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An Approach to Modeling Innovation Obsolescence

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***Abstract*. Currently, the Fourth Industrial Revolution (FIR) has a very strong impact on innovation activity and innovation obsolescence. In order to formulate a methodology for the selection of alternative solutions, it is necessary not only to take into account the impacts of FIR, but also to choose an approach for modeling innovation obsolescence. The aim is to propose a new approach for modeling innovation obsolescence, in which the influencing factors will already be present in the innovation development methodology.**

Keywords: alternative solutions, approach to modelling, innovation obsolescence.

I. INTRODUCTION

The rapid development of information technologies (IT) reduces risk, has a positive impact on the competitiveness of the enterprise, contributes to the faster and more targeted development of innovations in the industry [2]. The widespread implementation of such systems in the Republic of Bulgaria and the world, as well as the opening of European and global markets, created a dynamic and difficult to predict environment in which industrial companies and their competitors are forced to constantly develop and change their products and services. and thereby transform the accompanying business technology model [1]. In response to this need, a number of studies have been conducted. To establish control, organizations introduce formal methods for iterating technological and business processes and changing business models [15]. There are many tools and models for strategic innovation development. But most of them describe the problem statically, i.e. at a certain point in the development of the company, and the time factor is not taken into account, and it is the decisive one for any start-up business company [10].

This is precisely the reason to look for a new, integrated approach of methods and tools for the implementation of an information system related to the innovative development and obsolescence of industrial technologies [3].

The aim of the article is to propose a new approach to modeling innovation obsolescence, in which the influencing factors will already be present in the innovation development methodology.

II. EXHIBITION

The integrated approach to modelling obsolescence (innovative and planned) defines the following sequence, virtuality and solution scope, namely:

- A virtual server provides access to its own or licensed applications in the cloud for its own or licensed applications, without providing it with the ability to control or manage the infrastructure resources themselves.
- This provides the ability for the user to design, deliver and store networks and other computing resources, while retaining the right to add and run any other software.
- Load and run multiple applications and operating systems on a single machine, simulating an individual virtual environment. It is usually used for the installation of hardware devices in a customer base and that too as network devices [7].

Before starting the development of the technology solution, the modelling of the innovation is subject to a number of studies and validation of the marketing product idea as well as that of the sales channel. This reduces the risk of failure of volume developments in the market [12].

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The rapid development of communication and information technologies not only reduces risk, but also has a strong impact on the ability of industrial companies to develop innovative activities faster and more purposefully [6]. A dynamic and hard-to-predict environment is being created in which companies are forced to flexibly search for alternative solutions to the factors negatively impacting their activities. There are many tools and models for strategic innovation development and evaluation. Most of them describe the problem statically, i.e. at a certain point in the firm's development, while the components of time and innovation obsolescence are not taken into account [11].

2.1. Significance of the Innovation Development component

The influence of innovative development on technology arises from the improvement of existing and the construction of fundamentally new machines, devices and equipment [13]. According to their purpose and productivity growth rates, they can be divided into two main groups:

- machines and equipment with special requirements, intended to produce uniform production on a mass scale and

- machines and equipment intended for performing a variety of activities, i.e. with universal purpose.

In recent years, a trend of strong unification and standardization of the elements in machine assemblies based on the modular principle has been noticed. The goal here is to create conditions for the rapid assembly of machines with different technological purposes, but with a universal purpose, for the needs of the new cyber requirements [2].

The study of the regularities of the development and improvement of the technique with special and universal purpose makes it possible to determine the period in which the greatest effect can be obtained from a given generation of machines intended for a specific production process, and at the same time the period of transition to the production of new types of machines, for the new intelligent production systems [8].

In the modern conditions of accelerated scientific and technical progress, the importance of this direction and its manifestation on the rates and scales of the innovative obsolescence of the technique has significantly increased. The real consequence of this impact is expressed in increasing the scope and terms of innovative obsolescence of the machines and equipment in operation and the rapid change of their structural composition.

Innovative development is expressed in the creation of new materials [9]. They, in turn, have an active impact on accelerating the innovative obsolescence of the technology used in production. This influence is determined by the wide application of new materials, alloys, plastics and others with specific characteristics and suitability for processing a specific type of machine [4]. The extent of their use in production depends on the proportion of unnecessary equipment that is adapted to processing the old materials. This is precisely the impact of innovative development on technological processes.

