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Strategic Development of Enterprises in the Conditions of Digitalization According to the Principles of Industry 4.0

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ABSTRACT

The purpose of this study is to substantiate the principles of enterprises' strategic development in the conditions of digitalization according to the principles of Industry 4.0, which is determined by such global trends as flexible automation, network integration and intelligent technologies and involves the introduction of Internet of things technology, digital ecosystems, big data analytics and complex information systems, which are represented by digital platforms, for managing business processes. The methodological basis of the study is a systematic approach, which makes it possible to systematically investigate the phenomena and processes occurring today in the world economy under the influence of digitalization. The application of the system approach methodology makes it possible to use general economic research methods, including: system-structural and logistic analysis, comparative analysis and generalization, graphic. The main provisions of Industry 4.0 were highlighted, which the company must comply with in its development in order to meet international standards. The phasing of the enterprise' strategic development in the conditions of digitalization according to the principles of Industry 4.0 is proposed, which includes sixteen stages from the establishment of the mission to the control and evaluation of the enterprise's development strategy.

KEYWORDS: Strategic development, digitalization, Industry 4.0, innovative development, competitiveness, enterprise.

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Desarrollo estratégico de empresas en las condiciones de digitalización según los principios de la Industria 4.0

RESUMEN

El propósito de este estudio es fundamentar los principios del desarrollo estratégico de las empresas en las condiciones de la digitalización de acuerdo con los postulados de la Industria 4.0, que está determinada por tendencias globales como la automatización flexible, la integración de redes y las tecnologías inteligentes e implica la introducción de Internet, de las tecnologías, ecosistemas digitales, análisis de big data y sistemas de información complejos, representados por plataformas digitales, para la gestión de procesos de negocio. La base metodológica del estudio es un enfoque sistemático, que permite investigar los fenómenos y procesos que ocurren hoy en la economía mundial bajo la influencia de la digitalización. La aplicación de la metodología del enfoque sistémico permite utilizar métodos generales de investigación económica, que incluyen: análisis estructural y logístico de sistemas, análisis comparativo y generalización, gráfico. Se destacaron las principales disposiciones de la Industria 4.0, que la empresa debe cumplir en su desarrollo para lograr los estándares internacionales. Se propone la fase del desarrollo estratégico de la empresa en las condiciones de la digitalización según los principios de la Industria 4.0, que incluye dieciséis etapas desde el establecimiento de la misión hasta el control y evaluación de la estrategia de desarrollo de la empresa.

PALABRAS CLAVE: Desarrollo estratégico, digitalización, Industria 4.0, desarrollo innovador, competitividad, emprendimiento.

Introduction

Modern conditions of economic development are characterized by an increase in threats and risks related to the functioning of economic systems at various levels, intensification of competition on the market, rapid trends in consumer preferences, an increase in the cost of resources, etc. At the same time, new technologies are developing, including digital ones, which open up new opportunities for the development of economic systems and increasing the efficiency of their activities. Thus, one of the directions of the enterprises' development today is the principles of Industry 4.0, which is becoming a determining basis for the enterprises' development, increasing their competitiveness, including on the world market, etc.

The application of the Industry 4.0 principles enables enterprises to develop strategies that ensure the achievement of higher results in the modern conditions of digital

transformation, increase the effectiveness of activities, reduce own costs and increase added value due to the innovative component.

This and other principles of the formation of social development using innovations, digital technologies, creative approaches, changes in the value of knowledge and creative approaches determine the relevance of this study in the plane of substantiation of the principles of enterprise development according to the principles of Industry 4.0.

The purpose of the study is to substantiate the principles of enterprises' strategic development in the digitalization conditions according to the determining influence of the principles of Industry 4.0.

1. Literature Review

A sufficient number of scientific publications are dedicated to the enterprises' development in the conditions of digitalization, as well as their activities within the framework of the Industry 4.0 concept.

Scientists (Liu, H. et al., 2022) believe that to solve the problem of "Industry 4.0", manufacturing integrates the path of product development and service innovation and builds a path of high-quality transformation based on the service value chain. The authors define a complete process of service-oriented manufacturing and present and explore the vertical case study of China High Tech Aviation Industry Corporation. According to the authors, the logical evolutionary structure directs enterprises to build a spiral system of development, which includes static modernization and dynamic evolution of production.

