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EVALUATION OF THE INNOVATIVE POTENTIAL LEVEL OF CORPORATE MANUFACTURING COMPLEXES

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Abstract. *The paper proposes the author's methods of assessment conducting of the innovative potential of corporate manufacturing complexes. The format of the indicators calculation of the innovative potential evaluation at the stage of creation and innovations development has been isolated and provided. The system of indicators in the model of the innovative potential estimation of the corporate manufacturing complex was proposed. A methodological approach to the evaluation of innovative potential of the corporate manufacturing complex was developed based on the mathematical algorithm and interval estimates. A mechanism for managing the innovative potential of the corporate manufacturing complex has been formed..*

Keywords: *innovative potential, corporate manufacturing complex, evaluation methodology, innovations, innovative development, factor characteristics of potential.*

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Introduction

Innovations play a paramount role in the modern economy, becoming the main element of its functioning. Without innovations it is impossible to ensure the growth of the level of productive forces, to create conditions for the effective development of industrial production. Innovation is the basis for improving the quality and competitiveness of products. The ultimate goal of innovative processes is the practical implementation of new solutions, i.e. innovations. Achieving this goal is impossible without formation and functioning of the appropriate mechanism within the corporation allowing to work on the management of innovative processes. However, there is no renewal of the product nomenclature, the innovative potential remains rather low in a number of industrial corporations, which in turn negatively affects the development of the corporation on the whole and its divisions separately. It leads to the problem of improving the formation and evaluation of innovative potential and, as a consequence, the formation of a competitive nomenclature of industrial production (Tsoukas & Knudsen, 2002). The above issues are particularly relevant for modern manufacturing complexes where many market mechanisms, including those for managing innovative potential, are in the process of ongoing transformation and renewal. The unresolved number of theoretical and practical problems in the innovation sphere of corporations' activity made the topic of this research relevant.

Literature review

Research of managing innovative development of industrial corporation is devoted to the leading scientists' papers (Arogyaswamy, Koziol, 2005; Griffith et al., 2004; Lawson & Samson, 2001; Radjou et al., 2012). The problematic issues of providing strategic management for the innovative development of corporations have been revealed in the papers (Corey et al. 2014; Griliches, 1998; Mir & Watson, 2000; Tidd et al. 2001; Wilmott, 2009). Among the world-renowned scientists who study the problematic field of innovation and increasing of innovative potential, we highlight (Christensen, 2003; Delmas, 2002; Strecker, 2007; Styles & Goddard, 2004).

The most scientists' scientific achievements are devoted to the formation of conceptual foundations for managing the innovative development of economic entities at different levels of the economic system, to study prerequisites for ensuring the innovative development of corporations, to identify the economic, technical and technological factors for the activation of innovative processes in the activities of corporations. However, the issues of formation and implementation of the management mechanisms that provide enhancement of innovative potential and methods of its evaluation, taking into account the realities of the modern market economy, remain under-researched.

Metods

We will form the methodological bases of this research on the basis of the following approaches to carrying out the innovation assessment in the environment of industrial corporations and possibility of transition to the accumulation potential of the innovative experience:

1) resource approach to the evaluation considers the innovative potential as setoff resources or its combination, opportunities for their use, it pays attention to the presence of a set of the basic resource elements of innovative potential, and automatically determines the achievement of the set goals of innovative activity;

2) structural approach to the evaluation considers the innovative potential in terms of certain complex components that integrate resources necessary for the formation of innovative potential, allow them to maneuver, according to it such basic elements of innovative potential are highlighted as: human resources, information and methodological, organizational, logistical, scientific, technical, financial potential, etc.;

3) process approach to evaluation links the innovative potential with achievement of the innovation goals of the entities engaged in the development, implementation and commercialization of innovation, study only the use of innovative potential, it is focused only on the implementation and commercialization of innovation, i.e. in the last stages of the single innovative process, distracting from the features of certain resource components and conditions of their formation.

