

Models of cluster and digital integration of high-tech industries of the Eurasian Economic Union countries

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Abstract — The relevance of developing models reflecting the possibilities of integration processes and cooperation between high-tech industries of the countries of the Eurasian Economic Union (EAEU), taking into account trends in the digital transformation of the economy, is substantiated.

The aim of the study was to develop models of clustering and interconnected digitalization of high-tech industries in the EAEU. The leading research method was the modeling of institutional interactions, cooperative ties, the possibilities of end-to-end digitalization and the procedure for evaluating its effectiveness.

A structural model of institutional interactions of high-tech enterprises has been formed within the framework of cluster formations and technological platforms, contributing to innovative development. A conceptual model of legislative, infrastructural, scientific and technical conditions conducive to the formation of a single digital space is presented. A functional model of the interconnected digitalization of high-tech enterprises and the corresponding infrastructure of the EAEU countries has been developed. The block diagram of the procedure for evaluating the effectiveness of digitalization is presented.

Keywords — *Eurasian Economic Union, digital transformation, cluster, high-tech production, model*

I. INTRODUCTION

The experience of economy digitalization of various countries demonstrates effectiveness in terms of inter-regional cooperation development, inter-country cooperation, the formation of innovative infrastructure, etc., which together contribute to the building of global value chains within industries and cluster formations [1].

The establishment of the Eurasian Economic Union (EAEU), which includes such member countries as Russia, Belarus, Kazakhstan, Armenia, Kyrgyzstan, is aimed at creating a single economic space, which necessitates the construction of integration and cooperational inter-country

interactions based on the principles of digital transformation (DT).

The digitalization of EAEU countries economies is associated with the development of communication channels, digital government and online trading [2]; electronic commerce [3]; smart contracts on the blockchain platform [4]; transport and logistics sphere with appropriate infrastructure [5] and digital technologies; the unified architecture of the digital platform [6], which will contribute not only to the internal integration of the EAEU countries, but also strengthen the Union's position within the Greater Eurasia, as well as expand international cooperation [7]. However, these researches do not cover the problems of integration and cooperation of high-tech productions.

Regulatory, control and project documentation that contributes to the digital space creation, both within the EAEU member countries and between them, is reflected on the website of the Eurasian Economic Commission (EEC) (<http://www.eurasiancommission.org>). The interviews and reviews for 2018-2019, presented on the EEC website, indicate the need for industrial cooperation DT, routing and standardization of processes, electronic labeling and traceability of goods, development of digital platforms for interaction, which emphasizes the promise of research in the integration and digitalization of high-tech productions.

Scientific researches present a theoretical justification: clustering prospects in the EAEU countries [8]; the interconnected influence of technological platforms and clusters on the innovative development of high-tech productions [9, 10]; the need of production digitalization for effective cooperation [11], however, model ideas about the possibilities of cluster and digital integration of high-tech productions of the EAEU countries have not been formed.

In this regard, it is urgent to develop models that reflect the possibility of developing integration processes and cooperation between high-tech productions of the EAEU countries, taking into account the trends in the DT economy.

II. METHODOLOGICAL FRAMEWORK

The goal of research was to develop models of clustering and interconnected digitalization of high-tech productions of the EAEU countries.

The implementation of this goal was performed by a consistent solution of a number of tasks:

1. To form a structural model of the institutional interactions of high-tech enterprises within the cluster formations and technological platforms conducive to innovative development.

2. To introduce a conceptual model of legislative, infrastructural, scientific and technical conditions conducive to a single digital space formation.

3. To develop a functional model of the interconnected digitalization of high-tech enterprises and the corresponding infrastructure of the EAEU countries.

4. To present a procedure flowchart for evaluating the digitalization effectiveness.

The object of research is the high-tech productions of the EAEU countries and the corresponding infrastructure environment, which determine the innovative development of economic systems.

The subject of research is a set of specific economic relations, as well as tools, mechanisms and principles of integration and cooperation, stimulating the innovative development of high-tech productions in Russia and the EAEU countries.

The theoretical and methodological basis of the research were scientific publications on the following problems: development of integration processes and approaches to innovation management, including the high-tech field; the effectiveness of cluster interactions formation for the innovative development of high-tech productions; the formation and functioning of integration economic associations of the EAEU countries.

