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MANAGEMENT OF THE INNOVATIVE DEVELOPMENT POTENTIAL OF INDUSTRIAL ENTERPRISES IN THE DIGITAL ECONOMY

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The article considers the development of the approach to complex adaptive management of the potential for innovative development (PID) of the industrial enterprise in the conditions of the formation and development of the digital economy. The impact of information computer technologies of the fourth industrial revolution on each component subsystems (including their elements) of the PID of the industrial enterprise from the standpoint of ensuring its sustainable innovative growth are determined and systematized by the nature of action (favorable or unfavorable). Approaches to purposeful management of PID component subsystems of the industrial enterprise have been developed in order to update their condition in relation to external conditions and ensure favorable internal prerequisites for innovative development in the digital economy. Their application makes it possible to reasonably align the internal possibilities of innovative development of the industrial enterprise (its PID) with the external ones in the conditions of the digital economy. The enlarged scheme has been developed that reflects the sequence and content of the formalized procedures for managing the PID of the industrial enterprise in the context of its transition to the path of innovative development in the conditions of the digital economy. It can be used as a methodological basis for the implementation of the developed approaches in the practice of innovative activity of industrial enterprises. The presented developments collectively form the approach to complex adaptive management according to formalized PID procedures of the industrial enterprise, including its component subsystems-potentials and their elements, in the context of ensuring the compliance of internal and external conditions of innovative growth of the enterprise in the digital economy. The developed approach, in contrast to the existing ones, provides the adaptive management of all components (as well as their elements) of PID in a complex, which increases the degree of coherence and validity of the management of innovative development at industrial enterprises in the digital economy.

Keywords: innovative development, industrial enterprise, strategic management, potential of innovative development, digital economy, fourth industrial revolution, digital information technologies.

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Introduction and problem statement

Information and computer technologies (ICT) of the fourth industrial revolution (I4.0) gave a powerful acceleration to the processes of forming a

digital economy, which is characterized by the digitization of business processes and the transfer of business activities (various spheres of human life in general) to the Internet. Practice shows that ICT

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Management of the innovative development potential of industrial enterprises in the digital economy

I4.0 increasingly determine the competitive positions of enterprises both on the national and international markets, and at the same time ensure the development of the national economy, the growth of well-being and quality of standards of living among the country's population. For industrial enterprises of Ukraine based on production of the third and fourth technological systems, digitalization provides a chance for anticipatory innovative development. It involves not literally following the path that others have already taken occupying powerful market positions, but the search, strengthening and implementation of their relative competitive advantages, which will allow them to occupy leading positions in those fields of activity and in those markets where there are necessary and sufficient conditions for this. Since the development of industry affects the rates of NTP in almost all sectors of the economy, this will allow to form the prerequisites for the transition to the innovative advancement of the national economy as a whole. The formation and implementation of strategies for anticipatory innovative development of the enterprise presupposes the presence of a certain level of its innovative development potential (PID). According to the Network Readiness Index [1], the readiness of national economies for the digital economy is assessed by four comprehensive indicators: technology (ICT level I4.0); people (availability, access, resources, skills in using ICT I4.0); management (level of involvement and safety of use by people and organizations of ICT I4.0); impact (positive impact of ICT I4.0 on various aspects of human life). The evaluation of Ukraine's readiness for the development of the digital (network) economy, carried out according to the author's methodology [2] based on the point evaluations of four complex indicators of the Network Readiness Index [1], proved an average level of readiness, which is sufficient. From the viewpoint of a certain enterprise, these indicators characterize the state of digitization of the national economy as a whole, which outlines the general field of its activity. They also determine the direction of strengthening and implementation of the enterprise's PID for its transition to anticipatory innovative development. Accordingly, there is a problem of updating the PID of the enterprise to the realities of the digital economy, forming on its basis internal prerequisites for anticipatory innovative development, as well as bringing them into line with external ones. Its solution will make it possible to manage the innovative development of industrial enterprises reasonably and effectively in line with the concept of innovative advancement in the conditions of the

digital economy.

