

Estimation of interrelation of components of human capital and level of digitalization of industrial enterprises by method of modeling of structural equations

Kelchevskaya N.R.
Ural Federal University Named After the First President of
Russia B.N. Yeltsin
Yekaterinburg, Russia
n.r.kelchevskaya@urfu.ru

Shirinkina E.V.
Surgut State University
Surgut, Russia
shirinkina86@yandex.ru

Strih N.I.
Surgut State University
Surgut, Russia
strihn@yandex.ru

Abstract — The relevance of the study is due to the fact that today the use of digital technologies is perceived by the top management of many Russian companies still as a purely technological task, while the meaning of the happening digitalization is that Not so much technology, but the system of human capital Management and the organization of the company's activities change. The authors evaluated the impact of individual components of human capital on the digital and overall performance of industrial companies by modeling structural equations. The research focuses on such theoretical structures as digital culture, human capital management practices, and the digital knowledge of employees. The hypothesis of research is advanced and confirmed. The empirical basis was given by survey data of 75 enterprises.

Keywords — *human capital, digital economics, empirical analysis, structural equation method*

I. INTRODUCTION

Today, the use of digital technologies is perceived by the top management of many Russian companies as a purely technological task. While the meaning of the happening digitalization is that not so much technology changes, but the system of human capital Management and organization of the company's activity. Increasing the level of digitization becomes not only the task of specially designated IT professionals, but all employees of the company, starting with the general director, and ending with ordinary performers and workers. Without understanding the systemic changes taking place, it will be very difficult for Russian companies to withstand competition in current and future markets.

In this study the empirical analysis is carried out by the method of structural equations, the purpose of which is to advance the main hypothesis of the study-how the introduction of the strategy of human capital management affects the level of digitalization and The overall impact of industrial companies. It is obvious that in planning an effective strategy

of human capital Management in the conditions of digitalization of business processes it is necessary to integrate structural and social components, but the question of empirical evaluation is still relevant The impact of such components of human capital, such as the culture of digitization, the practice of human capital Management strategy, the accumulated knowledge of digital technology on the digital and overall performance of industrial companies.

Digitization is a factor in the competitiveness of enterprises, making it possible to reduce costs by up to 25%, so in international competition industry companies need to actively implement digital technologies and, as a result, New approaches in the management of human capital from the standpoint of the development of organizational digital culture and digital knowledge. Therefore, the first hypothesis for further empirical analysis is the assertion:

H1: The level of digitalization of the company has a significant relationship with the overall organizational digital culture, expressed through increased sales, reduced resource and labor intensity, the emergence of new consumers, the emergence of new products, services and opportunities.

Organizational digital culture. Organizational digital culture includes values such as novelty and digital innovation, as well as digital technologies aimed at increasing economic efficiency. Each of its elements has a strategic basis, whereas the very concept of organizational culture is the subject of a separate study. This study is important for its projection on the strategy of human capital Management. Research of elements of organizational culture in management of human capital was engaged Schulze and others. (2015), which highlight such elements as training, motivation and internal communication [1]. In order to formulate a special element of the general organizational culture relating to the principles of human capital Management, we use the term "digital culture", which

understands the intrinsic values and expectations shared by employees and aimed at the development and practical implementation of digitization for the systemic achievement of the overall performance of the company. In general, digital culture is formed by the internal goals of human capital Management and based on the principles of management at all levels. The specificity of business processes and organizational culture in enterprises with low level of digitalization is manifested in outdated processes and regulations, too rigid requirements to infrastructure, use of outdated management methods and systems Transmission of information [2]. The task of the top management is to transform the organizational culture towards increased flexibility, transparency of objectives and digitization. Digital organizational culture includes: 1. Interaction through digital technology. Interact through different digital technologies and identify appropriate digital communication tools in context. 2. Exchange through digital technology. Share data, information, and digital content with others through appropriate digital technologies. Act as an exchange mediator. 3. Civic participation through digital technology. Participate in the life of society through the use of public and private digital services. 4. Cooperation with the use of digital technologies. Use digital tools and technologies to work together and share resources and knowledge. 5. Online Etiquette. To know the rules and norms of behavior in the process of using digital technologies and communication in digital environments. Adapt communication strategies to a specific audience. Understand and take into account cultural and generational diversity in the digital environment. 6. Manage your digital identity. Create and manage one or more digital identities. Be able to protect your reputation. Consequently, the following hypothesis for verification is worded as follows:

H2: There is a significant correlation between digital culture and production efficiency.

