

Improving development management of knowledge-intensive production under the new industrialization

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Abstract—The process of massive transition of enterprises to Industry 4.0 is underway at the current stage. Under such circumstances the production units development management becomes impossible without a profound management processes transformation and the formalizing management actions. The purpose of the study is to improve the of knowledge-intensive industries development management through the creation of an algorithmic model of development in the new industrialization. In pursuit of this goal, the following tasks have been accomplished: subject-object relations were studied and attributed in knowledge-intensive industries development management; identified and formulated the basic principles of the development management model; identified the main levers of development management, taking into account interest groups; characterized by an elementary set of methods and tools for managing development; an algorithmic model for managing the development of high-tech industries was formed. One of the central elements of the proposed model is an assessment of the level of enterprise development. It includes compulsory monitoring of the production development and the degree of its knowledge-intensiveness. Assessment of the current development and interpretation of its results allow the selection of key indicators for a targeted impact on the development of high-tech production.

Keywords—*knowledge-intensive production; development management; algorithmic model.*

I. INTRODUCTION

In the current context, characterized by exponential technical, technological, computerized changes, there is a global intensification of economic processes and increased competition at all levels - from corporate to international. Under such conditions, one of the key economic development areas of the country is new industrialization, aimed at the deployment of knowledge-intensive industries. This is particularly true for underdeveloped regions.

Historically, there were several technological revolutions. Each of them, based on a variety of knowledge, had its own

characteristics. The modern stage of human development is characterized by the introduction of fundamentally new high-tech technologies in all areas of activity. As modern research has shown, the knowledge, created and distributed in different historical contexts, had a decisive influence on industry. Moreover, a changing knowledge environment defines the life cycle of production [1]. It can be observed that knowledge has become a key competitiveness source for developed countries, regions and industries [2].

In view of the above, an increasing number of industries are becoming high-tech, the knowledge-intensiveness of enterprises and the entire industrial sector is steadily growing. With the move to Industry 4.0, traditional approaches to production systems are changing in the direction of high technology. The concept of "smart production" has emerged. The number of studies devoted to the transition from theory to the practice of high-tech production is constantly growing. Scholars and practitioners develop and offer elements and their technical support for "smart production" [3]. The number of people employed in high-tech industries in the world is constantly increasing. For example, in the countries of the European Union, the share of the number of people employed in knowledge-intensive industries increased by an average of 0.82% per year in 2008–2017 [4]. High-tech industries require highly skilled employees. This should be taken into account in the development of knowledge-intensive industries. For example, human capital is distributed unevenly in the Russian Federation and location for the development of intellectual assets is important for local enterprises [5].

Features of the new industrialization, according to compared with the previous stages, are the speed, depth and breadth of changes [6]. Intensification research and practical experience lead to the accumulation of useful information. As a result, arrays of data are formed, the volume of which constantly grow. There is a BIG DATA problem, associated with exponential growth of knowledge, diversity and heterogeneity of information, degree of data structure [7]. For

adoption a sound management decision is necessary process information, the amount of which exceeds the limits of human capabilities [8]. You can overcome the problem of information processing only with the help of information technologies [9]. The use of information technology requires maximum formalization of the management process. Digital production management system determines the company's readiness for industry 4.0. One of the prerequisites for successful adaptation of firms to a new condition is the use of digital production management platforms and their development.

An effective tool for solving problems manage the development of industries in the above-described the conditions is the formalization of the management process and decision making. In this regard, the purpose of this research is to improve the management development of high-tech industries through the formation of algorithmic model of development in the conditions of new industrializations.

II. LITERATURE REVIEW

The scientific literature deals with various aspects of the industrial development of a modern operating enterprise. In particular, in the works of L.P. Dana and T. Dana being studied the features of the development of enterprises of post-socialist countries, in the context of the heritage of a planned economy [10]. Many scientists study the dependence of the country's economic growth (including: the level of gross domestic product and human development index) on the intensity of industrialization. Despite slight variations in chronological results across regions, in general, it is noted that industrialization has led to economic growth in different parts of the world. Such studies were performed for India [11], China [12], the Russian Federation [13].