Results

Evaluation indicators of the innovative potential level of the corporate manufacturing complexes

The issues of identifying and evaluating of the innovative potential to form a model for supporting its development take the fundamentally important place in the theory of innovation. It is possible to evaluate innovative potential by creating special questionnaires in which experts submit their marks. Such techniques have no reproducibility property, there are difficult for internal users to apply. There is a methodological discrepancy about the units of different indicators measurement. In our view, it is more rational to use relative indicators, which can be easily calculated by the parameters available to both internal and external analysts. The list of such indicators should guarantee the necessary and sufficient information on the status of innovative potential of the corporate manufacturing complex (Teeratansirikool et al., 2013). An assessment of the innovative potential of the corporate manufacturing complex should be made using an appropriate system of indicators, which vary depending on the stage of development and implementation of innovations, given that an important feature of a corporation's innovative development is its ability to adapt to internal changes and external influences (Tables 1, 2).

Table 1. Indicators of the innovative potential evaluation at the stage of innovation creation

Indicator	Calculation format	Legend
Share of costs for R&D in total costs	$K_1 = C_{R\&D} / C_{al}$	$C_{R\&D}$ - costs for R&D, C_{al} - total costs for manufacturing and selling new products
Share of the number of scientific and technical workers with the scientific degree in their total number	$K_2 = Q_{sf} / Q_{al}$	Q_{sf} - number of employees with scientific degree, Q_{al} - total number of scientific and technical workers
Share of scientific publications on the strategic direction of innovative development in the total number of scientific papers during the year	$K_3 = A_s / A_{al}$	A_s - number of publications on strategic direction of innovative development, A_{al} - total number of publications during the year
Level of providing innovative activity by the research equipment	$K_4 = O_{R\&D} / O_{al}$	$O_{R\&D}$ - cost of equipment for R&D, O_{al} - cost of fixed assets
Share of the value of licenses sold in the current year in the balance profit of the corporation	$K_5 = L / L_p$	L - the value of licenses sold in the current year, L_p - balance profit of the corporation for the same year
Share of the value of licenses sold in the current year in the balance profit of the corporation	$K_6 = L_b / L_p$	L - value of licenses sold in the current year, L_p - balance profit of the corporation for the same year
Number of prototypes developed by the corporation's own forces	K_7	X
Number of prototypes developed to order by a single corporation	K_8	X

Innovative development is carried out on the basis of an appropriate strategy, which is based on the innovative potential of developed innovations, taking into account the impact of the environment. The effectiveness of the innovations strategy of the corporate manufacturing complex depends on the quality of the information received from the external environment and analysis of the internal state. These indicators are used to assess innovative potential.

Table 2. Indicators of the innovative potential evaluation at the stage of innovation creation

Indicator	Calculation format	Legend
Physical deterioration of the equipment for R&D	K_1	X
Physical deterioration of the equipment for R&D	K_2	X
Retirement of the equipment for R&D	K_3	X
Renewal of the equipment for R&D	K_4	X
Share of new technologies mastered in the current year in the total number of technological processes	$K_5 = T_H / Tal$	T_H - new manufacturing processes, Tal - total production processes
Level of informatization of R&D related work	$K_6 = M_I / M_{al}$	M_I - number of job places equipped with computers M_{al} - total number of job places of scientific and technical workers
The level of professionalism of the scientific and technical staff	$K_7 = Q_{nf} / Q_{alf}$	Q_{nf} - the number of scientific and technical workers with basic higher education, Q_{alf} - total number of scientific and technical workers
Level of advanced training of scientific and technical personnel	$K_8 = X_{nf} / Q_{alf}$	X_{nf} - number of scientific and technical staff who have upgraded their skills during the year
Level of profitability of realized innovations	$K_9 = P_I / C_I$	P_I - income from innovation, C_I - costs associated with creating an innovation
Share of new goods in annual sales in the current year	$K_{10} = V_n / V_{al}$	V_n - sales volume of new products, V_{al} - total sales

An analytical review of the available techniques has demonstrated that there is clearly an insufficient amount of development to analyze and evaluate the innovative potential directly. We propose the following system of calculated indicators of the innovative potential of the corporate manufacturing complex (Table 3).

This system of indicators, on the one hand, allows to evaluate the current innovative potential, on the other hand, it includes the most important indicators for each of the components of the innovative potential, which ensures the completeness and complexity of its assessment (Atkinson, 2012).