The article by scientists (Richnák, P. et al., 2022) is based on the study of the potential of sustainable technologies in synergy with Industry 4.0 innovations and initiatives on renewable energy sources in production and logistics in the context of the SDG. The results of the authors' research prove the connection between ecological production, ecological logistics, reverse logistics and selected technologies of Industry 4.0.

Within the framework of the article, the authors (Waldemar Jędrzejczyk, 2021) analyzed the trends in the field of production caused by technological progress. The authors predict that the development and implementation of the concept of Industry 4.0 will require the most significant change in the profile of engineering personnel competencies - the engineering profession will evolve towards the role of a leader of change. Scientists consider

the human factor to be a key factor in the success of implementing the Industry 4.0 concept at enterprises.

The authors (Enji Li et al., 2023) are convinced that digitalization contributes to the optimization of the business environment, which directly affects the production and operational activities of enterprises. The results of the scientists' research demonstrate an increase in the factor productivity of the enterprise. As a result of the study, it is proved that the reduction of the enterprise's profit, the attraction of new enterprises and the increase of investments in research and development are important mechanisms of the development of the digital government to improve the factor productivity of the enterprise.

As a result of research by scientists (Shi Chen et al., 2023), it is stated that digital development is changing day by day, and the traditional manufacturing industry is gradually moving from extensive development to intensive development, the most visible manifestation of which is digital transformation and development of enterprises. The authors examine the internal mechanism of digital transformation, which, in their opinion, contributes to the green development of manufacturing enterprises from three aspects: product greening, technology greening, and investment greening.

The empirical results of the study (Jie Huang et al., 2022) demonstrate that the increase in administrative costs suppresses the development of the regional digital economy, i.e. the lag of indirect effects of innovative activity or the increase in labor costs necessary for innovative activity displace capital from factor resources. However, the authors prove that under the conditions of reducing management costs, the development of the regional digital economy increases the productivity of the enterprise.

It has been proven that the digital economy has become a great impetus for the sustainable development of enterprises. The authors (Zhou Z. et al., 2022) investigate the impact of the digital economy on the sustainable development of enterprises. The authors argue that the digital economy and the sustainable development of enterprises have obvious characteristics of spatial differentiation. It is clear that the digital economy can significantly contribute to the sustainable development of enterprises and play a role through regional innovation and entrepreneurship.

The authors of the study (Chen H., 2022) develop an understanding of the impact of intellectual property protection on the development of the digital economy and regional entrepreneurial activity. The article examines how digital technologies can increase business

efficiency through open innovation and commercialization efficiency in the context of small and medium-sized enterprises. The study demonstrates how open innovation and information and communication technologies improve productivity.

The result of the authors' research (Pronchakov Yu. et al., 2022) is the identification of management gaps that lead to the formation of digitalization problems at enterprises in the context of Industry 4.0. Scientists proposed a conceptual approach to managing the development of high-tech enterprises in digital transformation. The authors substantiated the concept of digital transformation management at a high-tech enterprise based on interdependent adaptive systems for planning digital transformation processes, monitoring and change management.

The study of scientists (Yin Shi et al., 2022) is devoted to the conceptual basis of the selection of partners for the management of digital green innovations. The results of the authors' research demonstrate the developed framework system and selection model that can be used to help enterprises in choosing joint investment partners for digital green and innovative projects for sustainable urban development.

However, despite the available publications in this field of research, the issues of strategic development of enterprises in the conditions of digitalization in accordance with the principles of Industry 4.0 are becoming more and more relevant and require further research.

2. Methodology

The methodological basis of the study is a systematic approach, which makes it possible to systematically investigate the phenomena and processes occurring today in the world economy under the influence of digitalization, as well as at the level of enterprises, taking into account the implementation of the Industry 4.0 principles. The application of the system approach methodology makes it possible to use general economic research methods, including: system-structural and logistic analysis when studying the principles of implementing the Industry 4.0 concept; comparative analysis and generalization method in the study of the main global technological trends affecting industrial production and contributing to the development of Industry 4.0, in substantiating the impact of Industry 4.0 technologies on the strategic development of world leaders' enterprises and the development

of strategic directions for the enterprises' development according to the principles of Industry 4.0 in the conditions of digitalization.