In modern studies, the most popular areas in which the development of production is seen as a transformation (targeted or reflex), carried out under the influence of various factors and processes. For example:

- sustainable development, aimed at ecologization of the enterprise, was investigated by P. Muñoz, G. Cacciotti, B. Cohen [14];

- the development of individual areas of the enterprise. Relationships with suppliers to ensure the sustainable development of the enterprise have been studied by C.-T. Lin, K.-P. Hung [15], problems of evolution and development of new products were considered by A. Distanont, H. Haapasalo, B. Rassameethes, B. Lin [16, 17];

- development of the enterprise under the influence of market dynamics, comparison of the enterprise and the phenomena of the economic environment, modeling of the environment of the enterprise studied V. Ti V.a, N. Bold, D.P. Anastasiu [18];

- socially oriented development, mechanisms that lead to changes in practical configurations, the relationship of development with the assessment of the state of the company, the problems of self-improvement of companies are considered by G. Sharma, A.J. Beveridge, N. Haigh, J. Hillman, S. Axon, J. Morrissey [19, 20];

- the development carried out by the enterprise under the influence of various socio-economic processes, including in times of crisis, the introduction of new technologies, presented

in their scientific works J. Jasinska, D. Ibarra, J. Ganzarain, J.I. Igartua [21, 22];

- in works of N.V. Kretova, E.Yu. Tsaregorodtseva, G.I. Khohlova was presented recommendations for the practical application of innovative management methodologies for the industrial sector [23].

It should be noted that in recent years, many authors have paid special attention to the theory of "smart production", which at the moment is the pinnacle of high-tech manufacturing [24].

III. METHODS

Theoretical and methodological basis of the research it is formed on the basis of fundamental scientific works on the theory of management of industrial enterprises, industries and complexes, theory of formation and improvement of mechanism of management of development industrial enterprise, scientific regulations, devoted to sectoral and territorial specificities activities of enterprises in conditions of uncertainty macro environment.

Instrumentalno-methodical research apparatus it is a set of basic methods scientific research: observation, generalization, synthesis, analysis (categorical, subject-object, system, structural, dynamic and comparative), graphical and tabular methods of presenting empirical and factual data. To build a development management algorithm high-tech industries in the work applied graphic analysis method.

The research is based on synthetic scientific platform based on the system, structural and logical, process and regulatory approaches, which allowed to attribute and form an algorithmic model management of development of high-tech industries in conditions of Informatization, BIG DATA and increased dynamic macro environment.

IV. RESULTS

Improving the management of the development of knowledge-intensive industries of modern industrial enterprises is based on the creation of an appropriate efficient algorithm. For practical purposes, algorithmic models of management of the development of high-tech industries are considered in separate aspects, in relation to specific tasks to be solved by the enterprise. The development management model should provide for the regulation of intra-system relations, as well as the interaction of objects with the subjects and the macro environment. The control objects are the functional subsystems of the enterprise and its structural elements.

This model is formed under the influence of a complex of factors of external and internal environment of the enterprise, which are characterized by varying degrees of controllability, in accordance with the mechanism for managing the development of the enterprise. The mechanism includes the following interrelated parts: a) assessment and analysis of the level of development of the enterprise; b) development management tools (including organizational and instrumental devices); c) special mechanisms for managing the development of functional subsystems and types of enterprise development..

When forming a development management model, it is necessary to be guided by certain principles, the observance of

which guarantees its efficiency and effectiveness. The following basic principles must be observed:

1) Continuity. Using the experience gained by the enterprise, using existing, previously developed and actively used models and management mechanisms that implement common management functions (planning, organization, coordination, motivation, accounting, control). Adaptation of management functions to the company's objectives is one of the key factors for intensifying the development of knowledge-intensive industries. This allows you to quickly find the best solutions in terms of the dynamic goals of the company [25]. Thus formed model of development management is easily integrated into the existing management system. For its formation requires minimal resources (financial, human, etc.). In addition, the model should provide for the accumulation of information necessary to manage the development of knowledge-intensive industries. In other words, in the structure of the model is necessary to make the element "Database".

2) Integrity. Since the elements of management of the development of high-tech industries are interrelated and interdependent, the channels of communication through which the information flow should be ordered and clearly defined.

3) Flexibility. Adaptability implies continuous improvement, the company's ability to respond adequately to the transformation of the macro environment. This is achieved through the use of new and replacement / modernization of existing elements and mechanisms. Thus, it is possible to use the experience of other firms, advanced scientific developments in the management of enterprise development; replenish the base of special development mechanisms.

4) Correlation. The goal of development must correspond to the level of development of the enterprise as a whole and production in particular.

