Використання бально-коефіцієнтного методу щодо оцінки ефективності функціонування високотехнологічного промислового підприємства

Актуальність. Розвиток високотехнологічних промислових підприємств в умовах соціально-економічної кризи світової економіки та високого рівня інфляції може стати одним з перспективних напрямів розвитку економіки України. Це дозволить країні випускати продукцію з високим рівнем доданої вартості, підвищити рівень експорту продукції, що буде сприятись підвищенню конкурентоспроможності вітчизняної економіки, зменшити залежність від технологій зарубіжних країн та зменшити залежність від сировинних коштів.
підприємств промисловості. Передумовами досягнення поставлених завдань є спрямування на міжнародні стандарти визначення ефективності високотехнологічної діяльності підприємства і оцінки конкурентоспроможності продукції, що нами виробляється. Для визначення рівня ефективності функціонування високотехнологічного підприємства необхідно визначити його високотехнологічний потенціал взагалі, який складається не тільки із виробничого потенціалу, а й науково-технологічного, організаційного, соціального та екологічного. У статті запропоновано бально-коефіцієнтний метод визначення єдиного інтегрального показника високотехнологічного потенціалу промислового підприємства з урахуванням експертних оцінок. Одним із найважливіших таких показників є визначення питомої ваги науково-дослідних розробок, що віднесені до вищої категорії якості. У зв’язку з цим у статті досліджено питання атестації якості високотехнологічних проектів. Де надається можливість прийняти рішення про взяття підприємством довгострокових інвестицій на підвищення високотехнологічного потенціалу підприємства на основі розрахунку очікуваних показників ефективності. Побудована таким чином інформаційна модель виступає як основа для вирішення завдань, пов’язаних з підвищенням ефективності функціонування високотехнологічного виробництва, визначенням економічно доцільних меж роботизації технологічних операцій, побудови моделей, використання параметрів і типу обладнання.

Висновки. У статті розроблено методику, з відповідною системою показників оцінки ефективності діяльності високотехнологічного промислового підприємства з використанням бально-коефіцієнтного методу. Визначено складові високотехнологічного потенціалу підприємства, а також вимоги та відповідність щодо атестації високотехнологічних проектів. Обґрунтовано вимоги до сучасної конструкторсько-технологічної документації розробки і випуску високотехнологічної продукції та до її техніко-економічного рівня формування інформаційної моделі розрахунку очікуваних показників ефективності.

Ключові слова: методика, бально-коефіцієнтний метод, експертні оцінки, високотехнологічне підприємство, модель.

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METHODICAL PROVISION OF ASSESSMENT OF THE EFFICIENCY OF THE FUNCTIONING OF A HIGH-TECH INDUSTRIAL ENTERPRISE ON THE BASIS OF SCORE-COEFFICIENT METHOD

Topicality. The development of high-tech industrial enterprises in the conditions of the socio-economic crisis of the world economy and the state of war in Ukraine can become one of the actual promising directions for choosing a strategy for the development of Ukraine's innovative economy. This will allow the country to produce products with a high level of added value, to increase the level of export of products, which will contribute to increasing the competitiveness of the domestic economy, reducing dependence on the technologies of foreign countries and leaving the
Problem statement and its connection with important scientific and practical tasks. Studying the experience of foreign countries shows that creating conditions for the sustainable development of the domestic economy by transitioning to an innovative-technocratic direction and reforming the high-tech sector does not mean the formation of economic prerequisites for exiting the crisis of domestic enterprises. That is why one of the conditions for the development of the high-tech sector of the economy of Ukraine as a whole. The realization of this goal is possible under the conditions of organizational and management decisions aimed at forming the demand for high technologies, promoting the transition of enterprises to high-tech conditions of development and modernization. And this is possible due to the creation of methodological support for the management of production and financial activities of national industrial enterprises.

