Assessment of the Intensity of Russian Machine-Building Complex Innovative Potential

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Abstract. This paper proposes a new approach to innovative potential assessment using the transfer function of the system. A mathematical model intended to manage the intensity of using the innovative potential of the machine-building complex of Russia was developed.

Key words: potential, intensity, innovation, transfer function, flow density, system stability.

Introduction

Technological development of society associated with informatization and computerization requires a change in the qualitative properties of the national economic system and its transition to new principles of functioning. According to the theory of complex open nonlinear systems, the possibility of a transition to a new path of development arises at bifurcation points - points of solutions ramification when the system is in an unstable state. This is the current state of affairs in the economic system. Instability leads to the impossibility of making reliable forecasts of system development, since it is significantly influenced by random factors that cannot be taken into account to the fullest extent. At the same time, the modern economic model, which is characterized as rapidly changing, requires maximum flexibility from all market agents. In such a situation such factors as scientific, technological, innovative, informational development of industries come to the fore. Accordingly, it is necessary to choose adequate methods for the management of key industries, which include machine-building. The relevance of the innovative and technological development of mechanical engineering in the Russian Federation is due to the need to increase the competitiveness of domestic products, increase exports and gain leading positions in world markets. Development of mechanical engineering in the Russian Federation at the present stage of economic relations is closely associated with innovative developments. Studies showed that innovative activity in the machine-building complex of the Russian

Federation is in its infancy, which is primarily due to low costs for technological, marketing and organizational innovations in the production of machinery and equipment[]. Another problem of mechanical engineering innovative development is weak diffusion of innovations. This is evidenced by an extremely small share of costs for personnel training and market research. Expenditures for technological innovations in the production of machinery and equipment by sources of financing show that the main source of financing is organizations' own funds. At the same time, it seems that active financial and regulatory government support, which exists in many countries, is needed to increase the competitiveness of innovative developments in the machine-building sector of the economy. The article proposes and tests new aggregate indicators for the assessment of the organization's innovative activity results.

1. Innovation potential in the system of innovative development of the industry

Unfortunately, innovation activity in Russia is characterized by low activity, despite the fact that it is innovations that are the main factor of economic growth. According to statistical studies, the share of organizations that carried out innovations in 2015 amounted to 10.6% of the total number of organizations. According to the research carried out by Rosstat in cooperation with the National Research University Higher School of Economics, factors hindering technological innovation include low demand for new goods, high cost of innovation, lack of information about new technologies and sales markets, and underdeveloped cooperation ties.

Innovative development at this stage is a priority area of the country's development strategy. The state pays special attention to the innovative development of the country - develops programs, strategies, decrees. So, transition to an innovative type of economic development is the main direction of development in strategic documents in the area of innovative development.

Innovation potential is the main feature of the innovation process. There is no generally accepted definition of innovation potential in the literature. In accordance with GOST R 54147-2010, innovation potential is a combination of various types of resources, including material, financial, intellectual, informational, scientific and technical and other resources necessary for the implementation of innovative activities.

From there innovation potential shall be understood to mean material, intellectual, personnel, financial and other capabilities of the production or socio-economic structure (of the industry, enterprise, region), with the help of which new technologies can be effectively used in practice.

Trends and practice of innovative development of domestic production give rise to the need to search for assessment methods that reveal the effectiveness of using the innovative capabilities of economic entities.

2. Indicators of innovation activity

The intensity of using innovative potential is one of the most important indicators of the organization's innovation activity.

The intensity of using innovative potential is characterized by the speed (V) and density (P) of the financial flow (F) aimed at the development and implementation of innovations.

The intensity of using innovative potential can be written as follows:

$$I = V\,P \qquad (1)$$

To determine the speed of the financial flow, it is proposed to use the linear time trend W_l of the transfer function of the innovation process in the following form [2-5]:

$$W_l = Vt + b, \qquad (2)$$

where V is the coefficient characterizing the speed of change of the innovation process transfer function (1/year),

t - trend time interval,

b - value of the transfer function at the point of reference.

The speed of change of the innovation process transfer function can be written as follows:

$$V = \frac{dW_l}{dt} \text{ (1/year)} \qquad (3)$$

It is possible to ensure the sustainable development of the innovation process by controlling the speed.

The density of the cash flow can be determined as follows.