In addition to these principles, it is necessary to consider the subject-object relationship in managing the development of knowledge-intensive industries. The subject of management are: a person, a group of persons, a specially created body or the society as a whole, which influence the managed system to achieve its goals. Through the implementation of the development management algorithm, the subject has a managerial effect on the object. The response of the object to the managerial impact is transmitted to the subject by the feedback channel. The object depends on the purpose of management. An effective model assumes the obligatory presence of an element for assessing the level of development. In the process of executing the algorithm, depending on the result of the assessment, it may be necessary to adjust the development goal. Consequently, it is possible to change the object of management impact.

To ensure a positive result in the improvement of management and the effective operation of the proposed algorithmic model, it is necessary to use the positive management experience at the enterprise. Operating enterprises already have their own management system and, accordingly, apply certain management principles and methods of managerial influence. If it is necessary to replenish (or transform) development management tools, one should take advantage of existing outside practical experience and relevant scientific developments.

An integral part of the management of the development of the company are levers that are: a) a form of realization of the interests of the subjects; b) a means of encouraging participants in the management process to act. The study of the development management practices of modern industrial enterprises allows us to group the levers that make up the management tools, taking into account groups interest (Table I).

TABLE I. THE LEVERS OF INDUSTRIAL ENTERPRISES DEVELOPMENT MANAGEMENT

Interested Groups	Levers
Shareholders	Dividends, profit per share, going concern value
Managers	Economic profit, rentability
Staff	Salary, labor standards, material and moral stimuluses
Consumers	Price, quality, insurance, discounts, ordering, reclamations
Creditors	Loan interest rates, loan collateral
State	Refinancing rate, exchange rate quotation, inflation rate, obligatory payments (taxes, surcharge, fines), subsidies, economic sanctions, patents, license, environmental taxes
Suppliers	Price, terms of delivery and payment, contracts, mutual settlements
Competitors	Market share, level of competitiveness
Investors	Investments, investment income, profit, market value of shares
Society	Business reputation, technological, industrial, environmental standards and norms, licenses

In the process of managing the development of knowledge-intensive industries, methods of managerial influence are used: a) organizational and managerial (organizational and legal, command and administrative); b) economic (economic and mathematical, financial) c) social (social and psychological). They constitute the elemental base of the structural-logical scheme of development management. In this case, each group of methods can be applied individually or their combinations, based on the purpose of the impact and location in the control algorithm. Methods and tools are part of a flexible system of elements of a development management mechanism. Their brief description is given in Table II.

TABLE II. BRIEF DESCRIPTION OF DEVELOPMENT MANAGEMENT METHODS AND INSTRUMENTS

Method groups	Composition of methods	Tools
Economic	Methods of motivating management subject to achieve corporate-wide development goals; financing methods; pricing methods; methods of stimulating employees and harmonizing stakeholders interests on the basis of achieving the goals and results of enterprises, etc.	Normative tools (tariffs, fines, etc.) Financial tools based on the distribution, control, incentive functions of finance. Analytical tools (analysis of factors determining development), etc.
Organizational and administrative	Fixing development management functions for the respective posts; the establishment of appropriate rights and obligations; organization of meetings; formation and organization of project teams, target cross-functional groups and others.	Legal instruments: permissive and prohibitive rules and regulations. Technological tools: techniques and means for constructing the technological sequence of specific processes stages, taking into account temporal, spatial and structural constraints, etc.
Social	Humanization of intragroup relations, relations between managers and employees through the implementation of the social justice principle; training seminars, etc.	Social tools based on the style of leadership, creative activity, corporate culture. Psychological tools based on motives, traditions and moral values of individuals, etc.

The management of the development of a knowledge-intensive production enterprise can be presented in an algorithmic form (Fig. 1).

