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## KNOWLEDGE-INTENSIVE TECHNOLOGIES AS A KEY FACTOR IN THE NEW DEVELOPMENT PARADIGM

**Abstract.** Modern high technologies are transforming the model of civilizational development toward increasing the value of knowledge as a necessary component of the transition from an industrial society to a post-industrial and knowledge society. Society is witnessing the realization of what in the mid-20th century seemed a distant prospect or a product of the emotion and experience industry: science fiction books and films. This paper examines the potential of modern technologies, knowledge, and information as necessary components of the high-tech development of a knowledge civilization. The theoretical and methodological foundation of the study is based on the provisions of structural-functional, systemic, and activity-based approaches. A combination of methods was employed: content analysis of openly accessible specialized scientific literature on the knowledge economy and high-tech development, as well as methods of abstraction and modeling. In the course of the research, the author drew upon the works of D. Bell and A. Toffler devoted to post-industrial society, high-tech development, the knowledge economy, and digitalization. The study also separately uses the provisions of S.D. Bodrunov on NIS.2, knowledge-intensive production, and noonomy, which make it possible to consider knowledge-intensive technologies not only as a sign of a post-industrial shift, but also as a prerequisite for deeper changes in production, labor, and social development.

**Keywords:** knowledge, information, knowledge-intensive technologies, high technologies, post-industrialism, post-industrial society, NIS.2, knowledge society, socio-humanitarian technologies, digitalization.

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### 知识密集型技术成为新发展范式的关键因素

**摘要:**当代高科技正在改变文明发展模式,使知识价值在从工业社会向后工业社会和知识型社会转型中的作用不断增强。社会正在见证这样一种现实:那些在20世纪中叶还被视为遥远前景,或被看作情感和体验工业产品的内容,如科幻小说和电影,如今正在逐步实现。本文探讨现代技术、知识和信息作为知识型文明高科技发展必要组成部分的潜力。本研究的理论与方法论基础源于结构功能论、系统论和活动论的相关原理。研究采用综合方法,包括对公开获取的关于知识型经济和高科技发展

的专业学术文献进行内容分析,以及抽象和建模方法。在研究过程中,作者参考了D. 贝尔和E. 托夫勒关于后工业社会、高科技发展、知识型经济和数字化的研究成果。同时,本文还单独运用了S.D. 博德鲁诺夫关于第二代新工业社会、知识密集型生产和智慧经济的相关观点,从而将知识密集型技术不仅视为后工业转向的表现,也视为生产、劳动和社会发展发生更深层变化的前提。

**关键词:** 知识、信息、知识密集型技术、高科技、后工业主义、后工业社会、第二代新工业社会、知识型社会、社会人文技术、数字化。

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Contemporary processes of civilizational evolution are marked by transformative changes of post-industrial development in virtually all areas of public life [Malakhova, 2016], which inevitably impacts the very fabric of society. As S.D. Bodrunov notes, the terms «knowledge economy» and «information society» have entered common usage in political, economic, and academic discourse [Bodrunov, 2019].

The authors' approaches relating to the so-called «post-industrial wave» present the qualitative characteristics of the new information society and knowledge economy from various aspects and perspectives. One of the fundamental and defining factors is the radical shift toward a high-tech economic structure. Society is witnessing processes described in the works of D. Bell and A. Toffler within the theory of information (post-industrial) society and the third stage of the wave concept of society, where the interpenetration (convergence) of technologies is rapidly increasing. The works of American sociologist M. Castells and Japanese economist T. Sakai have gained widespread popularity. S.D. Bodrunov cites these works in his examination of the network structure of society and the paramount importance of knowledge in social development [Bodrunov, 2016].

N.N. Trofimova offers the following interpretations of the knowledge economy [Trofimova, 2022]:

1. A segment of the economy associated with the production and transfer of knowledge.
2. Knowledge-intensive sectors of the economy.
3. Economy as a whole, where intellectual potential and the production, distribution, and use of knowledge are of strategic importance.

Economic development, particularly production (both tangible and intangible), implies the growing value of knowledge as a strategically essential asset across all economic categories, i.e., it contains permanent trends toward a transition to a knowledge economy. It is important to note, however, that a knowledge economy is not identical to S.D. Bodrunov's noonomy, but rather serves as one of the prerequisites for a more profound transformation of production, labor, and needs. Criterion indicators that represent the share of knowledge economy in the institutional development of the state should include the number of professionals engaged in research and practical implementation of scientific research results, the level of R&D funding in the overall structure of public expenditures and R&D commercialization (Rodina, 2019), the share of high-tech industries and their distribution across economic sectors, the impact of high technology on the quality of life of the population, the interpenetration of technologies (convergence), etc.

