

Review Paper

Modernization Processes Development in the Implementation of Intellectual Capital in a Crisis

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Received: 16-11-2022

Revised: 28-02-2023

Accepted: 04-03-2023

ABSTRACT

The urgency of the study was driven by the search for effective solutions for the intellectual capital activation and the modernization potential of economic systems formed by it in the economic crisis. The study aims to formalize the modernization process and transform the intelligence into the results of updating the economic system through the application of economic and mathematical modeling of the investing intellectual capital factor impact into the modernization potential. The main research methods are systems analysis, which allowed to formalize the transformation of intellectual capital into modernization potential, and correlation-regression analysis, which was used to design the enterprises' behavior modernization under the influence of intellectualization. The article constructs the economic system modernization process, which reflects the qualitative influence of the intellectual capital features on the sequence of modernization transformation of the economic system. The study has practical value for economic systems, as the proposed methodological and applied provisions, allow the use of available intellectual capital for modernization transformations provoked by global digitalization and the growing pace of innovation, limited material and energy resources in greening and increasing competition.

HIGHLIGHTS

- ① The study is driven by the search for effective solutions for activating intellectual capital and modernizing economic systems during economic crises.
- ① The aim of the study is to formalize the modernization process and transform intelligence into results by applying economic and mathematical modeling of investing intellectual capital factors.
- ① Systems analysis and correlation-regression analysis are the main research methods used to design the enterprises' behavior modernization under the influence of intellectualization.
- ① The study constructs an economic system modernization process that reflects the qualitative influence of intellectual capital features on the sequence of modernization transformation of the economic system.

Keywords: Enterprises' modernization, intellectualization, investment

In the context of the global economic crisis caused by the global pandemic, infrastructure companies, on the one hand, lost the tourist and international transportation markets (according to international organizations, only the aviation sector in 2020 lost about 40% of traffic) (Kniazieva *et al.* 2021).

On the other hand, intellectualization, accelerated

How to cite this article: Kucheruk, G., Vovk, O., Kovalenko, N., Romakh, V. and Shevchenko, V. (2023). Modernization Processes Development in the Implementation of Intellectual Capital in a Crisis. *Econ. Aff.*, 68(01): 569-581.

Source of Support: None; **Conflict of Interest:** None



development of digital and virtual communication technologies in energy and telecommunications enterprises have outlined new opportunities for market expansion or capacity building. In the described processes, the paradigm of modernization development also changes the following, so there is a necessity of reorientation from the introduction of technical updates on human-centric technologies of services rendering and virtual technologies expansion. The loss of industrial capacity and the reduction of income provoke more systems crises in the manufacturing sector, industrial production. Thus, there are economic opportunities for the dominance of the infrastructure sector in the formation of capital and investment.

At the same time, in the conditions of a pandemic the territorial limits of the person sharpens, psychological and value landmarks are activated, unique inquiries develop. It provokes the search for new methodological provisions to ensure sustainable adaptability to the behavior of consumers and staff, understanding their needs, and standardization of virtual communications. The theory of cognitive economics partially reveals the issue of anthropocentrism in economic research. The combination of cognitivism with the scientific principles of regulating innovative development in the strategic management of enterprises infrastructure sector modernization will substantiate the behavior patterns of both subjects and objects of study.

In modern challenges, the enterprises' modernization is seen as a process of updating all aspects of management and innovation and investment activities organization with the development potential activation. In this context, the main enterprises' modernization priority should be the focus on scientific and technological progress, their entry into the sustainable development trajectory through targeted basic transformations aimed at the future. Such modernization should focus on human intelligence development, the intellectual capital formation, which, in an organic relationship with the strategic goals of enterprise development, will ensure the modernization processes' effectiveness. Modern provisions of the modernization theory arose under the influence of the processes of innovation, digitalization and intellectualization, dynamism, and stochastic development. According to V.M.

Polterovich (1998) and N.A. Mamontova (2013) modern challenges have changed the basic features, transformed the world-view and value aspects of the paradigm of civilizational development, which soon will act as recommendatory, adaptive, and unstable imperatives :

- ♦ digitization and dynamism of mathematical tools improvement associated with the information technology development;
- ♦ deepening of knowledge and mass, availability of information about generally accepted theories, basic models, which in general provoke the intellectualization of both man and his professional skills;
- ♦ accumulation of large arrays of empirical data and the availability of technical tools for their analysis, generalization;
- ♦ mass information provokes superficial knowledge, which affects the quality of competencies and professionalism of staff;
- ♦ in the center of scientific research is human behavior and its interests, with technical and others, applied sciences become a tool for designing and forecasting during conditions of uncertainty and stochastic behavior of organic systems;
- ♦ a combination of scientific approaches from different scientific fields and their adaptability, synergy, which allows clarifying the human world-view dynamic transformations.