Analysis of recent publications on the problem. In the technical and economic literature and periodicals, the number of publications devoted to various mechanisms of business process
management is growing. These so-called technological innovations of an organizational, economic, social and other nature are a kind of tool for increasing production efficiency. Accelerated development of this priority issue requires an urgent need to increase labor productivity due to the introduction of new and improvement of existing mechanisms, methods and forms of economic management at all levels of management, taking into account international standards for evaluating products with high added value. The following domestic scientists are engaged in the search for methods of evaluating the effectiveness of the high-tech industrial enterprise: Fedulova L.I., Zabarna E.M., Filippova S.V., Knyazevich A.O., Davymuka S.A., Salikhova O.B., Krekhivskyi O.V. as well as foreign scientists: Pinchot H., Pinchot E., Romer P., Jedkvist Ch., Lundvall B.

Allocation of previously unsolved parts of the general problem. The uniqueness of high-tech enterprises is their independence and uniqueness of production and management systems that are able to produce products with high added value. In order to objectively assess the efficiency of such enterprises, it is necessary to develop a system for calculating the relevant indicators. However, the methods of evaluating the effectiveness of the operation of a high-tech industrial enterprise have not been sufficiently developed and implemented in the science and practice of the domestic high-tech industry.

Formulation of research objectives (problem statement). To provide methodical support for evaluating the efficiency of the operation of a high-tech industrial enterprise based on the point-coefficient method.

Materials and Methods. The results of the comparative analysis and theoretical generalization of developments, scientific approaches to evaluating the effectiveness of the functioning of high-tech industrial enterprises are highlighted in publications of a fundamental, analytical and practical nature, which form the material and methodological basis of the study. Efficiency was assessed using the point-coefficient method. This method is based on an integral indicator and an expert assessment based on the results of the assessment of scientific and technical, production, organizational, socio-economic potential and additional preliminary studies.

An outline of the main results and their justification. The general target system of a high-tech enterprise requires the implementation of such basic subsystems as socio-economic and scientific-technological components, as well as production-sales and management-organizational. In order to effectively assess the quality of functioning of a high-tech enterprise, a methodology for determining its potential must be developed.

High-tech (HT) industrial enterprises include such enterprises that use advanced industrial technologies, know-how and the latest components, which are developed both by their own research departments and institutions, and acquired through outsourcing and produce high-tech products that meet international standards and belongs to the fifth-sixth technological systems. These are the companies of the future, which have highly qualified employees with a flexible and adaptive way of thinking and organization of the management system. The main values of such enterprises are freedom and independence, where there is no authoritarianism, a complex bureaucratic system of subordination and a hierarchical structure. These are organizations of a new type of management, in which a team of employees is built, whose duties are interchangeable and can change depending on goals and results.

This definition of the authors regarding the suitability of a high-tech enterprise is confirmed in the city of Odesa by the working enterprise of Odeskabel PJSC. This is Ukraine's largest manufacturer of cable and wire products, which uses modern innovative equipment, raw materials from Japan and produces high-tech products.

The mission of this enterprise is the process of manufacturing high-quality cable-conductor products that transmit energy, heat and light, allow the exchange of information with light, and, in this way, help customers in realizing their right to live and work in safe and comfortable conditions. The production capacity of the plant allows to fully satisfy the needs of the Ukrainian market. Currently, the export volume of the Ukrainian market is 31.8%. The plant's products are exported to more than 20 countries on the markets of the European Union, the Middle East and Africa (Suslov O., Dukova D., 2021).

The study of the experience of foreign countries, in particular China, made it possible to consider the principles of the introduction of the targeted approach, which was implemented by the Chinese leadership, for the integration of its main aspects into the economy of Ukraine. Efforts were specifically aimed at innovatively active enterprises in the following measures: 1) granting state privileges to such enterprises without mandatory examination, but with the help of implementing a certification mechanism; 2) access to preferences in the public procurement system.
The practice and results of the operation of industrial enterprises show that the low level of innovation processes at enterprises requires state support of enterprises that produce high-tech products. A restraining factor is also the unfoundedness of the scientific and methodological basis capable of realizing the possibility of describing such a process and the mechanisms of their implementation (Davimuka S.A., Fedulova I.I., 2017).

