DIGITAL ECONOMY AS A CHALLENGE TO THE FORMATION OF INTELLIGENT INFRASTRUCTURE OF TECHNOLOGICAL DEVELOPMENT AT INDUSTRIAL ENTERPRISES

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Abstract: *The problem of the impossibility to ensure the technological development of industrial enterprises in the new economic conditions of digitalization based on traditional approaches developed for the conditions, in which modern high-tech enterprises no longer operate, determined the core scientific idea of the study. It forms a conceptual model for the intelligent infrastructure of technological development at industrial enterprises based on the principles of infrastructure-reproduction approach.*

Domestic and foreign management theory presented with a variety of concepts, including those focused on modern aspects of management, due to structural changes in the economy based on digital technologies, do not give a sufficiently clear idea of the management features of the intelligent infrastructure formation for technological development at industrial enterprises in the new economic conditions. This is an urgent scientific problem to be solved.

The proposed concept is based on methods of system analysis and scientific modelling, economic-statistical methods (grouping, typing, constructing time series, determining ratings, etc.), to analyze and compile statistical information, identify trends and characteristics of technological development at industrial enterprises, analytical method when performing analytical calculations, graphical method for the visualization of the results.

From the infrastructure-reproduction approach the article reveals the components of the conceptual model for intelligent infrastructure of technological development at industrial enterprises, and presents the essential links between them, due to the task of achieving the target results in the field of technological development in the digital economy. The presented model can influence the management orientation of a modern industrial enterprise and the choice of an acceptable organizational solution in the field of staff intellectual resources management for its technological development. These results will allow developing research, designing and implementing organizational and management systems and mechanisms to ensure the technologization based on effective intellectual and resource support in the industrial sector in the digital economy.

Keywords: *Intelligent infrastructure, Intellectual resources, Infrastructure and reproduction approach, Technological development, Industrial enterprises, Digital economy, Staff.*

1. INTRODUCTION

In modern conditions of world economy development, one of the most relevant and important factors for economic growth is the digitalization of the economy.

It is the digitalization of the economy that becomes a priority for the innovative development of economic systems and a tool for creating long-term competitive advantages.

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The study of the processes of forming and developing the digital economy, and, consequently, the directions of digital enterprises transformation in the context of the fourth industrial revolution development is becoming more and more relevant.

The world leader in the digital economy share in GDP is the USA (10.9 %), the second is China with its share of 10%, and in Russia's GDP is 3.9 %, which is almost 2.5 times lower than in leading digital economy countries (Table 1) [1].

Table 1. The contribution of the digital economy to Russia's GDP and its components in comparison with other countries, %

	Russia	USA	China	5 Western European countries*	Brazil	India
Household spending in the digital sphere	2.6	5.3	4.8	3.7	2.7	3.2
Companies' investments in digitalization	2.2	5	1.8	3.9	3.6	2.7
Government digitalization costs	0.5	1.3	0.4	1	0.8	0.6
ICT export	0.5	1.4	5.8	2.5	0.1	5.9
ICT import	-1.8	-2.1	-2.7	-2.9	-1	-6.1
Total	2.9	10.9	10	8.2	6.2	6.3

* Great Britain, Germany, Italy, France, Sweden

Industrial enterprises cannot exist without modernization in the digital economy. Modernization should be aimed at qualitative changes to meet the principles of system theory, where the main one is development. The modernization of an industrial enterprise at the output provides qualitatively new opportunities, including technical, financial and economic stability of the enterprise [2, 3].

The main principles of the modernization concept are: the principle of innovation by Joseph Schumpeter; the principle of the evolutionary approach in Economics [4, 5]; the principle of cyclical development [6]; the principle of technological dynamics and economic growth [7, 8, 9].

The problem is that the practical work on the transformation of an industrial enterprise and its modernization is based on the terminology of the fourth industrial revolution (industry 4.0), which has not been fully formed, due to the speed and scale of changes [10].

Industry 4.0 involves the creation of digital enterprises based on the digitization of all physical assets and their integration into the digital ecosystem together with partners taking part in the value chain. At a fundamental level of the fourth industrial revolution there is the transition from simple ICT-enhanced digitalization to innovations based on combinations of technologies [11].

2. METHODS

The study as a whole (at the stages of solving all its tasks) is focused on a dialectical approach to the study of socio-economic systems formation and development patterns, methodology of system analysis, as well as a logical approach (formal and mathematical logic), involving objectivity and comprehensiveness of consideration, not contradiction, sufficient justification.

In the process of accumulating information, factorological, empirical and statistical material, it is necessary to carry out scientific observation on the basis of non-complete statistical observation using the statistical method of the main sample population array investigation. Analysis of trends, updating the formation of the intelligent infrastructure for technological development at industrial enterprises in conditions of diversification and technological modernization in modern economy, is carried out on the basis of a systematic approach using methods of analysis, synthesis, systematization on the basis of economic and statistical methods of statistical summary and grouping, presentation of statistical data, ranking.