The described features of the new paradigm of economic systems modernization are manifested through the massive changes in technological systems, stages of industrialization, acceleration of economic cycles. Thus, the emergence of scientific theories of neomodernism, neo-industrialization, the preconditions for the transition to VI-VII technological systems provoke disparities in the perception and awareness of behavior norms or efficiency. Economic systems, which were formed during the industrialization or development of production technologies, today are not able to quickly activate the modernization potential and restructure the resource space to meet new challenges - consistency of economic efficiency with human-centered markets and unique quality of services. This creates new dominants, creative sectors of the economy (IT, private communications

markets, education, energy, virtual social networks, logistics companies, environmental and volunteer organizations, etc.), which concentrate capital but do not produce material products - only provide services or meet the social needs of society.

Thus, in modern conditions, along with the established concepts and imperatives of their application in the modernization theory, there is a scientific task of expanding the existing paradigm of civilizational development. The functioning of infrastructure enterprises today takes place in the context of globalization, intellectualization, and the institutional norms formation, capital growth, and modernization potential, which together ensure the effectiveness of enterprises' innovative renewal, their resource efficiency. The strategic concept of modernization processes management allows coordinating the modernization potential realization direction, investment, and innovation activity with the existing tendencies of institutional and integration influences. However, civilizational structural changes that take place in the functioning of modern economic systems at the international and national levels require the search for appropriate scientific and methodological solutions, the development of adaptive mechanisms, and reorientation to meet new economic challenges.

Education and intellectualization are given the key role in modern scientific works by scientists in substantiating the tools of the innovative development theory. For example, A. Arora and A. Gambardella (2003), A. Jaffe, J. Lerner, and S. Stern (2005) focus on research on competence building and dissemination of knowledge, modernization processes of interaction of economic entities, and mass as motivators for increasing the world national economies effectiveness. There is also an increasing role of high-tech and service spheres of the economy in the national revenue-generating factors. O.A. Dovgal (2013) argues that the development of scientific and applied research in modern manifestations determines the speed of economic development, and an important condition is the synergistic interaction of science with business and the state.

In this interpretation, modernization potential depends on the pace of innovation development. Considering the influences of institutional and scientific, and technical factors on innovative

development, O.S. Boyko (2014) argues that the modernization potential is the internal capabilities and ability of the enterprise to transform. N.O. Afendikova (2017) argues that the modernization potential is a set of elements to ensure the solution of modernization problems. That is, the authors consider the ability and direction of modernization potential, without disclosing its structure, composition, and role in the modernization process in the enterprise.

MATERIALS AND METHODS

In the process of research and formalization of methodological tools for designing modernization processes using intellectual capital, the following methods were used: analysis method - to identify trends of modernization changes under the influence of the modern transformation, determine conditions and identify determinants of modernization of infrastructure enterprises; grouping method - to describe the list of factors, systematization of dynamic quantitative indicators of enterprises' modernization; method of abstraction and formalization - to substantiate the conceptual foundations of resource support for the transformation of intelligence and resources in the modernization process; methods of correlation-regression analysis - to formalize the system of factors, their interactions on the indicators of modernization and investment of intellectual capital in modernization.

The proposed approach to economic and mathematical modeling of the intellectual capital impact on the modernization effectiveness was carried out on the basis of the infrastructure enterprises functioning statistical data. The research was conducted by scientists from the National Aviation University, National Transport University, Odessa National Maritime University, Alfred Nobel University. The study was implemented in three stages:

At the first stage, the authors formalized the theoretical basis of the study, established methodological tools, and identified methods of analysis and evaluation. The authors reveal the existing scientific approaches to the interpretation of basic concepts, design of the modernization process, management of intellectualization processes in a crisis. At this stage, the purpose, goals, and

objectives of the study, the main measures to achieve the goals are also set.

The second stage of the study was to design the processes of intellectual capital influence on the infrastructure enterprises modernization effectiveness. The conditions and factors of the modernization process in the crisis were formalized. In the processes of experimentation and analysis of trends in enterprises modernization, the system of indicators for assessing the effectiveness of investing intellectual capital in modernization processes was specified. The authors have developed correlation-regression models for analyzing the impact of activation and intellectualization of the modernization process in economic systems.

