SIMULATION OF STRATEGY DEVELOPMENT PRODUCTION IN DEFENSE-INDUSTRIAL COMPLEX[1]

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The article describes the methodological framework and tools for manag-ing the strategic development of production created by the defense-industrial complex of Russia. A model of the development strategy of producing the products is worked out, the background and stability of the simulation results are analyzed.

Keywords: *modeling, strategy, defense-industrial complex, development, manufacture, production.*

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МОДЕЛИРОВАНИЕ СТРАТЕГИИ РАЗВИТИЯ ПРОИЗВОДСТВА ПРОДУКЦИИ В ОБОРОННО-ПРОМЫШЛЕННОМ КОМПЛЕКСЕ

В статье рассмотрены методологические основы и инструментарий управления стратегическим развитием производства продукции, создаваемой оборонно-промышленным комплексом России. Разработана модель стратегии развития производства данной продукции, проанализированы исходная информация и устойчивость результатов моделирования.

Ключевые слова: *моделирование, стратегия, оборонно-промышленный комплекс, развитие, производство, продукция.*

1. Introduction

On modeling strategies for the development of manufacturing production in the defense-industrial complex (DIC) is dedicated to a number of scientific studies [1, 2, 3]. However, considered in these papers models have mostly conceptual character. They are generally not considered interbranch balance in the defense industry sectors; solution of the problem is sometimes performed under deterministic factors, which is not true; various strategies to increase production of military and civil products created by defense enterprises are not considered in complex; available statistical database not fully used and technological connection of military production are not included in the structure. Therefore there is an urgent need to develop methodologies and modeling tools development strategies of manufacturing production, created the DIC.

2. Methodological framework and tools for managing the strategic development of production created by DIC

The following main features has production in the defense-industrial complex:

– large scale and a huge range of products produced (up to 2 million titles);

– increased the possibility of monopolization of production;

– a significant division of labor in the defense industry and the high level of specialization in it, which complicates the managerial decisions and increases the transaction costs of production;

– smaller than most other sectors of the economy, connectivity with the market , as defense companies are less focused on the mass market. The main share of products manufactured by enterprises of defense industry for the state routinely and therefore the possibility of use in this limited market relations;

– large, compared to other industries, the susceptibility to the budget deficit, since the bulk of the defense enterprises largely financed from the federal budget;

– tradition and the great positive experience centralized vertical control defense companies as to ensure their activities created a complex and extensive system of resource allocation and management of state property.

Therefore, regulation of long-term development of production in the DIC is implemented primarily by strategic management rather than market.

Conducted analysis of multiple sources showed that the problem of strategic management of manufacturing production in DIC systemic has not yet been solved, because it is a complex and multi-component. One component of it (the problem) is a methodological and instrumental. It concerns the establishment of the criteria, rules, principles, methods, techniques, algorithms, procedures development, evaluation and validation of promising directions of development of production created by the DIC. Another component – provides – is to create the most effective mechanisms for achieving production goals defined priorities of its development. The third component – the realizable – is directly in the management of manufacturing production.

The first problem is solved mainly customers products created DIC. The main criteria used by them in dealing with this problem are often military-technical rather than economic performance. However, in terms of modernization of defense industry is necessary to mobilize its adaptive capacity in the long term. This leads to the need to improve the methodological foundations and tools development strategy production in DIC.

Validation of the indicated methodological foundations expedient to, in our opinion, under the following scheme: “the construction of a military

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mission – the situation in the economy – government, military and economic policy – an analysis of production in DIC – develop strategies and programs for the development of this production". Techniques and methods of influence on the development of production tools are strategic management. The main elements of this toolkit include models, algorithms, and performance. They should, in our view, to cover all components of the following relationship: factors phenomena → factors → direction of development → projected results → planned changes that achieve the projected results. This tool should be focused on the new challenges of military construction in the modernization DIC optimize the level and structure of defense production.