Analysis of recent research and publications

Numerous works of domestic and foreign scientists are devoted to the problem of research. Among those published in the last 5 years, the works of a number of scientists should be mentioned. M. Ustenko, A. Ruskykh [3] considered digitalization from the standpoint of ensuring high competitiveness of the enterprise in the conditions of the formation of the digital economy. I. Migus, Ya. Koval [4] researched the impact of digitalization on the innovative development of enterprises, considered its positive and negative aspects, as well as its role in the formation of prerequisites for innovative development. They proposed new approaches to managing the digitalization of the company's activities. O. Hudz, S. Strelnikova [5] disclosed the peculiarities of organizational and information management of the enterprise development in the conditions of the formation of the digital economy, proposed approaches to the implementation of new models of organizational and information support for development. M. Teplyuk [6] considers ICT I4.0 as drivers of innovative business development, in particular, the following: digital idea, smart applications and analytics, Internet of Things, digital cloning, cloud technologies, etc. Nevertheless, he emphasizes that in the conditions of digitization, the driver of innovative business is also the innovative culture of personnel and consumers. O. Polous [7] carried out a systematic analysis of the digitalization indicators of Ukrainian enterprises, identified the existing shortcomings of digitalization processes, and proposed recommendations for their elimination. Z. Zhou et al. [8] proved the positive impact of digitalization on the sustainable development of enterprises in economically developed regions and urban agglomerations of the People's Republic of China. They showed that digitalization contributes to the sustainable development of enterprises through the implementation of appropriately oriented innovations in the regions. Yongzhang Peng, Changqi Tao [9], based on the data of real enterprises, proved the significant impact of digitalization on the efficiency of their activities and stimulating the transition to the innovative development. Tao Zhang et al. [10] using the model they developed based on data from manufacturing companies listed on the Shanghai and Shenzhen Stock Exchanges showed that there is a close relationship between digital transformation and production efficiency. They proposed measures to promote digitalization of production at Chinese enterprises. X. Zhao et al. [11] proved the existence of a relationship between

the digital transformation of manufacturing enterprises and their innovative activity, offered recommendations for digitalization and modernization of the manufacturing industry of the PRC, as well as promoting the innovative development of manufacturing enterprises. C. Himang et al. [12] proposed a system of indicators for determining the stages of ICT I4.0 implementation, which allows to increase the accuracy of managing the selection of relevant areas of innovative development. But their proposals are to a greater extent expedient to be applied at the level of the industry, rather than at the level of an individual enterprise.

Summarizing the results of the performed analysis, it should be outlined that the positive influence of digitalization on the formation of internal prerequisites for the innovative development of enterprises is substantiated in the available works. A number of aspects of managing individual components of the enterprise's PID in the context of ensuring its transition to the innovative development in the digital economy are disclosed. However, the issue of complex management of all components of the industrial enterprise's PID (including their separate elements) in the conditions of digitalization is unresolved. The issue of defining approaches to the actualization of PID in the context of the implementation of ICT I4.0 in various areas of market-oriented innovative activity of industrial enterprises is also resolved insufficiently. And this does not allow to realize fully the existing PID, as well as to form on its basis effective strategies for the innovative development of the industrial enterprise in the conditions of the digital economy.

The purpose of the article

The purpose of this research is to develop the approach to complex adaptive management of the potential of innovative development of the industrial enterprise in the digital economy in the context of its transition to the innovative growth.

Results of the research

To achieve the specified goal of the study, the following main tasks were as follows:

- to determine the impact of ICT I4.0 on the component subsystems (as well as their elements) of the PID of the industrial enterprise from the standpoint of forming the prerequisites for its innovative development;

- to determine approaches to the adaptive management of PID subsystems of the industrial enterprise to ensure conditions for its innovative development in the digital economy;

- to determine the sequence and content of

complex adaptive management procedures according to formalized PID procedures of the industrial enterprise in the context of its transition to the innovative development in the conditions of the digital economy.

According to [13], the PID of the enterprise is defined as a set of its interconnected resources and capabilities for their implementation, which determine its ability to develop in the innovative way. In its composition, the following potential subsystems are distinguished: market, as the presence of market demand supported by the purchasing power of consumers (requests) for innovations, or the possibility of its formation (for radical innovations); innovative, as the ability of the company's personnel to translate the achievements of science and technology into innovative products that satisfy consumer requests; production and sales, which determines the technical capacity and economic feasibility of manufacturing and commercializing innovations that meet consumer demands.

Taking into account the essence of the mentioned potentials-subsystems of PID, as well as the role and consequences of the introduction of ICT I4.0 in the industrial sphere as a whole [14], the effects of ICT I4.0 on the components of subsystems and elements of PID of the industrial enterprise are determined (Table 1).