H3: There is a significant correlation between digital culture and overall organizational performance.

Human resources management practices include the whole range of applied Technologies of planning, organization, control and motivation of employees for the purpose of efficient work of the enterprise, which are realized on a systemic basis [3].

The problems of mastering the digitization of the enterprise mark the lack of readiness of the personnel: their "technological incompetence" and "lack of involvement and interest". Somewhat surprising is the fact that the "newcomers" (early stage of digital development) are less likely to face most of the problems listed. Probably, the smaller difficulties of the companies, which are at the initial stage of their digital development, are connected with the fact that the projects implemented at this stage can be relatively simple: it is unlikely that the "beginner" will take the implementation Technologically complex projects.

The main problems of "newcomers" are related to the lack of experience in project implementation (57%) And a shortage of qualified managers (49%). Empirical work suggests different degrees of influence of human capital management practices on the level of digitalization of the industry. For

example, foreign scientists Li L., Su F., Zhang V, Mao Li L., Su F., Zhang W., Mao J. On the example of medium and small businesses do not find a meaningful relationship between the strategy of human resources management and digital strategy, as well as the level of digitization, however, emphasize the creation of a business team new Thinking and organizational culture [4]. Thus, the following hypotheses are formulated:

H4: There is a significant correlation between the practices of human capital management and the level of digitization of production.

H5: There is a significant correlation between the practices of digital human capital management and overall organizational performance.

Digital human capital management tools that integrate social components such as the concept of digital culture and human capital management practices, as well as structural components presented as Organizational and managerial approaches to the management of new digital knowledge and to the issues of known boundaries and having some contribution to the company's effectiveness.

Hecklau, F., Galeitzke, M., Flachs, S., Kohl, H. Claim: «... New strategic approaches to integrated human resource management are needed to cope with the knowledge and competence issues associated with new digital technologies and industrial processes in manufacturing companies» [5], but, research is conducted only in the context of a strategic approach to staff development. Benesova, A., Tupa, J. Argue that leadership, training and exceptional abilities are key factors in stimulating the digital engagement of staff [6]. According to the authors, companies that are intensively supporting the training of employees and students as future professionals, practice a consistent policy in the field of digital research. Colbert A., Yee N., George G. [7], analyzing the gap between the needs of the industry in the field of digitization and existing technologies, determine the key directions of digital literacy development. As noted, digital fluency is defined by the knowledge and skills that are required for the safe and efficient use of digital technologies and Internet resources. Digital literacy is based on digital competence (digital competencies) — the ability to address diverse challenges in the use of information and communication technologies (ICTs): To use and create content using digital Technologies, including search and exchange of information, answers to questions, interaction with other people and computer programming.

It is worth mentioning the shifting emphasis on the development of composite, integrated skills of cooperation and communication in the digital environment as opposed to narrowly understood computer literacy. It is important to consider digital skills that encompass ICT technical knowledge in close connection with soft skills and general knowledge.

For example, this approach is vividly illustrated by the "Target Competency Model 2025" prepared by BCG on the basis of consensus-opinion of experts and analysis of approaches of the Library of competences of Lominger, Sberbank, RosExpert/Korn Ferry, HSE, WorldSkills Russia and Global Education Futures. In addition to the purely

technical skills of working with digital devices, this model includes cognitive and socio-behavioural competencies aimed at ensuring a comfortable existence, effective communication and self-development of the person in Digital environment. On the basis of these competences it is possible to allocate the basic directions for development: 1) digital skills and knowledge. For example, basic digital literacy, data analytics, machine learning, artificial intelligence, programming, IT systems architecture, cyber security; 2) skills and knowledge that help to cope with the volatility and uncertainty of the future. For example, adaptability, critical and systemic thinking, ability to cope with stress, change management, business planning, ability to self-learning in accordance with the concept of "lifelong learning"; 3) skills and knowledge, which help to cope with a large flow of information, including basic skills of programming, search, processing and analysis of information, information hygiene, media literacy, as well as management of attention; 4) skills and knowledge that define high communication abilities for effective interpersonal interaction. For example, ability to work in a team, cooperation, self-presentation skills, business negotiation skills; 5) skills and knowledge that cannot be mastered by the machine. For example, empathy and emotional intelligence, creativity and non-standard thinking, management of robotic processes.