The transition to a post-industrial economy based on the NBICS convergence platform, which presupposes a new quality of knowledge and a new level of knowledge-intensive technological development, is the subject of close attention from economists, political scientists, philosophers, and futurologists. So-called «new» technologies – digital, cognitive, bio-, nano-, additive, and social, etc. – are intensively evolving, forming a knowledge «superstructure» over the traditional world of machine technology. «Hybrid» technologies are becoming commonplace as a combined toolkit of machine and non-machine technologies for guiding and regulating natural processes to achieve social goal-settings [Bodrunov, 2018]. In this case, it is crucial that we are not talking about displacing material production, but rather about saturating it with knowledge, scientific components, and new forms of labor organization.

It should be noted that development based on knowledge and «new» (knowledge-intensive) technologies implies not only the transformation of existing ones but also the creation of new high-tech industries with technological and intellectual potential being the key elements of knowledge and production synergy, the creation of new value, the expansion of competitive advantages, technological self-sufficiency, etc.

The definition of «technology» is of Greek origin, including «τέχνη» (skill, craftsmanship, art) and «λόγος» (thought, science, word). Introduced into semantic circulation in 1772 by Johann Beckmann, it was associated with craft skills, and more broadly, industrial mastery. The modern interpretation is adjusted to changes associated with the development of civilization and encompasses scientific and methodological approaches, tools, and processes for achieving goal-setting.

In the context of growing creative and innovative trends in economic transformation, the value of technological potential distinguished by breakthrough knowledge intensity and a range of competitive advantages over existing technological products is also growing. In this regard, we classify technologies based on their life cycle and value for the economy as a whole [Bagirova, 2018; Melnichuk, 2003]:

- unique, used on the basis of exclusive (monopoly) ownership granted by intellectual property rights;
- advanced, differing from traditional similar technologies by technical and economic advantages – novelty and economic effect, enhanced efficiency, an expanded range of competitive advantages, and environmental friendliness;
- traditional, used everywhere and supporting the usual standard of living, production and economic performance;
- obsolete, not meeting modern standards, characterized by low efficiency, high maintenance costs and wear level, technological backwardness and extremely low competitiveness.

The differentiation between unique and breakthrough technologies which contain a significant share of knowledge and require significant investment, including highly skilled human resources, lies in their nature of origin, goal-setting, and impact on the market component of civilizational development.

Thus, according to A. Gerasimov, digitalization is a source of higher importance for the production potential in the economy, which evolves based on the convergence of material resource components and cyber-physical systems [Gerasimov, 2019], which imply a significant share of knowledge component. In this case, the platform foundation for the evolution of production is the production potential generated during the industrialization period of the Soviet Union.

Knowledge transforms the potential of scientific research into a fundamental asset of critical technologies that shape national security and the technological sovereignty of the state. In the military-industrial complex, this involves research and development of the latest types of weapons. Knowledge-intensive technologies enable the high-tech development of promising areas of industrial potential and economic sectors, including the civilian sector (smart manufacturing, nanosystems industry, biomedical and cognitive technologies, unmanned and autonomous systems, etc).

The importance of technological potential as a guarantee of a high quality of life for citizens, well-being, and the preservation of the state's global strategic security is supported by the shift toward the demand for intellectual and creative activity, rather than the mere creation of material goods. In a post-industrial economy, the value of socially created goods is increasingly shifting toward a range of intangible qualities. In S.D. Bodrunov's approach, this shift should be viewed not as the disappearance of material production, but as a change in its quality due to knowledge, science, technology, and creative labor [Bodrunov, 2018; Bodrunov, 2019].

According to S.D. Bodrunov, the resource component of a high-tech economy is changing in a post-industrial society. Information is becoming the most important resource and product [Bodrunov, 2018]. The very existence of information presupposes its processing and analysis, which implies a high level of societal development and employee qualifications. Knowledge is becoming the primary, inexhaustible asset of the post-industrial economy and information society, the foundation of intellectual interaction between the state, society, business, and the academic community based on the «quadruple helix» principle of human-centered civilizational development. In order to implement the nootransition, it is essential to distinguish between information as a transmitted and processed resource and knowledge as the result of human cognitive and creative activity [Bodrunov, 2018; Dmitriev, 2025].