The leading research method was the modeling of institutional interactions, cooperative ties, and the possibilities of interconnected digitalization. The information base of the research was: empirical and factual data and official materials of the heads of states, governments, ministries and departments of the EAEU member countries, EEC materials; scientific papers in the form of monographs, dissertations, articles reflecting the results of domestic and foreign authors on the topic of research.

III. RESULTS

A. A model for the interaction of cluster formations and technological platforms; DT model

The list of priority sectors of the economy for industrial cooperation among the EAEU countries includes such high-tech productions as aircraft, automobiles, machine tools, production of road-building, agricultural, railway equipment, a complex of petrochemicals and processing, etc.

According to the EEC report, after some decrease in mutual trade volumes, already in 2017, the mutual trade turnover of the EAEU countries increased by 26.1%, there was also an increase in the growth rate of industrial production (1.7% versus 1% in 2016) due to scientific and technical cooperation and the development of cooperation in the innovation sphere [12].

The growth potential of mutual trade and mutual direct investment requires the use of mechanisms that stimulate integration processes and contribute to the development of cooperation between high-tech productions of individual EAEU countries [11].

An analysis of the scientific results and regulations in this area revealed the absence of models for the innovative development of high-tech productions in the EAEU countries, aimed at improving the efficiency of integration and cooperation, taking into account the trends in DT.

The innovative development and adoption of the latest technologies within the inter-country integration is of prime importance for all EAEU member countries. Integration in the field of innovative development of high-tech productions will ensure a synergistic effect from the joint use of the intellectual, scientific, technical and production potential of various EAEU countries, eliminate duplication of developments, accelerate technology transfer, and build effective value-added chains.

The research of experience and potential of clustering high-tech productions in world practice, described in scientific publications, allowed to formulate the following conceptual approach for the EAEU countries:

- The formation of clusters and associations on the basis of technological platforms will facilitate the implementation of joint innovation and investment projects by the EAEU countries, the commercialization of scientific research and the organization of competitive high-tech productions. Such forms of integration contribute to the establishment of partnerships and business contacts, stimulating vertical and horizontal cooperative interactions, contributing to the innovative development of the EAEU countries and more efficient integration of their economies.

A structural model of interactions between high-tech enterprises, which are part of a cluster, which in turn can be inter-country coordinated by an appropriate technological platform, has been developed (Fig. 1).