At the last stage of the study, calculations of the dynamics of integrated indicators of modernization of enterprises in the transport sector of the infrastructure sector were performed according to the author's models. The authors also clarify and generalize the theoretical and applied aspects of designing the modernization process under the intellectualization influence.

RESULTS AND DISCUSSION

In the pandemic conditions and the subsequent economic crisis, the following economic problems are inherent in the Ukrainian economic system:

- ♦ absence of acceptable and affordable sources and forms of investing intellectual capital in the enterprises' modernization;
- ♦ the long-term orientation of the national economy to the development of industry has provoked a structural and production crisis regarding the need for mass renewal of obsolete equipment, raising quality and safety standards, competitive positions. In addition, in the context of world markets globalization and reorientation to provide services, meet the demands of man as the main consumer, there is a problem of overproduction and further losses.
- ♦ the spread of information and digital communications provokes superficiality in human perception of the world around us, most purchases are made using the technology of the "Internet of Things", through the mental or individual perception of human value. In these conditions, transport and logistics, and

information services make up most of the value of the purchased goods, which ultimately affects their dominant position in the structure of national economies' income.

- ♦ insufficient institutional support at the national and regional level provokes spontaneity both in the use of intellectual capital and in the enterprises' modernization;
- ♦ low level of education quality at the national mass provokes low motivation of the personnel to increase of competencies, professional training during work, an increase of professional skills;
- ♦ maintaining the focus in the production of goods on energy and resource consumption, low institutional support for energy-saving technologies;
- ♦ focus on the modernization of technologies on foreign economic trends and the formation of external demand for them, which increases the cost of modernization, reduces the pace of innovation development and their competitiveness;
- ♦ the availability of cheap labor maintains the tendency of no need for technological improvement, staff intellectualization, production of high-tech and competitive products;
- ♦ preservation of raw materials and the industrial nature of the national economy provokes a decrease in the international competitiveness of domestic enterprises.

The solution to these problems is possible with a thorough reform of the national economy and reorientation to intellectual capital development. In the context of integrated globalization and the openness of global technologies and resources to innovation, Ukrainian enterprises can be competitive in areas of intellectual orientation that do not require large investments (Vrontis *et al.* 2021). Infrastructure enterprises in such challenges occupy an intermediate position as their development and modernization depend on the intensification of human intellectualization and innovative economic development. In the realities of the Ukrainian economy determining the vector of modernization of infrastructure enterprises are

the following patterns in the implementation of intellectual capital:

- ♦ fragmentation of national economy technological structuring, caused by the uneven distribution of state investment support and private capital: the priority of industry (due to the disproportion of regional location in the industrialization of the Soviet economic system, Ukrainian territories were allocated to high optimization), military production, electricity, IT;
- ♦ social disparities between incomes in the public, private sectors, individual industries, which together provoke low purchasing power and labor migration of qualified personnel. For example, in the early 2000 XX century in the water transport sector, due to crisis downtime and lack of technical modernization, only 5,000 employees remained, specific skills and professional competencies of staff were lost (Guliyeva *et al.* 2018);
- ♦ reform of the public sector of the economy and the system of education and science in recent years depends on external financing, while the international competitiveness of domestic products is mostly low and does not provide inflows of financial capital into the domestic economy;
- ♦ introduction of electronic institutional regulation and permitting reduces the level of corruption in the economy, but high tax rates hinder the development of small business, which negatively affects the scale of infrastructure enterprises;
- ♦ regional-territorial reform, on the one hand, provokes uneven distribution of national capital, labor, and technology, and on the other - promotes intensification of modernization processes and motivation of territorial economic entities to attract capital, modernize infrastructure to develop communication with foreign markets.

Any sphere of enterprise activity under the influence of modernization undergoes both positive and negative changes, the coherence of which occurs in the processes of satisfying modernization needs (Polishchuk *et al.* 2019). Thus, the conditions for the modernization of enterprises are the demands of society and individual enterprises for the

transformation of resources into intellectual capital, as well as the presence of economic catalysts to accelerate these processes. In this context, the main motivators for the modernization of infrastructure enterprises should be the focus on the transformation of intelligence into capitalized intellectual potential. Catalysts are seen as functions to stimulate and accelerate the modernization and conversion of intellectual resources into potential, while they must remain unchanged and resistant to the backlash of the enterprise, i.e., maintain the principles of impartiality and equality for all enterprises in the infrastructure sector. Therefore, we describe the main motivators of modernization of the enterprise, which will reveal the characteristics of determining the innovative development of the modernization potential implementation effectiveness for the main purposes:

- ♦ First: increasing the resource efficiency of modernization;
- ♦ Second: digitalization of business processes;
- ♦ Third: intellectualization of personnel and technical systems;
- ♦ Fourth: improvement of processes and technologies of production of quality products;
- ♦ Fifth: technical and technological update;
- ♦ Sixth: increasing competitiveness.