In this context, we consider it appropriate to make a note regarding the demarcation of the concepts of «knowledge» and «information,» as there are instances of their being equated. Information can be defined as data whose nature does not change with variations in its representation and is an object of storage, transmission, and processing. From a philosophical perspective, information is a fundamental concept, representing a reflection of existing reality – the real world, through which an individual understands changes occurring in space. From a technical perspective, the following definition is noteworthy: information is a sequence of signals transmitted from a transmitter to a receiver, accumulated in a storage device, processed, and output as deliverables [Wiener, 1958]. While knowledge is the product of cognition, the result of human activity – the so-called cognitive process. The manifestation of knowledge is based on the systematic organization of information, which reflects reality in synergy with existing experience, logical justification, and necessary conclusions. Considering the second signaling system, only humans possess knowledge, which is one of the fundamental differences between humans and the animal world.

Let us note the specific dual manifestations of knowledge and information in the context of their properties necessary for the development of high technologies and the characteristic features inherent in both knowledge and post-industrial evolution [Chirkov, 2020]:

- knowledge and information are global in their manifestation of limitless properties;
- in the information society in a spatial-territorial context, they have no limitations on the level of distribution, limited only by artificial institutional barriers;
- a growing trend towards a permanent increase in the extent of knowledge and information exchange;

- scenario-based unpredictability of the consequences of the application and generation of new knowledge as a component of high technologies. This feature depends on the goal-setting of the actors involved in the creative process of post-industrial development factors;
- development of a special ecosystem where knowledge and information acquire the status of a commodity (service) with a fairly rapid rate of distribution and consumption;
- the same knowledge and information can be used repeatedly, while simultaneously in different places without restrictions on application agency;
- knowledge and information are a consequence of human cognitive activity, which can be repeatedly transmitted without losing their properties. On the contrary, in the process of transfer and use, knowledge can potentially acquire new derivatives, facilitating the generation of new emergent properties.

These properties contribute to the blurring of boundaries between the production of goods and the provision of services, transforming the economy into a service-based plane of functioning under the influence of high technology. Major corporations are now offering not just a brand, but a comprehensive solution with the product serving as a platform for delivering high-quality services. The traditional consumption model is shifting to a «product as a service» model [Mironova, 2025], where the synergy of knowledge and technology is fundamental. However, this servitization does not negate the productive nature of high-tech development: it changes not only the form of product delivery but also the knowledge-intensive nature of its creation, maintenance, and use.

The importance of the creative component in the intellectual process of creating value-based goods is growing. The demand for a special environment for the creative and intellectual technologies (an ecosystem) is growing, with human activity having a special role as a source of new ideas and approaches to technological development. This thesis suggests the interaction of human potential and high-tech development, including the influence of high technologies on the development of new capabilities for humans and society.

Given the stated trend of interdependence between high technology and human potential, we present the main qualitative characteristics of the content of labor that arise under the influence of the creative-intellectual ecosystem of replacing capital-intensive technologies with knowledge-intensive ones:

1. Emergence of new professions and fading of existing ones [Gubernatorov, 2024], which expands the range of opportunities for the actualization of intellectual capital, but gives rise to a complex set of issues associated with the previous format of labor and the individual's place within it.

2. The nature and intensity of the production process are changing, which is caused by an effect formed by a complex set of constituent factors: the growing role of knowledge and technology in the creation of goods; the expansion of the variety of operations, which gradually become more complex as the knowledge-intensiveness of the created product increases; the need for a creative approach to addressing non-routine tasks.

3. Permanent reduction in employee dependence on a fixed workplace and the employer's means of production. This transformation is driven by the growing importance of information and communication technologies and the capabilities of digitalization.

4. Performance evaluation criteria are changing based on the transformation of the nature of working activity. The effect of synergy and emergence of knowledge-intensive technologies and

teamwork is increasingly taking up a larger share in the production process, which is significantly more effective than previous approaches of the industrial economy.

5. Variability of product lines and services provided is subject to further addition and expansion, including due to a reduction in life cycles and changes in the product range and production characteristics, which affects the need for continuous improvement of employee qualifications and verification of knowledge and competencies.