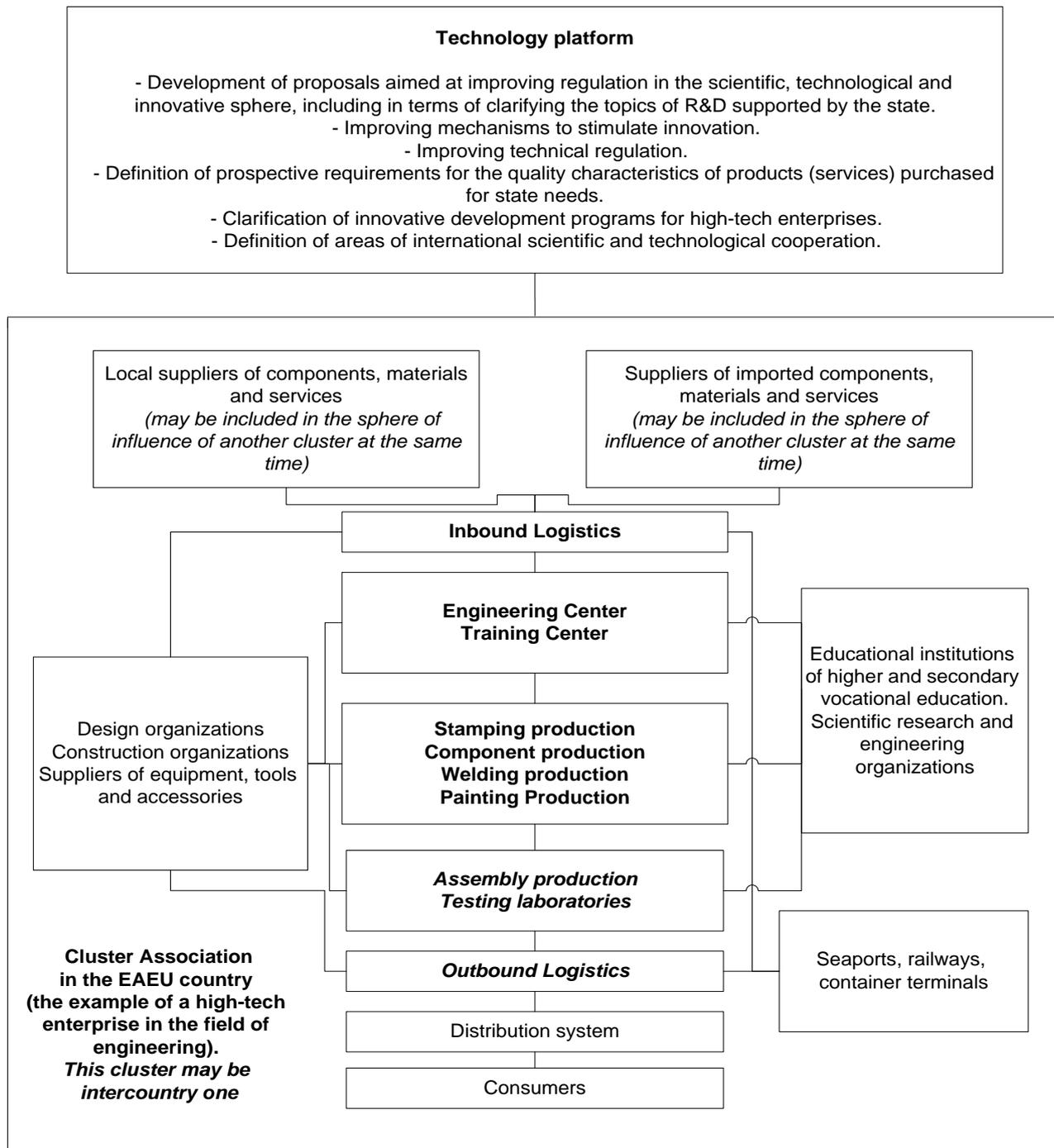


Fig. 1 Structural model of institutional interactions of a high-tech enterprise within the cluster formations and technological platforms (Compiled by the authors)

The model will make it possible to organize effective institutional interactions within cluster formations established on the basis of technological platforms. The technology platform management body will act as a coordinator of scientific, technical and innovation policy, develop proposals for state orders for research and development, and organization of innovative products production, which will attract additional volumes of grant and subsidiary state financing, for example, from the Ministry of Industry and Trade of Russia. At the same time,

the synergistic effect of cooperation and access of all participants of the innovation infrastructure to specialized information, the building of mutually beneficial value-added chains, risk sharing, etc., will lead to the development of mutually complementary breakthrough technologies by high-tech enterprises, which will increase the level of mutual investments, and increase the export of knowledge-intensive products will provide a foreign investment inflow.

In the model in Fig. 1, bold elements of the cluster union, which are of the cluster responsibility, all the other members of the cluster are the sphere of cluster influence. Elements in bold italics can be part of a cluster union of another country, with the formation of an inter-country cluster.

In today's conditions, the development of information technology is considered as one of the criteria for the sustainable development of states. Consequently, the DT mechanism acts as a driver of high-tech transformations, facilitating the transformation of production processes and cooperative interactions to improve the quality and reduce the cost of high-tech products, and, as a result, increase the competitiveness of not only individual productions, but also countries and inter-country associations.

All DT mechanisms require the development of information and communication technologies and the training of specialists in this field. Specific digital technologies form innovative network mechanisms that expand and deepen cooperation in the high-tech sphere of the EAEU countries, in terms of R&D, the introduction of new technologies and processes, the dissemination of high-tech products, the intellectual modernization of existing and the development of new productions.

In the field of high-tech productions, DT mechanisms are based on automated process control systems, additive manufacturing, logistics operations automation, life-cycle management systems for high-tech products and customer relationships. It is proposed to use the already created - the Eurasian technology transfer network and the Eurasian industrial cooperation and contracting network - as the institutional basis that regulates and stimulates the development of DT mechanisms for high-tech productions of the EAEU countries.

A conceptual model was proposed. It combines various conditions for the formation of a single digital space, which consists in the following set of actions:

1. To identify a list of priority types of economic activity in the field of high-tech cooperation;
2. To define the area of responsibility of Eurasian networks - industrial cooperation and contracting; technology transfer;
3. To study the best practice of the creation and functioning of industrial and innovative infrastructure;
4. To assess the performance of existing Eurasian technology platforms;
5. To analyze orders, decisions, development programs regarding the DT of the EAEU countries, including the digital agendas of individual countries for the long term [12];
6. To formulate the DT concept of the economy of high-tech productions of the EAEU countries:
 - Goals of the DT: development of digital economies to intensify integration processes and innovative and cooperative development.