3. Results

The completed production cycle allows to accumulate added value, which contributes to increasing incomes and improving the lives of the population. Therefore, industrial production should be aimed specifically at creating an appropriate cycle and reducing the level of the raw material base of industry. The development of high-tech industry, taking into account the added value by the countries of the world, allows us to conclude that the increase in such value has a positive effect on the general economic development and, as a result, contributes to the improvement of the standard of living of the population (Table 1).

The peculiarity of the enterprises' development in terms of the introduction of new technologies has a noticeable imbalance, since the progress in digitalization is faster than the reproduction of new technologies, they are reproduced on the basis of previous results. If we consider the import of digital products, then the renewal rate of this sector is quite high, which makes it possible to completely change the equipment every 2-3 years, but such a tie to imports cannot be the basis of the company's competitiveness.

Therefore, in order to ensure high enterprises' competitive positions of the industrial sector, it is important to create such a product that will have a high added value, which will ensure an increase in budget revenues and improve the general socio-economic development of the region and the state as a whole.

As can be seen from Table 1, such leading countries as Singapore increased the share of high-tech industry with added value over the analyzed period from 64.7 to 82.06%, which allowed the country to significantly improve its competitive position in this sector on a global scale. Switzerland increased such production from 38.5 to 65.5%, betting on the development of high-tech industries. Germany increased the production of high-tech products from 47.9 to 61.2%, which significantly contributed to the economy's development.

The USA has reduced the growth rate of high-tech equipment by 2.54% since 1990. However, this decrease can be explained by the rapid growth of technologies in the period up to 2018. The USA is one of the leaders in the world market of innovative products and the development of digitalization, so the growth rate will be lower than in developing countries.

Market coverage and positioning in the relevant segments allows such countries to maintain their positions in the long term. However, according to analytical data, rapid growth will not occur due to the initially high base of comparison of achievements.

Table 1: Ranking of countries by the share of medium and high-tech industry,
 (% of added value in production)

Country	Year										
	1990	2000	2013	2014	2015	2016	2017	2018	2019	2020	2021
Singapore	64,76	74,20	76,28	75,93	75,88	74,85	75,42	78,57	83,73	80,58	82,06
Denmark	38,12	38,27	51,98	52,73	53,31	52,65	53,83	54,39	56,98	55,33	58,47
Hong Kong, China	27,56	39,50	34,13	33,93	36,06	36,61	37,38	38,47	38,07	37,32	37,33
Japan	50,87	50,90	55,01	55,34	56,21	56,77	56,57	56,91	56,91	56,91	56,91
Sweden	41,71	49,17	52,53	53,15	44,65	51,61	50,94	51,11	51,62	51,89	52,81
Switzerland	38,56	52,37	62,71	62,57	63,00	63,56	63,32	65,05	66,22	65,55	65,55
Turkey	26,34	27,76	29,89	29,93	29,24	29,78	29,94	30,82	33,66	35,83	36,74
UK	44,76	41,91	43,47	44,74	44,56	42,54	42,19	42,93	43,42	48,17	48,17
Estonia	16,86	16,74	26,94	28,14	28,39	25,72	26,64	27,43	25,78	29,43	30,21
Lithuania	20,96	15,15	19,46	17,84	20,84	23,62	20,55	22,26	23,01	24,68	29,26
Slovenia	33,07	36,36	49,66	48,03	47,33	37,41	37,09	37,98	37,13	36,83	36,92
United Arab Emirates	37,63	37,63	37,78	37,87	37,83	35,93	35,92	36,63	37,49	39,19	39,21
United States	48,65	50,00	46,05	45,78	47,04	46,60	46,25	46,57	46,32	46,02	46,11
Ukraine	20,95	22,30	32,92	39,39	29,58	30,03	28,44	26,01	27,37	31,80	32,68
Poland	33,70	26,60	34,31	35,21	33,94	33,98	32,99	32,74	32,23	32,28	33,25
Portugal	19,28	24,89	24,72	24,51	24,62	24,41	23,90	24,42	24,47	25,96	27,13
France	51,71	45,36	46,14	46,58	47,04	47,98	49,89	48,38	50,20	50,94	52,38
Germany	47,96	53,95	59,18	59,29	60,59	60,70	60,91	60,87	59,86	60,38	61,25
Slovak Republic	25,85	33,66	47,82	49,43	47,48	49,39	47,77	47,93	49,51	51,17	52,78
Canada	38,18	43,24	37,24	36,36	37,04	38,44	37,15	36,35	36,36	36,93	37,45