Defense-industrial complex in modern conditions must simultaneously solve two problems: its innovative modernization of enterprises and increasing the production of military products in accordance with the growing and changing needs of the Armed Forces of the Russian Federation. Simultaneous solution of these problems is possible in the transition from the reducing DIC development, carried out in the first decade of the XXI century, to advanced innovative reproduction of military products. Based on the foregoing, the development strategies of production in the DIC (S) may be the main ones that provide:

1) S_n – the highest possible volume of defense products $У_в^в$ for all branches DIC subject range, nomenclature, and completeness of the required volume of production of the end products for military $У_в^*$ and civil $У_{гт}$ purposes:

$$S_n \Rightarrow \max\{У_{вn}^{в}\} at \{У_в^* = У_{вт}^*\} and \{У_г = У_{гт}\}; \quad (1)$$

2) S_m – the maximum possible volume of military products group priority in the period under DIC branches, subject range, nomenclature, completeness and the required volume production of the end products for military and civil purposes:

$$S_m \Rightarrow \max\{У_{вm}^{в}\} at \{У_в^* = У_{вm}^*\} and \{У_г = У_{гт}\}; \quad (2)$$

3) S_1 – maximum possible volume of military products only one, the most important industry in the circumstances DIC, subject range, nomenclature, completeness and the required volume of manufacture of final products for military and civilian:

$$S_1 \Rightarrow \max\{У_{в1}^{в}\} at \{У_в^* = У_{вт}^*\} and \{У_г = У_{гт}\}; \quad (3)$$

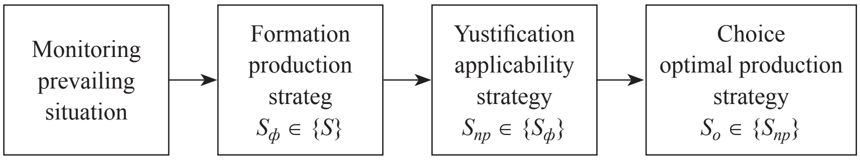

Fig. 1. *Scheme of selection the optimal strategy of manufacturing pro-duction in DIC*

Based on estimates of existing environments: military-political, military-strategic, economic, financial, social, etc., can be selected by the applicable strategy (S_{np}) of the number of possible ($S_ф$). Further, the number of applicable strategies must choose the best strategy for the development of production in the DIC (S_o). Selection circuit optimal control strategy this process is shown in Figure 1.

Choosing the most appropriate development strategy in the defense industry production should be carried out by the optimality criterion (K_o) during this process $t_н$:

$$K_o : S_o \in S \Rightarrow \max\{У_в^в(t_н)\} \quad (4)$$

Final adoption of the administrative decision of choosing considered advisable to carry out the strategy, taking into account the criterion of its suitability (K_{np}) in period $t_н$:

$$K_{np} : S_{np} \in S \Rightarrow \{У_в^в(t_н) \geq У_в^{втр}(t_н)\} \quad (5)$$

Currently, the defense-industrial complex is realized first of the considered strategies.

3. Initial information needed for modeling the development strategy of manufacturing production in the defense-industrial complex

Analysis of the available information base on the problem at hand shows that it is advisable to use solutions aggregate and sectoral industrial structure consisting of eight branches of DIC: aviation, rocket and space, shipbuilding, arms industry, ammunition and special chemicals industry, radio industry, the communications industry, electronic industry and three industrial complexes state economic system (SES) which is outside the DIC, but has a strong influence on his development: construction; mining and manufacturing.

When modeling the production strategy should be used as the main source of information both quantitative and qualitative characteristics of the economic system of the state, the defense-industrial complex, its integrated structures and businesses. It should be noted that most of them are interrelated, are constantly changing over time (updated) and are not always subject to the description of regularities due to the influence of the external environment and uncertainty [4].

