Method for evaluating innovativeness of an enterprise in the conditions of the digital economy

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Abstract. The article discusses a method for assessing the innovativeness of an enterprise in digital economy, based on the collection of information according to the certain assessment criteria, and also includes a developed mathematical apparatus for calculating the integral index of innovativeness. The article proposes an “Entry-Exit” assessment model.

1. Introduction

In the digital economy, the main factor ensuring the competitiveness of an enterprise is the ability to innovate [1]. To ensure this the company should accumulate sufficient resources, provide itself with innovative potential. In addition to preparing the base, the company must constantly use it for the development and production of innovations, in other words be an innovatively active enterprise.

With the transition to a model where innovation is a key factor in the development of an enterprise, the question of assessing innovation has become acute, since the company's management needs to have a complete understanding of the economic economy for competent decision-making [2].

At the moment there are many approaches to assessing innovation, most of them are based on collecting information on a set of criteria and then calculating the average value by the arithmetic mean or root mean [3]. The advantage and at the same time the disadvantage of these methods is their simplicity. The proposed report is devoted to a non-standard method of assessing innovation activity - a method based on the “Entry-Exit” model [4].

2. “Entry-Exit” model

The objective of the research is to develop a method for assessing the innovative activity of an enterprise based on the "Entry-Exit" model. The method is suitable for the conditions of an industrial enterprise, providing the collection of a large set of indicators, which, after processing, can be converted through a mathematical apparatus into a single integral index of innovation. The method model consists of three main parts and is also called the "Input-Output" model (figure.1).
The model receives as input the values of indicators - a set of values $X$, the input parameters. The initial values are transformed by a mathematical apparatus consisting of functions and coefficients, which are designated as the group $Z$. The output is the values of the group $Y$, by which the integral index of innovativeness is determined. The integral index of innovativeness is calculated according to formula 1.

$$ I = X\alpha + Y\beta + Z\gamma, \quad (1) $$

where: $I$ - the index of innovativeness; $X$ - input parameters; $Y$ - output parameters; $Z$ - conversion parameters; $\alpha$ is the entry coefficient; $\beta$ is the yield factor; $\gamma$ - conversion factor.

From here it is necessary to find the alpha, beta and gamma coefficients. We transform equation 1, taking from it the natural logarithm, formula 2.

$$ \ln(I) = \alpha \ln(X) + \beta \ln(Y) + \gamma \ln(Z), \quad (2) $$

Let's take a closer look at $X$, $Y$, $Z$ - this is a set of conditions that influence each other and set innovative activities.

Factors $X$ include factors of the innovative potential of the enterprise [5]:
- The innovative climate of the enterprise
- Availability of information
- Knowledge and experience management system
- System of motivation and training of employees
- Information and communication technologies

The factors that form the mechanism $F$ are the innovative activity of the enterprise [6]:
- Timely delivery of materials
- Equipment upgrade
- Providing investment flows
- Project management system

Let's list the factors of result $Y$ - innovative performance [7]:
- Product patenting system;
- Strategic marketing system;
- Product distribution system.

Therefore, innovativeness can be represented as a function that depends on $X$, $Y$, $Z$, formula 3.

$$ I = f(X;Y;Z), \quad (3) $$

Each of the indicators that define $X$, $Y$, $Z$ are assigned significance coefficients:
1) from 0 to 10 - the indicator's power, in other words, how much it is able to express itself and influence innovativeness, the magnitude of the indicator's amplitude.
2) The degree of influence on innovativeness in the range from -5 to 5, which expresses the relationship between the indicator and innovativeness.

The degree of influence can be directed in different directions: a value from 0 to 5 means a positive impact on innovation, a value from 0 to -5 means a negative impact on innovation, a value of 0 means no impact on innovation.
The same can be represented as a vector with a deflection angle $\varphi$. The influence is positive if $\varphi = (0; 180]$, negative if $\varphi = [-180; 0)$, has no effect if $\varphi = 0$.

Thus, the expression can be written in the form of formula 4

$$I = Y \cos \varphi_y + X \cos \varphi_x + Z \cos \varphi_z,$$  \hspace{1cm} (4)

This equation describes innovative activity only if the factors $X$, $Y$, $Z$ do not depend on each other, otherwise they will begin to duplicate each other. Therefore, it is necessary to apply the coefficients of influence.

$Kxz$ - coefficient of dependence of $X$ on $Z$.
$Kyz$ - coefficient of dependence of $Y$ on $Z$.
$Kxy$ - coefficient of dependence of $X$ on $Y$.

Then the values of the functions $X$, $Y$, $Z$ take the form according to the formula 5,6,7:

$$X_f = K_{yx}Y + K_{zx}Z + X,$$ \hspace{1cm} (5)

$$Y_f = K_{yz}Z + K_{yx}X + Y,$$ \hspace{1cm} (6)

$$Z_f = K_{zx}X + K_{zy}Y + Z.$$ \hspace{1cm} (7)

Then the sought function of innovation activity can be represented in the form of formula 8:

$$I = X_f \cos \varphi_x + Y_f \cos \varphi_y + Z_f \cos \varphi_z.$$ \hspace{1cm} (8)

The proposed formula has a graphical display in the form of a set of functions with given amplitudes $X$, $Y$, $Z$, which is shown in Figure 2.

The proposed methodology for assessing the value of an enterprise's innovativeness, in addition to the interrelation of factors, takes into account the strength of their manifestation, their focus on achieving the key goal of the organization - the implementation of innovations. The use of the vector approach expands the possibilities of analytical presentation and interpretation of the results obtained, which is necessary to increase the level of innovativeness of the organization.

3. Conclusions.
The article describes an "Entry-Exit" model for assessing the innovativeness of the enterprise. Also the mathematical apparatus for assessing and deriving a single integral index of the innovative activity of the enterprise is analyzed, the final formula is derived, which takes into account the degree of
influence of the indicator on innovativeness, the amplitude force, as well as the degree of mutual influence of indicators. In the future, it is possible to conduct a study in order to adapt the given methodology to specific industries and enterprises. Other original assessment methods should also be considered.

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