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SYNERGY OF THE INNOVATION PROCESS IN HIGH-TECH INDUSTRIES

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Abstract

The objective to localize the focus of management influence or partial introduction of innovations in knowledge-intensive industries does not lead to synergy and slows down the production process. The theory of innovations should be supplemented in terms of ensuring relationship between the types of innovation process synergy. This, in turn, presupposes actualization of innovations classifications for the purpose of synergy process formalizing. The authors presented a multidimensional classification of innovations, taking into account dynamics knowledge-intensive industries development and the synergy of the innovation process. The problem of innovations compliance with production and management systems presupposes different types of synergy; therefore the authors have given a classification of the innovation process synergy. To calculate the synergy effect within the framework of the proposed approach, the multipliers are classified according to the types of synergy. To quantify the synergy effect, a multiplier method was proposed based on the additive set of criteria. The resulting formula for calculating the synergy effect of the innovation process takes into account the influence of both the multipliers and the accelerator or acceleration coefficient that determines the synergy boundaries. To substantiate the points of innovative growth, a fractal reproduction model has been proposed, which can be combined with the paradigms of the science-intensive industries cyclical development.

Keywords: Innovations in high-tech industries, synergy of the innovation process, synergy effect, points of innovative growth, cyclical development of high-tech industries

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1. Introduction

As noted by economists Averin (2019) and other researchers, economy digitalization requires a change in approaches to the innovation process management. Agreeing with the importance of the "orchestrator", in our opinion, it is expedient to justify additional classifications of innovations for the purpose of synergetic process formalizing. However, the problem of innovations and production management systems compliance requires a detailed description of various types of synergies within the framework of the innovation process. As has been widely discussed in the literature (Larionov et al., 2018), synergy is the receipt of an additional effect or an increase in the result for a given amount of resources. At the same time, the process result improvement itself has not been brought to the level of structural and logical schemes and algorithms.

2. Problem Statement

The main research problems are as follows:

- In the scientific literature insufficient attention is paid to additional classifications of innovations for the purpose of formalizing the synergetic process.
- A detailed description of various types of synergies within the innovation process has not presented in scientific studies.
- The classification of multipliers by type of synergy has not been introduced into scientific circulation.
- To quantify the synergy effect, the multiplier method based on additive criteria matching was not used.
- The resulting formula for calculating the synergy effect of the innovation process did not include multipliers and an accelerator or an acceleration factor that determines the synergy boundaries.

3. Research Questions

This study aims to find answers to the questions in the following aspects:

- updating the classification of innovations for the purposes of the synergetic process formalizing;
- characteristics of various types of synergies within the innovation process;
- classification of multipliers by types of synergy;
- description of the algorithm for calculating the synergy effect of the innovation process.

4. Purpose of the Study

To describe the algorithm for calculating the synergy effect of the innovation process taking into account the multipliers by the synergy types, within the framework of innovations and production and

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management systems compliance with the accelerator or acceleration factor that determines the synergy boundaries.

5. Research Methods

The research is based on the method of science-based analytics. To achieve the set goals and objectives it is aimed to use the experience and achievements of foreign and Russian scientists. The solution of tasks is carried out on the basis of general scientific research methods application alongside comparative and logical analysis. The classification method is widely used, in which information is distributed on the basis of comparison and is divided into groups based on common characteristics.

5.1. Classification of innovations for the purposes of the synergetic process formalization

In the scientific literature there are many classifications of innovations (Grishin, 2017), however, as a part of the synergy of innovation process, this issue has not been widely developed. As previously noted by the authors, “based on the synergy of the innovation process, architectural, engineering and infrastructure innovations can be distinguished” (Titova & Ilinskaya, 2020, p. 130).

Structural innovations are the core of architectural innovations; institutional - managerial ones are the basis of infrastructural innovations. Engineering innovations determine various management problems, therefore, if the old management system functions, then sooner or later it will enter into dissonance with innovations, the overcoming of which presupposes fractal dynamics of development (Kantelhardt, 2009). Therefore, fractal innovations are the key link in engineering. The large-scale invariance of fractal objects may not appear immediately, but only through several levels of institutional and management decisions.

The author's classification of innovations, taking into account the dynamics of economic development and the synergy of the innovation process, is shown in Figure 1.

