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Intellectual development of high-tech production on the basis of the formation of its organizational and technological system in a riskogenic innovation economy

Abstract

The *aim* of the article is an attempt to form the basic methodological provisions for the smart development of organizational and technological systems in high-tech production in a risky innovation economy. *Methodology*. Methodological support for research on justification of the structure of the future system requires a methodology that is adequate to the content of the process of creating organizational and technological system in high-tech production, as well as data on the volume, specificity and dynamics of the representations of this type of system. When constructing such a methodology, it is necessary to proceed from the general principles of building systems. *Results*. An approach to the formation of a unified methodological basis for the creation of organizational and technological systems in the domestic high-tech production is given. The goal and objectives, composition and structure, main characteristics and parameters, the order of functioning of such a system are defined. Consistently a team of specialists is formed, the concept of creating the system itself is developed, the goals and objectives, the required efficiency, the description of possible conditions of use, as well as the prediction of constraints are determined. The general principles of creating an organizational and technological system are formulated: integrity, hierarchy, situationality, change of basis, analogy of structures. The most important aspects of its creation and synthesis are defined: functional, structural, technological. *Value/originality*. The main method of smart development of OTS in HT is the method of hierarchical decomposition by aspects, levels and stages of construction of the system, which allows not only to unbundle the task based on the ratio "whole – part", but also to implement the "right of intervention" and "dependence of levels".

Keywords

Smart development, high-tech production, organization, technology, system, model, risk, innovative economy

JEL: C61, L64, L65, O14

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1 Introduction

Many practical tasks are solved by organizational structures using appropriate technical means. The organizational structure and the technical means at its disposal constitute an organizational and technological system (OTS) in high-tech (HT) production.

In the National Economic Strategy for the period until 2030, direction 10 – Industry defines the following strategic objectives: "Creation of stable domestic demand for domestic products; ensuring integration of the Ukrainian industrial sector into global value chains, creating conditions for expanding exports of industrial products; strengthening the competitiveness of industrial products manufactured in Ukraine; introduction of resource- and energy-efficient technologies; creation of new industries by encouraging innovative activities of enterprises in all regions of the country using the competitive advantages of each of them" (National, 2021).

In 2019, the national government approved the "Innovation Development Strategy to 2030", which states: "Investments in intangible assets over the past 15 years amounted to about 2-4% of total capital investments, and the share of activities related to high-tech (with a total research and development cost intensity in relation to gross value added of 13.6% or more) and medium-tech (with a total research and development cost intensity in relation to gross value added of 3.2-13.5%) in the volume of industrial products sold in 2017 was 11.3%" (Strategy, 2019). And further: "The share of high-tech exports in the total exports of industrial products in Ukraine in 2017 was only 6.9%" (Strategy, 2019).

For the domestic economy and its competitiveness in the world market, it is important to competently develop the production of HT in the first place. This will not only create new jobs, provide an inflow of investment, but also win economic competition and military action in the east. Under conditions of military aggression, it is necessary to pay attention to the creation of industrial enterprises for the intelligent development and production of HT products, especially dual-use. For this purpose it is necessary: to invest in prospective developments, in production of element base and finished products, in human resources; to attract current groups of scientists from various domestic research institutes and talented young people, who can be offered decent salaries; to cooperate closely with experts from other countries.

Perhaps it makes sense to create a special technopark with a fully closed cycle of both development and production of the element base and finished devices. In this case, the centralized purchase of technologies and equipment for production will help optimize costs.

2 Analysis of recent research

In the process of preparing this material, the authors drew attention to the scientific works of the following scientists: Borodakiy Yu., Kravchuk P., Batkovsky M. (2014), Budkin V. (2005), Datta A., Mukherjee D., Jessup L. (2015); Fedulova L. (2008), Heets V. and Seminozhenko V. (2006), Gusev E., Mukhametzyanov Z., Razyapov R. (2017), Khubka V. (1987), Mistrov L. (2004), Lysenko Yu. and his collegues (2009), Obolenskyi V. (2003), Poloskov S. (2020), Rossokha V. (2003), Salikhova O. (2008; 2011), Udovenko V. (2017), Usov V. and Oborskyi H. (1995), Vasiliev O. (2011), Vitlinsky V. (2007), Yakubovskyi (2009), Yehorov I. (2015).