The need for mass retraining of the released workforce is evidenced by Sirkin H., Zinser M., Rose J. [8]. This is primarily about the development of digital knowledge skills that allow employees to adapt to the changed working processes and requirements of employers. On the basis of the examined researches we formulate the following hypothesis for checking:

H6: There is a significant correlation between digital knowledge and the level of digitalization of business processes.

The general model for empirical analysis of the hypothesis is shown in Figure 1.

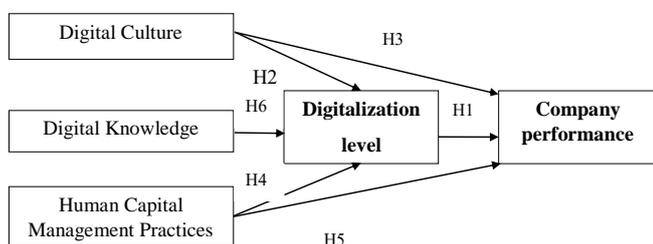


Fig.1. Theoretical model of interrelation of digital culture, practices of management of human capital, knowledge about digital technologies, level of digitization and efficiency of companies.

II. DATA COLLECTION AND RESEARCH METHODOLOGY

For the purpose of carrying out empirical analysis on the test of formulated hypotheses the method of modeling of structural equations (ISU) which is an effective method of quantitative investigation of implicit theoretical constructions in Modern social studies when checking the conformity of theoretical models of existing practice in general. The method

of modeling structural equations is a synthesis of such methods as the confirmation factor analysis and regression, allowing to conduct research in a different direction [9]. Often in modern management studies are used methods of IAS for the purpose of checking the alleged hypotheses, as well as to assess the reliability of the presented theoretical design.

The popularity of the concept of the MCM method in foreign studies in management is explained by its ability to take into account misreporting or latent variables. The ISU is based on a system of equations consisting of several parts, and the observable or explicit variables are represented by a certain numerical expression measured directly.

The structural component reflects the relationship between the implicit variables in the simultaneous system of equations and thus the measurement component in the form of an equation evaluates the contribution of each explicit variable to an implicit variable (Figure 2).

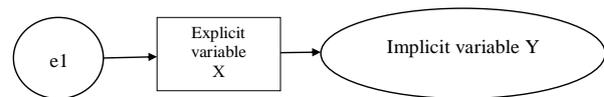


Fig. 2. The path diagram of the relationships between the explicit and implicit variables and the structure. Source: Compiled by the author on [10].

The IAS method consists of the following stages: The first stage uses the confirmation Factor analysis ("confirmatory"-confirming). This analysis allows to confirm whether theoretical representations really correspond to empirical data.

This study uses the traditional method of the main component to identify the factor load levels of each observable variable. When discussing the method's scientific methods, we will note the following. An important task of the IAS method in management studies is to reflect the degree of conformity of internal representations and expectations of respondents with a theoretical priori design, which is a variable of internal and external management environment Company. Basing on subjective estimations of respondents, this method allows to estimate degree of such conformity and suitability for further analysis of theoretical representations. Partly this method from this position is similar to the method of expert estimations, except that at acknowledgement of validity of the structure the most important-expert, and all opinions are used. This, in turn, avoids the problem of selectivity of the survey inherent in the expert method, which often cannot be confirmed.

The variables to simulate. Questions on organizational culture, digital culture and learning practices have been adapted from a study by scientists at the Higher School of Economics [11].

Data collection. Data collection was carried out as a result of the survey of enterprises, 75 enterprises were interviewed. Several methods of information gathering were used: online poll, telephone and personal interview. Telephone and personal interviews were conducted jointly with the Center for sociological and marketing research. The online poll was held on a semi-formalized questionnaire.

To determine the volume of representative sample, the following parameters are accepted with a confidence probability-95%; Confidence interval or error-5%; Volume of the general population-3183 respondents. For the estimated volume of sample taken 1500 people, from 75 enterprises formed and distributed 20 questionnaires. During the initial stage of the statistical study 330 questionnaires were incomplete and thus invalid, in the end, validity is 78%, which is a good result, because in similar foreign surveys The level of "return" is about 45% the application provides encoding of data questionnaires.

III. THE RESULTS OF THE STUDY AND THEIR DISCUSSION

In the first stage to study the structure of the relationship of variables in the simulation, a factor analysis to determine the size of the factorial loads of each variable.