That is why the study proposes one of the methods of assessing the effectiveness of the functioning of high-tech industrial enterprises. A comparison of the actually achieved results (P) with the level of indicators at which it is possible to predict the prerequisites for the development and implementation of the potential of a high-tech enterprise (P0) will allow to determine the quality of its activity (Q):

\[ Q = \int (P_i - P_0) > \text{min.} \] (1)

Indicators characterizing the level of high-tech activity of an industrial enterprise can be classified according to the following groups (Table 1).

<table>
<thead>
<tr>
<th>Classification features</th>
<th>Indexes</th>
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<tbody>
<tr>
<td>A set of indicators for calculating the effectiveness of R&amp;D implementation and the company's ability to produce finished high-tech products</td>
<td>- the share of scientific achievements attributed to high technologies in the final result of the enterprise's activity; - the level of patented scientific and technological developments and inventions and exported licenses for their use; - the value of research and development, aimed at the implementation and reflection in programs of the domestic economy in 5-7 years of those developments and inventions developed at this enterprise; - the specific weight of high-tech products in the total volume of manufactured products</td>
</tr>
<tr>
<td>A number of indicators that determine the degree of influence of the introduction of high technologies and know-how on increasing the scientific and technological level of industrial production in the industry</td>
<td>- the share of high-tech products produced by the enterprise based on its own scientific and technological developments in the total volume of the enterprise's output; - the dynamics of product renewal as a result of the introduction of high technologies at the industrial enterprise; - increasing the level of labor productivity and production due to the implementation of enterprise developments;</td>
</tr>
<tr>
<td>A set of indicators that determine the duration of the &quot;research - production - sales&quot; cycle</td>
<td>- cycle duration intensity factor (calculated as the ratio of the total productivity of individual cycle stages to the total cycle duration, while breaks and downtime are not included).</td>
</tr>
</tbody>
</table>

Source: developed by the authors.

In order to determine the level of efficiency of a high-tech industrial enterprise, one should first determine the level of its high-tech potential. In general, high-tech potential can include not only the production component, but also others (Table 2).

Based on the results of the evaluation of the potentials listed in Table 2, we will determine a single integral indicator of the high-tech potential of an industrial enterprise. It is determined using expert evaluations based on the point-coefficient method. In our study, experts are representatives of industrial enterprises and representatives of the scientific field.

We consider the existing types of assessments and their characteristics in Table 3. In the process of planning the development strategy of a high-tech enterprise, attention should be paid to the indicator of the specific weight of research developments in the system for evaluating the quality of the functioning of a high-tech enterprise. Such a result is the indicators of the quality certification of the implementation of high-tech projects. Such data are included in the system of evaluation of the quality of functioning. It is the certification data that should, first of all, be included in the system of evaluation of the quality of works of a high-tech enterprise (Knyazechvich A.O., 2017).

Attestation of design and technological documentation for the latest developments of high-tech products or technological processes is based on the selection of one of two relevant quality criteria at two levels: 1) global or 2) the highest quality level.
### Characterization of the potential of a high-tech enterprise