When creating a system, one of the central issues is its appearance (purpose and objectives, composition and structure, main characteristics and parameters, order of functioning). A study designed to substantiate the appearance of a future system is called by some scientists a system synthesis. To date, methods for creating systems of various types have been developed. At the same time, methods of creating HT production OTS are not sufficiently developed, and the only methodological basis for creating OTS is in its infancy.

3 General understanding of the content and structure of the OTS in HT production

In general terms, the content of the OTS can be presented as follows. First, based on the assignment of the body responsible for the creation of the future OTS (hereinafter referred to as the Customer), a group of experts conducting research to justify the overall shape of OTS (hereinafter referred to as the Developer), develops a draft concept (concept) of creating OTS, which contains: and tasks of OTS, definition of the necessary effectiveness of OTS, description of possible conditions of OTS application as well as forecast of restrictions (financial, material, technological, space, time, etc.) within which OTS will be created.

The concept of creation of OTS of HT of production accepted by the Customer serves as a starting point for the further, more detailed processing of the general look of OTS. The developer, considering the OTS as a functioning integrated system "immersed in the environment", identifies the possible external relations of the OTS and determines the relevant basic properties and characteristics (parameters) of the system. Based on the results, the Developer then directs the study to the OTS, conventionally representing it as possible components. Each of these components is studied separately as a "black box" in the appropriate environment, which allows to identify their external relations and determine the properties and characteristics (parameters). Further consideration of the components of the OTS in the language of relationship to each other allows the Developer to define the structure of the OTS and refine its external properties and characteristics (parameters). The Developer continues the gradual downward movement of research within the OTS until the desired degree of detail in the OTS structure in HT production is achieved.

Along with the deepening of research in the process of creating the OTS, there is a reverse upward movement. Research returns to the surface of the OTS, which are filled with more specific ideas about its structure, characteristics (parameters) and functioning. The external and internal relations, properties and characteristics (parameters) of the OTS are revealed as a result of this cyclical movement of research. The developer combines into groups that correspond to one or another of its qualitative aspects (purpose, tasks, functions, structure, etc.).

Moving from one qualitative aspect of the OTS to another, the Developer's study covers a set of relations, properties and characteristics (parameters)

of the OTS, which serve as a basis for refining its previously identified relations, properties and characteristics (parameters) in the production of HT.

As a result of this mutual movement of research, the OTS seems to "return" to the Developer sequentially from each of its qualitative sides, involving the environment in this movement. The creation process goes from one type of OTS to another, more and more meaningful and concrete. The analysis of the general form of the OTS is combined with its construction.

Thus, in the process of creating a TS, there is a gradual increase in the completeness of ideas about the structure, characteristics (parameters) and functioning of the OTS. The developer considers the OTS from different qualitative sides. The translational and inversional nature of the research is complemented by cyclical upward and downward movement. The alternative variants of OTS give way to the corresponding variants. At the final stage of construction, the best variant of the OTS variant of own HT products is selected in the sense accepted by the Customer.

Methodological support for the justification of the structure of the future OTS requires a methodology that is adequate to the content of the OTS creation process, as well as data on the volume, specificity and dynamics of OTS representations. When constructing such a methodology, it is necessary to proceed from the general principles of OTS construction.

4 General principles of the creation of OTS in HT production

The principles for the creation of OTS in general express the existing experience of the creation and application of OTS in HT production and play a regulatory role in relation to the content and structure of OTS research. The principles of integrity, hierarchy, situationality, change of grounds, and analogy of structures are proposed to be included among the general principles of the creation of the OTS.

A. The principle of integrity requires to consider the creation of a TS as a complex system of interrelated and interacting processes. The objective source of creation integrity is the OTS, and the direct basis of creation integrity is the team of specialists performing research, because it determines what exactly and in what volume is included in the process of construction, in what framework and form certain research is performed and their results are presented. The principle of integrity also requires the allocation in the construction of such a main process, which performs a coordinating system-forming function and determines the direction and content of the entire OTS creation. Other construction processes in relation to the main process should be considered as auxiliary (supporting).