The proposed concept is based, in total, on: methods of system analysis and scientific modelling as part of the study of the intelligent infrastructure for technological development in the integrity, unity and interconnection of its constituent parts; economic and statistical methods (grouping, typing, building dynamics series, determining ratings, etc.) to analyze and synthesize statistical information, to identify trends and peculiarities of scientific and technological development at industrial enterprises; calculation and analytical method when performing analytical calculations; graphical method for rendering the obtained results.

3. RESULTS

Thus, the conditions of modern socio-economic transformation impose special requirements for managing the technological development of industrial enterprises on an innovative basis and necessitate the creation of an intra-company relatively autonomous system for providing intellectual resources, among which the intellectual resources of the staff and their intellectual potential play the important role [12].

In connection with the formation and development of the digital economy, to be a global trend in technological development, the problems of increasing the innovative activity of industry have become one of the priority modern economy ones. In such conditions, a goal-oriented formed team of highly intelligent employees is the basis for effective intellectual and innovative activity of an industrial enterprise. It increases the level of its production and, consequently, its competitiveness. As a result, managing the intellectual potential of the company's staff, including the implementation of management functions for its planning, formation, development, use and transformation into economic potential, becomes an inevitable necessity.

The main prerequisites determining the need to create an in-company system for managing employees' intellectual resources as part of the enterprise management system are:

- the need to develop strategies and tactics in the field of managing staff's intellectual resources;
- a wide list of functions for managing staff's intellectual resources;
- the need to improve information and analytical support for the process of staff intellectualization;
- the need determined by the economic feasibility of improving the quality of management decisions made in relation to the process of staff intellectualization;
- the possibility of reducing the degree of uncertainty and risk in the implementation of innovative projects of technological development at the enterprise;
- the need to coordinate the interaction of many different departments of the enterprise, whose activities are related to the intellectual resources of the staff;
- the specifics of tools and methods for managing staff's intellectual resources;

- the ability to improve the efficiency of the distribution and use of staff's intellectual resources, belonging to the active part of the company's intellectual assets affecting the efficiency level of the use of other company assets (tangible and intelligent);
- a real possibility of multiplying the company's income from the effective use of intellectual resources of staff in the field of technological development projects on an innovative basis.

Thus, the process of staff intellectualization at the modern technological enterprise should be integrated into the cycle of project activity, having a significant impact on its economic results (Figure 1).

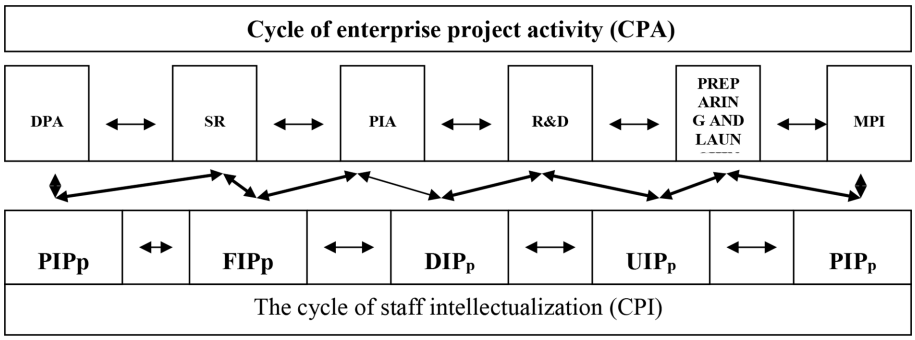

Figure 1. Relationship between the company's project activity cycles and staff intellectualization:

DPA – development of the project activity, SR - scientific researches; PIA - planning innovative activities, R&D – research and development work, MP – mass production, MPI – managing the product implementation , PIPp – planning the intellectual potential of staff, FIPp – formation of intellectual potential of the staff, DIPp – development of intellectual potential of the staff, UIPp – use of the intellectual potential of staff, TIPp– transformation of the intellectual potential of the staff

The basis for the effectiveness of the interconnections between *CPA* and *CPI* is a certain goal-oriented management impact on the intellectual potential of the staff, both in qualitative and quantitative terms. It affects the economic results of innovative projects of technological enterprise development.

Define the main elements of the conceptual model for intelligent infrastructure of technological development at industrial enterprises and their functional significance (Table 2), designed as a set of interacting object and subject of management, to provide the necessary parameters of management indicators.

Then the conceptual model for the intelligent infrastructure of technological development at industrial enterprises can be presented as follows (Figure 2).