Table 3. System of indicators in the model of the innovative potential estimation of the corporate manufacturing complex

Innovative potential components, where K-weight of the impact of the component on the innovative potential on the whole (*Ki*)	Indicators of the innovative potential components	The weight of the indicator impact on the relevant component of innovative potential (*Mi*)	Normative value of the indicator (*Ni*)
Financial - *K1*	Coefficient of provision by own funds	*M1*	*N1*
	Coefficient of current liquidity	*M2*	*N2*
	Coefficient of the own funds autonomy (independence)	*M3*	*N3*
Production - *K2*	Share of fixed assets in total assets	*M4*	*N4*
	Share of inventories in current assets	*M5*	*N5*
	Coefficient of the fixed assets disposal	*M6*	*N6*
Business - *K3*	Turnover coefficient of fixed assets	*M7*	*N7*
	Coefficient of the profitability of the own capital	*M8*	*N8*
	Coefficient of the profitability of current assets	*M9*	*N9*
Management - *K4*	Share of intellectual workers in the total staff	*M10*	*N10*
	Share of skilled workers in the total number of staff	*M11*	*N11*
The material and technical component - *K5*	Coefficient of the intellectual property security	*M12*	*N12*
	Share of costs for technological, organizational and marketing innovations in total production costs	*M13*	*N13*
	Coefficient of development of new equipment	*M14*	*N14*

The following comprehensive assessment of the innovative development potential of the corporate manufacturing complex has been proposed on the basis of the indicators system of all components of the innovative potential:

$$K_{ip} = \sum_{i=1}^{n} K_i \times Y_i \quad (1)$$

where: *n* - number of components of the innovative potential included in the integrated assessment;
Ki - the coefficients of the impact significance of the i-th component of the innovative potential.

$$\sum_{i=1}^{n} K_i \times Y_i = 1 \quad (2)$$

Y_i is relative indicators characterizing each i-th component of the innovative potential.

It follows:

$$\begin{aligned} Y1 &= M1X1 + M2X2 + M3X3, \\ Y2 &= M4X4 + M5X5 + M6X6, \\ Y3 &= M7X7 + M8X8 + M9X9, \\ Y4 &= M10X10 + M11X11, \\ Y5 &= M12X12 + M13X13 + M14X14 \end{aligned} \quad (5)$$

where: M*1* … *M14* - coefficients which take into account the impact significance of the indicator on the relevant component of the innovative potential of the corporate manufacturing complex;
X1 ... *X14* - indexes characterizing the degree of conformity of indicators values of financial, production, business, management and logistical component of the innovative potential with the normative value of these indicators.

The total value of the coefficients weights of all indicators within each group of components of the innovative potential is equal to one, i.e.:

$$M1 + M2 + M3 = 1, M4 + M5 + M6 = 1, M7 + M8 + M9 = 1, M10 + M11 = 1, M12 + M13 + M14 = 1. \quad (4)$$

Thus, a comprehensive indicator of the innovative potential of a corporate manufacturing complex can be presented in the expanded form:

$$\begin{aligned} K_1 = {} & K1(M1X1+M2X2+M3X3)+K2(M4X4+M5X5+M6X6)+ \\ & +K3(M7X7+M8X8+M9X9) + K4(M10X10+M11X11)+ \\ & +K5(M12X12+M13X13+M14X14) \end{aligned} \quad (5)$$

Further, based on the analysis of reporting data of the corporate manufacturing complex and calculation of the integrated indicator of the innovative potential according to the formula (5), it is possible to conclude the level of innovative potential formed within the corporate manufacturing complex up to the time of the analysis (Becheikh et al., 2006). The following levels of innovative potential can be distinguished depending on the calculated value of Ki: high innovative potential ($K \leq 2$) , mean innovative potential ($2 > K_i \geq 1{,}5$) and low innovative potential ($K < 1{,}5$).

Methodical approach to the innovative potential evaluation of the corporate manufacturing complex

The methodical approach to the evaluation of the innovative potential of the corporate manufacturing complex based on an integrative approach, as a synthesis of resource, structural and process approaches, which, unlike the existing ones, allows to determine the threefold essence of the innovative potential of a corporation namely to isolate resource, efficient and internal levels, and allows not only to calculate the integrative index of innovative potential, but also to classify corporations by its size (Fig. 1), consisting of such successive stages (Prajogo, 2016; Therrien et al. 2011).