B. The principle of hierarchy is inextricably linked with the principle of integrity and complements it. In accordance with the principle of hierarchy between the processes of OTS creation, in addition to the relationship "whole – part" should be established relations of subordination "main process – supporting process". At the same time during the main process of construction the goals, data on available resources and conditions of application of OTS for research in the framework of ensuring the processes of realization of the final positive results are determined. In the same framework, assumptions about the ways and means of achieving the goals in the given constraints are justified, which are then consumed in the research of the main process of building OTS.

C. The principle of situationality. In constructing a view of the general shape of the OTS changes. Its various qualitative aspects are consecutively considered. The degree of detail and specificity of the view increases. Therefore, each temporal intersection of the OTS should correspond to a very specific situation due to the choice of the main construction process and auxiliary processes.

D. The principle of changing foundations. The creation of the OTS includes research on the disclosure of the properties and characteristics (parameters) of the system through the analysis of its external and internal relations and research on the construction of the OTS through the composition of its functions, structure, components. Based on this, the principle of change of grounds indicates that in the process of construction there should be a successive transformation of some factors (properties, structure, characteristics and parameters of the OTS), which played the role of consequences of other factors (external and internal relations), into their original forms. manifestations, into causes. Such a change in cause-and-effect relations determines the translational nature of the process of creating a synthesized OTS.

E. The principle of analogy of structures implies a certain coincidence of the structure of OTS construction with the structure of information-logical relations in the Developer's researches. At the initial stages of justification of the system type, the structure of the OTS is largely determined by the structure of the Developer's studies, modeled on the structures of previously synthesized OTS. At the final stages, the structure of the TS created basically repeats the structure of the OTS.

The principles of OTS creation provide a general, initial idea of the properties and structure obtained in the final result of OTS. In addition to the underlying principles, it is necessary to introduce the concept of the basic structural elements of a OTS in order to implement a meaningful construction in the production of a OTS as a complex system. The meaning of these concepts is revealed in the categories of OTS creation.

5 Categories of OTS synthesis and creation

Categories of OTS types, based on the development of the creation process in time and detailed consideration, are divided into two parts that complement each other. The first one characterizes the deployment of the OTS construction in time and contains the stages and phases of OTS creation. The second part of the categories characterizes the content of the design process related to the qualitative aspects of the OTS, and contains the aspects and levels of OTS creation in HT production.

Stage of construction of OTS – a part of OTS, which is conditionally allocated in time, within which the volume of ideas about the quality, characteristics and functioning of OTS, sufficient to decide on the completion of construction or on ways to continue it.

Stages can be distinguished as a part of OTS (Figure 1):

– development of the concept (plan) of creation of OTS;
– OTS creation with the "real" achieved form of the main subsystem (subsystem performing the main function of OTS) and "ideal" (in principle possible) types of subsystems performing non-basic (providing in relation to the main) functions realized in the set restrictions;

OTS creation at the types of subsystems realized in the set restrictions, carrying out the next most important function after OTS and "ideal" account of the subsystems carrying out other providing functions. And so on in descending order of importance of the functions of the subsystems;

– OTS creation at the form of OTS as a whole realized in the set restrictions.

The category "stage" of OTS is a consequence of the implementation of the principles of hierarchy, situationality and analogy of structures and expresses the predominant focus of research on the construction of OTS, and on a group of qualities and characteristics (parameters) of OTS. Each of its stages is decomposed into stages of creation and implementation. The creation phase of the OTS is part of the synthesis phase, in which a certain level of validity of a fixed group of qualities and characteristics (parameters) of the OTS is achieved. Creation phases can include (Figure 2): setting the construction task; pre-planning research on the creation of OTS: development of alternative options of OTS type or, further, OTS options (OTS components); assessment of effectiveness and selection of the preferred alternative OTS option (OTS components); analysis of stability of the preferred OTS option (OTS components) when factors change, which are weakly formalized (not formalized), additionally subject to accounting in agreement with the Customer.

The most important of these stages is the task of creating OTS (OTS components) in CT production, which determines the course of subsequent research and its results. Due to the uncertainty of the Customer's targets, initial data, as well as for other reasons, the problem statement when creating the OTS is usually specified.

The main aspects of the creation of OTS (Figure 3) are functional, structural and technological aspects. This is because the essence of the functioning of the OTS is structural in nature, and the structure of the OTS is functional. At the same time, the functional and structural qualities of OTS are quantified in its characteristics and parameters.

