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Methodological tools for assessing the competitiveness of enterprises of the mining complex

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Abstract

Relevance. The mineral resource complex of Russia remains the basis for the sustainable development of the state and its competitive advantage in world trade. As before, up to 70% of the foreign exchange earnings of the Russian Federation is formed thanks to its products, including metallurgy. The mining industry is a backbone for the national economy, determining the efficiency and nature of the development of related sectors, provides a decisive contribution to the formation of the stabilization fund and the country's gold and foreign exchange reserves. The competitiveness of a country (national competitiveness) is made up of the competitiveness of regions, industries, enterprises and organizations, their ability to win and strengthen their leading positions in domestic and foreign markets. Competitiveness management requires constant evaluation of this parameter.

The purpose of the research is the development of methodological tools for assessing the competitiveness of mining enterprises, taking into account the sectoral approach.

Research methods. The work uses general scientific methods of analysis and synthesis, program-target approach, economic, logical and logical-structural analysis, methods of comparison, analogy, expert assessments.

Results. The article presents the results of the analysis of the methods used to assess competitiveness, and the rationale for the need for an industry-specific approach to the implementation of assessment procedures. A system of partial assessment factors is proposed that characterizes the competitiveness of mining enterprises, taking into account the specifics of their production activities. The expediency of referring to a comparative assessment on the Harrington desirability scale, introducing additional products into the procedure for assessing profit and profitability indicators and calculating an integral indicator is proved. The proposed methodological tools have been tested for the conditions of four gold mining enterprises.

Conclusions. The proposed methodological tools make it possible to obtain the most reliable assessments of the competitiveness of mining enterprises, taking into account the specifics of the industrial activity of the latter. Of particular note is the possibility of using the developed methodological tools for assessing the investment attractiveness of enterprises in the mining complex.

***Keywords*:** competitiveness, mining enterprises, methodological tools, factors, integral indicator, algorithm.

Introduction

In modern economic science, much attention is paid to competition issues. The need to identify the most competitive enterprises for the state is a key condition for the distribution of subsidies, grant-in-aids, tax breaks, and for investors - the key to obtaining the desired effect. Advantages in activity for any enterprise under preferential treatment, especially for small and medium-sized enterprises, put them in a better position than other participants in economic activity. The organization, formation and development of such enterprises lead to the creation of jobs, reduce social tension, and solve other issues of national importance. To quantify the competitiveness of enterprises and goods, there are many methods developed by foreign and domestic authors. All the most well-known methods and models for assessing competitiveness today can be divided into two groups: calculation (analytical) and matrix (graphic). At the same time, there are many classifications, where these groups are divided into a number of additional methods. For example, calculation methods are divided into specific, complex, integral, benchmarking, etc.

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The analysis shows that the following methods take place in practice:

– based on the theory of comparative advantage; the approach was first proposed by D. Ricardo [1]; the modern interpretation of the method, according to the models of Heckscher–Ohlin, Samuelson–Stolper and others, – the country exports those types of goods for which its productivity is higher than that of the counterparty country, and imports goods of those industries in which productivity is lower (in relation to international competition);

– based on the assessment of the competitiveness of products; proposed by R. A. Fatkhutdinov, A. A. Voronov and others; according to this method, the higher the competitiveness of its products, the higher the competitiveness of an enterprise is; the disadvantage of the method is that the competitiveness of an enterprise is determined only by the competitiveness of products;

– based on the theory of effective competition; proposed by I. A. Maksimova, D. A. Milgrom [2] and others; according to the method, the most competitive are those enterprises where the work of all departments and services is best organized; the method involves the use of mainly expert assessments, which does not make it possible to objectively determine the level of competitiveness of an enterprise;

– competitiveness assessments based on a systematic approach involve evaluating the results of interdependent systems; the evaluation determines the significance of each criterion; requires the use of cumbersome economic and mathematical models;

– based on an assessment of the level of use value; proposed by K. R. Nurmaganbetov, N. D. Esmagulova [3] and others; the level of competitiveness is determined by the totality and relative importance (quality, price, level of sales organization) of the consumer properties of the product; do not give a full assessment of the competitiveness of the enterprise;

– based on market share calculation; proposed by L. V. Tselikova [4] and others; an increase or decrease in the share in the range from 0 to 100% indicates the level of competitiveness; disadvantage – when determining the place of an enterprise in the market, it is impossible to determine the reasons for the identified situation and, accordingly, develop the necessary strategy to increase competitiveness;

– using an ideal product (or a model with an ideal point); proposed by O. V. Kirilova, S. F. Golov (in the version with the measurement of the degree of satisfaction of the need for the product); the degree of deviation of the proposed product from the ideal is determined; disadvantage – subjectivity in determining the characteristics of an ideal product, the use of expert assessments.