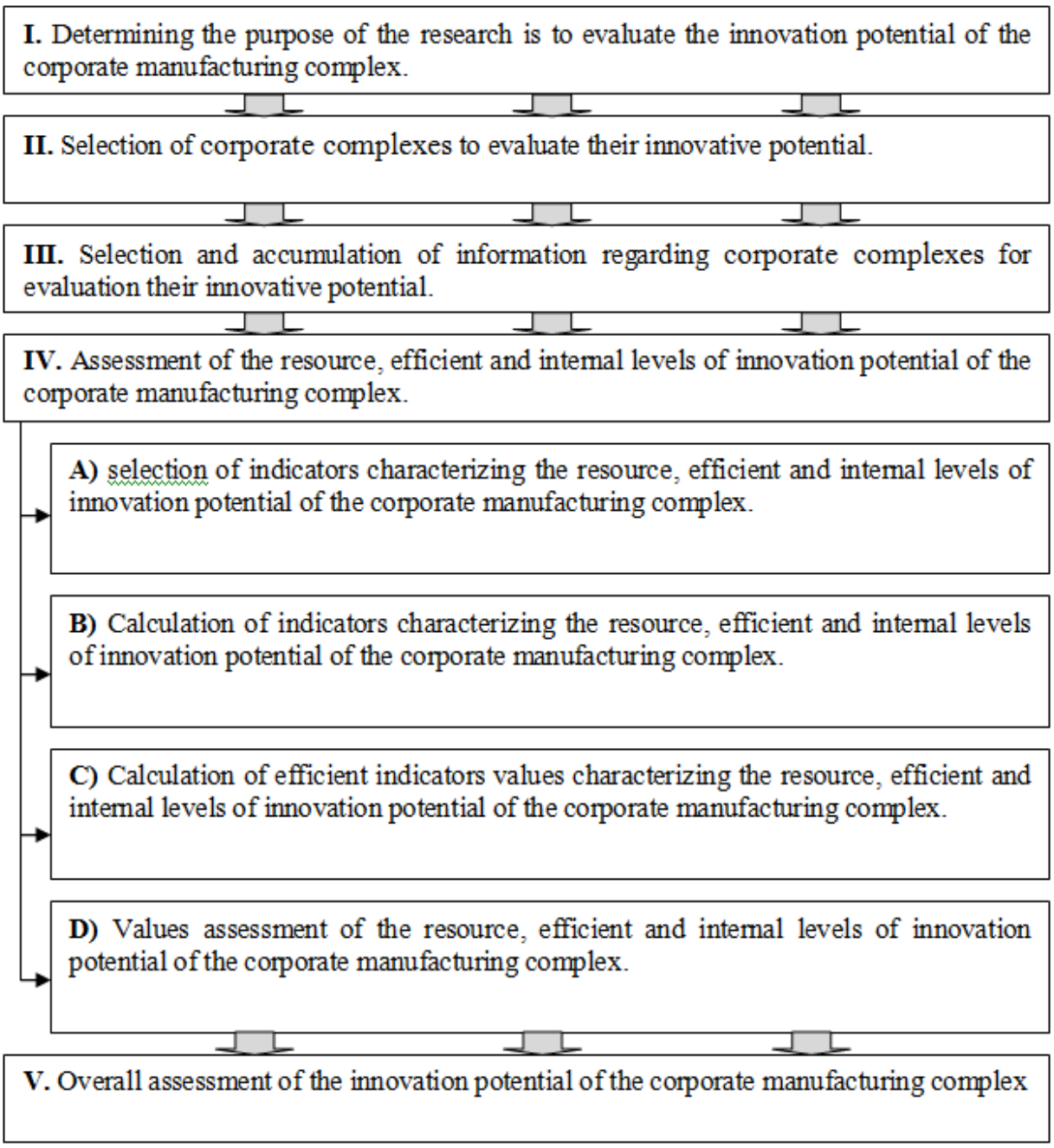

Figure 1. Stages of the methodical approach for the innovative potential evaluation of the corporate manufacturing complex

Exploring the innovative capabilities of such a complex business entity as an industrial corporation, it is necessary to establish a mutual influence on the performance of each of the indicators individually and collectively, to find out the innovative potential of each of the stakeholder groups, its realized and unrealized components (Getz & Robinson, 2003).

Thus, the innovative potential of the industry is a function of many variables:

$$\varphi_{pg} = f(K, t) \tag{6}$$

Definition (6) allows us to investigate the functional interaction of the potential components of an industry in which an industrial corporation operates; to identify the

most influential factors in a set of integrated metrics; to find out realized and unrealized components of potential components.