As it follows from the analysis of Table 1, the effects of ICT I4.0 on the PID of the industrial enterprise that operates in the conditions of digitalization of the economy can be divided into two groups: positive ones that contribute to the creation and implementation of strategies for its innovative development, ie market opportunities; negative ones that create numerous problems not only for the transition to the innovative development, but also to the very existence of the enterprise, ie market threats. In these conditions, PID must be purposefully managed in order to use market opportunities and counteract market threats.

Based on the generalization of the results of the analysis of literary sources on the subject of the study and the data of Table 1, a set of approaches is defined, as well as methods and tools for managing PID components of the industrial enterprise in the digital economy (Tables 2-4).

Analysis, systematization and generalization of the content of Tables 2-4 made it possible to determine the sequence and content of formalized PID management procedures of the industrial enterprise in the context of its transition to the innovative development in the conditions of the digital economy. The generalized scheme of the

Table 1

The influence of ICT I4.0 on the potentials-subsystems of PID of the industrial enterprise

Subsystem potentials and their constituent elements	Positive influence	Negative influence
Market potential: marketing component (strategic and operational marketing)	The possibility of a radical transformation of the existing market or the formation of a new one based on the introduction of innovations, which, in turn, enables the application of the strategy of innovative anticipation	The threat of moral obsolescence of products, a decrease in the effectiveness of marketing methods and tools, a decrease or loss of competitiveness, loss of market positions and markets in general
Innovative potential: intellectual, informational, interface, research components	Improving the quality and productivity of innovative activities (creation, selection, modeling of objects and processes, testing of innovations), the quality and efficiency of its information support, the effectiveness and efficiency of the interaction of participants in the innovation process based on ICT: augmented and virtual reality, product cloning, Big Date, artificial intelligence, cloud computing, etc	The need for constant updating of knowledge and skills (training, retraining), the disappearance of the need for specialists in traditional professions and the growth of the need for new ones. Increasing demand for creative professionals and decreasing demand for professionals performing monotonous standard work. Aggravation of contradictions: talent is mediocrity, the owner of intellectual capital is an employee. Growing technological and intellectual inequality and, accordingly, economic and social inequality
Production and sales potential: organizational and managerial, financial, personnel, technical and technological, marketing components	A sharp increase in productivity, a decrease in the cost of production. Increasing efficiency of adaptation of production and logistics to changes, the possibility of programming changes. Individualization of production, products, marketing and logistics while simultaneously increasing their efficiency and reducing cost. Automated management (in real time) of production, self-diagnosis and self-adjustment of equipment. Horizontal and vertical system integration, which combines all systems of supply management, production, marketing, logistics, as well as their participants at all levels. Product life cycle management. The latest forms of labor organization, artificial intelligence in management. The basis is the combination of ICT I4.0 [15]	Permanent adaptation of business, changes in its orientation and form. Radical transformation of production, marketing and logistics. The need for frequent changes (updating) of technological equipment, technologies, means and communication technologies. Continuous training and retraining of personnel and management. Constant renewal of personnel due to the increase in the need for specialists in creative professions and the decrease in those who perform standard monotonous jobs. And also as a result of the growth of technological and intellectual inequality of workers in view of their capabilities. Changes in organizational management structures and forms of labor organization, forms of labor relations, introduction of informal employment. Psychological problems of personnel due to the growing role of artificial intelligence in decision-making, man-machine conflicts

Source: developed by the authors.

management process is presented in Figure.

The scheme presented in Figure shows the following sequence of decision-making procedures:

– the selection of directions for innovative development of the enterprise (block 4) taking into account the information from blocks 1, 2, 3, 5, as

well as the favorable and unfavorable effects of ICT I4.0 on the state of PID (see Table 1);

– monitoring (block 6) of compliance of the internal conditions of innovative development (characteristics of PID, its subsystems and their elements, block 5) in the selected areas (block 4)

Table 2

Approaches to the management of the market potential of the PID subsystem of the enterprise

Components of market potential	Methods and tools	Input information (knowledge)	Results: new information (knowledge), management methods, etc.
Marketing	Strategic marketing	Trends in changes in macro- and micro-environmental conditions. Problems (actual or projected) of consumers of the enterprise. Trends in the implementation of ICT I4.0 at the enterprise	Promising directions of innovative development and markets (their market segments or niches). The results of the analysis of the compliance of the strategy of innovative development with the conditions of the external environment. Recommendations for adjusting/changing the marketing component of the innovative development strategy at the enterprise
	Operational marketing	Data on the effectiveness of traditional methods and tools of the innovation marketing complex. Trends in their improvement	Recommendations on improving existing or implementing new tools and methods of marketing innovations at the enterprise