Separately, we can note the dynamic method for assessing the competitiveness of enterprises (V. V. Krivorotov [5], D. S. Voronov [6]).

To assess the competitiveness of an enterprise, a product, various criteria and indicators are used. According to M. Porter [7], indicators and criteria can be divided into natural (natural resources, geographic location) and artificial (technologies used, economic environment, etc.), as well as internal (production and economic potential, marketing, personnel, etc.) and external (government influence, the socio-economic situation of the country, the nature of markets, etc.). Depending on the choice of the method for assessing the level of competitiveness, an enterprise can determine and operate with indicators characterizing the goods produced, or determine the indicators used in the analysis of the production and economic activities of the enterprise (i.e., determine the level of competitiveness of an enterprise by the competitiveness of manufactured goods or by competitiveness production activities of the enterprise). In a number of methods, the authors propose formulas for calculating the integral indicator of the competitiveness of an enterprise or products based on partial indicators. Often, various criteria, indicators are combined into functional groups. So, R. A. Fatkhutdinov proposes the following groups of indicators for assessing the competitiveness of an organization:

1) advantages in the external environment (macro environment, regional infrastructure, micro environment);

2) advantages in the internal environment (technology, organization of processes, resources);

3) advantages in the quality and resource intensity of manufactured goods, innovations (goods, innovations, services);

4) market advantages (in terms of market size, number of competitors, efficiency and reliability of financial transactions, trade security).

In the work of L. V. Tselikova, the indicators are combined into 8 groups [4], etc.

Currently, among specialists there is no single point of view on the composition of indicators characterizing the level of competitiveness of an enterprise, which is noted in a number of studies [5, 8]. Often, when assessing competitiveness, a set of indicators is used, the number of which is measured in tens and reaches hundreds. It is unrealistic to obtain identical indicators in such quantity from a competing enterprise for their comparison. At the same time, some indicators are insignificant and have little effect on the level of competitiveness of the enterprise, but the analysis of their significance is not carried out. As V. E. Goryunov notes [9], "even if it were possible to establish an absolutely complete list of competitiveness factors, then, according to systems theory, the assessment of the properties of an object based on the assessment of its extremely elementary components does not ultimately give an adequate assessment of the object under consideration, since these elementary components determine the properties of the object not autonomously, but in combination, in interaction with each other, which is not taken into account when assessing the object under study element by element". In addition, an excessive increase in the number of competitiveness factors (in the case of a theoretical assumption of the possibility of forming an absolutely complete list of factors) leads to the fact that the laboriousness of their mathematical processing becomes extremely high, and the task of collecting the necessary data is practically impossible, which significantly reduces the practical applicability of such methods of assessing the competitiveness of enterprises.

An analysis of competitiveness assessment methods also showed that almost all authors are trying to develop universal methods with universal indicators that can be applied to enterprises of any industry, of any type and scale of production. The noted shortcomings of existing approaches to assessing the competitiveness of enterprises limit the possibility of their prac-

tical application for assessing the competitiveness of enterprises that differ in the specifics of production activities, which include the mining industry. This circumstance requires an industry – specific approach to assessing competitiveness, which the proposed methodological tools implement.

Results

The main requirements for the methodology for assessing the competitiveness of a mining enterprise are as follows:

1. The methodology should use the minimum possible number of indicators provided with the necessary information;

2. The system of indicators should reflect natural resource, environmental, social and institutional factors;

3. The methodology for each industrial type of minerals (combustible, metallic, non-metallic, fresh and mineral waters), the scale of the deposit (small, medium, large, unique) should include the use of a specific set of indicators;

4. The methodology should take into account not only internal, but also external factors.

To assess the competitiveness of enterprises, the calculation and interpretation of integral indicators are used. With their help, the whole set of economic, technological, organizational and other factors is taken into account. The influence of these factors is reflected through quantitative and, in some cases, qualitative private indicators. The evaluation procedure is carried out by calculation and expertise. Experts conduct an intuitive-logical analysis of the problem with a quantitative assessment of judgments and formal processing of the results. The problem of determining the competitiveness of mining enterprises belongs to the class of problems with sufficient awareness. Hence the generalized opinion of the expert group is close to the true one.