In order to build the economic and mathematical model, all stakeholders were divided into 6 groups: investors; employees; consumers; state and local authorities; suppliers; partners. The number of indicators affecting the innovative potential of the corporate manufacturing complex differs in each of the stakeholder groups. Therefore, the potential function (7) in each group has a different number of variables depending on the number of indicators $K = K(k_1, k_2, \dots, k_n)$.

For further calculations, each of the analyzed indicators is normalized by the largest of values:

$$k_{ij,norm} = \frac{k_{ij}}{k_{i,max}} \tag{7}$$

This is a classic method of stochastic modeling of economic activity (Macpherson, 2005). It establishes a link between indicators of economic activity when the relationship between them is not strictly functional and may be distorted by other random factors. This method is a quantitative method for determining the closeness and direction of communication between selected variables. The correlation coefficient is calculated by the formula:

$$r_{xy} = \frac{\Sigma_{i=1}^{n}(x_i - \bar{x})(y_i - y)}{\sqrt{\Sigma_{i=1}^{n}(x_i - \bar{x})^2 \Sigma_{i=1}^{n}(y_i - \bar{y})^2}} \tag{8}$$

where x_i, y_i - values of the variables, connection between which is established, $\bar{x}, \bar{y}$ - their average values respectively.

The correlation coefficient demonstrates the strength of the relationship and its nature: if the coefficient is positive, the connection is direct, if negative - the inverse connection. The interpretation of the correlation coefficients is as follows:

$$\begin{aligned}
|r_{xy}| &= 0 && \text{- no connection;}\\
0 < |r_{xy}| &> 0{,}3 && \text{- connection is very weak;}\\
0{,}3 \le |r_{xy}| &< 0{,}5 && \text{- connection is weak;}\\
0{,}5 \le |r_{xy}| &< 0{,}7 && \text{- average connection;}\\
0{,}7 \le |r_{xy}| &< 0{,}9 && \text{- connection is high;}\\
0{,}9 \le |r_{xy}| &< 1 && \text{- connection is very high;}\\
|r_{xy}| &= 1 && \text{- connection is complete}
\end{aligned} \tag{9}$$

At the same time, it is clear that a thorough analysis of economic activity cannot be limited to identifying the impact of individual indicators on the activity of an entire industry. Only an integrated analysis of the cumulative balanced scorecard makes it possible to conclude that the industry has realized and unrealized potential in the sphere of innovative activity. Therefore, we have introduced vector potential functions:

$$\bar{\varphi}_i = \bar{\varphi}_i(k_1, k_2, \dots k_n) \tag{10}$$

where i - number of the stakeholder group, $k_{1norm}, k_{2norm}, \dots k_{n,norm}$ - vector coordinates - normalized values of influence indicators on the innovative potential of the corporate manufacturing complex.

Since we have normalized all the impact indicators by maximum values, the maximum values of the vectors coordinates do not exceed 1. We calculated the values of normalized indicators by the results of statistical studies, so these values form the components of vectors of realized potential $\bar{\varphi}_i^{\text{р}}$:

$$\bar{\varphi}_i^{\text{р}} = \bar{\varphi}_i^{\text{р}}(k_{1norm}, k_{2norm}, \dots, k_{nnorm}) \quad (11)$$

Unrealized potential is the difference between maximum achievable and realized potential. From the above definitions, the realized potential $\bar{\varphi}_i^{\text{р}}$ characterizes ability of the industry to function and practically use the existing opportunities, and the unrealized potential $\bar{\varphi}_i^{\text{Нр}}$ is opportunities for further development. The quantitative side of the introduced vector functions is characterized by their modules. The module of the maximum achievable potential is calculated with the formula:

$$\left|\bar{I}\right| = \sqrt{1^2 + 1^2 + \dots + 1^2} = n \quad (12)$$

The module of realized potential of all stakeholders' groups will be calculated by the formula:

$$\left|\bar{\varphi}_i^{\text{р}}\right| = \sqrt{(k_{1norm})^2 + (k_{2norm})^2 + \dots + (k_{n,norm})^2} \le \sqrt{n} \quad (13)$$

The module of unrealized potential is accordingly calculated by the formula:

$$\left|\bar{\varphi}_i^{\text{Нр}}\right| = \sqrt{(1 - k_{1norm})^2 + (1 - k_{2norm})^2 + \dots + (1 - k_{n,norm})^2} \le \sqrt{n} \quad (14)$$

In formulas (12) - (14), n is the number of indicators in each stakeholder group.