<table>
<thead>
<tr>
<th>List of potentials of a high-tech enterprise</th>
<th>Characteristic</th>
</tr>
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</table>
| Scientific and technological potential | It characterizes the scope of the results of the effective implementation of the scientific and technological reserve of the enterprise, namely:  
  – latest patents and licenses (even borrowed ones) and current developments. It is evaluated as an indicator of determining the efficiency (per 1 hryvnia of costs) of high-tech facilities;  
  – shares of the economic effect from the introduction of scientific inventions and achievements in the total amount from the volume of high-tech products;  
  – scientific capacity of products - this indicator can be calculated by the ratio of high-tech products produced in accordance with the planned scientific and technological developments and inventions of the enterprise to the amount of costs for their development and development;  
  – the specific weight of the reduction in the cost level of high-tech products from the increase in the level of production from the introduction of scientific and technological developments and inventions, as well as company patents. |
| Production potential | It is determined by a set of indicators of the production capacity of the research department belonging to it (research hubs, incubators, laboratories and experimental production units) and the main production of the industrial enterprise. Also among the indicators are such as the effectiveness of meeting product delivery dates, the coefficient of rhythmicity of the release of high-tech products. |
| Organizational potential | Determines the complexity of the structure of the enterprise itself, the flexibility of the management system (Learn Management), the ability to restructure and reform. |
| Social potential | It characterizes the level of novelty and socialization of the team as a team and is determined by the following indicators:  
  – the number of highly qualified workers;  
  – the number of workers with scientific degrees of doctor of philosophy and doctor of science;  
  – the total number of employees who raise their scientific level every year;  
  – the number of person-years of higher education per employee of research and basic production;  
  – the number of copyright certificates and inventions per 100 engineering, technical and scientific workers who are engaged in high-tech inventions and inventions;  
  – personnel turnover. |
| Ecological potential | It characterizes the level of pollution and emissions from the production of high-tech products into the environment. |

Source: compiled by the authors.

### Types of assessments of high-tech potential of an enterprise

<table>
<thead>
<tr>
<th>List of grades</th>
<th>Characteristic</th>
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| complex (F)    | when experts assess the quality of the enterprise's high-tech functioning by the sum of potentials using the point-coefficient method. The calculation formula is as follows:  
  \[ F = \sum_{i=0}^{n} Q_j \cdot R_i \],  
  where \( Q_i \) is the coefficient of significance of the j-th parameter in the total number of indicators for assessing the quality of the enterprise's high-tech operation by individual potential; \( R_i \) – indicator evaluation, which is determined by points; n is the number of indicators in a separate potential. |
| average score   | determined for each indicator in a separate potential and depending on the number of experts. |
| a general indicator of the quality of the enterprise's high-tech functioning | it is possible to determine by summarizing the results of the previous (average) assessment separately for each potential |

Source: determined by the authors.
The design and technological documentation for the latest high-tech products is characterized by the level of the designed products and, in terms of its main technical and economic parameters, corresponds to the current global trends in technology and know-how, which can be completely new and have no analogues - these are world-class quality criteria.

Design and technological documentation for products that are being developed in an updated form with those products that were produced earlier, but currently differ in the presence of high technological parameters. This type of product must have a technical and economic level that meets the highest modern standards both for domestic production in Ukraine and for similar equipment produced abroad - these are quality criteria of the highest level.

It is recommended to carry out project certification through the following stages. The first stage, which is called preliminary research, is carried out at the stage of drawing up the technical task. At this stage, the degree of novelty, importance and perspective of the topic is evaluated, as well as the complexity of the design solution. Preliminary attestation can be carried out by the scientific and technical council of the enterprise.

The second stage, which is called the final certification, is carried out after testing a series of industrial samples of the developed products.

The final attestation should be carried out by the interdepartmental scientific attestation commission, which consists of representatives of authoritative organizations, such as the National Academy of Sciences of Ukraine, the Ministry of Education and Culture of Ukraine, and the main research institutes that contribute to the innovative development of the country. During the second stage of attestation, the quality of the design and technological documentation for the developed products should be taken into account, as well as documents that confirm the high level of technological, metrological and organizational support for new developments (such as ISO 9000, TQM, DSTU).

To assess the quality of design and technological documentation, you can use your own methodology, in which the indicators will be combined into one integral indicator (Table 4).