Source: summarized by the author based on <https://www.strategy-business.com/feature/00370?gko=e606a>.

Ukraine also improved its position from 20.9% to 32.6%, but this is not enough for the effective functioning of this sector and maintaining competitiveness. The problem of the digital technologies' development in the high-tech industry requires significant investment funds, and there are certain obstacles to their attraction in Ukraine.

The above proves that the enterprise' strategic development in conditions of digitalization, regardless of the sphere of economic activity, should be based on the use of technologies and principles of Industry 4.0. The main characteristic features of the principles of Industry 4.0 are the maximum automation of production with the possibility of automating the production management process in real time. Production of individual products with minimization of the cost of its production due to the use of the latest technologies that speed up production processes at minimal costs. Internet technologies that provide communication processes between users are actively developing. Thus, in the field of industrial innovations, four types of technologies are defined as the main technologies that will contribute to the development of Industry 4.0:

firstly, the Internet of things technology, which facilitates the automatic exchange of data between machines and devices based on sensors, which allows for maximum automation of the processes of data collection, processing and exchange;

secondly, digital ecosystems that accumulate interaction between physical objects, software systems with Internet technologies;

thirdly, big data analytics, which allows analyzing large data sets using cloud technologies, artificial intelligence technology;

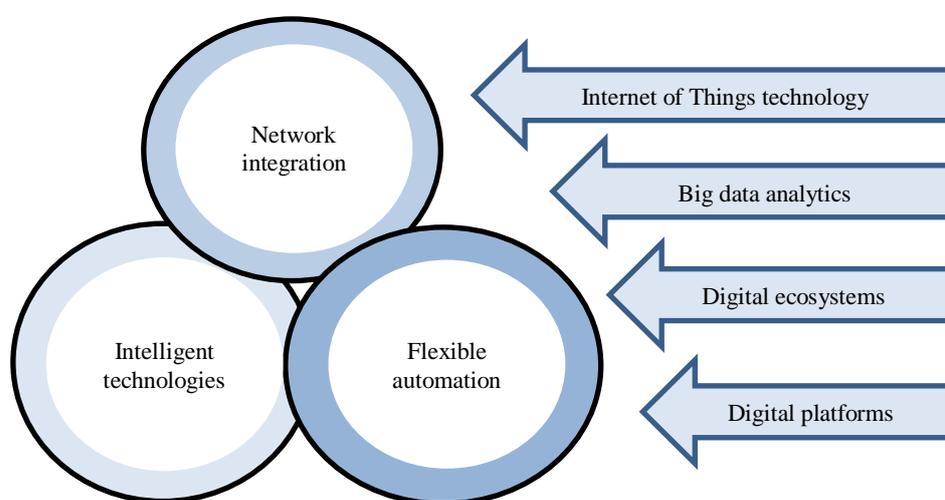
fourthly, complex information systems, which are represented by digital platforms, for managing business processes. Such technologies introduce the principles of robotics, virtual reality, artificial intelligence and others into the spheres of economic and social life.

The main directions of innovative development in the context of the Industry 4.0 are determined by three global trends, namely: flexible automation, network integration, intelligent technologies (Fig. 1). In global development, enterprises and large companies that are the first to implement the latest technologies based on digitalization of business are called "Beacons", that is, the vector to which all other companies should strive in their strategic development.