Source: developed by the authors.

with external conditions (blocks 1, 2, 3);

– making management decisions (block 7) based on monitoring results: in case of compliance, development in the chosen direction and continuation of monitoring; in case of inconsistency, PID management (block 8) in order to ensure the required state of its subsystems and their elements (Tab. 2-4);

– after improving the state of the PID according to the management results (block 8), a refined assessment (block 9) of the compliance of the internal conditions of innovative development with external ones is performed, based on its results, the following

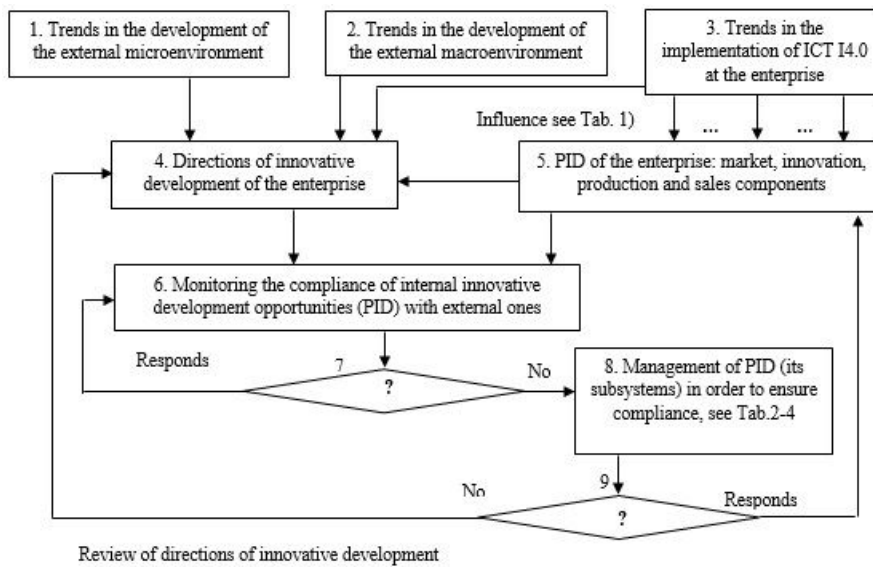
decisions are made: in case of ensuring compliance, development in the chosen direction and continuation of monitoring; in case of inconsistency, revision of directions of innovative development.

The presented scheme reflects the formalized sequence of procedures of complex adaptive PID management at the industrial enterprise that has transferred to the innovative development in the conditions of the digital economy.

Conclusions

Summing up, the following conclusions can be drawn.

1. The impact of ICT I4.0 on each component



The scheme of PID management at the industrial enterprise in the context of its innovative development in the conditions of the digital economy (authors' development)

Table 3

Approaches to the management of the innovative potential of the PID subsystem of the enterprise

Components of innovation potential	Methods and tools	Input information (knowledge)	Results: new information (knowledge), management methods, etc.
Intellectual	Innovative management. Creative management. Personnel Management. Personnel marketing	Trends in changing needs for creative specialists of certain specialties, capable of producing and using new knowledge, capable of using it effectively to create and test ICT I4.0 innovations. Information and knowledge about new approaches to the creation and commercialization of innovations based on ICT I4.0	Determination of needs for specialists of a certain profile. Recommendations regarding the adjustment of personnel policy, in particular, the selection of personnel, directions for updating their knowledge and skills, development of creative abilities, motivation of creative work in conditions of digitalization
Information	Management of knowledge. Knowledge Marketing	Information on trends in the development of NTP in the enterprise's field or related fields, as well as in the field (field of activity) of consumers. Forecasts regarding directions of production and use of new knowledge in the field of the enterprise or related fields	Recommendations on the orientation of the system of production and use of information and knowledge to the most promising types of them, which can be commercialized by turning them into objects of intellectual property, products, technologies or management methods
Interface	Knowledge Marketing Personnel Management. Partnership Marketing	Information and knowledge about the latest methods and forms of forming innovation project teams, existing and possible conflicts in their activities, as well as in the interaction of the subjects of the innovation process. Information and knowledge about ICT I4.0, which contribute to the interaction of subjects of the innovation process and teams of innovation projects	Recommendations on improving approaches to the formation of innovative project teams, ensuring effective interaction of their members, motivating their creative cooperation in conditions of digitalization. Recommendations for resolving individual, intergroup and other conflicts of innovation project subjects and innovation project teams
Research	Innovation Management. Marketing of Innovation	Information and knowledge about the possibilities of application in the innovation process of ICT I4.0: augmented and virtual reality, product cloning, Big Data, artificial intelligence, cloud computing, etc.	Recommendations for improving approaches to the generation and selection of ideas, design, creation, laboratory tests, market testing of innovations based on ICT I4.0