A. Within the functional aspect of creation the role and place of OTS among other systems, appointments and tasks, ways of the decision of problems are proved, functions of OTS and the general order (principles) of its functioning are defined. Since the functions of the OTS are divided into internal and external, the functional aspect of the OTS in accordance with the principles of integrity, hierarchy and analogy of structures is divided into external and internal.

The external-system functional aspect of the OTS creation in relation to the intra-system one plays a purposeful and integrative role, since it determines the conditions in which the internal functional form of the OTS is justified. The intra-system functional aspect of the OTS in relation to the external system is fundamentally important.

In the process of building the OTS, as required by the principle of situationality, the functional aspect of the synthesis plays mainly the role of the main process and is dedicated to justifying the organizational structure and functions (tasks) that the system should perform. It begins and ends with the construction of the OTS.

B. The structural aspect of the OTS creation is a consequence of the principles of integrity, hierarchy and analogy of structures and is devoted to the substantiation of the composition, the set of external and internal relations, the order and content of the interaction of OTS components in the production of HT.

C. The characteristics and parameters of the OTS corresponding to the OTS qualities identified in the course of functional and structural synthesis are defined in the technical aspect – the creation of the OTS.

OTS is a set of interrelated and interacting components. It is impossible to justify its structure, determine the nature and composition of links, quality and characteristics (parameters) of components and the system as a whole at once. Therefore, in accordance with the principles of integrity, hierarchy and analogy of structures, the OTS creation process is also decomposed into