The factor loads represented in the component matrix are interpreted by absolute value, the higher the load, the more the variable correlates with the factor, and the greater the variable is due to this factor. The main component method allows you to determine how many factors to take as their number is unknown beforehand. In factor analysis The important concept is the generality – it is a part of variance of variables, explained by the main components, i.e. factors, and is calculated by sum of squares of loads on a line. For this purpose we use rotation at factor analysis, the given rotation is necessary to define the maximum value of the variable on one factor and the smallest-on other factor, because it is important, that one and also variable did not load other factors, it must load only one factor. Thus, we use the rotation of VariMAX with the normalization of Kaiser.

TABLE 1. ROTATED MATRIX COMPONENTS

	Component				
	1	2	3	4	5
DIGIT_TECH_13	,946				
DIG_TEHC_7	,946				
HUM_CAPIT_15	,946				
DIG_CULT_8		,928			
DIGITAL_CULT_18		,897			
DIG_TEHCN_12	,515	,807			
HUM_CAP_9	,515	,798			
PERF_10			,996		
PER_19			,996		
DIG_KNOW_16				,875	
DIG_KNOW_14		,502		,640	
HUM_CAPITAL_17	,438			,568	
PERFE_11					,971

Factor selection Method: The main component method.
 Method of rotation: VariMAX with the normalization of Kaiser.
 a. Rotation has been over 7 iterations.

The inverted matrix allows to define, which variables load each factor, thus the load is considered normal from 0.4. The obtained results allow to interpret as follows: The first factor is loaded with all variables except PERF_10 and DIGITAL_CULT_18.

Indicators of the adequacy of the sampling of Kaiser-Meyer-Olkina (KMO) and the Alfa Kronbach criterion indicate the adequacy of the results of the factorial analysis.

TABLE 2. RESULTS OF FACTOR ANALYSIS. COMPILED BY THE AUTHOR

Factor	Variable code	Average value	Standard deviation	Number of observations N	Alpha Cronbach
Digital Culture	DIG_CULT_8	9,23	1,718	1170	0,753
	DIGITAL_CULT_18	4,20	2,200	1170	0,769
Digital Knowledge	DIG_KNOW_14	4,47	1,660	1170	0,775
	DIGIT_KNOW_16	7,85	5,720	1170	0,827
Human Capital Management Practices	HUM_CAP_9	4,26	1,376	1170	0,757
	HUM_CAPIT_15	9,23	1,718	1170	0,758
	HUM_CAPIT_17	6,76	3,273	1170	0,774
Digitalization level	DIG_TEHC_7	9,23	1,718	1170	0,758
	DIG_TEHCN_12	15,49	4,805	1170	0,728
	DIGIT_TECH_13	9,23	1,718	1170	0,758
Company performance	PERFE_11	2,66	1,581	1170	0,789
	PERF_10	2,29	1,414	1170	0,790
	PER_19	4,26	1,376	1170	0,790

By the value of factor loads indicators it is obvious that in digital culture a significant role is given to the company's directions, which have been implemented for their own needs on implementation of digital solutions during the last 3 years, as well as understanding The most serious factors preventing the company from increasing its digitalization. In the field of knowledge about digital technologies, the level of awareness about the development prospects of different digital technologies is significant. The main initiators of the implementation of the Digital Solutions Project and the existence of a documented strategy for human capital Management in the transition to new digital technologies are important in human capital management practices (Program, plan, roadmap, etc.) For the next 5 years. By the level of digitization of the company factor load is characteristic of the understanding of the positive result of the implementation of the project on the implementation of digital solutions, as well as technological trends that affect the company's business today.

To determine the influence of factors on the company's performance, we will build a guiding chart using the application to SPSS Amos, with the calculation of standardized coefficients, coefficients of steam regression between variables and factors, quality indicators Model (Fig. 3).

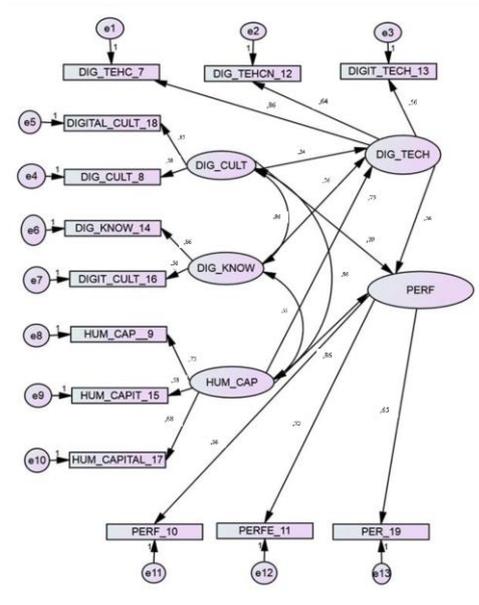


Fig. 3. A guiding model with standardized coefficients of empirical estimation by the method of modeling of structural equations. Source: Compiled by the author with the help of SPSS AMOS software.