Source: developed by the authors.

of the subsystem (including their elements) of the PID of an industrial enterprise from the standpoint of its innovative development is determined. According to the nature of the impacts, they are divided into two groups: those that have a positive impact on the PID and contribute to bringing its characteristics to the conditions of the digital economy; such that have a negative impact on PID and reduce the possibilities of its adaptation to the conditions of the digital economy.

2. Approaches to purposeful management of PID subsystems of the industrial enterprise have been developed in order to update their condition in relation to external conditions and ensure favorable internal prerequisites for innovative development in the digital economy. The application of the proposed approaches makes it possible to align reasonably the internal capabilities of the industrial enterprise's innovative development (its PID) with the external ones in the conditions of the formation of the digital

Table 4

Approaches to the management of the production and sales potential of the PID subsystem of the enterprise

Components of production and sales potential	Methods and tools	Input information (knowledge)	Results: new information (knowledge), management methods, etc.
Organizational and managerial	Innovative management. Personnel Management	Information and knowledge about the trends in the creation and implementation of the latest organizational forms of management at the enterprise, other industries, as well as at the enterprises of competitors. In particular, those based on ICT I4.0 (their combination) [15]: industrial Internet of Things, Big Date, cloud computing, machine learning, etc.	Recommendations on the formation of a real-time enterprise management system, the integration of information into single self-regulating systems of managers, ICT and 4.0, automated production, manufactured products, and consumers
Financial	Financial management	Information and knowledge about the possibilities of using Internet banking, financial management systems with ICT I4.0	Recommendations for improving the system of calculations and financial management of the enterprise as a whole on the basis of ICT I4.0
HR	Personnel management. Personnel marketing	Forecasts of needs for specialists of certain specialties and areas of training, based on the chosen direction of innovative activity of the enterprise. Forecasting changes in these needs according to trends in the development of the external environment	Recommendations on the provision of human resources for certain areas and specialties of training. Recommendations for updating the knowledge and skills of the company's personnel in the conditions of the digital economy
Technical and technological	Knowledge marketing. Competitive analysis. Production management.	Information and knowledge about the implementation (possibility of implementation) at the enterprise (adjacent industries) of production based on ICT I4.0 and their combination, in particular [15]: artificial intelligence, industrial Internet of Things, Big Date, cloud computing, machine learning, additive manufacturing, etc Information and knowledge about the effectiveness of traditional marketing tools in the digital economy.	Recommendations for the implementation (such as those based on ICT I4.0) of automated productions that are managed with the use of artificial intelligence in real time. This will ensure the efficiency of their adaptation to changes in the external environment, as well as high productivity, improve quality and reduce the cost of production. The introduction of additive technologies will speed up the fulfillment of individual orders and ensure product customization
Marketing	Innovation marketing	Information and knowledge about the effectiveness of traditional marketing tools in the digital economy. Information and knowledge about the possibilities of using ICT I4.0 to combine information flows characterizing production processes, marketing support for the commercialization of innovative products, logistics, interaction with consumers (direct and reverse), etc.	Recommendations for the implementation of marketing innovations to increase the effectiveness of its methods and tools, their adaptation to the conditions of the digital economy. The combination of information demand and supply for prompt bringing them into line, more complete satisfaction of consumer requests aimed at solving their problems, purposeful formation of demand for radical innovations. It will also allow controlling material flows, manage promptly and reasonably the solution of emerging problems

Source: developed by the authors.

economy.

3. The sequence and content of the formalized procedures of complex adaptive PID management at the industrial enterprise in the context of its transition to the innovative development in the conditions of the digital economy are defined. A consolidated PID management scheme of the industrial enterprise in the digital economy is proposed, which can be used as a methodological basis for the implementation of the developed approaches in the practice of innovative activity.