The absolute value of density is estimated as:

$$\Delta = F_2 - F_1, \qquad (4)$$

where F_1 is the input value of the financial flow in the system (innovation costs),

F_2 is the output value of the financial flow after innovation transformation into a product.

The relative density can be calculated using the following formula:

$$P = \frac{\Delta}{F_1} = \frac{F_2 - F_1}{F_1} = W - 1 \qquad (5)$$

So, the intensity of the innovation flow can be found according to the following formula:

$$I = \frac{dW}{dt}(W - 1). \qquad (6)$$

Table 1 contains information about the innovative potential of the machine-building complex based on the statistical data [3-13]. The transfer function of the system, the speed of change of the transfer function and the intensity of the innovation process were determined.

Table 1. Innovative potential of mechanical engineering

Years	2011	2012	2013	2014	2015	2016	2017	2018
Innovation costs X, billion rubles	10.6	11.7	12.3	14.6	19.2	18.0	18.6	13.9
Shipped goods U, billion rubles	47.3	58.4	62.3	68.8	56.2	56.6	97.0	68.2
Transfer function $W_l = Vt + b$	4.5	4.9	5.0	4.7	2.9	3.1	5.2	4.9
Transfer function change speed $V = \frac{dw}{dt}$	-	0.4	0.1	- 0.3	- 1.8	0.2	2.1	- 0.3
Intensity of the innovation process I = V(W – 1)	-	1.56	0.4	- 1.1	- 3.4	0.42	8.8	- 1.2

Figure 1 shows real and linear approximation of the transfer function of mechanical engineering innovative potential use intensity [1]. It is seen from the Figure that the transfer function Wp is oscillatory. The linear approximation is decreasing:

$$W = b - kt, \qquad (7)$$

where b = 4.6 billion rubles,

k = - 0.07 is the speed of change of the process 1/year.

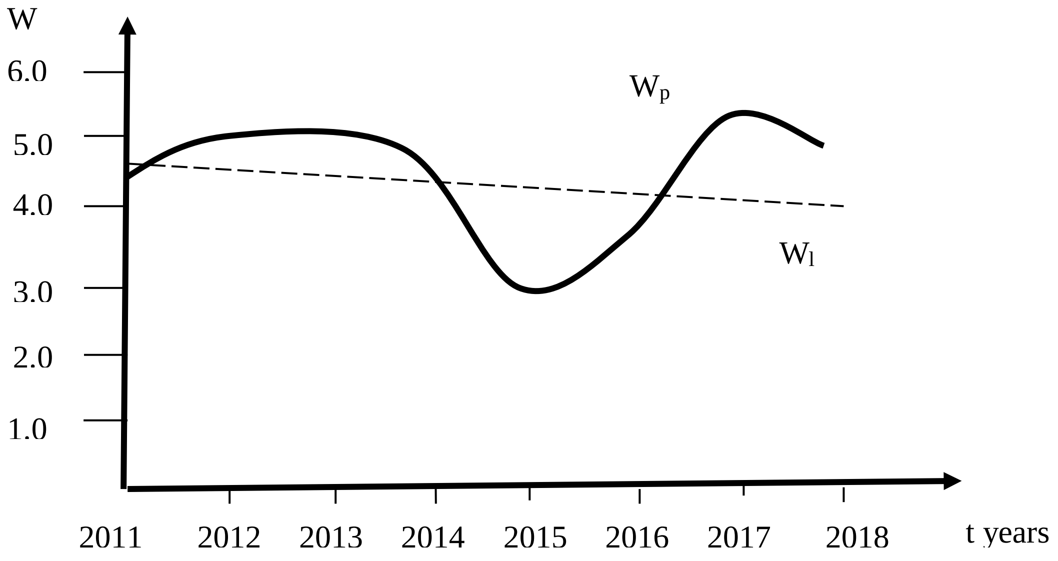

Fig. 1. Real and linear approximation of the transfer function of mechanical engineering innovative potential use intensity

Figure 2 shows changes in the transfer function - Wp($_t$) and intensity - I(t) of the innovative process of mechanical engineering in time. The Figure shows that the transfer function is oscillatory.