In the presented travel model with standardized coefficients ovals are identified factors-implicit variables; rectangles are explicit variables; lines with double arrows denote covariance of factors; Single-arrow lines-the direction of the relationship. It is obvious that all coefficients are standardized and therefore suitable for comparison. The value of the quality indicators or the consent of this model indicates that the significance of the results is acceptable.

Thus, it is possible to speak about the following results of testing of hypotheses put forward in the given study:

The H1 hypothesis is refuted. Despite expectations, the significant relationship between the level of digitalization and overall performance of the company is not found, it may be due to the fact that the surveyed companies are not clearly perceived by specialists and managers on Information technology problems of the lack of digitalization, and in most cases are not yet the subject of strategic planning.

Companies in the infrastructure industries are more likely to notice a tangible or significant result of such an efficiency assessment as improved accuracy and quality. The banking sector is more often indicative of a significant or substantial result in increasing the flexibility of processes, strengthening their focus on customer needs, increasing sales, and the emergence of fundamentally new products. The industrial sector of the economy points to the low impact of projects in terms of increasing sales and the emergence of new

consumers, as well as the emergence of fundamentally new products, services and opportunities. Enterprises, which are at a mature stage of development, slightly more noticeably indicate the business effect on such parameters as reduction of resource capacity, the emergence of fundamentally new products, services and opportunities, the possibility of compliance with mandatory Standards and customer requirements.

The hypothesis of the H2 is refuted. There was no significant link between the organizational digital culture and the level of digitization due to the low level of involvement of staff in the Digital development project. Digitalization of business processes will give an impetus to the general complication of all professions, on the one hand, releasing the time of employees to solve more complex and creative tasks, on the other – significantly increasing the requirements to their qualification. This will result in a new approach to the distribution of responsibility, in contrast to the long-term principle of "1 person-1 task": One employee or a small team. Therefore, as part of the principles of organizational culture is the ability to work in a team where you need to be responsible for a complex process/product or several processes of different profiles. As a result of increasing penetration of algorithms and computer solutions will be reorientation of labor market needs on "human in Man", on creativity, on cultural, value aspects of interaction-all that machines can not Implement.

The H3 hypothesis is confirmed, the digital organizational culture influences the overall efficiency of the company, and the special role is given to the awareness of the companies' experts about the digital offers available on the market, about the experience of digital Projects by other companies, about the effects they have received, as well as initiating a top management for the implementation of digital projects.

The H4 hypothesis is confirmed. Existing practices of human capital management mainly influence the level of digitization, and the qualification of employees is a part of important variables. In companies with low level of digitalization as an impediment in 33% of cases there is a low qualification of staff. Almost twice as often companies in the early stages of development face the problem of high cost of operating systems (82% versus 41-45% in other companies). It turns out that if they are different and can be invested in the project, the cost of continuous maintenance of the system for them can become a serious obstacle. "Newcomers" are limited in possibilities of expansion of digital projects and due to low development of infrastructure (71% against 38-45% from other companies), and also unwillingness of employees to change habitual forms of work (59% against 34%-29% from other companies).

The H5 hypothesis is refuted. Significantly sustainable relationship of the impact of human capital management practices on the overall performance of the company, because this indicator is mainly due to other factors, such as the impact of market, general economic, Political as well as production, financial and investment management. However, this is also due to the fact that only 12% of companies have a strategy of managing human capital in the transition to new digital technologies for the next 5 years as a separate document. If you add to this number of companies that do not have such a

strategy as a separate document, but it is at least allocated in a separate section, the sum we get 17% (12% + 5%) Companies, which in some form or another have drawn up a strategy of human capital Management in the transition to new digital technologies. Exactly as much (17%) Do not plan to use digital technologies in the next 5 years at all. More than a quarter of companies (27%) Include the use of digital technology only in operational planning within a year. Approximately the same (26%) Do not emit "digitization" in a separate direction or separate section, but, in any case, take into account the possibility of using digital technologies (or as independent projects-12%, or within the implementation of long-term investment Projects – 14%).