- Potential effects: acceleration of the capital flow, technology, specialists; reduction of the early stages of the innovation life cycle to the stage of launching to the market and acceleration of their diffusion.
- Risks: The possibility of interventions in digital streams and cyberthreats.
- Activities: Development of the regulatory framework for the digital economy. Stimulating and supporting innovative projects as part of the digitalization of high-tech productions. Creation of expert sites, research centers for the development of innovation. Investing in the best innovative projects in the field of digital space, etc.

B. Functional model of interconnected digitalization of high-tech enterprises, a flowchart for its effectiveness assessment

A functional model of the interconnected digitalization of high-tech enterprises and the corresponding infrastructure of the EAEU countries has been formed, contributing to a synergistic combination of technologies and information, and, as a result, economic efficiency and innovative development of high-tech productions.

As the main recommendation for the cooperative interaction of high-tech, for example, engineering productions, it is proposed to use the transition to open ERP systems (Enterprise Resource Planning) of national developers, as the basis of the DT industry of the EAEU countries (Fig. 2).

Modern engineering companies have previously implemented ERP systems that optimize the entire production cycle, from the occurrence of the customer's need in product, to the formation of the need to purchase the required resources, using the reverse planning method ("pulling system", the "explosion" method), significantly reducing the tracking time of subject of labour or downtime of jobs. However, the implemented systems come from the West and are created by various manufacturers (Sap R/3, BAAN, Microsoft, Oracle), which are difficult to integrate with each other to organize cooperative interactions. Such dissimilarity of input and output information of various ERP systems of high-tech productions makes communication interactions difficult when organizing joint production in the EAEU countries.

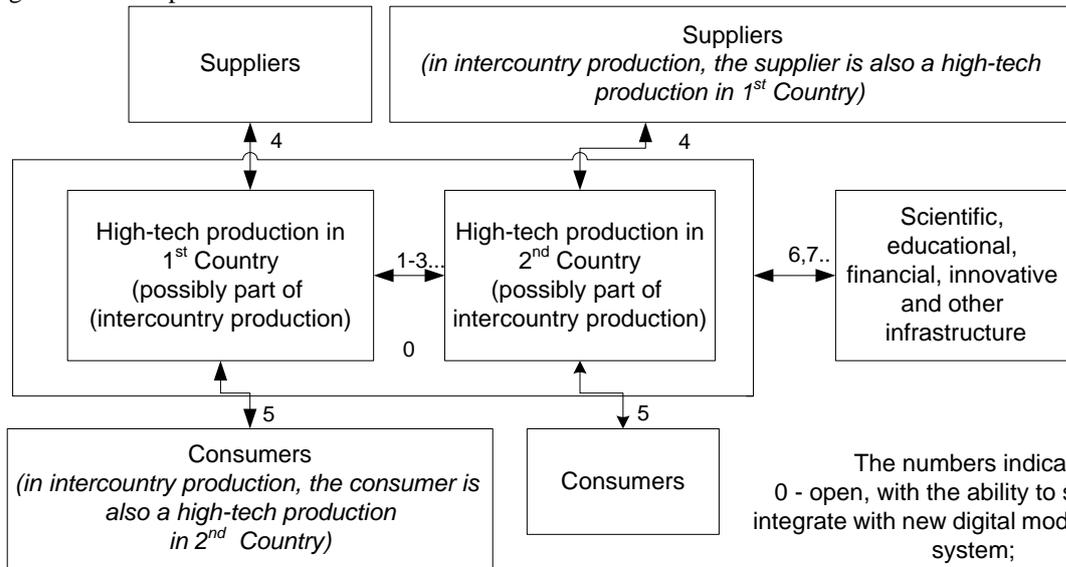
In this regard, it is proposed to use the Russian ERP system created by 1C, which is an analogue of foreign developments. In addition, the transition to national information systems in the supply chain management (SCM - Supply Chain Management), production systems (MES - Manufacturing Execution System), customer relations (CRM - Customer Relationship Management), product life cycle (PLM - Product Lifecycle Management), etc., integrating with ERP-systems.