It is advisable to include indicators to the basic indicators of operational activity of the corporate manufacturing complex characterizing the status and efficiency of innovative processes. The state of operating activities can be estimated by the reproducibility coefficient of the innovative process; the efficiency is evaluated by the level of the share of operating expenses in terms of income (revenue) from products sales. The reproducibility coefficient of the innovative process C_i characterizes the adequacy of the innovative process within a fixed period of time. It is calculated by the following formula:

$$C_i = \frac{S_U - S_L}{6 \times \sigma} \quad (15)$$

where S_u , S_L - upper, lower tolerance limits of the controlled parameter;
σ - mean square deviation of the controlled parameter.

Assessment of the reproducibility level is carried out on the following scale:

$$C_i = \begin{cases} \ge 1{,}33 \text{ - controlled process;} \\ (1;1{,}33) \text{ - adequate process within the controlled parameter;} \\ (0;1) \text{ - inadequate process} \end{cases} \quad (16)$$

Assessing the values of the factor traits of the innovative potential of the corporate manufacturing complex, we have highlighted three levels *(y=0; y=c; y=d)* which meet the following qualitative estimates:

$$y = \begin{cases} d - \text{high level;} \\ c - \text{middle level;} \\ 0 - \text{low level.} \end{cases} \quad (17)$$