These global trends were discussed at the World Economic Forum in Davos, which was held in May 2022. Due to the global COVID-19 pandemic, global trends in the

development of industry and production have changed not only in terms of technology, but also require radical changes in the communication aspect. The limitations in communications caused by the spread of the pandemic forced businesses around the world to adapt to new forms of communication, which led to the emergence of new digital platforms that were implemented in all communication processes (from production to training).

Figure 1: The most important global technological trends affecting industrial production and contributing to the development of Industry 4.0



Source: created by the authors based on: <https://www.strategy-business.com/feature/00370?gko=e606a>; World Economic Forum

Adaptation to such conditions contributed to the review of communication operations and contributed to the increase of labor productivity, cost savings for office premises in those sectors of the economy where it is possible. The development and implementation of digital technologies is carried out not only at the level of production, but also in social life.

The strategic development of enterprises under such conditions is characterized by the introduction of new technologies in production, due to which significant financial advantages are obtained. To achieve a high level of development in the concept of Industry 4.0, an enterprise must meet certain requirements, such as: obtaining a significant effect, successfully integrating several development scenarios, having a scalable technological

platform, a high level of development of change management and cooperation within the framework of Industry 4.0. When implementing development strategies, enterprises can use the algorithm of actions of large companies that have become "Lighthouses" on the international market, adapting their capabilities to their own.

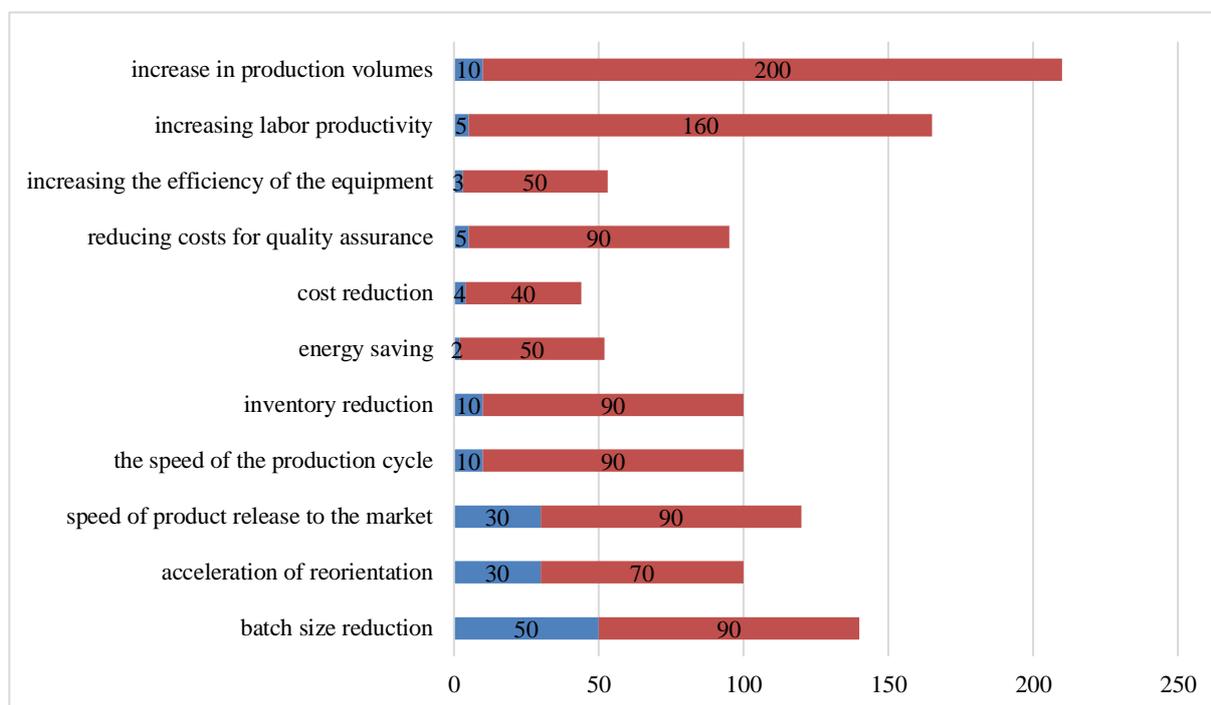
The development of enterprises should be based on the introduction of the latest technologies and take into account the features of the fourth industrial revolution. The main aspects of such development include the determining role of the development of human capital. Thus, according to McKinsey research, less than 5% of professions are subject to complete automation. For others, partial automation of manual work is possible, which will help increase the level of labor productivity and reduce the routineness of operations, which will positively affect the employee's well-being (<https://www.oecd.org/cfe/smes/2090740.pdf>).