6. Increase in the number and variety of non-routine tasks arising in the process of changes in working conditions, market demands, needs and wishes of the target audience, which presupposes a different architecture for the management of human resources and intellectual potential in the context of ever-increasing competition in a high-tech economy;

7. The significance of labor and the status of professional activity are changing. Employees' attitudes toward careers are also undergoing transformation, given that many physically demanding and exhausting types of professions are either undergoing significant changes or disappearing in general, freeing up the service sector and manufacturing niche for knowledge-intensive professions and high-tech activities.

Closely related to the changing content of labor is the definition of the American economist R. Florida, who proposed calling the social group closely associated with the post-industrial economy the «creative class» [R. Florida, 2005]. Yu. V. Latov notes the transition from capitalism, the secondary phase of social formation, to a new, tertiary formation, accompanied by numerous contradictions [Latov, 2024], which are discussed in numerous discourses and examined and analyzed in scholarly works devoted to the transition to a post-industrial society.

The topic of post-industrial society and the creative class as actors in the post-industrial economy deserves special attention. American sociologist D. Bell, in his works (*The Coming of Post-Industrial Society* and *The Age of Disunity*), identifies the key factors and causes of the transition to a new type of society. He also notes that the definition of «post-industrial society» is most appropriate for reference in studies of subsequent development (the development of civilization), since other terms characterize only one aspect or focus on a specific feature (for example, «information» society, «new type» society, etc.). The definition of «post-industrial society» emphasizes the overcoming of the industrial nature of the previous mode of production in the emerging new society.

D. Bell lists the following characteristic features of the «post-industrial society»: the paramount importance of theoretical knowledge as a source of new economic and political decisions; the transition from material production to a predominantly service sector; the creation of technological potential of an intellectual type; knowledge becomes the main value contributing to economic development and growth; decisions are made on the basis of intellectual technology, excluding the intuitive component; education and competencies become the basis of the elite (meritocracy) of the post-industrial society; the growing role of women in society (in the economy, in public administration); education becomes a key sector, one of the prerequisites for development. He argues that these constants will persist at each specific stage of the post-industrialism development. However, according to the scholar, this does not mean post-industrialism will completely replace industrial society. He draws an analogy with ancient frescoes, where new images are added layer by layer over time. Similarly, in the development of civilization, newer phenomena superimpose on previous ones, leveling out some of the characteristic features of society and shaping its unified texture [Bell, 1999].

In this context, it is necessary to voice the position of S.D. Bodrunov, which contains a critique of the views of «post-industrialists». The scholar believes that the importance of the service sector has been unjustifiably exaggerated. According to him, a significant portion of industrial production potential has been transferred to the periphery, to the so-called states of the economic South [Maslov, 2020]. He also notes the duality of post-industrialism: despite the external growth of the service sector, the knowledge-intensive nature of industrial processes that meet society's needs is maintained. Knowledge, a specific resource, increasingly predominates over material resources and is implemented not only in technology and production but also infiltrated into all areas of society as part of global digitalization processes, fundamentally altering its narratives and structure [Bodrunov, 2024].

According to a number of scholars, given the centrality of knowledge and information in post-industrialism, one of the crucial elements of political, economic, and social life is the establishment of a social structure in convergence with information and communication technologies and the intellectualization of labor. The ever-increasing volumes of data arrays require a significant enhancement in technological digital potential, with the parallel development of the corresponding supporting infrastructure to meet the ever-increasing needs of the information society.

One of the stages of high-tech development is the emergence of a digital society («Society 5.0») marked by a comprehensive digital transformation where technologies create a unique ecosystem. This ecosystem, in synergy with knowledge, generates significant emergent potential for post-industrial evolution. Digital society is often characterized by describing the corresponding supporting infrastructure that directly impacts digital technologies. Furthermore, researchers of post-industrial evolution describe the transformation of social connections, social practices, and public relations in a digital society.

In a post-industrial society, the socio-cultural aspect of consumption is changing as the development of the service and digital economy transforms the value system, especially among the younger generation. Consumption ceases to be merely a process of satisfying basic needs and becomes a creative approach to identity construction.

Post-industrial society implies a descriptive approach to examining technology infrastructure. At the same time, it is appropriate to correlate the impact of technology on changing social relationships, ties, and practices. Information has a dual function, serving both as an infrastructural and an intermediary function, collectively ensuring constructive interconnection and interaction between participants in the process, and being an essential element of a specific ecosystem. For example, N.D. Uzlov mentions that humanitarian technologies possess significant resource-intensive potential, given the multiplicity of agencies aimed at managing complex structural systems, from the individual to society as a whole. They are specific, given the nonlinear nature of the connections and interactions of the elements that shape social impact [Uzlov, 2011].