The transformation of intelligence into a capitalized potential will ensure the stability of the innovative development trajectory through a purposeful modernization process: technical and technological and logistical improvement with a focus on future technologies. In modern challenges of changing the paradigm of economic development and accelerating cyclicity, the intellectualization of infrastructure enterprises determines the direction and structural adjustment of the economic space (Štefko *et al.* 2021). The current characteristics of infrastructure enterprises' modernization are flexibility and adaptability, dynamism and multicomponent, synergy, and stochasticity (Britchenko & Saienko, 2017). Intellectualization and digitalization, liberalization of markets, and publicity of activities, as mass trends in the development of infrastructure, require the formalization of methodological support and standardization of behavioral scenarios.

According to the study, we should note that the economic systems modernization potential is comparable and determined by the intellectual capital of the enterprise. Therefore, the availability and direction of modernization potential depends on the growth of knowledge, intangible and intellectual assets, corresponds to the processes of their transformation into intellectual capital and the implementation of the main functions of the innovation process. At the same time, the implementation of strategic goals of efficiency and competitiveness of renewal and transformation of the enterprise should be ensured. Consider in more detail the relationship between intellectual capital and modernization potential in the process of transforming resources into modernization opportunities (Fig. 1).

The quality and structure, availability, and acceptability of intellectual capital for the company form the modernization effectiveness through phases: “resource supply” - “intellectualization” - “capitalization” - “modernization potential” -

“modernization” (Vovk, 2020). In this process, the modernization potential of enterprises is seen as a set of resources and means (opportunities) to activate them in the modernization process with subsequent innovative renewal of assets, technical support, service technologies, and enterprise systems management, which in the synergy of effects forms the effectiveness of economic development. Transformational change of resources into modernization potential is carried out under the influence of modern demands and accents to ensure the competitiveness of new products, the widespread use of digital management and communication technologies, human-centered in internal and external economic priorities. This provokes new challenges and imbalances, the timely identification and coordination of which requires constant training and skills acquisition in both staff and technical management systems.

The process of conversion of resources and intelligence in the internal environment is parallel to the process of intellectualization and innovative