For their strategic development, enterprises today, according to digital technologies and open access to global platforms, can be involved in global industrial corporations, which in their development form appropriate industrial innovation hubs, which include innovation, scientific centers, platforms for start-ups and other things that allow to get involved in global cooperation to many enterprises.

Thus, according to the research conducted at enterprises that are the leaders in the use of Industry 4.0 technologies, the effectiveness of the implementation of digital technologies has been proven. The range of changes before and after the implementation of changes characterizes the improvement of the determinants of strategic development (Fig. 2).

For each individual enterprise, this range of improvement will be different depending on its development and the available resource base for making changes. The openness of business to cooperation on a global scale significantly exceeds the risks of competition in the market. For domestic enterprises, one of the main obstacles to the implementation of relevant innovative development measures is the lack of financial capacity. Enterprises do not have enough resources for such large-scale transformations, and the attraction of investors is complicated by many factors. In order to attract investment resources, enterprises need to develop appropriate investment projects today, which allow them to attract the necessary funds for the restoration of industry and business.

Figure 2: The influence of Industry 4.0 technologies on some determinants of the strategic development of world leaders' enterprises (% change)



Source: generalized based on World Economic Forum.

Emphasis in such developments should include measures that will promote energy efficiency, environmental friendliness of production, promotion of intellectual and personnel development, involvement of digital technologies, search for new forms and methods of conducting business taking into account modern requirements.

The strategic development of enterprises in the conditions of digitalization in accordance with the principles of Industry 4.0 should include such a sequence of implementation stages as (Fig. 3):

- definition of the mission of the enterprise in accordance with the principles of Industry 4.0 in the conditions of digitalization;
- assessment of the level of environmental instability, possible threats and risks regarding the functioning of the enterprise;
- identifying the goals of innovative activity in accordance with the existing potential of innovative development;
- the choice of enterprise management methodology in accordance with the principles of Industry 4.0;