The main part of the original information about the state and development of production in the defense industry can be represented in a vector and matrix forms. Number of characteristics of database objects at the same time reaches tens of thousands of units depending on the scope and detail of the process. Therefore, the analysis of possible the update in time the main characteristics of production should be based on their variability. It should be noted that for each of the integrated structure or defense companies has its own characteristics variability values of these characteristics. Therefore, when modeling production strategy in the defense-industrial complex is necessary to use the average values of the characteristics in the period under review.

As an indicator of the necessary information to the update source or a reasonable period of its time-lag in the presence of obsolete raw data appropriate to use the average time stability information $T_у$. Then the essence of estimates of the variability in time of the initial information is reduced to the definition $T_у$ and is as follows:

– select the required time;

– assigns a range of relative error of initial information;

– made the formation of groups of objects (elements) on levels of selected characteristics, for example, in terms of manufacture of military products, the value of fixed assets of enterprises, etc.;

– these groups are made so that there is sufficient from the point of view of the requirements of mathematical statistics the number of objects (elements) in a given interval changes considered characteristics;

– for the control periods conducted selection of objects (elements) from the values of selected characteristics in either group;

– for each object (cell) taken from their aggregate growth is determined by the relative value of selected characteristics of a given time interval, and then the value is the average relative increase on the above characteristics for each group of objects (elements);

– is determined by the average time for each stability characteristics of the object (element) to control time for the given values of the relative error;

– is determined by the average time the stability characteristics at each control time point for each group of objects (items) depending on the permissible error rate (for DIC in all its branches, the integrated structures and enterprises).

Given the frequency of updates of the basic process of production in the defense industry, it can be argued that much of this information source has a relative error of 15–20% [5]. Therefore, an important issue in determining the strategy of development of production in the defense-industrial complex in the forecast period is to obtain a high degree of reliability indicators of variability in time the main characteristics of industries, integrated structures and defense enterprises. To predict the variability within certain time intervals specified characteristics can use the following relationship:

$$Y_n = (-1)^n Y_1 + (-1)^{n-1}(n-1)Y_2 + +(-1)^{n-2}\frac{(n-1)(n-2)}{2!}Y_3 + ..., \quad (6)$$

where Y – the value of the function at fixed times;

n – number of the interval;

$$Y_n = Y_0[1 + \xi(e^{n\lambda} - 1)], \quad (7)$$

where $\xi = \frac{2(k_1 - k_0)}{\lambda(e^{\lambda}+1)}$ – a function of acceleration gain values of the selected characteristics;

Y_0 – basic (initial) value characteristics;

k_1, k_0, λ, e – coefficients determined by statistical data;

$$Y_n = Y_0\left[1 + \sum_{i=k}^{n-k}(a\Delta t_i^2 + b\Delta t_i + c)\right], (8)$$

where Δt_i – i-th time interval;

a, b, c – the parameters of the equation.

To use expression (8) the approximate parameter values a, b and c can be obtained by processing the source data by the least squares.

4. Model development strategy of manufacturing production in the defense-industrial complex

Positing of the problem is formulated as follows. It is known:

– the set of states of the economic system of the state of SES $\{Mn_{PE}^{P}\}$ and DIC $\{Mn_{PV}^{P}\}$ – many of their characteristics $\{Mn_{PE}^{H}\}$ and $\{Mn_{PE}^{H}\}$ at the moment;

- the set of predictive states SES $\{F_S^S\}$ and DIC $\{F_M^S\}$ – a lot of them and predictive characteristics $\{F_{CS}^S\}$ and $\{F_{CM}^S\}$;

– the set of predictive features volumes of gross output of SES $\{Fv_{CS}^S\}$ and DIC $\{Fv_{CM}^S\}$;

– state vector DIC ($L, N, N_z, W, U_E, U_W, O, Q, R$) and the elements of matrix of technological $\|a_{ij}\|$ and functional-territorial $\|l_{ij}\|$ relations of its branches, integrated structures and enterprises;

– multiple levels of customer needs in the final military products, characterized by components of the vector $\{Q_w^{PT}\}$;