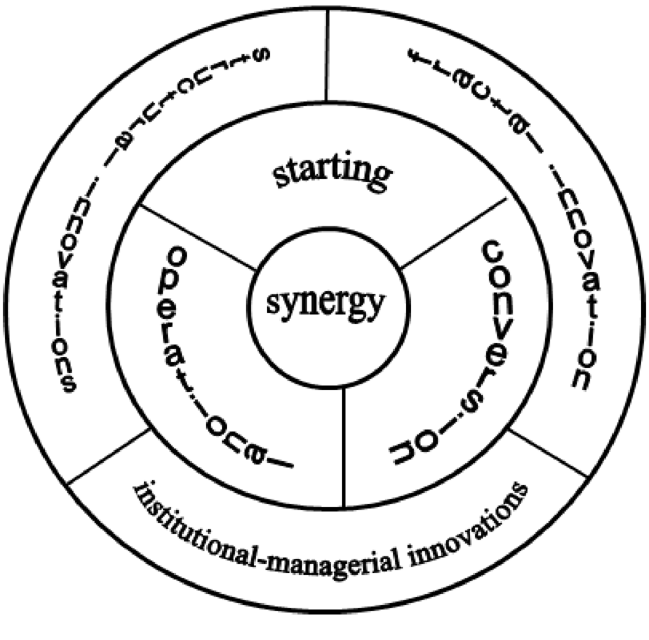

Figure 1. Multidimensional classification of innovations within the innovation process synergy

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5.2. Classification and characterization of various types of synergy in the innovation process

As shown in Table 1, within the framework of the innovation process, three types of synergy were identified: starting, operational and conversion.

The starting synergy is to ensure:

- establishing a balance between traditional and new professions; matching the workers qualifications to the quality of new blue-collar professions;
- amount of changes (restructuring, reengineering of business processes;
- negative need for additional financial restrictions.

Operating synergy in the production subsystem depends on two options for the use of production capacities.

If the production capacity is used at 100%, then there is a need to update technology for the production cycle, to change the sequence of work, to ensure design and technological preparation of production and technological process improvement due to its final stages (assembly, finishing, customization).

If the production capacity is used less than 100%, then the extension of the product range is required until eliminating profit losses due to the low utilization or underutilization of production capacities. Here updated are the theorem on overcapacity and control of the minimum percentage of the average annual production capacity use. The higher the degree of product differentiation is, the greater the deviation of the utilized capacities, production volumes and prices from the most efficient ones.

This problem is more relevant for high-tech innovative enterprises with a large number of specialized equipment units, fixtures and fittings. In relation to the installed general-purpose equipment, the situation can be assessed as an attractor that resists innovation by increasing the risk of financial inadequacy. To resist the noted tendencies, it is recommended to set the calendar characteristics of the differentiation procedure sequences.

Within the logistics subsystem, operational synergy involves aligning supply logistics with a new product range plan and equipment generation. Operational synergy in sales logistics involves creation of a new type of demand and market, as well as the identification of the existing type of demand and its satisfaction by types of business models: B2B, B2C, B2G, G2B.

Operational synergy in the quality subsystem presupposes creation of its new properties, significantly modified or not available before. Analysis of global markets has shown that the listed properties are most often derived from a set of implemented innovations and intangible characteristics (brand management (Larionova et al., 2021), Harvey Leibenstein's effects (Leibenstein, 2000)) in certified business processes.

Conversion synergy implies implementation of a set of changes and creation of a new business pattern based on demand, scale and market. To ensure the organizational diversity of the system, each level of an organization, as the authors have already proposed, should be divided into a number of sublevels and transitions between them, so as to create, for example, a multidimensional model of network configuration interaction (Sumbarova et al., 2020).

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Proposed are the change of the strategy and principles for the development and choice of methods for implementing the strategy and the choice of methods for their adjustment. A promising approach to improving strategy development algorithms involves the following conditions:

- synergy of micro and macro indicators; the direction of the cyclical dynamics of economic development and innovations life cycle;
- reduction and diffusion;
- hedging the negative dynamics of environmental factors;
- torsion of the system elements in order to achieve singularity of result.

5.3. Classification of multipliers by types of synergy

Within the framework of the proposed approach, the classification of multipliers according to the types of synergy, which underlies its mechanism of manifestation, has been carried out.

The suggested synergy multipliers are presented in Table 1.

Table 1. Types of multipliers

Synergy type	Labeling	Type of multiplier
Starting	$Mr_{1.1}$	Profession multiplier
	$Mr_{1.2}$	Change multiplier
	$Mr_{1.3}$	Investment multiplier
Operational	$Mr_{2.1}$	Multiplier of production capacity use
	$Mr_{2.2}$	Logistics effect multiplier
	$Mr_{2.3}$	Quality multiplier
Conversion	$Mr_{3.1}$	Multiplier of business model efficiency
	$Mr_{3.2}$	Multiplier of strategic efficiency
	$Mr_{3.3}$	Multiplier of cyclical behaviour

The calculation of synergy multiplier indicators is presented in Tables 2, 3, 4.