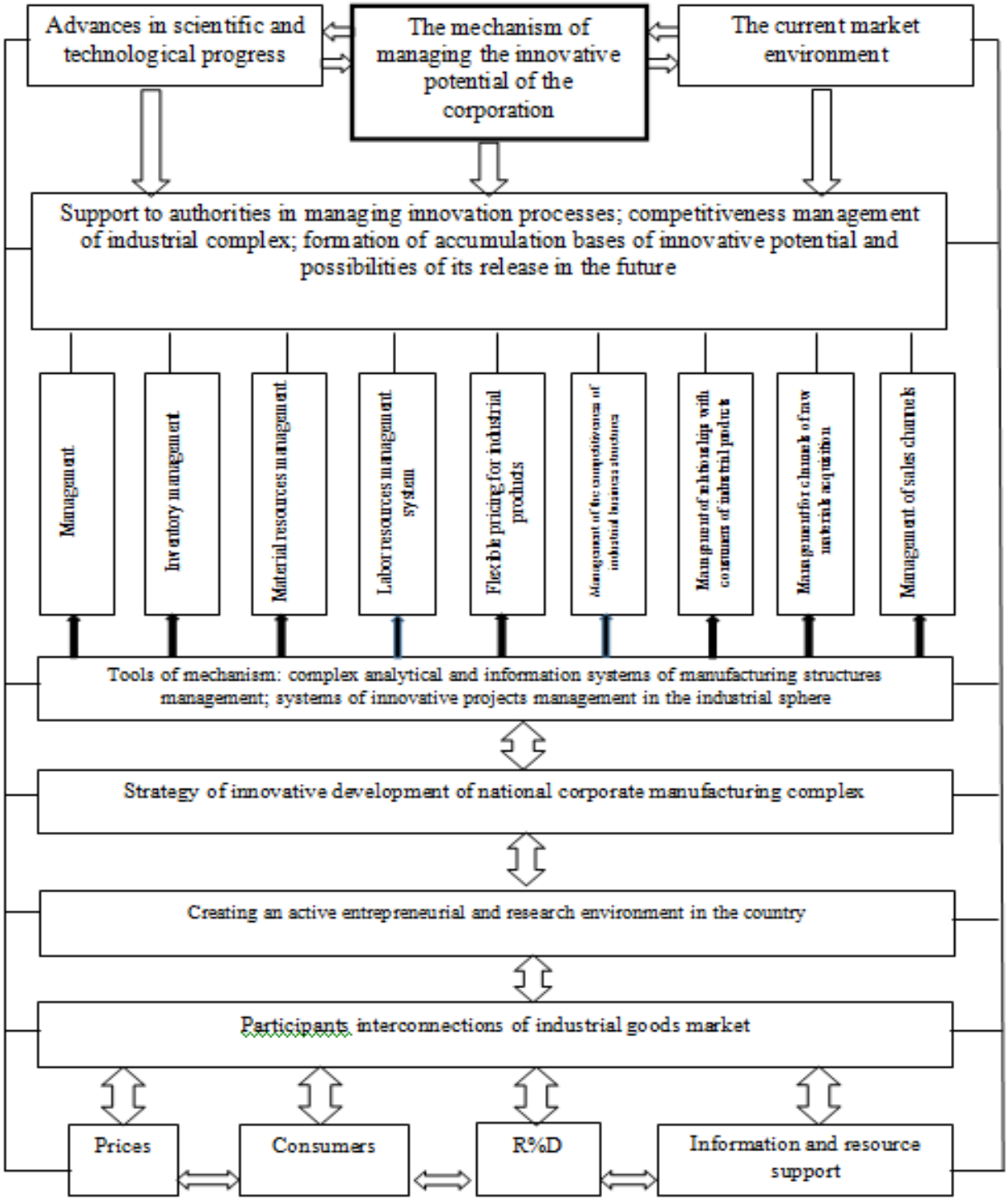

Figure 2. Projections of the mechanism for managing the innovative potential of the corporate manufacturing complex

If you measure the scores on a 100-point scale, the high level will correspond to a value of d = 100 points, an average one to$c$ = 80 points, and an unsatisfactory one to 0 points. The unevenness of the developed rating scale enables to take into account the condition that it is impossible to fully compensate the unsatisfactory value of one of the indicators by the high level of the others. Figure 2 presents the projections of the mechanism for managing the innovative potential of the corporate manufacturing complex.

The level of the innovative potential use of the corporate manufacturing complex, in turn, depends on the quality of the adopted innovative and investment decisions at each stage of the innovative process, as well as on the degree of information provision of this process. Today, there is an urgent need to develop a coherent and flexible management mechanism for industrial innovative potential, which not only has to meet the current requirements of global competition, but also to align the resources and strategic goals of innovative development of the country on the whole.

According to the research result, it can be concluded that formation of a mechanism for managing the innovative potential of the corporate manufacturing complex will facilitate the successful doing business through the introduction of innovative technologies and will give a new impetus for understanding the importance of innovation for the development of the national economy by business systems.

Discussion

Summarizing the research results of the innovative potential impact on the development of the corporate manufacturing complex, we note that innovative processes and development of industrial corporations are two inseparable components of building their effective production and economic activity. In the future we can say that the innovative capabilities of industrial corporations and their innovative potential is the core of the entire potential of the corporate structure of the national economy. For successful operation and comprehensive development of a corporate manufacturing complex in the country, a number of certain conditions are required, which depend on the ability of corporations to constantly transform and increase the efficiency of innovative processes.

The organizational and economic management mechanism of the innovative potential of the national corporate manufacturing complex can ensure the implementation of the chosen strategy aimed at obtaining a high-efficiency result in the program of creating innovative products (services) and high technologies, also it must take into account the elements of market design, which should be conducted for individual parts of the economic entities, taking into account the internal features and demands of the global product market.

Conclusions

The peculiarities of formation and management of the innovative potential of the corporate manufacturing complex have been identified. The authors proposed a system of innovative potential indicators calculation. The conditions for the

formation of a management mechanism of the innovative potential of the corporate manufacturing complex were substantiated. It is determined that in order to manage the innovative activity of the corporate manufacturing complex and to develop a system of measures for the organization and implementation of innovative projects, it is necessary to have a reliable assessment of the innovative potential of industrial production. The prerequisite and important component of innovation is innovative potential, so it is extremely important for the corporate manufacturing complex to know and understand the theoretical basics, patterns of the process of formation, enhancement, evaluation methods and directions of its effective use.

Propositions were developed on the formation of the management mechanism of the innovative potential of a corporate manufacturing complex which should operate on the basis of certain management methods and comply with modern principles: validity, efficiency, complexity, purposefulness, adaptability and flexibility. It was substantiated in the scientific paper that formation of a comprehensive management mechanism of innovative potential will allow to receive feedback from research institutions, to analyze results of their scientific research and to make certain adjustments in different variants of innovative development models of the national corporate industrial complex.

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