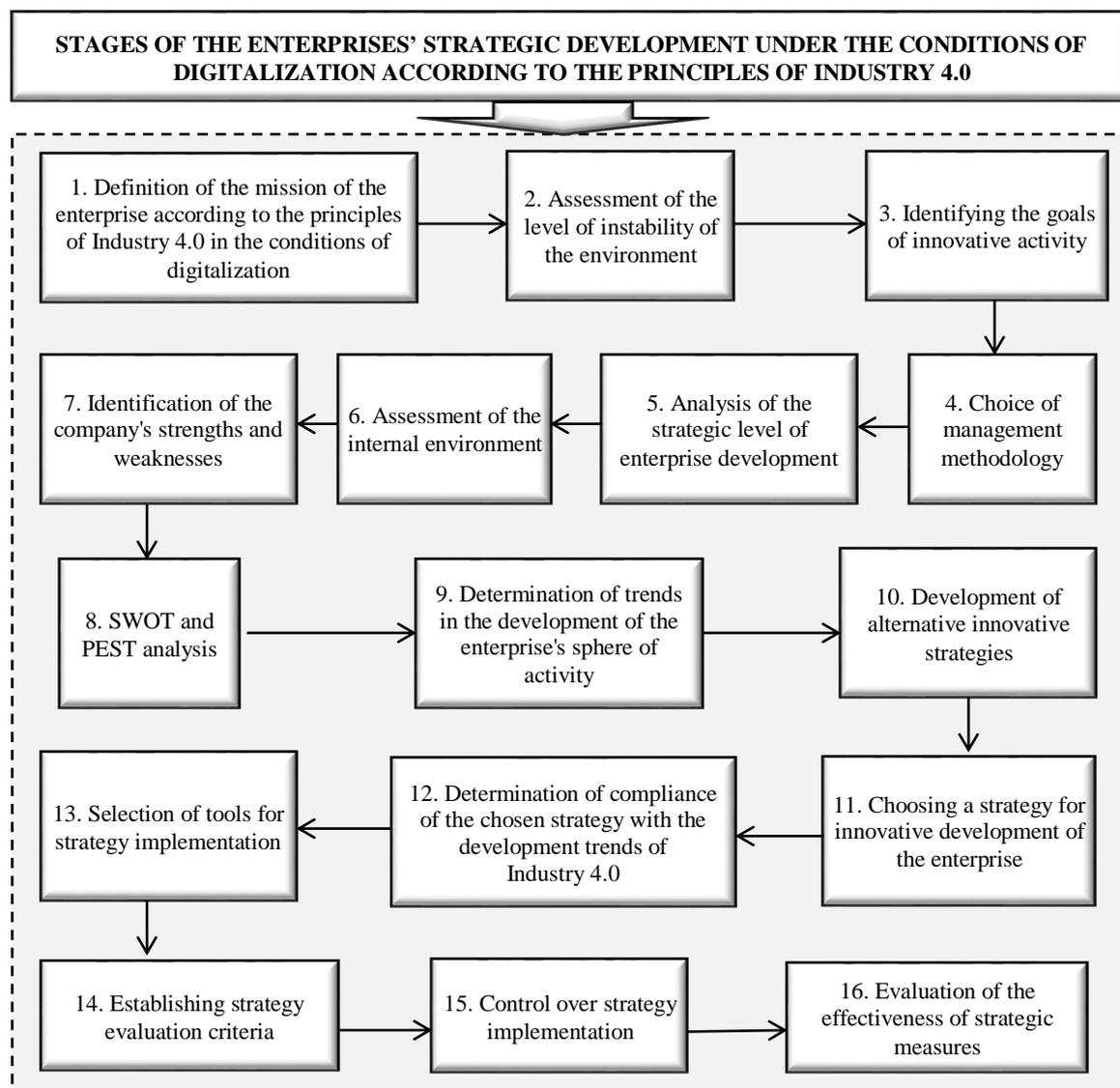
- analysis of the strategic level of enterprise development;
- assessment of the internal environment;
- identification of the company's strengths and weaknesses;
- SWOT and PEST analysis;
- determination of trends in the development of the enterprise's sphere of activity in conditions of digitalization;
- development of alternative innovative strategies;
- choosing a strategy for innovative development of the enterprise;
- determination of compliance of the chosen strategy with the development trends of Industry 4.0 in accordance with the field of the enterprise;
- selection of tools for the implementation of an innovative enterprise development strategy according to the principles of Industry 4.0;
- establishment of criteria for evaluating the strategy of innovative development in accordance with the principles of Industry 4.0;
- control over the implementation of the strategy according to the principles of Industry 4.0 in the conditions of digitalization;
- evaluation of the effectiveness of strategic measures.

The proposed stages of forming an enterprise development strategy according to the principles of Industry 4.0 in the conditions of digitalization include the stages from establishing a mission to monitoring and evaluating the enterprise development strategy.

The strategic development of enterprises in the conditions of digitalization according to the principles of Industry 4.0, as shown by world practice, enables enterprises to obtain certain advantages, including:

- establishment of a closer relationship with consumers and suppliers thanks to the use of information about production, logistics, demand in real time;
- greater flexibility of the enterprise, which is especially important in the conditions of increasing threats and risks, which is achieved due to the implementation of simplified processes and joint open infrastructures, which in the conditions of digitalization enables the enterprise to produce differentiated products in order to identify the unsatisfied needs of consumers and due to their accurate satisfaction to increase one's own competitiveness on the world market and to open up new opportunities for the development of the enterprise;

Figure 3: Stages of the enterprise' strategic development in the conditions of digitalization according to the principles of Industry 4.0



Source: suggested by the authors

- increase efficiency and improve the value chain and increase workplace safety through the implementation of digital technologies;
- to improve product quality, for example, due to rapid response and intervention to prevent errors in the production process, due to real-time monitoring, etc.