The H6 hypothesis is confirmed, there is a significant steady influence of digital knowledge on the level of digitization of the company. . Just over a third of respondents (37%) Believe that the specialists of their company have all the necessary information about the development of digital technologies and well understand the extent of their possible impact on the company's business. A quarter of the number of respondents (25%) Less confident in the knowledge of their specialists and their ability to assess the extent of the possible impact of digital technologies on the activities of enterprises. Thus, at least 2/3 respondents (total-62%) Provide a sufficiently high level of awareness and competence of its employees in assessing the impact of digital technologies on the activities of enterprises. During the interview, representatives of the companies also noted that they are quite satisfied with the volume of their information on digital technologies and understand their possible impact on the company's business.

IV. CONCLUSION, RECOMMENDATIONS FOR FURTHER INVESTIGATION AND LIMITATIONS

This study assesses the impact of individual components of human capital on the digital and overall performance of industrial companies based on the methods of factor analysis and modeling of structural equations. The research base was the experience of 75 Russian companies.

The focus of the study is theoretical structures such as digital culture, human capital management practices, and the digital knowledge of employees. The analysis of human capital management practices showed that only 12% of companies have a strategy of human capital Management when switching to new digital technologies for the next 5 years as a separate document. In companies, which actively increase the competence of employees in the field of digitization, broadcast and implement the principles of the international standard, get a business effect on such parameters as reducing the resource capacity, the emergence of fundamentally new Products, services and opportunities, the ability to meet the required standards and requirements of customers.

Contrary to expectations, there was no significant link between the organizational digital culture and the level of digitization due to the low level of involvement of staff in the digital development project, but the digital Organizational culture affects the overall performance of the company, with a special role is given to the awareness of specialists of companies about the digital offers available on the market, the experience of digital projects implementation by other companies, about received These effects, as well as initiating a top management for the implementation of digital projects.

In this study, we also did not address the issues of digital security of companies and employees as a way to minimize risk. Economic security, which is primarily related to fraud detection and prevention, which is directly linked to cyber security and privacy (protection of systems against burglary to steal Information). Today, the use of digital technologies is becoming a matter not only of specially designated IT professionals, but of all employees of the company, starting with the general director, and ending with ordinary performers and workers. Without understanding the systemic changes taking place, it will be very difficult for Russian companies to withstand competition in current and future markets.

References

- [1] M. Schulze, H. Nehler, M. Ottosson, and P. Thollander, "Energy management in industry – a systematic review of previous findings and an integrative conceptual framework," *Journal of Cleaner Production*, vol. 112 (13/14), 2015, pp. 3692–3708.
- [2] J.-B. Lesourd and J.-M., "Ruiz Human Resources for Energy Management: The case of French Industry," *Engineering Management International*, vol. 2, 1984, pp.195–198.
- [3] E. Shirinkina and A. Kodintsev, "Management of human capital in the national economy: Estimation and simulation," *Revista Espacios*, vol. 39 (44), 2018, p. 28.
- [4] L. Li, F. Su, W. Zhang J.-Y. Mao, "Digital transformation by SME entrepreneurs: A capability perspective," *Information Systems Journal*, vol. 28(6), 2018, pp. 1129-1157.
- [5] F. Hecklau, M. Galeitzke, S. Flachs, and H. Kohl, "Holistic Approach for Human Resource Management in Industry. 4.0," *Procedia CIRP* 54, 2016, pp. 1-6.
- [6] A. Benešová and J. Tupa, "Requirements for Education and Qualification of People in Industry 4.0," *Procedia Manufacturing*, vol. 11, 2017, pp. 2195-2202.
- [7] A. Colbert, N. Yee, and G. George, "The digital workforce and the workplace of the future," *Academy of Management Journal*, vol. 59 (3), 2016, pp. 731-739.
- [8] H. Sirkin, M. Zinser, and J. Rose, "The Robotics Revolution. The Next great Leap in Manufacturing," Boston: BCG, 2015, p. 28.
- [9] B. J. Babin and G. Svensson, "Structural equation modeling in social science research," *European Business Review*, vol. 24 (4), 2012, pp. 320–330.
- [10] B. M. Byrne, "Structural Equation Modeling With AMOS," Routledge, 2000, 418 p.
- [11] Digital economy: global trends and Russian business practice. National Research University Higher School of Economics, URL: https://docviewer.yandex.ru/view/175985858/?*