Figure 2 presents a functional model of end-to-end digitalization of high-tech enterprises and related infrastructure. The digitalization model, through the use of multi-module ERP systems, will optimize integration and cooperation in the high-tech sphere of the EAEU countries, contributing to the synergistic combination of technologies and information, which will positively affect the economic efficiency and innovative

development of high-tech productions.

It should be borne in mind that the introduction of any digital control system for high-tech production requires the reengineering of technological operations and the restructuring of business processes before the introduction

of ERP systems. Accordingly, in order to increase the competitiveness of high-tech productions of the EAEU countries, it is important to remember that the costs of introducing DE systems should not exceed the potential synergy effect from cooperation interactions.



The numbers indicate:
 0 - open, with the ability to scale and integrate with new digital modules ERP – system;
 1-3... - engineering digital resources (CAD / CAM / CAE); digital manufacturing system management resources (MES); Product Life Cycle Management (PLM), etc. ;
 4 - digital supply chain management (SCM) resources;
 5 - digital resources for customer relationship management (CRM);
 6.7 ... - digital resources of electronic document management, banking and financial electronic systems, etc.

Fig. 2. Functional model of interconnected digitalization of high-tech enterprises and related infrastructure of the EAEU countries (Compiled by the authors)

A flowchart of the procedure for assessing the digitalization effectiveness has been developed (Fig. 3), based on a generalization of approaches to the quantitative and qualitative assessment of the effectiveness of open ERP systems implementing for managing high-tech enterprises and the corresponding infrastructure in the interests of innovative development.

The complexity and duration of the ERP-systems implementation is determined by the quality and quantity of formalized business processes of a high-tech enterprise, the availability of qualified personnel and the implementation team, the territorial distance of project participants, which is especially important when integrating individual participants in cluster formations into a single process system.

Implementation of an ERP system is notable for its high cost and resource intensity, unique implementation at a specific high-tech enterprise. There are two directions for

determining the effect of automated systems introduction: economic - using economic analysis and investment management; process - using project management approaches and a balanced scorecard.

The use of financial and economic indicators to assess the effectiveness of automation projects implementation does not reflect the multifaceted specifics of individual business processes. This drawback is compensated by the additional use of the project management methodology, where network and calendar planning, as well as a balanced scorecard are used to analyze the effectiveness of ERP systems implementation. As a result, the automation project is detailed for operations, each of which is evaluated for feasibility/effectiveness, taking into account the criteria for lead time and cost.