– multiple levels of needs in the final of civilian products , characterized by components of the vector $\{Q_g^{PT}\}$;

– a set of strategies $\{C\}$ DIC management and hypotheses $\{G\}$ to build the highest possible volume of production of the end of military products;

– the range of the estimates of the human factor $\{P_F\}$, characterizing aptitude management and production staff DIC;

– the set of values of the time factor $\{T_F\}$, characterizing the processes of production of final products for military purposes;

– the set of indicators $\{I_U\}$, needed to measure levels of the state of the processes involved;

– set of criteria $\{K_R\}$, required for sound management decisions, ensuring customer satisfaction in military products;

– the set of constraints, assumptions and conditions $\{M_o, M_y, M_n, M_н\}$, associated with levels of need in the final production of military purpose, level and time $\{t_n\}$ increasing the volume of its production, as well as modeling features of the process.

Then formalized presentation of the problem will be as follows:

$$\Lambda_Z = f\begin{Bmatrix} Mn_{PE}^P, Mn_{PV}^P, Mn_{PE}^H, \\ Mn_{PE}^H, F_S^S, F_M^S, Fv_{CS}^S, \\ Fv_{CM}^S, U_E, \\ U_W, L, N, N_Z, W \\ O, Q, R, a_{ij}, l_{ij}, Q_w^{PT}, \\ Q_g^{PT}, C, G, P_F, T_F, \\ I_U, K_R, M_o, M_y, \\ M_n, M_н, t_n \end{Bmatrix} \quad (9)$$

$$\psi : \left\{Y / \Sigma_Z : E_Z \xrightarrow{\Theta} Y(Mod)\right\} \xrightarrow{\Theta} P_E \Rightarrow K_E \quad (10)$$

where ψ – matching operator of the real process of production of its model mapping;

Y – numeric expression of the general simulation result of the process;

Mod – different simulation results of this process;

Λ_Z – the set of values of certain factors and characteristics of the process;

Σ_Z – mapping assigning to the set of characteristics E_Z set of simulation results $Y(Mod)$;

Θ – multiple input factors used in the simulation;

P_E – indicator (s), assessing the state of the control DIC;

K_E – criteria characterizing optimal production process control products.

It is required to determine the strategy for manufacturing of production, the implementation of which will provide a vector of output of the final product by industry DIC $Q(t_n) = \sum_{i=1}^{m} Q_i(t_n)$, where the component of the volume of production of the end products for military purposes $Q_w^w(t_n) \in \{Q_{wi}^w(t_n)\}$ is the maximum under the following conditions and limitations:

$$D_n(t_q) \geq 0,\ C^n \in \{C_i^n(t_n)\};$$
$$G^n \in \{C_i^n(t_n)\};\ t_{nm} \geq t_n > 0;$$
$$Q_w^w(t_n) \geq Q_w^{PT}(t_n) \qquad (11)$$

$$\{N(t_n),\ N_z(t_n),\ F^O(t_n),\ W(t_n),\ O(t_n),$$
$$Q_g(t_n),\ R(t_n) > 0;\ Wu < W_i\},\ (12)$$

when $(i = \overline{1, n-1})$,
where $Q_{w1}^w : Q_{w2}^w : Q_{w3}^w : \ldots : Q_{wn}^w = K_1 : K_2 : K_3 : \ldots : K_n$ – the completeness condition of the vector of output of military products; matrix elements technological links $\left\| a_{ij} \right\| \geq 0$; matrix elements of territorial and functional connections $\left\| l_{ij} \right\| \geq 0$, $D_n(t_q)$ – vector potential decline in production of military products, caused by the modernization of defense industry enterprises; C^n, G^n – adopted the strategy to expand the scope of manufacture of military products; Wu – capacity "narrow" by industry capacity (industries) DIC; W_i – production capacity of the i-th industry DIC; t_n, t_{nm} – current and required time increasing the volume of manufacture of military products to the desired level; $N(t_n)$ – the number of able-bodied population of the country; $N_z(t_n)$ – the number of employed labor force; $F^O(t_n)$ – the vector end civilian products; $O(t_n)$ – gross output vector; $Q_g(t_n)$ – the vector of final products of civil designation; $Q_w(t_n)$ – the vector of final products of military purpose; $R(t_n)$ – the number of jobs.