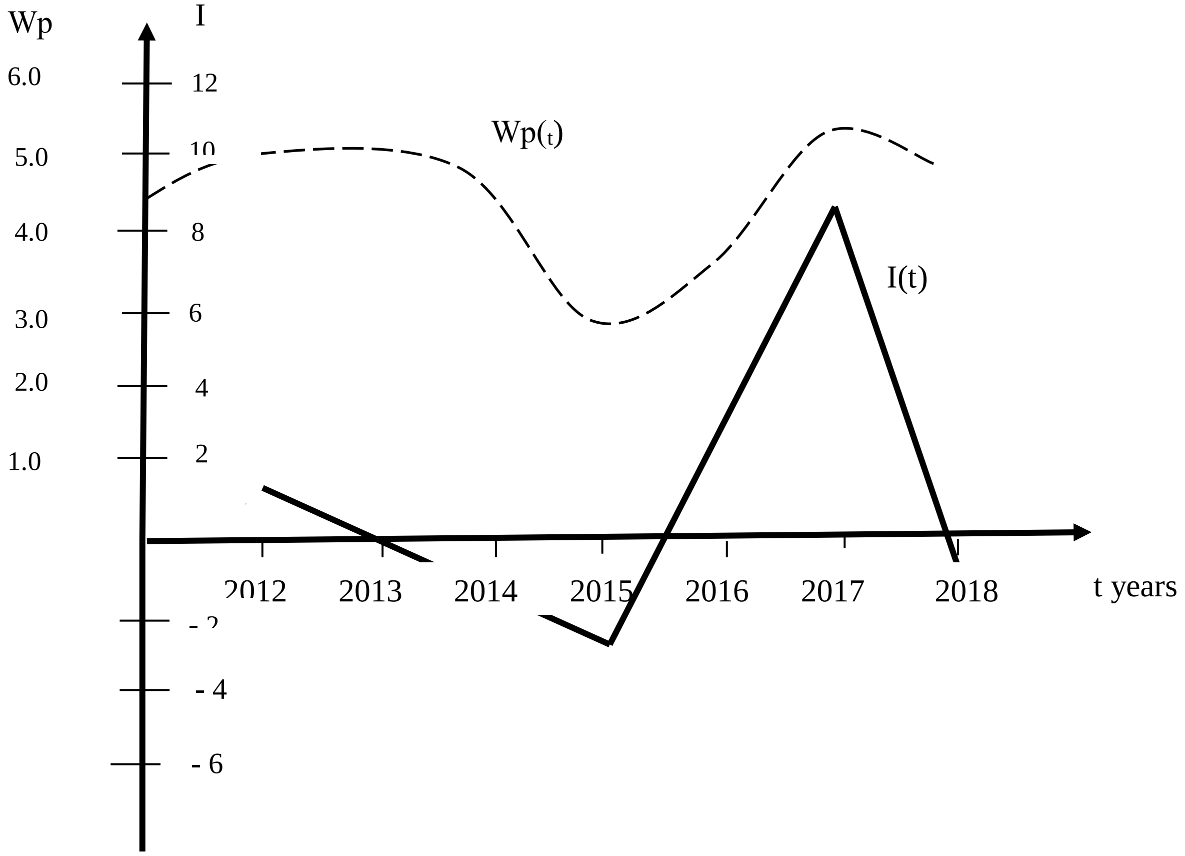

Fig. 2. Mechanical engineering innovation process intensity

3. Results of innovation flow intensity mathematical modeling

Based on the results of the study, the following conclusions can be drawn:

1. The intensity of the innovation process allows studying effective management of the system. The positive part I(t) means the effective potential, the negative part means the negative efficiency of the system. Inflection points mean system transition from negative to positive speed and vice versa. The amplitude of this function can be used to estimate the maximum values of both positive and negative system efficiency.

2. The average flow speed can be found using the following equation:

$$Iav = , \int_{T_1}^{T_2} I(t)dt \qquad (8)$$

The positive intensity of the innovation flow (see Fig. 2) is about $Iav_{+} = 9$ units. The negative intensity is about $Iav_{-} = 7$ units.

3. Turbulence (vorticity) of the process can be found by the following formula:

$$Z = n/T = 0.3, \quad (9)$$

where n = 2 is the number of peaks of the innovation process intensity function (pieces),
T = 7 - time interval at which the peaks occur (year).

4. Having determined the points of intensity function transition through the time axis, it is possible to predict and control innovative processes of the system.

5. It is possible to assess the effectiveness of innovation processes management based on the ratio of the positive area of the innovation flow intensity to the negative one.

Conclusion

So, mathematical modeling of the innovation flow intensity makes it possible to find optimal parameters for machine-building complex effective management.

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