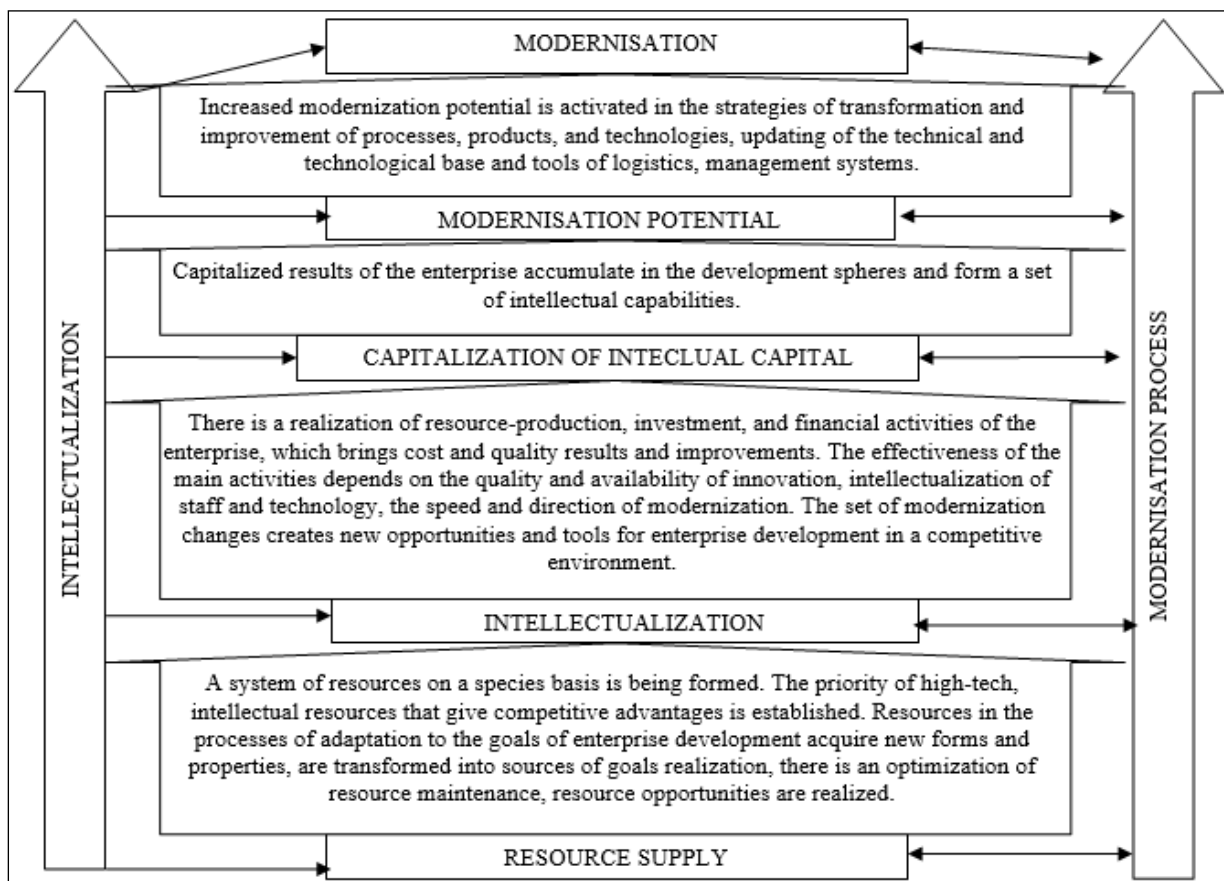


Fig. 1: Processes of resource support and transformation of intellectual capital during the modernization goals implementation at the enterprise

enterprise adaptation, which depends on the influences of the external environment. It should be noted that the level of subjects intellectualization of the external infrastructure sector environment creates conditions for the modernization of infrastructure enterprises through the tools of institutional regulation:

- ♦ focus and scale of institutional and innovation support,
- ♦ educational and scientific support and development of the knowledge economy,
- ♦ financing and fiscal incentives,
- ♦ integration with international investment funds and the formation of conditions for attracting investors;
- ♦ focus on preventive strategic programming of national or territorial competitive advantages in the field of intellectual development;
- ♦ accumulation of intellectual capital, provoked by requests for global modernization of infrastructure - roads, bridges, pipelines, data networks.
- ♦ security control over sectors of strategic importance and the status of “critical infrastructure” (energy, rail transport, communications), which requires monitoring of innovative developments and their corresponding modernization.

In these conditions, the set is attributed to the main areas of intellectual support of the modernization process:

- ♦ increasing the quality of competencies and knowledge, which affects the growth of the high-tech production share in structural economies, competitiveness in international markets, increasing the population welfare;
- ♦ integration of intellectual capital and global dissemination of innovative knowledge contributes to increasing competition between enterprises and market liberalization, which optimizes the modernization of enterprises following consumer demands;
- ♦ promotes changes and structural transformations of industries, territorial economic systems with priority to search for new ways, mechanisms of innovative development;

- ♦ formation of qualitative characteristics of development processes based on basic research and relevant innovations in the institutional, socio-cultural, political, infrastructural, production spheres of the economy;
- ♦ structural changes that correspond to the rethinking of social values, worldview priorities, and economic interests;
- ♦ institutional changes that involve the mobilization of innovative resources and the transformation of the financial, economic, political, cultural sphere of society.

These areas of intellectualization are complex tools for the modernization of economic systems. In developmental theories, in fact, large-scale modernization is provoked by the emergence of fundamentally new technologies and knowledge of their application, which, as a rule, relate to the means or technologies of production. The transition of key innovations and knowledge to the level of diffusion application and adaptation of economic systems to their everyday use determines the duration of the economic cycle, the transformation of the regulatory and institutional, and the market environment (Alvino *et al.* 2021). The effectiveness of the implementation of each stage of the intellectual development of innovations and their dissemination provokes requests for new tools and technologies, which leads to the emergence of innovations. At the same time, the orientation, scope, and properties of acceptability of innovations were formed in the previous stages.

Applying economic-mathematical modeling based on correlation-regression analysis, we determine the nature and significance of the impacts on the modernization of the infrastructure sphere transport sector. The significance of these indicators' influence is determined by using the matrix of tightness and the exclusion of indicators interchangeability (X) from the integral equation that affects the dependent variable (Y). The influence of indicators (X) on the indicator “dynamics of intellectual capital investment in the modernization of transport enterprises” (U) was calculated using regression analysis. The set of indicators included the dynamics of the time change:

- ♦ freight turnover (X1);
- ♦ passenger turnover (X2);

- ♦ cost of fixed assets (X3);
- ♦ pre-tax performance of transport sector enterprises (X4);
- ♦ the level of depreciation of fixed assets (X5);
- ♦ number of employees at transport enterprises (X6);
- ♦ import-export operations for the provision of transport services (X7);
- ♦ costs of innovative research in the sector (X8);
- ♦ GDP in final consumption prices (X9);
- ♦ price index for transport products (X10).

