technologies also include:

– Extended reality (XR or Cross Reality);
– Cinematic reality (CR);
– Visuo-Haptic Mixed Reality (VHMR);
– 360 virtual reality (or 360 VR, or mobile VR), it is touted as «interactive and immersive content that completely surrounds the user, as if it were standing in the middle of a scene»;
– Substitutional Reality (SR);
– Simulated reality.

IDC estimates that the global market for mixed reality digital business technologies in 2021 amounted to almost 82 billion USD, the consumer segment of their augmented reality (AR/VR technology) accounts for the largest share of almost 56 billion USD [11]. As can be seen from Table 1, the growth in the supply of personal computers compared to last year reached a turning point in the third quarter of 2021 (Q3 2021). According to the International Data Corporation (IDC) Worldwide Quarterly PC Monitor Tracker, the number of deliveries has decreased compared to the same period in 2020 [2]. While many countries, especially in developing Asia Pacific, continued to show solid demand and fulfilled delayed orders, key markets in North America and Western Europe experienced significant declines, mainly due to a certain degree of easing in consumer demand, than for the same quarter of last year (Q3 2020). Moreover, while improved in some aspects, supply and logistics problems persisted from previous quarters, further squeezing the market, which was already facing rising prices due to cost pressures.

Another digital business technology that is successfully used in the world is Cloud Computing, which is a model for convenient access on demand to a common pool of computing resources that are properly configured. Cloud computing can be generated independently by business structures, or they can use ready-made solutions from such, for example, large companies as HP, Dell, Oracle and others. But, in any case, the business structure that uses this digital technology will have the following economic advantages:

– the rate of growth of its own business or its elements;
– cost savings, because you do not need to buy your own computing pools and systems;
– access to cloud services for business management from anywhere on the planet where there is internet;
– the ability to work together with data for subsidiaries;
– the ease of scaling business data and business management methods;
– you juice the reliability of cloud computing at the expense of the provider;
– the ability to use cloud computing by small businesses and individual entrepreneurs.

At the same time, the following forms of cloud computing can be used in business: PaaS (Platform-as-a-service) – platform as a service; IaaS (Infrastructure-as-a-service) – infrastructure as a service.

Artificial intelligence (AI) is another of the areas of digital business transformation that is widely used in the world, and consists in the reproduction of intelligent reasoning and actions using computing or information systems and other artificial devices, that is, such a digital business technology in which the system shows the ability to correctly interpret exogenous data, learn from this data and use the knowledge gained for specific purposes in business management through ability to adapt flexibly. In economics, the AI can be applied in almost all sectors and at all levels, but most of all it is used at the design level to increase the efficiency of new product development, at the production level to effectively improve business processes and automate control and business management, at the logistics level to improve supply route planning and reduce delivery time, at the promotion level to predict the volume of support services and their amount of funding, etc.

In addition to the above-mentioned digital business technologies that are actively transforming global trends in the development of the economies of the world, it is necessary to separately highlight the recently invented ones, such as «Smart Factory», «Smart Manufacturing», «Factory of the Feature». The term Smart Manufacturing defines the US National Institute of Standards and Technology (NIST) as follows: it is «fully integrated enterprise production systems that are able to respond in real time to changing production conditions, supply chain requirements and meet customer needs» [12]. Coordinator of ICT projects in the Seventh Framework Program of the European Union on Scientific and Technical Cooperation, divides the factories of the future into three main types – digital (Digital), «smart» (Smart) and «virtual» (Virtual) [13].

Table 1

Best companies, PC shipments worldwide, market share and annual growth, Q3 2021 (deliveries in thousands of units)

Company	Supply for the 3rd quarter of 2021	Market share for the 3rd quarter of 2021	Sending for the 3rd quarter of 2020	Market share for the 3rd quarter of 2020	3K21/3K20 Growth
1. Dell Technologies	7666	22.0 %	6359	17.0 %	+20.6 %
2. Lenovo	4238	12.2 %	3966	10.6 %	+6.9 %
3. MSW	3971	11.4 %	5679	15.1 %	–30.1 %
4. HP Inc.	3723	10.7 %	4711	12.6 %	–21.0 %
5. Samsung	2875	8.3 %	3370	9.0 %	–14.7 %
Other	12328	35.4 %	13417	35.8 %	–8.1 %
Just	34801	100.0 %	37502	100.0 %	–7.2 %

Note: built on the basis of data [2]

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The following systems and digital business technologies are used in the Digital Factory:

– with computer-aided design systems CAD/CAM/CAE;
– product data management system (PDM, Product Data Management);
– application software for and product lifecycle management (PLM, Product Lifecycle Management);
– electronic machines;
– 3D printers and other additive technologies.

The following digital business technologies are used in the «Smart Factory»:

– automated process control system;
– synchronous production planning (APS, Advanced Planning and Scheduling);
– production process management system (MES, Manufacturing Execution System);
– industrial Internet of Things (IIoT, Industrial Internet of Things);
– big data (Big Data).