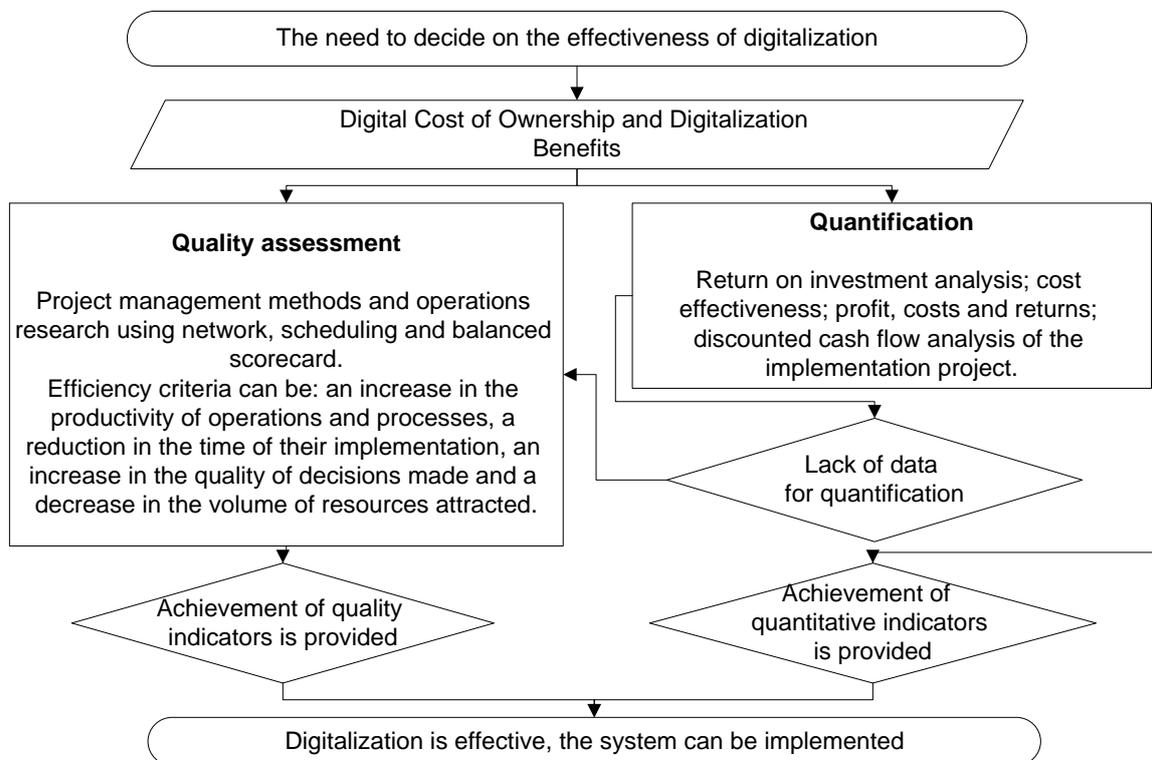


Fig. 3. The flowchart of the procedure for assessing the digitalization effectiveness, based on a synthesis of approaches to the quantitative and qualitative assessment of the effectiveness of ERP systems implementation (Compiled by the authors)

IV. DISCUSSION

Regarding the development of integration processes and approaches to innovation management, including the high-tech sphere, the researches of the following authors were analyzed: S.I. Dolgov, A.N. Spartak, V.V. Avilova, F.N. Shaikhutdinova, N.V. Natapova, E.V. Gorelova, S.A. Khapilin, L.V. Andreev and others.

Regarding the effectiveness of the cluster interactions formation for the innovative development of high-tech productions, the researches of the following authors were analyzed: D.

Martukh, V. Albino, J. Bouchard, T. Brener, M. Porter K. Ketels, L.S. Markov, S.R. Derving, R.T. Strazetdinov, A.A. Brazhkin, M.A. Nikolaev, A.N. Dyrdonova, F.V. Shutilov and others.

Regarding the formation and functioning of the integration economic associations of the EAEU countries, the opinions of the following authors were studied: A.Yu. Melvin, V.I. Pantin, V.I. Pankov, V.I. Shulga and others (Russia), N.A. Antanovich, E.M. Babosov, A.N. Danilov, S.V. Reshetnikov and others. (Belarus), A.Sh. Ishmukhametov, M. Laumullin, B. Sultanov, K. Tokaev and others (Kazakhstan).

It has been established that in the scientific papers of various authors, the problems of interdependent modernization of national innovation systems of the EAEU countries, due to the innovative development of high-tech productions, have not been studied enough. The debatable nature of publications on the high-tech productions development in the context of the

economy digitalization was revealed, which served as the basis for choosing the direction of this research.

Scientific novelty lies in the justification that the formation of cluster unions, in conjunction with the development of technological platforms and the application of approaches to the digital transformation of the economy, will contribute to integration processes, the formation of cooperative ties, and, as a result, the innovative development of high-tech productions in the EAEU countries.

The practical significance lies in the development of model ideas about the possibilities of enhancing the innovative development of high-tech productions of the EAEU countries. The results of the research are focused on the practical use of ministries and departments, trade missions, high-tech productions and other organizations related to determining the prospects for economic development and industrial policy of the EAEU countries.

V. CONCLUSIONS

A structural model of the institutional interactions of high-tech enterprises within the cluster formations and technological platforms as tools for innovative development with the potential of cooperative attraction of mutual, external investments and state financing has been developed.

A presented conceptual model combines the totality of legislative, infrastructural, scientific, technical and other conditions that contribute to the single digital space formation, based on the identification of prerequisites for digitalization of the EAEU countries economies.

A functional model of the interconnected digitalization of high-tech enterprises and the corresponding infrastructure of the EAEU countries has been formed, contributing to a synergistic combination of technologies and information, and, as a result, economic efficiency and innovative development of high-tech productions.

A flowchart of the procedure for assessing the digitalization effectiveness has been developed, based on a generalization of approaches to the quantitative and qualitative assessment of the effectiveness of the open ERP systems implementation for managing high-tech enterprises and the corresponding infrastructure in the interests of innovative development.

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