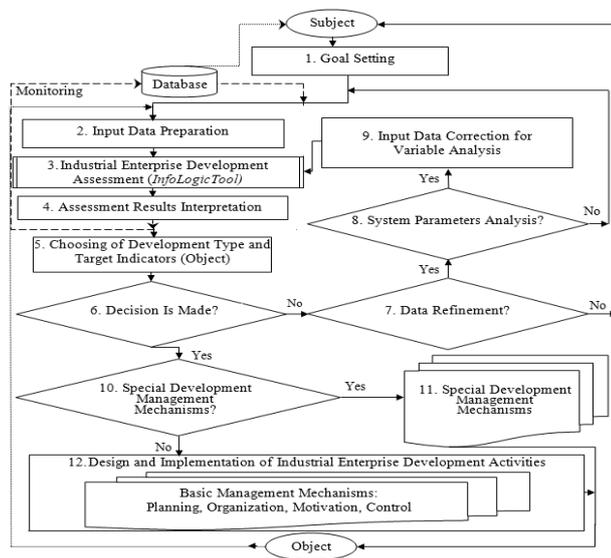


Fig. 1. Algorithmic model of enterprise development management

Such an approach to recording a development management model was chosen because of its clarity. In addition, it allows the use of digital technology in the production development management system.

In managing the development of high-tech production, the most important factor of subject-object interaction is the goal-setting of the company. In the practical implementation of this

algorithmic model, it should be borne in mind that the objectives of management influence may be different and depend on the enterprise (mission, economic status, etc.). Databases are formed by analytical services on the basis of information from various sources (own, state, industry, statistical, etc.).

The basic mechanisms are a mandatory attribute of the management of the development of high-tech production. Special mechanisms are included if necessary. If the special mechanisms were used by the enterprise earlier, then, if necessary, the enterprise can use its own experience. If such a need arose for the first time, then it is possible, for example, to apply third-party experience in the formation of such mechanisms. In the course of its operation, an enterprise should create and supplement the base of special development mechanisms. This will speed up decision making in standard situations and ensure growth.

One of the central elements of the proposed model is an assessment of the level of enterprise development. It includes mandatory monitoring of the development of production and the degree of its knowledge-intensiveness. This takes into account: the availability of modern production technologies, their prospects and compliance with industry standards; innovative activity of the company; the number of own development projects, their quality and efficiency; human resources, etc. Assessment of the current development and interpretation of its results allow the selection of key indicators for targeted impact. Critical for development are indicators that determine the ability of an enterprise to respond to changes in the external and / or internal environment. They predetermine the equilibrium state of the enterprise, its security, stable functioning and sufficient progressive dynamism in the prevailing conditions. To implement block 3 (Fig. 1), the authors developed a computer application InfoLogicTool. This tool was developed using Fuzzy Logic and modern IT methods in the MathCad software environment. Approbation of the methodology showed the acceptability of the approach proposed in this work.

V. DISCUSSION

The algorithmic model for the development of high-tech production developed in the process of research has been successfully used in several machine-building enterprises. The proposed toolkit has been applied at enterprises with different levels of development, different production cultures and degree of knowledge-intensiveness. As a result of practical application, this toolkit has demonstrated its effectiveness in making decisions on the development of knowledge-intensive production and the company as a whole.

It should be noted that blocks 2, 4, 5 present the greatest difficulties for practitioners. Consequently, further developments will be aimed at formalizing the processes indicated in these blocks.

VI. CONCLUSIONS

In modern conditions, the basis for ensuring the competitiveness of industrial enterprise are: the use of advanced technologies, innovative development, the introduction of digital technologies in production and management, scientific organization of labor, automation of

management decision-making, etc. Industrial enterprises, along with others, are forced to intensify the modernization of their own production and management through the use of high technologies. Only such an approach allows manufacturing companies to comply with the requirements of new industrialization and market leadership.

The proposed algorithmic model of development management allows you to effectively manage the development of high-tech production in the conditions of BIG DATA based on the formalization of the management process. This model provides effective interaction between the subject and the object of management, taking into account the goals of the organization and the existing database. The management of the development of knowledge-intensive industries is based on a permanent assessment of the level of development using modern digital tools (InfoLogicTool), subsequent interpretation of the results, selection of the type of development and target indicators. The model involves basic enterprise management mechanisms and, if necessary, special development management mechanisms.

Further research will be aimed at improving the developed model and the study of special mechanisms for managing the development of industrial enterprises. Under the conditions of Industry 4.0, it is necessary to ensure the maximum formalization of management processes for the development of knowledge-intensive industries. The focus will be on the following processes: a) collecting and preparing input information; b) interpreting the results of the development assessment; c) selecting the optimal type of development and targets. In addition, according to the authors, it is necessary to test this mechanism in high-tech enterprises of various industries (not only industrial). As a result, it will be possible to adapt the model to the specific conditions of the new industrialization. This will allow to form a fairly universal toolkit for managing the development of a high-tech enterprise.

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