- ♦ from 1 to 0.91 - excessive and dominant influence;
- ♦ from 0.9 to 0.71 - strong influence;
- ♦ from 0.7 to 0.51 - moderately strong impact;
- ♦ from 0.5 to 0.31 - weak impact;
- ♦ from 0.3 to 0 - insufficient impact.

The calculations showed a strong influence of the coefficients X6 (0.99), X10 (0.77) and X3 (0.6), while (X3) has an inversely proportional nature of the effects (Table 1-2).

Thus, the volume of intellectual capital investment in the enterprises' modernization in the infrastructure sector depends on the innovation and competence of staff, the dynamics of enterprise income, as well as the state of fixed assets. In addition, the proposed system of indicators has mutually exclusive parameters that are excessively complementary: the obtained values of indicators X1 and X2 (freight

To establish the strength of the indicators interaction and their integrated interaction in the formation of the resulting value of investment activity of enterprises of the transport complex used the Cheddock scale, which reflects the strength of the relationship of the resulting indicator with determinants based on the following values:

Table 1: Coefficients of indicators change influencing dynamics of investment of the intellectual capital in modernization of the transport enterprises

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
2011	0.96	1.06	1.03	1.21	0.16	1.002	0.98	1.16	1.05	1.2	1.17
2012	0.82	0.92	0.98	1.22	-23.6	1.001	0.9	0.83	1.1	1.08	1.08
2013	1.2	0.96	0.96	1.15	0.7	1.01	0.905	0.85	1.08	1.043	1.02
2014	1.34	0.89	0.88	1.52	-0.92	0.53	0.99	1.22	0.92	1.044	1.26
2015	10.86	0.94	0.91	0.78	2	1.16	12.22	0.95	1.16	1.25	1.36
2016	1.31	1.02	1.05	1.07	1.25	0.96	0.97	0.9	1.05	1.19	1.06
2017	1.24	1.05	0.97	0.94	0.79	0.94	0.97	1.2	1.16	1.25	1.14
2018	1.29	0.99	1.05	1.24	1.37	1.09	0.99	1.2	1.25	1.19	1.04
2019	1.07	0.98	1.02	0.99	0.63	0.93	0.97	1.1	1.02	1.11	1.05

Table 2: The value of the correlation coefficient of investment indicators of intellectual capital in the enterprises' modernization

	Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y	1.000										
X1	-0.252	1.000									
X2	-0.463	0.682	1.000								
X3	-0.602	-0.358	-0.107	1.000							
X4	0.220	0.402	0.052	-0.247	1.000						
X5	0.411	0.374	0.449	-0.692	-0.002	1.000					
X6	0.999	-0.250	-0.454	-0.607	0.188	0.426	1.000				
X7	-0.202	0.276	0.002	0.277	0.455	-0.406	-0.214	1.000			
X8	0.284	0.313	0.332	-0.475	0.030	0.794	0.284	-0.029	1.000		
X9	0.454	0.650	0.280	-0.655	0.380	0.546	0.453	0.255	0.602	1.000	
X10	0.751	-0.292	-0.711	-0.152	0.162	-0.156	0.750	0.209	-0.140	0.319	1.000

and passenger turnover, respectively) correlate with the indicator X10 (price dynamics). In this way, the significance of the relationship between the resulting indicator and the determining indicators is consistent. To establish the functional impact of the proposed indicators on the integrated value of modernization activity, we will conduct a regression analysis to determine the nature of the impacts (Table 3-4).

The determined significance of the indicators allowed to formulate an integrated indicator of infrastructure sphere transport enterprises modernization activity and the scale of the national economy, based on the economic and mathematical design of linear regression, in which the basic values $b_0 = 0.338$; $b_1 = 0$; $b_2 = 0.897$; $b_3 = 0.02$; $b_4 = 0.019$; $b_5 = -1.855$; $b_6 = 0.873$; $b_7 = -0.940$; $b_8 = 2.3953$; $b_9 = -0.068$; $b_{10} = 0$:

$$I_{ma} = -0.338 + 0.897 X2 + 0.02X3 + 0.019X4 - 1.855X5 + 0.873 X6 - 0.940X7 + 2.3953X8 - 0.068X9 \dots(1)$$