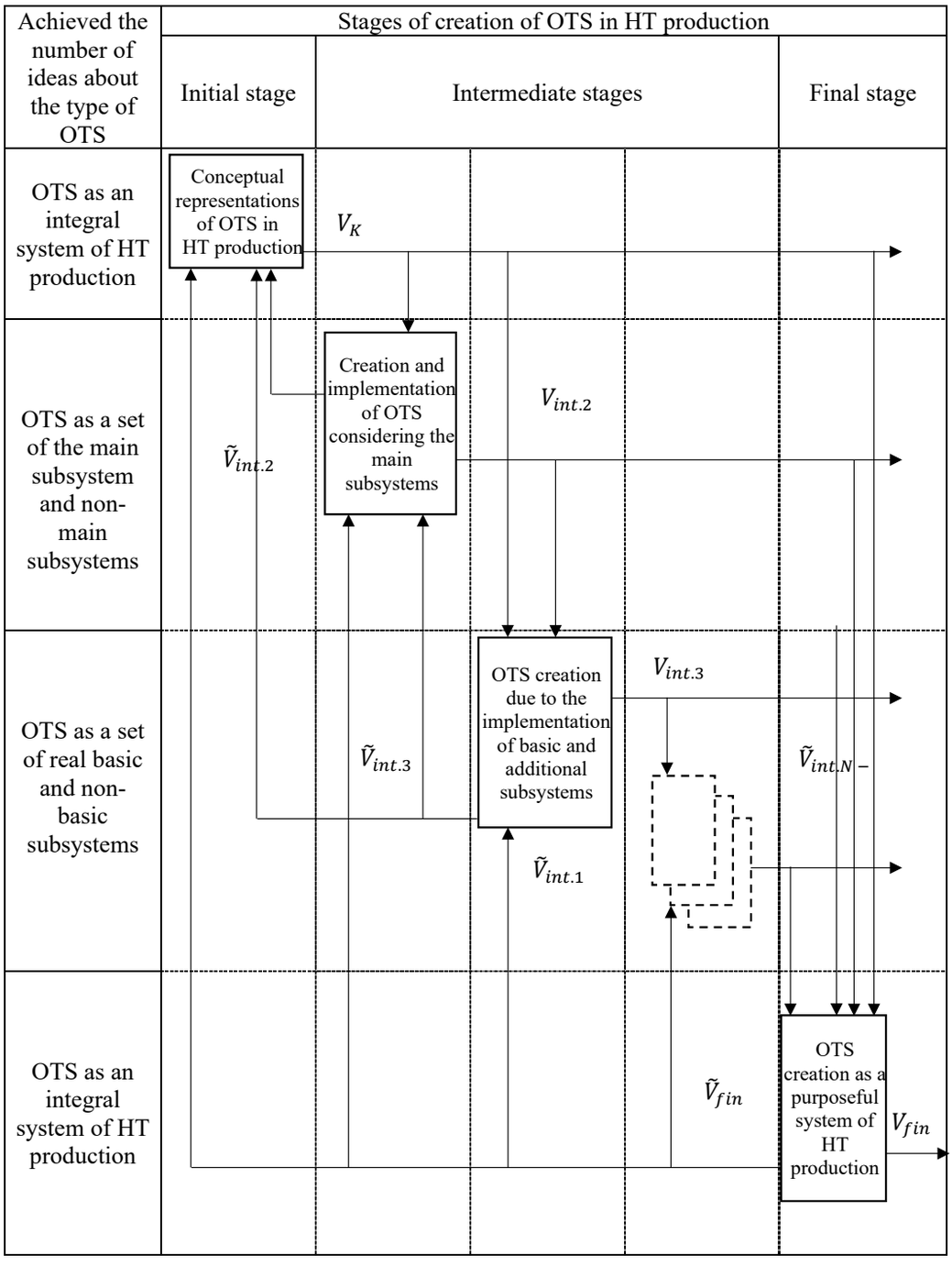

FIGURE 1 Stages of synthesis and creation of OTS in HT production
Source: authors' own development

processes, the content of which reveals the categories of creation levels for HT production.

The external qualities of the TS manifest themselves in its interaction with the surrounding systems (in the environment). However, the essence of these qualities is determined by the internal structure of the OTS. The qualities of the components of an OTS are manifested in the corresponding environment. At the same time, their cause is contained in the structure of smaller components. The increasing degree of detail of the OTS consideration is fixed in the levels of its description. These levels correspond to the levels of OTS creation (Figure 4).

The upper level is the level of external system analysis. Separate – the levels of intra-system analysis. At the level of external system synthesis OTS is considered as a complete system without disclosing the content of its construction.

At the levels of intra-system synthesis, an OTS is a set of interacting components. The number