In total, the presented model for intelligent infrastructure of technological development at industrial enterprises can influence the management of a modern industrial enterprise and the choice of an acceptable variant of an organizational solution in the field of staff management, from the point of view of the interests of its technological development. This allows:

- making links between the management system of employees' intellectual resources and the general enterprise management system;
- taking into account factor influence of the internal and external enterprise environment;

- specifying the elements of an in-company system for managing employees' intellectual resources;
- forming criteria for effective enterprise employees' intellectual resource management;
- determining the tools for managing impact on the process of staff intellectualization in order to achieve the management targets.

Table 2. The main elements of the conceptual model for intelligent infrastructure of technological development at industrial enterprises

Model element	**Functional value of the element**
Management object is the process of staff intellectualization	Providing the required mode of dynamics of the staff's intellectual potential by specially organized management
The subject is module for innovation-oriented staff intellectualization management *(MIOPIM)*, including subsystems: - producing and improving the staff's intellectual potential; - effective use of intellectual potential	*MIOPIM* is intended for constructive participation in innovative processes of technological development at the enterprise as a subject through managerial influence on the staff's intellectual potential to achieve the targets of technological development
The result of managing staff intellectualization is the output value $X_{out}(t)$	Management performance indicator (*Xout (t)* is staff's intellectual potential, ΣIPp)
Team impact on *MIOPIM*	A given team (input) impact on the subject of management ($X_{in}(t)$ is the reference values *IOPIM)*
Managing (regulating) influence on the process of staff intellectualization $(X_p(t))$	Managing influence of *MIOPIM* on IP_p in the process of its planning, formation, development, use, transformation in the intellectual and innovative cycle
Factor influence of the internal and external enterprise environment (f_i (t))	Perturbing effect causing unplanned changes in the output value $X_{out}(t)$

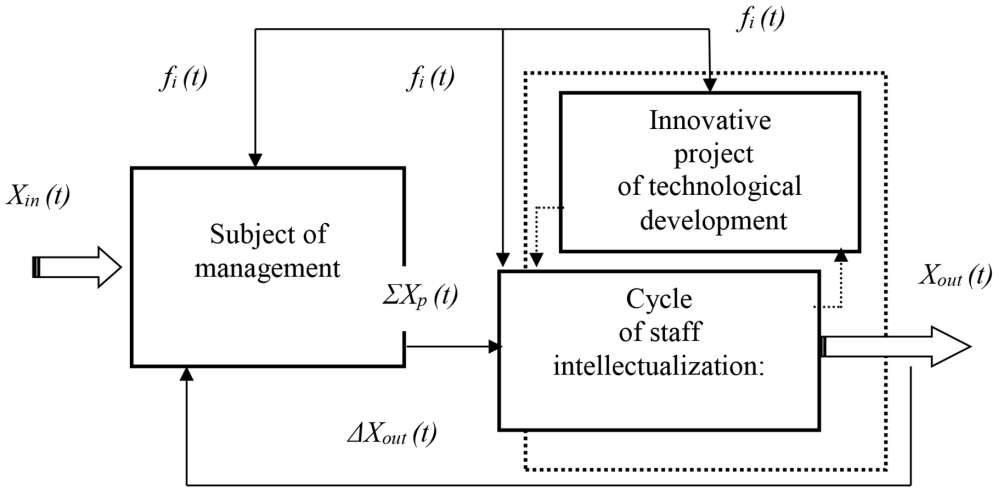

Figure 2. Conceptual model for intelligent infrastructure of technological development at industrial enterprises:

- Xout(t) is result of staff intellectualization management – output value in the form of a comprehensive assessment of economic parameters of intellectual staff potential;
- Xin(t) is the specified team (input) effect on the management subject (reference parameters);
- fi(t) is factorial influence of the internal and external enterprise environment, causing unplanned changes in the output value Xout(t);
- ΣXp(t) is a managing (regulating) impact on the process of staff intellectualization;
- ΔXout (t) is deviation Xout(t) from the reference parameters of management

4. FUTURE RESEARCH DIRECTIONS

Further research stages of intellectual infrastructure for technological development of industrial enterprises suggest:

- clarification and specification of management functions within the infrastructure;
- development of organizational solutions for integration of intellectual infrastructure into the enterprise management system;
- formation of managing measures for the reproduction process of staff intellectualization;
- methodological preparation for the economic assessment of management results.

5. CONCLUSION

In general, in the context of the globalization of the digital economy, a qualitative transformation of industrial enterprises at the organizational level is inevitable. The fact is that for the economy of active innovative transformations at the period of digitalization, it is essential not to reproduce copies of a typical product, but to develop and create qualitatively new types of goods and services. Thus, a popular approach to analyzing the activities of a modern industrial enterprise and making appropriate effective management decisions is not only considering the enterprise as a sum of tangible and intellectual resources, but also the increased importance and role of the latter in the activities of a modern enterprise.

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