Factories use the following digital business technologies:

– enterprise resource planning (ERP, Enterprise Resource Planning);
– customer relationship management system (CRM, Customer Relationship Management);
– supply chain management (SCM, Supply Chain Management).

The market size of digital factories (additive technologies, PLM systems, hardware and numerical software, machine tools, etc.) reached 260 billion USD in 2020 and is projected at 740 billion USD by 2035. The market size of «smart factories» – respectively, 490 billion USD already had in 2020, and is expected to reach 1.35 trillion USD. According to virtual factories, experts estimated 690 billion USD in 2020 and predict nearly 1.5 trillion USD by 2035 [2].

Another rather interesting application of digital business technologies is the use of the digital twin (Digital Twins) in business, the definition of which was first provided by the consulting company Gartner: «the digital twin is the digital representation of a real object or system» [14]. They also named those business structures that most actively used digital twins in 2021, and these are: Cisco Systems, Colgate-Palmolive, Johnson&Johnson.

Organizations allocate their investments in the digital transformation of their businesses (DX) to a number of strategic priorities that align with what they expect to achieve over a long period of time while fulfilling their digital mission. Many of these priorities are pooled around operational goals, including back-office support and infrastructure for core business functions such as accounting and finance, human resources, legal issues, security and risk, and corporate IT. Similarly, the priorities of innovation, scaling and operation relate to a wide range covering large-scale operations, including manufacturing, construction and design. Key business functions covering this area include supply chain management, engineering, design and research, operations and operations in manufacturing plants, and finally customer experience (a specific area that covers all customer-related functions and related digital business technologies that digital business transformation (DX) supports, marketing and sales). While back-office support and infrastructure, as well as innovation, scaling and operation priorities, will reflect significantly higher overall costs throughout the forecast, investments in customer experience will grow faster.

Let's conduct a correlation analysis of indicators of digital business transformation and indicators of market capitalization of individual countries, the results of which are presented in Table 2.

The use cases of digital business transformation in the smart economy – discretely funded efforts that support a specific programmatic goal – that will receive the greatest costs will be distributed among three strategic priorities. Investments in robotics manufacturing will grow to 120.6 billion USD in 2025, followed by autonomous operations and 360-degree customer management at 90.9 and 74.7 billion USD, respectively. Cases of using digital business transformation in the smart economy with the fastest cost growth will be virtualized student workspaces (43.8 %), mining assistance (39.1 %) and advanced design management (34.5 %). Of the more than 300 use cases of digital business transformation in the smart economy, only five will have less than 10 % in five years during the forecast period.

Table 2

Correlation of indicators of digital transformation of business and market capitalization of countries for the period 2020–2021

Countries	Ukraine	Croatia	Romania	Bulgaria	Slovenia	Lithuania	Estonia	Latvia	United States
Ukraine	1	0.98	0.92	0.74	0.98	0.94	0.48	0.96	0.43
Romania	–	1.00	0.96	0.82	0.98	0.96	0.57	0.97	0.40
Croatia	–	–	1.00	0.92	0.95	0.99	0.76	0.97	0.54
Slovenia	–	–	–	1.00	0.78	0.88	0.92	0.80	0.46
Bulgaria	–	–	–	–	1.00	0.97	0.56	0.99	0.50
Lithuania	–	–	–	–	–	1.00	0.72	0.72	0.61
Estonia	–	–	–	–	–	–	1.00	0.69	0.54
Latvia	–	–	–	–	–	–	–	1.00	0.45
United States	–	–	–	–	–	–	–	–	1.00

4. Conclusions

The paper shows that the industries that will have the highest costs of digital business transformation in the smart economy throughout the forecast are discrete and technological production, followed by professional services and retail. Together, the two manufacturing industries will account for nearly 30 % of all digital business transformation costs in the smart economy, accounting for more than 816 billion USD in 2025. The economic sectors that will experience the fastest growth in the costs of digital business transformation in the smart economy as forecasted for 2020–2025 are construction (21.0 %), securities and investment services (19.2 %) and banking (19.0 %).

The United States will be the largest geographic market for digital business transformation spending in the smart economy, providing approximately one-third of global volume throughout the forecast. Western Europe will be the second largest spending region for digital business transformation in the smart economy, after China. China will also provide the highest growth in the cost of digital business transformation in the smart economy at 18.4 %. Latin America will be the second fastest growing region with 17.5 %.

The study of the state of the smart economy and digital transformation of business according to the concepts Industry 4.0 and 5.0 indicates a significant potential for the use of digital technologies in business and a significant economic effect of their use, which requires further refinement.

This provides significant economic advantages in the adaptation of economic agents to the conditions of introducing digital business transformation in the context of Industry 4.0 and 5.0.

Conflict of interest

The author declares that she has no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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