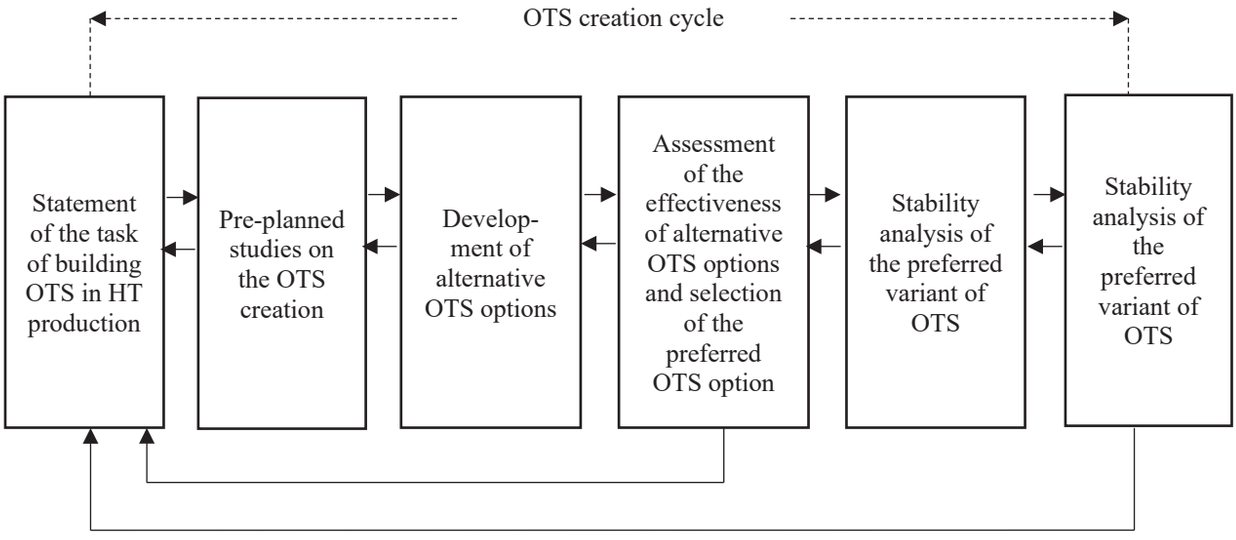

FIGURE 2 Phases of OTS creation

Source: authors' own development

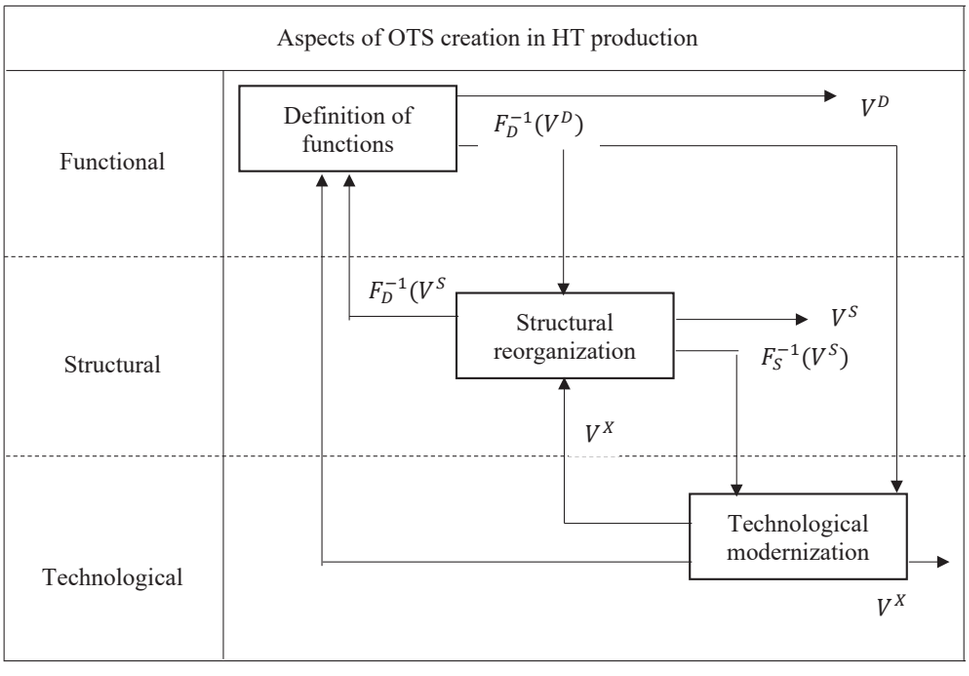

FIGURE 3 Aspects of OTS creation in HT production

Source: authors' own development

of levels of intra-system synthesis is determined by the required depth of disclosure of the OTS design. The level of synthesis of the external system provides justification of the qualities, characteristics (parameters) and functioning of its components, justification of which occurs at the levels of synthesis of the internal system. The level of synthesis of the external system begins with the synthesis of the OTS, at this level it ends. In the process of synthesis, the necessary correspondence between the qualitative characteristics of the TS, its structure and functioning, between the characteristics (parameters) of the TS components and the characteristics (parameters) of the system as a whole is gradually achieved as a result of multiple transitions from level to level of synthesis. Aspects and levels of construction are "embedded" in each other, in turn playing the role of the main process of OTS creation.

In the process of creativity, ideas about the general shape of the OTS change. Embodying these moving ideas, the categories as forms of construction organize the content of creativity. Between the categories of creativity there are mutual transitions, penetration into each other. The change of categories of creativity is caused by the exhaustion of possibilities of quantitative substantiation of