4. Discussion

Supporting the research of scientists (Abed Thamer K., 2020), it should be noted the relevance of the developed approach to increasing the efficiency of business processes at

virtual machine-building enterprises, which consists in improving the existing methodical and software tools for supporting the life cycle of products of such enterprises within the framework of Industry 4.0. These propositions have a practical meaning, which consists in the possibility of ensuring the formation of the enterprise's marketing policy, the deployment and support of the effective functioning of virtual production enterprises in various branches of industry.

In our opinion, articles (Krykavskyy Y. et al., 2019; Ivanova N. et al., 2021; Savin S. et al., 2021; Khrushch N. et al., 2022) have practical significance for the development of enterprises, which consists in the outlined drivers of the development of the supply chain in the conditions of "Industry 4.0"; the authors' definition of the DT effect in the cross-section of strategic and operational changes in the supply chain; clarifying the readiness and ability to implement digital technologies in the activities of enterprises.

Sharing the opinion of scientists (Saniuk S. et al., 2018), we would like to note that the really new concept of Industry 4.0 opens up new opportunities for the development of large enterprises, which allows for the formation of competitive advantages in the market and significantly increases their competitiveness. The authors give practical recommendations, namely, identify the most important problems that SMEs must overcome in order to build modern production networks together.

We consider the research of scientists (Đaković Radojičić I. et al., 2022; Pohrebniak A. et al., 2021) to be relevant, which consists in the analysis of the framework conditions of the system at the stage of scaling the life cycle of the enterprise in the digital dimension. Based on the results of determining the most developed factors, as well as the most poorly developed factors, the authors note the conditions that affected the results of the study and justify why the improvement is important.

Of practical importance is a study (Frepoli Cesare et al., 2022) designed to develop a flexible digital platform called FPoliAAP that aims to facilitate the orchestration of complex workflows by taking advantage of modern software development and data management tactics while leveraging the latest technologies developed in national laboratories.

Relevant in the current conditions of the development of digitization processes is the research of the authors (Zhygalkevych Zh. et al., 2022), within which it is proved that the digital economy is based on innovations with the application in production, promotion, sale,

delivery of goods and services of Industry 4.0 technologies. The modeling of the influence of the digital economy on the innovative development of enterprises deserves attention.

We support the proposals of the authors (Lingur L. et al., 2022; Tulchynska, S. et al., 2021; Vovk O. et al., 2021) regarding the improvement of the system for the formation of corporate social responsibility and the introduction of digitalization of the enterprise, which makes it possible to optimize information systems of enterprises, automate management procedures, and create new channels of communication with consumers and beneficiaries.

The analysis of the mentioned publications confirms the relevance of the research direction and the need to outline strategic prospects for the enterprises' development in the conditions of digitalization according to the principles of Industry 4.0.

Conclusion

The strategic development of the enterprise in the conditions of digitalization, regardless of the sphere of economic activity, should be based on the use of technologies and principles of Industry 4.0. The introduction of innovative technologies should be carried out according to a new principle, namely, high-quality introduction of technologies with access to new standards. It is not economically expedient to carry out gradual improvement of the technology, as it has been used until now. The enterprise should have several scenarios of its development and gradually implement them, which will allow to achieve the necessary results more efficiently and quickly. Using such a revolutionary approach allows you to radically change work methods and reach a new level of efficiency, which will allow you to develop and implement continuous improvement programs using digital technologies. Implementation of the principles of Industry 4.0 in the enterprises' strategic development makes it possible to obtain a significant effect, to implement the successful integration of several development scenarios and provides for a high level of development of change management and cooperation within the framework of Industry 4.0.

The scientific novelty of the study consists in the development of the stages of enterprises' strategic development in the conditions of digitalization according to the principles of Industry 4.0, which are based on a systemic approach and, unlike the established ones, take into account the experience of successful practices of highly competitive enterprises in the world market.

The conducted study of the enterprises' development in the international aspect on the basis of Industry 4.0 allows us to draw a conclusion about the effectiveness of such a strategic direction in the modern global development of the economy.

Further research requires the development of alternatives for enterprises' strategic actions according to the principles of Industry 4.0 in the conditions of digitization of the global economic space.

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