Formulation of the problem may be somewhat different if, instead of the vector $Q_w^w(t_n)$ defined by the vector $O(t_n)$, $W(t_n)$, $R(t_n)$, $N_z(t_n)$, $F^O(t_n)$ and then a transition to vectors $Q(t_n)$, $Q_w^w(t_n)$ using analytical relationships between them derived from econometric models V. Leontief and Cobb-Douglas.

5. Sustainability assessment of simulation results

For the effects of random and uncertain set of factors is necessary to the stability assessment of the obtained solutions of the problem, i.e. simulation results [6]. At the same time under the stability of the solution we mean a measure of the reaction or the degree of enhancement (weakening) of the perturbing influence on the process in the expanded reproduction of innovative products.

If the output parameters (indicators) model studied beyond the limit, it is considered that the model behaves erratically in respect to this parameter, which is part of the original information or conditions of the problem being solved. In general, there are three types of sustainability indicators obtained solutions: static, dynamic and "threshold".

Under static indicators of stability of solutions are understood indicators that reflect the ratio of probability characteristics of input and output parameters of the process model with fixed parameters of the distribution laws of the conditions of the problem solved in the simulation development strategy production in DIC.

Dynamic performance evaluation to determine the stability of the solutions allow changes depending on the probabilistic characteristics of the output parameters of the model under investigation by amending the relevant characteristics of the input parameters of the model development strategy production in DIC.

Under the "threshold" refers to making sustainability indicators such indicators by which the solution is determined in the course will whether or not a change in the law distributions of the parameters of the problem conditions to change the output parameters of the process model for the established maximum values.

Input parameters P_{vh} models can be technological coefficient matrix $\left\| a_{ij} \right\|_t$, the components of the final product Q and others, and as the output of the process P_{vyh} models can be used: the average time to increase production of the final product for military use, the probability of growth of the military (civil) of production, the average volume of gross, intermediate and final products by branches of DIC and others.

To obtain the best estimate of the stability of solutions obtained by the model development strategy in the manufacturing of defense industry production, it is necessary to use the criterion of sustainability, built on the basis of sustainability indicators. Analysis of the initial information, methods solution of the problem and planned outcomes of the process simulation shows that as the stability criteria derived solutions to the problem, you can use the following parameters (see Table 1).

Using the indicators and criteria of stability of the solutions obtained decisions (simulation results of the test process) can be released singling out from the entire set of input parameters random process model subsets that have the greatest impact on changing the output parameters of the process model. The resulting significance levels of each of the model input parameters allow us to estimate how accurately in terms of the required reliability outcomes should ask the law of distribution of each of its input parameter.

6. Conclusion

The presented model of development strategy manufacturing of production in the defense-industrial complex is a new tool base choice and inform decisions on the construction of optimal process management strategic development of DIC in order to create a new image of the Russian Armed Forces. The implementation of this model in

Table 1.

Sustainability performance simulation results development strategy in the defense industry production

Static sustainability indicators	Dynamic sustainability indicators
1. The ratio of the relative magnitudes of the maximum deviations of input and output parameters of the models.	1. Change in the relative values of deviations depending on changes in the input models.
2. Ratio values of the coefficients of variations of input and output parameters of the models.	2. Changing the values of the coefficients of variations of the output based on changes in input patterns.
3. Variance ratio values of input and output model parameters.	3. Changing values dispersions output depending on changes in the values of input variances models.
4. Ratio values of various input and output parameters of models.	4. Changing parameters at the output changes depending on the values of these input parameters models.

practice can improve the scientific validity and optimal control of manufacturing of production produced DIC in the long run.

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