where I_{ma} – integrated indicator of infrastructure sphere transport enterprises modernization activity. We also propose to single out the integrated indicator of infrastructure sphere transport enterprises modernization activity. For the analysis of which the results of correlation analysis were used, and in the regression model the indicators describing a technical condition and conditions of the technological armament of the enterprises are applied. The values were obtained according to the regression model as follows: $b_0 = 0.2623$, $b_1 = 0.12622$, $b_2 = 0.8626$, $b_3 = -0.8626$, $b_6 = -0.0789$:

$$I_{ma} = 0,2623 + 0,12622 X3 + 0,86826 X6 - 0,07892 X10 \dots(2)$$

The calculations of modernization activity of transport enterprises in the infrastructure sphere showed that with the growth of revenues and prices, as well as the number of staff, the modernization activity of transport enterprises in the infrastructure sphere also increases (Table 5).

Table 3: The results of a linear regression analysis of the modernization activities intensification of transport sector enterprises

Indicators of regression statistics of the model					
Numerous R	1				
R - square	1				
Normative R - square	65535				
Standard error	0				
Observation	9				
The results of dispersive analysis					
Indicators	df	SS	MS	Significance F	
Regression	10	83.98656	8.398656		
Surplus	0	0	65535		
Total	10	83.98656			
	Coefficients	Standard error	t - statistics	Low 95%	High 95%
Y-variable	-0.33803	0	65535	-0.33803483	-0.338034828
X1	0	0	65535	0	0
X2	0.897584	0	65535	0.897584246	0.897584246
X3	0.026703	0	65535	0.026703306	0.026703306
X4	0.019602	0	65535	0.019601691	0.019601691
X5	-1.85563	0	65535	-1.85563128	-1.855631278
X6	0.873557	0	65535	0.873557454	0.873557454
X7	-0.94051	0	65535	-0.94050825	-0.940508253
X8	2.395108	0	65535	2.39510814	2.39510814
X9	-0.06878	0	65535	-0.06878496	-0.068784961
X10	0	0	65535	0	0

Table 4: The results of linear regression analysis of the modernization process intellectualization of infrastructure sphere transport sector enterprises

Indicators of regression statistics of the model						
Numerous R	0.998783					
R - square	0.997567					
Normative R – square	0.996107					
Standard error	0.202167					
Observation	9					
The results of dispersive analysis						
Indicators	df	SS	MS	Significance F	Indicators	
Regression	3	83.7822	27.9274	683.299	5.94432E-07	
Surplus	5	0.204357	0.040871			
Total	8	83.98656				
	Coefficients	Standard error	t - statistics	P-value	Low 95%	High 95%
Y-змінна	0.260226	1.024769	0.253936	0.809657	-2.37402	2.89448
X 1	0.126219	0.519319	0.243048	0.817624	-1.2087331	1.461172
X 2	0.868262	0.043908	19.77449	6.11E-06	0.755392255	0.981131
X 3	-0.07892	1.153668	-0.06841	0.94811	-3.044521	2.886674

Table 5: The results of calculating the dynamics of integrated indicator of infrastructure sphere transport enterprises modernization activity

Years	Integral indicator of modernization intensification	Integral indicator of the intellectualization of the modernization process
2011	0.95034	1.1661
2012	0.82471	1.1048
2013	1.190826	1.1049
2014	1.327928	1.2056
2015	10.8133	10.7676
2016	1.30013	1.1484
2018	1.27871	1.1874
2019	1.06129	1.1395

Thus, both the activity of modernization and the intellectualization of the modernization process significantly accelerated (in both cases 10 times) in 2015. The main factor in this change was the launch of government programs for the construction and modernization of transport infrastructure, as well as the organizational restructuring of the railway transport management system by merging into a consolidated company. Thus, in the scale of the domestic economy there was an increase in investment and job creation (Table 1). Given the identified statistical trends and factors to ensure the effectiveness of modernization, we offer the following areas of intensification of modernization activity of enterprises in the infrastructure sector:

- ♦ attracting resources and external and internal sources to invest in innovative developments and increase staff competencies;
- ♦ liberalization of the transport services market in order to stimulate demand for services and create favorable conditions for cargo owners, passengers (Yaroshenko *et al.* 2018);
- ♦ acceleration of transportation and ensuring the speed of cargo and passengers service;
- ♦ development of the market of innovative technologies not only in the information communications sector, but also in information support of transport enterprises management, incl. combination of sectors for the provision of related services;

- ♦ creating conditions for increasing the welfare of the population and accelerating the turnover of capital in production, which will positively affect the growth of profits, and thus form the modernization potential;
- ♦ institutional support to be implemented in tax policy, consistency of investment interests between business owners and credit opportunities to attract investment, simplification of customs and logistics procedures;
- ♦ further implementation of European and international standards with increasing the competitiveness of domestic enterprises and their integration into international transport corridors;
- ♦ increasing activity in the markets of investment capital and the formation of innovation and investment attractiveness of transport enterprises;
- ♦ ensuring the stability of industrial production and consumption of industrial products, with the use of motivators for the development of domestic producers, energy conservation and environmental protection.