Therefore, the definition of «technology» is applicable not only to areas directly related to engineering or technical skills, but, in the context of post-industrial society and the growing value of knowledge, to any field of society. Technologies are classified into political, educational, financial, economic, managerial, social, and humanitarian categories. This classification represents the range of applications and variations of methods for systematizing activity in modern civilizational development.

The convergence of digital and humanitarian technologies is leading to the emergence of a high-tech arts and humanities, which, in addition to their positive potential, pose hidden threats to individuals and society. Thus, high-tech humanitarian technologies are potential tools for manipulating consciousness at various levels – mental and psychological. M.G. Delyagin believes that these technologies have a dual nature [Delyagin, 2000]. In addition to their primary purpose of improving communications, generating analytical, informational, and organizational capabilities, fostering a positive corporate culture and image, and so on, they have the potential for negative, destructive impacts on individuals and society as a whole.

In this regard, special attention should be paid to the consideration of socio-humanitarian technologies of influence [Podberezkin, 2019] on the individual's value-motivational component, and technologies for manipulating social groups through «soft» methods of persuasion, cultural influence, and social engineering for the covert management of behavior in the face of ever-increasing threats.

The strategic significance of socio-humanitarian technologies lies in their potential as an instrumental component, which can potentially be used not only for human resource management and monitoring and studying economic processes, as discussed above, but also for manipulation and influencing individuals and the social space as a whole, which, accordingly, implies a variety of effects in the context of influencing the dynamics of social development. In this regard, the necessity of engaging so-called high-hume technologies (high-level humanitarian technologies) in the process of influencing individual and public consciousness in today's reality lies in the fundamental transformational changes in the economy and society.

These processes are accompanied by technological changes in production chains, which, in turn, are changing the structure of the global economy, increase the share of the service sector and intensify competition in the struggle for consumers. In this context, one of the competitive advantages will potentially be the minimization of the time it takes to satisfy consumer demand, which, according to N.V. Vasilenko, will require the implementation of the following areas [Vasilenko, 2019]:

- assessment of the transformation of information into products and services from the perspective of a humanitarian approach to create an ethical and value-ideological filter necessary to prevent the potential threat of destructive changes to the existing format of society;
- gradual adaptation of the population to high-tech changes in the digital space.

Given the close relationship between the knowledge economy and technology development, we believe it is necessary to articulate the semantic content of the high-tech industry – advancements in technology – in the context of the transition from industry affiliation to the focus of infrastructural support for economic development.

Thus, McQuaid substantively delineated the concept of «high-tech advances» in his methodology for identifying the initial producers of high-tech products in the subsequent chain of utilization and capitalization of their advances. He distinguishes between innovation and technological advancement, thereby confirming the distinction between the closely related definitions of «knowledge-intensive technologies» and «high technologies» as identifications from the perspective of outcome and process.

Butchart, Breheny, and McQuaid formulated a methodological framework for conceptually differentiating high-tech industries, which represents a variation on the grouping of industry indicators (measures) based on research and development intensity, including the share (as a

percentage) of personnel engaged in research and experimentation out of the total number of personnel of an economic entity.

According to M. Cedrini and M. Fontana, the near future will see an expansion of institutional approaches in economic science [Cedrini, 2018]. This reality necessitates the adjustment of economic models to the knowledge-intensive and high-tech development of post-industrialism, amid rapidly changing, turbulent processes.

The economic impact lies in the use of accumulated knowledge through high technology. However, alongside this positive impact, it is necessary to consider the potential negative impact of knowledge and high technology on society [Lachinina, 2020]. This threat is growing in the context of geopolitical uncertainty and turbulent global processes.

Finally, keep in mind that in the current reality, the industrial and post-industrial segments of the economy continue to function in parallel, with new knowledge-intensive forms not immediately displacing industrial ones, but rather overlapping them and changing their quality. At the same time, digital transformations and high technologies are accelerating the pace of knowledge accumulation and improving personnel competencies in the face of increasingly complex goods creation processes. The most important prerequisite for the development of a knowledge economy and advanced technologies is the stability of the institutional environment, supporting its development and improvement in line with processes occurring in a turbulent environment, while maintaining the significant role of fundamental science.

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