The changes occurring from the application of new technologies in all cases play an active role in the production process, as a result of which the relative share of the old technological processes is constantly reduced, and together with them, the machines and equipment used for this purpose. On the other hand, it is related to the professional training, the improvement of the methods of increasing the qualification and the training of the personnel in the enterprise [14]. Substantial changes occur in the qualification composition of the personnel, as a result of which a large number of new professions appear, old ones disappear, changing the ratio between individual groups of professions, which is the subject of Industry 5.0. Different human resources management practices in competitive environment are described. Organizational learning is a basic component of organizational intelligence. Also, it is a strategic organization re-source that appears in all organizational levels. Organizational learning is based on the integration of individual and group level of learning. Transformation into a learning organization will assure advantage in knowledge-based economy trough creativity and intelligence of organization’s personnel and its ability for learning and development [16]. The methodology and the aim of the research, the concrete tasks and results of implemented research in factories from machine-building and human resources are object in Industry 5.0 [17].

The development of the technique leads to significant changes in the methods of its exploitation on the one hand, and on the other hand to the improvement of the methods for changing the nature of the work and increasing the qualification of the personnel.

2.2. Significance of the Innovative Obsolescence component

At the current stage of technical development worldwide, innovative obsolescence takes precedence over physical obsolescence. Therefore, a particularly important point in this direction is the correct determination of the degree of innovative obsolescence. The goal is to establish the impact of innovations on the technical, economic and social results of industrial activity. Correct assessment of their impact on the scale and timing of innovative obsolescence is of utmost importance for timely elimination of the negative consequences of their impact. This process is influenced by the two directions of innovative obsolescence.

The first direction of innovation obsolescence is an inevitable consequence of innovation development in the field of technique and technology in industries producing industrial products [5].

Cost growth in industries that produce industrial products is relatively decreasing. The rate of decline depends on the rate of labor productivity growth already on a global scale. The rate of real product cost decline will be lower than the rate of productivity growth. This rate is determined by the ratio between the "growth of labor productivity" index and the "growth of real wages" index. Given that the growth of real wages is lower than the newly created value of the public product, it can be said that the rate of real decline in the price of products equals n% per year.

In this way, the social cost of engineering products will be determined by the expression:

$$K_i = \frac{K_0}{(1+0{,}01b)^{t-1}} \quad (1)$$

where K_i is the value of the article; K_0 is the value of the product in the first year; b – relative decrease in the cost of the product compared to the increase in labor productivity; t – final year.

The deprecation of the same products as a results of innovation obsolescence in the first direction is determined by the expression

$$K_n = K_0 - K_t = \left[1 - \frac{1}{(1+0{,}01b)^{t-1}}\right] \quad (2)$$

where K_n is the innovation obsolescence in the first direction.

The second direction of innovative obsolescence arises under the influence of innovative solutions, expressed in the designed and implemented in production new, more modern, more productive and with better technical and economic indicators machines, devices and equipment compared to those produced before them. In these cases, the efficiency of using the old machines and equipment will be significantly lower, and they themselves will depreciate to a certain extent. The effect of using such machines and technologies will be reduced, and the amount of this reduction will depend on the strength of the manifestation of the factors characterizing their innovation obsolescence. The second direction of innovation obsolescence contains some features that most fully reveal its essence and the economic consequences of its influence on the elements of production. The main feature is that it gives rise to a partial or complete devaluation of machines and technologies and their use value, as a result of which there is a need to replace technically obsolete machines before the period of their physical wear and tear has expired. The economic expediency of such a replacement is not determined by the very fact of the appearance of new machines with a similar technological purpose, but above all by the degree of innovation obsolescence of the existing machines and the level of reduction in economic efficiency from their continued use. It should be borne in mind that the loss of consumer value and the need to replace machines and technologies with new ones is determined by a number of factors reflecting the specific directions of the influence of innovative development.

Taking into account these factors characterizing the qualitative side of innovation development and obsolescence allows to reveal not only the mechanism of its impact on production efficiency indicators, but also its impact on different sides of the production process.

2.3. An integrated modelling approach

For a more accurate and correct accounting of the benefits and effects of innovation development and innovation obsolescence, the development of the problem should be considered comprehensively. This means that the problem characterizing the qualitative nature of indicators such as the ***degree of innovativeness*** and ***innovation activity***, which are inherent in innovation development and the indicators of innovation obsolescence, are part of the alternative solutions inherent in rapid innovation obsolescence. Therefore, both components should be considered as a complex integrated solution model. The integrative nature of this approach is based on the fact that it involves more influencing factors influencing the efficiency of the innovation activity of industrial firms. The solution structure includes several methods defined as an integration model [4]:

- ***Method for determining the degree of innovation (J_{ino});***

Mathematical methods and models can be applied to determine the degree of innovativeness of products and processes, and specific indicators are used to solve them:

- Technical indicators (new);
- Indicators determining user essence (applicability);
- Commercial implementation (market).