The development of intellectual capital, innovation, industry, and infrastructure components allows us to assert the existing potential for infrastructure sector modernization, which will ensure the optimal level of its use in the future and increase economic development, promote in-depth cooperation with our partners. Infrastructure enterprises' modernization management takes place in the latest transformations and dynamics of restructuring of economic technologies, structural space, and sectoral economic systems under the influence of global trade and political confrontations, pandemics, and accelerated, chaotic, digitalization of life and human relations. Not only the worldview of a person change, but also the awareness of his role, significance, and prospects of personal realization. In times of open opportunities and freedom of movement, totality, and accessibility of educational prospects, minimization of time of information dissemination and its processing a person cannot realize his professional skills, comprehend the value of the received information, ensure the quality of life, get a job accordingly. Such tendencies are

provoked not only by the period of the global pandemic but also by the reorganization of the civilizational paradigm of development.

After all, economic dominance is changing: industrial industrialism, consumption of resources, and ensuring commercial efficiency are losing value in the modern world. Priorities in development processes are personalized services, communication and infrastructure technologies, social responsibility and environmental friendliness, as well as the knowledge economy and intelligence, as a new factor in capital formation. Intellectual and innovative activity is considered by many scientists. In particular, the attention of scientists to the determinism of innovation and intellectualization in the development of the regional economy is emphasized (Butko *et al.* 2020; Tulchynskyy, 2018; etc.). Modernization processes have become the object of analysis of economic systems in terms of eliminating technological wear and tear and renewal (Tulchynska, 2014). However, these scientists have not identified the role and importance of intellectual capital in modernization processes. Thus, during the crisis, infrastructure companies realize the accumulated potential not only for technological renewal but also for finding management mechanisms for modernization, the implementation of staff intelligence in crisis management.

Note that the study allows us to conclude that our country has developed an information and analytical framework to ensure the modernization of infrastructure in the context of stimulating the intellectualization of enterprises. The basis of this toolkit is international, national, and regional statistical observations which include indicators of education and staff competencies, innovation activity of enterprises (Kucheruk *et al.*, 2020). However, due to ambiguity and inconsistency of methodology, inconsistency of different systems, absence of common standards for collecting and disclosing information, tools, and methods for monitoring domestic stakeholders' requests for intellectual innovation solutions, assessing and forecasting the impact of intellectual capital on the country's economy need to be improved.

CONCLUSION

The study allowed to formalize the processes of

modernization of economic systems taking into account the role and impact of intellectual capital. It is established that the transformation of resources in the process of modernization requires intellectual support and capitalization of assets. This allows you to maximize the cost and competitiveness of the enterprise. It is established that the amount of intellectual capital investment in the infrastructure sector enterprises modernization processes depends on the innovation and competence of staff, the dynamics of income of enterprises, as well as the state of fixed assets.

Applying economic and mathematical modeling, the integrated indicators of modernization activity and intellectualization of the infrastructure sphere transport enterprises modernization process were formalized. The analysis of the proposed indicators showed that both the activity of modernization and the intellectualization of the modernization process significantly accelerated (in both cases 10 times) in 2015. The main factor in this change was the launch of government programs for the construction and modernization of transport infrastructure, as well as the organizational restructuring of the railway transport management system by merging into a consolidated company. In the context of the crisis provoked by the global pandemic, the implementation of intellectual capital in the process of modernization should be aimed at finding management mechanisms for modernization, the implementation of staff intelligence in solving crisis problems.

Further research should be aimed at building integrated management systems for intellectual capital in the process of economic systems modernization. This will minimize the cost of other economic resources and ensure energy savings and increase the intelligence use effectiveness. Also in the processes of analysis of the intellectual capital effects on the infrastructure sector enterprises' modernization effectiveness, the lack of analytical standards and processes was revealed. Therefore, in the future it is necessary to formalize the proposed methodological approach to assessing the factor impact of intellectualization on the enterprises' modernization. Further modernization under such conditions will be strategic and accelerate development processes.

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