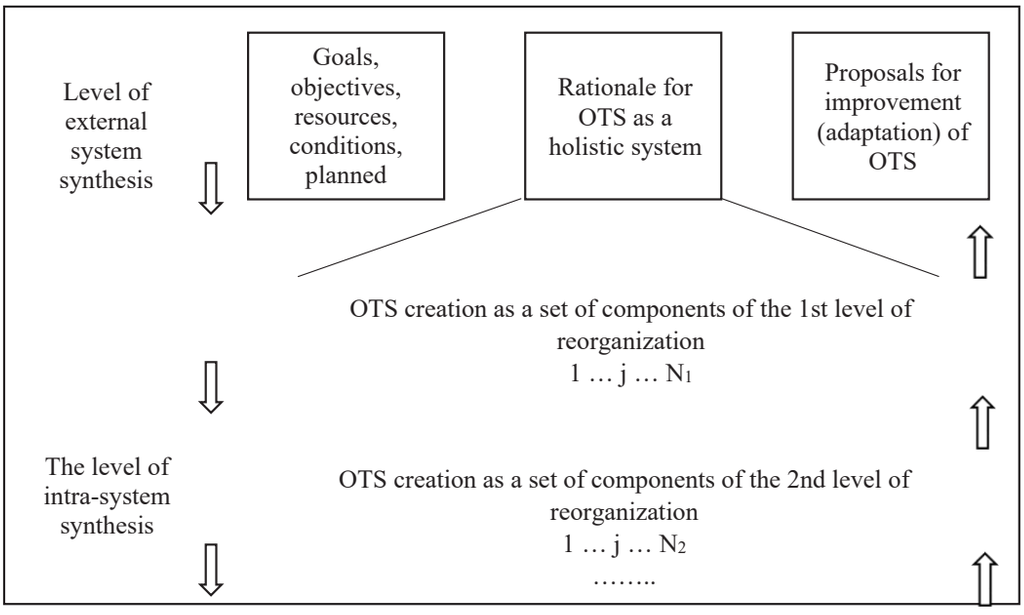

FIGURE 4 Levels of synthesis and creation of OTS in HT production
Source: authors' own development

qualities, characteristics (parameters) and functioning of OTS within the framework of the given form of construction and the necessity of their qualitative changes.

Decomposition according to the stages of TS creation serves as a basis, on which other types of decompositions are "strung" (Figure 5).

At the same time, within each stage of decomposition by stages (aspects and levels) of creation, they are "embedded" in each other, alternately performing a hierarchical main role. At the same time, within each type of decomposition, the hierarchical main aspect (level, stage, phase) can also change. As a result of this complex progressive movement of species within each type of decomposition, a cyclical iterative process with a non-stationary hierarchical structure is formed, which provides a gradual justification of the qualities, characteristics (parameters) and order of functioning of the future OTS.

6 Conclusions

The solution of particular problems of the intellectual development of OTS in HT production, arising in the decomposition of the general problem in the risky innovation economy, can be obtained using the known methods of synthesis of systems.

Empirical evidence collected by scientists in many countries has shown that state intervention translates into efficiency and sustainable growth at the

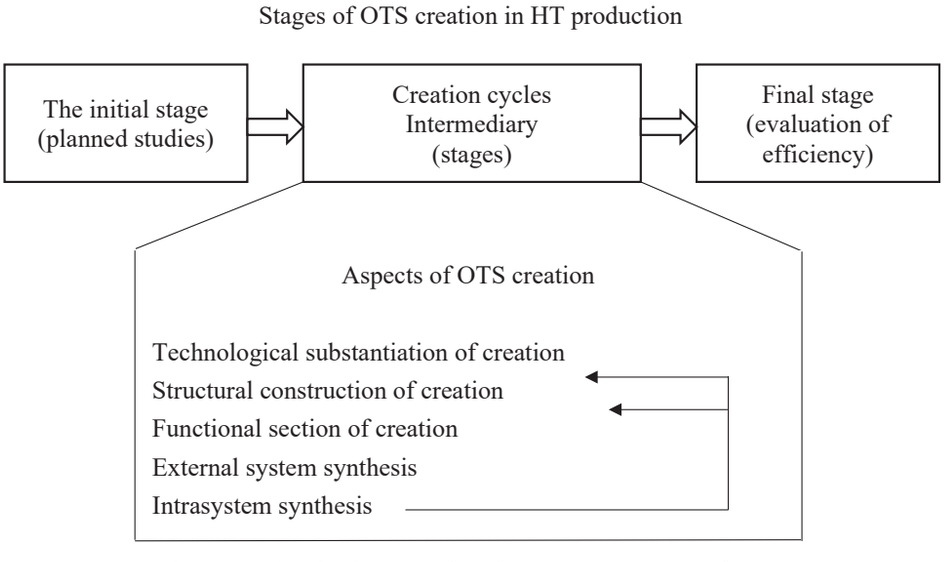

FIGURE 5 The OTS smart development in HT production
Source: authors' own development

enterprise level under certain conditions – domestic competition, international trade flows, research and development cooperation, labor mobility, foreign direct investment, quality management and transparency of HT bodies.

However, the presence of these conditions alone does not guarantee the growth of HT. Countries differ in their methods of stimulating HT, which differ significantly from the trajectories of their previous development, reflecting values, behavioral attitudes, traditional thinking and historical ties between the key actors of the HT process – enterprises, research institutes and educational institutions. Therefore, each country context considers a specific set of problems and ways of solving them.

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