Table 2. Starting synergy multiplier

Labeling	Calculation
$Mr_{1.1}$	1/ share harmonized in terms of personnel and functions of the workplace in the total number of workplaces
$Mr_{1.2}$	1/ share of organizational change in managerial decisions
$Mr_{1.3}$	1/ marginal propensity to invest

Table 3. Operational synergy multiplier

Labeling	Calculation
$Mr_{2.1}$	1/ production capacity utilization rate
$Mr_{2.2}$	1/ rhythm factor taking with reference to input and output streams
$Mr_{2.3}$	1/ share of certified processes in the total number of business processes

Table 4. Conversion synergy multiplier

Labeling	Calculation
$Mr_{3.1}$	1/ business model efficiency
$Mr_{3.2}$	1/ strategy efficiency
$Mr_{3.3}$	1/ share of technologies that correspond to the cyclical stage paradigm

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To quantify the synergy effect a multiplier method based on additive criteria matching has been proposed.

6. Findings

6.1. The resulting formula for calculating the synergy effect of the innovation process

The problems of mathematical interpretation have been investigated in the scientific literature (Malinetsky, 2012), however, there have been no studies of the influence of various multipliers and accelerators on the synergy effect. This article has taken into account all the indicators of the multipliers of various synergy types. At the same time, in addition to the multipliers, the synergy effect is also influenced by the accelerator or the acceleration coefficient, which determines the synergy boundaries.

Synergy is not a unidirectional process, but an accelerator (Ap) which is a targeted interval indicator, an excessive value of which can lead to synergistic chaos, and its minimization will lead to a significant weakening of the synergy effect. The accelerator is the incremental capital intensity ratio is calculated by the formula (1).

$$\text{Ap} = Lim\frac{\Delta\text{К}}{\Delta D} \quad (1)$$

where: ΔK – capital intensity;

ΔD – increase in operating income.

With reference to all the proposed multiplication and acceleration coefficients, we can write the formula (2) for calculating the synergy effect (SE),

$$\text{ЭС} = \omega\sum(\alpha\text{M}_1 + \beta\text{M}_2 + \text{ɣ}\text{M}_3) \pm \varphi\text{Ap} \quad (2)$$

where: ω - fractal correction factor that takes into account the non-stationarity of the system and the attractor type;

M1 – starting synergy multiplier;

M2 – operational synergy multiplier;

M3 – conversion synergy multiplier;

α, β, ɣ – significance coefficients of multipliers;

φ– macroeconomic correction factor.

The process of introducing innovations, which is constantly reproduced both in time and by activity type, corresponds to the signs of a regular logical fractal, since there are at least two scales of parameters, within which the designations of tuples are not identical or are not trivially invariant. The fractal should provide a synergy multiplier. The archetype of innovations can be rightfully interpreted as a tuple - an ordered set of components - elements of a tuple.

The branching of the result evolutionary paths is well known in management (Dashkova et al., 2020), when the quantitative variation of the organization constants retains the attraction of the same attractor, and the process returns to the same structure and mode of the system motion. If a threshold change in the critical values of the parameters is reached, then the mode of the system motion changes qualitatively - the system falls into the attraction domain of another attractor. The introduction of architectural and disruptive innovations can be rightfully interpreted as an n-dimensional scale transformation.

7. Conclusion

The influence of innovations, manifested at the level of organizational consistency, allows considering organizations as non-stationary, pulsating, complicating and degrading dissipative structures. An innovative process that provides various paths of evolution is primarily associated with bifurcations when the environmental constants change.

Under the critical value of the control parameter there are two possible development patterns in terms of management stages.

The scenario of stagnation turns non-stationary organizational ones into degrading ones and provides a loss of efficiency. The scenario of innovative growth provides efficiency through the complication of non-stationary objects parameters: dissipativity through pulsating development becomes more complicated and provides multiplied efficiency, which was reflected in the resulting formula for calculating the synergy effect.

The dynamic component is associated with non-stationarity, where innovation plays the role of a soliton, a structural unit in the status of a stable solitary wave propagating in a nonlinear environment (Ogorodnikova, 2016). The control task is to impart fractal wave properties to the innovative soliton. In this case, it is necessary to preserve both its own structure and action pattern, as well as the implementation of interaction with each other.

Non-stationarity is an important characteristic of the internal and external environment of a science-intensive enterprise, in which the equilibrium described by kinetic equations does not have time to be established, therefore, it must be patrolled by the static component. The static component is stationary structures that are attractors of self-organization processes (Ilinskaya, 2017).

An attractor in control is an attracting fixed point, a kind of goal or target. On the basis of this, it becomes possible to predict the course of innovations introduction, proceeding from the goals of the processes (structures-attractors of evolution) and from the whole, proceeding from the general trends in the deployment of processes in systems as integral formations, at the dynamic level of all science-intensive systems development.

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