The obtained results solve collectively the urgent task of developing the approach to complex adaptive management of the potential of innovative development at the industrial enterprise, including its component subsystems-potentials and their elements, in the context of ensuring compliance with the internal and external conditions of innovative growth of the enterprise in the digital economy. In contrast to existing approaches, it provides adaptive management of all components of the PID at the industrial enterprise in complex, which increases the degree of consistency and reasonableness of management.

Further research should be aimed at forming the foundations of the organizational and economic mechanism for managing the innovative development of industrial enterprises in the digital economy.

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УПРАВЛІННЯ ПОТЕНЦІАЛОМ ІННОВАЦІЙНОГО РОЗВИТКУ ПРОМИСЛОВОГО ПІДПРИЄМСТВА В ЦИФРОВІЙ ЕКОНОМІЦІ

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Статтю присвячено розробленню підходу до комплексного адаптивного управління потенціалом інноваційного розвитку (ПІР) промислового підприємства в умовах формування і розвитку цифрової економіки. Визначено і систематизовано за характером дії (сприятливі чи несприятливі) впливи інформаційних комп'ютерних технологій четвертої промислової революції на кожну зі складових підсистем (включаючи їх елементи) ПІР промислового підприємства з позицій забезпечення його стійкого інноваційного зростання. Розроблено підходи до цілеспрямованого управління складовими підсистемами ПІР промислового підприємства з метою актуалізації їх стану стосовно зовнішніх умов і забезпечення сприятливих внутрішніх передумов інноваційного розвитку в цифровій економіці. Їх застосування дозволяє обґрунтовано приводити у відповідність внутрішні можливості інноваційного розвитку промислового підприємства (його ПІР) до зовнішніх в умовах цифрової економіки. Розроблено укрупнену схему, що відображає послідовність і зміст формалізованих процедур управління ПІР промислового підприємства в контексті його переходу на шлях інноваційного розвитку в умовах цифрової економіки. Вона може бути використана як методичне підґрунтя впровадження розроблених підходів в практиці інноваційної діяльності промислових підприємств. Представлені розробки у сукупності формують підхід до комплексного адаптивного управління за формалізованими процедурами ПІР промислового підприємства, включаючи його складові підсистеми-потенціали та їх елементи, в контексті забезпечення відповідності внутрішніх і зовнішніх умов інноваційного зростання підприємства у цифровій економіці. Розроблений підхід, на відміну від існуючих, передбачає адаптивне управління всіма складовими (а також їх елементами) ПІР у комплексі, що підвищує ступінь узгодженості і обґрунтованості управління інноваційним розвитком промислових підприємств в цифровій економіці.

Ключові слова: інноваційний розвиток, промислове підприємство, стратегічне управління, потенціал інноваційного розвитку, цифрова економіка, четверта промислова революція, цифрові інформаційні технології.

MANAGEMENT OF THE INNOVATIVE DEVELOPMENT POTENTIAL OF INDUSTRIAL ENTERPRISES IN THE DIGITAL ECONOMY

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The article considers the development of the approach to complex adaptive management of the potential for innovative development (PID) of the industrial enterprise in the conditions of the formation and development of the digital economy. The impact of information computer technologies of the fourth industrial revolution on each component subsystems (including their elements) of the PID of the industrial enterprise from the standpoint of ensuring its sustainable innovative growth are determined and systematized by the nature of action (favorable or unfavorable). Approaches to purposeful management of PID component subsystems of the industrial enterprise have been developed in order to update their condition in relation to external conditions and ensure favorable internal prerequisites for innovative development in the digital economy. Their application makes it possible to reasonably align the internal possibilities of innovative development of the industrial enterprise (its PID) with the external ones in the conditions of the digital economy. The enlarged scheme has been developed that reflects the sequence and content of the formalized procedures for managing the PID of the industrial enterprise in the context of its transition to the path of innovative development in the conditions of the digital economy. It can be used as a methodological basis for the implementation of the developed approaches in the practice of innovative activity of industrial enterprises. The presented developments collectively form the approach to complex adaptive management according to formalized PID procedures of the industrial enterprise, including its component subsystems-potentials and their elements, in the context of ensuring the compliance of internal and external conditions of innovative growth of the enterprise in the digital economy. The developed approach, in contrast to the existing ones, provides the adaptive management of all components (as well as their elements) of PID in a complex, which increases the degree of coherence and validity of the management of innovative development at industrial enterprises in the digital economy.

Keywords: innovative development, industrial enterprise, strategic management, potential of innovative development, digital economy, fourth industrial revolution, digital information technologies.

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