Technical (J_{teh}), consumer (J_{pot}), investment (J_{inv}) and other indicators (J_{kk}, J_{eko}) are used at the idea screening stage when developing new products

$$J_{ino} = J_{teh} + J_{pot} + J_{mt} = J_{teh} + J_{pot} + J_{inv} + J_{kk} + J_{eko} \quad (3)$$

The degree of J_{ino} innovation is defined as the sum of the results of the separate indicators, taken as relative weights, subject to the condition:

$$J_{teh} \le 1;\ J_{pot} \le 1;\ J_{mt} \le 1;\ J_{ino} \le 3.$$

$J_{mt} = J_{inv} + J_{kk} + J_{eko}$ – market indicators.

When using the condition:

$$J_{mt} \le 1, J_{inv} \le 0{,}33, J_{kk} \le 0{,}33, J_{eko} \le 0{,}33.$$

Technical indicators (J_{teh}) are the most important because the main thing about them is the higher productivity, as well as the economy of materials, labor, energy, quality improvements and others of the new product compared to the old one or similar to it. The technical indicator (newness) has 100% significance in the study. The remaining indicators can take zero values (0%).

Hence $J_{ino} = J_{teh}$.

- ***Method for innovation activity ($S_{(t)}$);***

The determination of innovation activity over a given period of time, under predefined parameters, can also be modelled. Through the innovation activity model, it is revealed how products are perceived as attractive among real and potential users. The innovation activity model can be widely used in product and technology forecasting.

$$S(t) = m.f(t)\ , \qquad (4)$$

$$S(t) = m.\frac{(p+q)^2}{p}.\frac{e^{-(p+q)t}}{\left(1+\frac{q}{p}.e^{-(p+q)t}\right)^2}\ , \qquad (5)$$

where **m** is final marketing potential.

The model is suitable for use in a wider range of innovative products, although solutions vary widely.

- ***Innovative aging method (M);***

Innovative obsolescence is measured by the degree of depreciation of any of the functions of old machine designs compared to those of newly manufactured innovative ones. They are determined using the formula:

$$M=W.K \qquad (6)$$

where M is innovation obsolescence, (depreciation of the functions of old machines in BGN); W - initial value of the old machine in BGN; K - coefficient accounting for the percentage level of innovation obsolescence, changes in the limits $-1 \leq K \leq 1$, as:

- at K=1,0 there is no innovation obsolescence (the machine is 100% innovative);
- at K=0,5 the machine is half innovatively obsolete or 50%;
- at $K \leq 0$ the machine is completely innovatively obsolete or with 0% innovativeness.
- ***Method for alternative solutions (AR).***

The rapid innovation obsolescence of products and services presents humanity with the solution of the problem of removing the harmful consequences of its impact. Alternative solutions against rapid innovation obsolescence AR depend on

$$AR=F(J, S, M) \qquad (7)$$

where J is the degree of innovation; S - innovation activity; M – innovative obsolescence.

The relationships between these components define a system dependency, or the entire functional structure has a systemic character. Therefore, it can also be represented as an integrated model based on system dependence or an integrated model.

The model is based on the following mathematical relationship:

$$(J_n.\left(\frac{1}{n}\right)).S_n - (J_m.\left(\frac{1}{m}\right)).M_m = (J_n.\left(\frac{1}{n}\right)).S_n - AR \ (8)$$

where: J_n is the value of the base (innovation) product, at a certain degree of innovation; S_n - the investment return time for the innovation (base) product, or the time when the product is in operation (it is customary to call it the "period of innovation activity"); n – number of periods (months, years), before and after the occurrence of innovation obsolescence; M_m – the time since the occurrence of innovation obsolescence of the base product; m - number of periods (months, years) after the occurrence of innovation obsolescence.

III. CONCLUSONS

Based on the above, the following conclusions can be drawn:

- The methodology for choosing alternative solutions against rapid innovation obsolescence has been formulated.
- The interrelationship (constellation) between innovation development, innovation obsolescence, innovation activity and programmed obsolescence was investigated.
- An integrated model was developed and pro-posed for the selection of alternative solutions against rapid innovation obsolescence based on the methods for: determining the degree of innovation; innovation activity; innovative obsolescence and for alternative solutions.

The development of innovation technology is closely related to the operational life of machines and their physical and innovation obsolescence. This aging can be predicted and partially controlled.

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