<table>
<thead>
<tr>
<th>Indexes</th>
<th>Formula</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall assessment of the quality of the project in points ($Q_{pr}$)</td>
<td>$Q_{pr} = \sum_{i=1}^{m} \sum_{j=1}^{n} U_{ij} \cdot B_{ij}$</td>
<td>Where $m$ means types of design and technological documentation (DTD) for technological/organizational/metrological support projects. Each project has n quality indicators. $U_{ij}$ represents the weighting factor of each indicator, and $B_{ij}$ represents the number of points assigned to each indicator according to the established scale.</td>
</tr>
<tr>
<td>The total economic effect of the activity of a high-tech industrial enterprise ($E_{Σ}$)</td>
<td>$E_{Σ} = Σ_{pr} + Σ_{v}$.</td>
<td>The amount of profit received from the activities of the research production divisions will be denoted as $Σ_{pr}$, and the size of the annual effect obtained from the implementation of the high-tech enterprise's developments will be denoted as $Σv$.</td>
</tr>
<tr>
<td>The efficiency of the high-tech enterprise ($E_{HTA}$)</td>
<td>$E_{HTA} = Σ_{Σ}/C_{Σ}$.</td>
<td>This ratio shows the relationship between the final economic effect and the total discounted costs, denoted as $C_{Σ}$.</td>
</tr>
<tr>
<td></td>
<td>$E_{HTA} = Σ_{Σ}/C_{ps} + C_{sr} + C_{dc} + C_{rw} + F·I)$.</td>
<td>The final reduced costs consist of various components, including current costs for the production and sale of high-tech products ($C_{ps}$), costs for scientific and research works ($C_{sr}$), costs for design and construction works ($C_{dc}$), research works ($C_{rw}$), as well as the amount capital investments in fixed assets of a high-tech enterprise (I). These costs are reduced to a single dimension using an efficiency factor (IF) to ensure uniformity and comparability.</td>
</tr>
</tbody>
</table>

Source: determined by the authors.

The authors implemented the proposed methodology at the following VT industrial enterprises and made comparative calculations (Table 5).
It is possible to use this system of indicators as a tool for analysis and information provision of existing business processes in high-tech production within the framework of a reengineering project. When developing such an information management system, it would be advisable to use international experience and focus on the use of CASE technologies (Computer Aided Software/System Engineering).

In this context, to increase the potential of the enterprise, you can successfully use the CASE tool called BPwin. Using BPwin as a tool will allow developing an information model of the investment process aimed at increasing the potential of the enterprise and transforming it into a high-tech enterprise.

This information model is necessary for a detailed description of investment processes aimed at creating a higher potential of the enterprise and transforming it into a high-tech enterprise. When developing this model, strategic and technical goals are taken into account, which are defined in the company's competitive strategy (Fedulova L.I., Zabarna E.M., Filippova S.V., 2016).

After creating an information model, it is possible to make a decision on long-term investments aimed at increasing the potential of the existing enterprise and its transformation into a high-tech enterprise. To achieve this goal, CASE tools, in particular BPwin (Fig. 1), can also be effectively used to create an information model that evaluates expected performance indicators.

---

**Table 5**

<table>
<thead>
<tr>
<th>High-tech enterprises</th>
<th>Results of implementation of the methodology and final calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJSC &quot;Odessa plant radial drilling machines&quot;</td>
<td>1.2</td>
</tr>
<tr>
<td>JSC &quot;Pervomaisk deeselmash&quot;</td>
<td>3.9</td>
</tr>
<tr>
<td>OJSC &quot;Odeskabel&quot;</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Source: determined by the authors.

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**Fig. 1.** A fragment of the model of information calculation of expected performance indicators in the formation and use of the potential of a high-tech enterprise.

Source: developed by the authors.
Conclusions and perspectives of further research. The constructed information model is the basis for solving tasks related to the evaluation of the effectiveness of the creation and functioning of high-tech production, the determination of economically feasible limits of robotization of technological operations, as well as the selection of parameters and the type of equipment. In today’s changing market conditions, constant improvement of the methodology for assessing the high-tech potential of industrial enterprises is a necessity for a more accurate assessment of their competitiveness. In addition, the certification of high-tech projects needs improvement with an in-depth preliminary assessment in order to produce world-class high-tech products.

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