Experts establish and compare groups of the most significant positive and negative factors of the competitiveness of mining enterprises:

$$F_p = F_n, F_p > F_n, F_p < F_n,$$

where F with indices "p" and "n" are positive and negative factors of competitiveness. The most preferable condition for a positive assessment: positive factors are greater than negative factors. For the selection of factors, it is proposed to take into account the main specific features of the industry:

1. The amount of mineral resources, including technogenic waste, off-balance reserves (reserves that cannot be used at the present time due to imperfect technologies, low prices, lack of demand for raw materials, etc.);

2. Mining and geological conditions of mining;

3. The quality of the mineral;

4. Technogenic and environmental impacts during mining;

5. Institutional environment (a set of legal, social, political and economic rules that define the scope of the enterprise);

6. Dependence on world prices for products.

The choice of factors is carried out on the basis of a comprehensive analysis of the work of the industry, individual enterprises, the study of scientific and reference literature. According to the results of an expert survey of specialists, for a comparative assessment of the competitiveness of enterprises developing gold deposits, 12 significant factors with approximately equal significance were proposed for the conditions of the pre-project stage (table 1).

Positive factors:

$$a_1, a_2 \dots a_i;$$

a_1 – estimated indicator – profit to cost ratio (cost effectiveness ROTC – total cost); a_2 – sufficient geological knowledge (reserves of the deposit of higher categories according to the current classification; if there are reserves of lower categories, they are transferred to higher ones according to the presented coefficients), a score factor; a_3 – prospects for replenishment of reserves (reproduction of the mineral resource base); a_4 – favorable mining and geological and hydrological conditions; a_5 – estimated indicator of the minimum industrial content of useful components in the ore in comparison with the average for the industry; a_6 – the presence of unused waste with valuable consumer properties;

Negative factors:

$$b_1, b_2 \dots b_i;$$

b_1 – unfavorable environmental situation around the enterprise; b_2 – presence of mining risks; b_3 – environmental risks (impossibility to comply with environmental regulations); b_4 – presence of hazardous waste; b_5 – administrative risks (the possibility of temporary suspension and even a complete ban on production activities by government departments and bodies exercising control and supervision over the safe conduct of work, compliance with sanitary and economic standards, fire safety standards, etc., interaction of the enterprise with government structures in the process of production activities); b_6 – a significant proportion of lagging technology.

Factor b_5 is external, the rest are internal.

Depending on the method of development (underground, open, geotechnological, underwater), type of mineral, produc-

Table 1. Factors of competitiveness of mining enterprises
Таблица 1. Факторы конкурентоспособности горнодобывающих предприятий

Positive factors	Negative factors
a_1 – field development profitability	b_1 – unfavorable environmental situation around the enterprise
a_2 – sufficient geological knowledge	b_2 – presence of mining risks
a_3 – availability of replenishment prospects	b_3 – presence of environmental risks
a_4 – favorable mining and geological and hydrological conditions	b_4 – presence of hazardous waste
a_5 – high minimum industrial content of useful components in the ore	b_5 – administrative risks
a_6 – the presence of unused waste with valuable consumer properties	b_6 – a significant proportion of lagging technology

tion capacity of the enterprise, the main factors of the enterprise's competitiveness may be different. To obtain the same type of indicators, the desirability function of E. K. Harrington is used, according to which the evaluated factors will receive a point score. The formula for calculating the generalized indicator of competitiveness is as follows:

$$D = d_1 + d_2 + \ldots + d_i, \quad (1)$$

where D – generalized indicator of competitiveness.

Ultimately, in the evaluation process, a generalized indicator is obtained that characterizes the system of evaluated factors with the help of private indicators.

The second criterion indicator is additional profit, the third one is profitability related to the use of off-balance reserves and waste, which increase the mineral resource base of the enterprise [10]. To calculate them, the size of the cost of additional production, the cost of obtaining it, profit, profitability of mining is determined, which are calculated taking into account the extraction of metal from the tailings of ore processing, off-balance reserves, and overburden processing (mainly rock mass). In the process of calculations for specific deposits, individual indicators are adjusted:

– the reliability of the deposit reserves is taken into account; for this, reserves are adjusted according to the recommended reliability factors [11];

– the value of the deposit reserves is calculated taking into account the increase in value due to the additional volume of mineral resources (off-balance reserves, mining and processing waste);

– for a group of precious metals, the prices for which are characterized by a very significant volatility of the market rate, a sensitivity analysis of the financial indicators of the enterprise to changes in world prices for products is carried out or the price of the metal is adjusted for the estimated price risk.

Competitiveness is assessed by the degree to which the maximum value of the generalized indicator of competitiveness and the maximum indicators related to additional products have been achieved. As a method that facilitates the search for the best option, a method is proposed for evaluating decisions by the degree to which a given set of goals is achieved [12]. The essence of the method lies in the fact that the effectiveness is evaluated by the degree of achievement of a given combination of target criteria indicators. Each solution is considered as a point in the n-dimensional Euclidean space, the

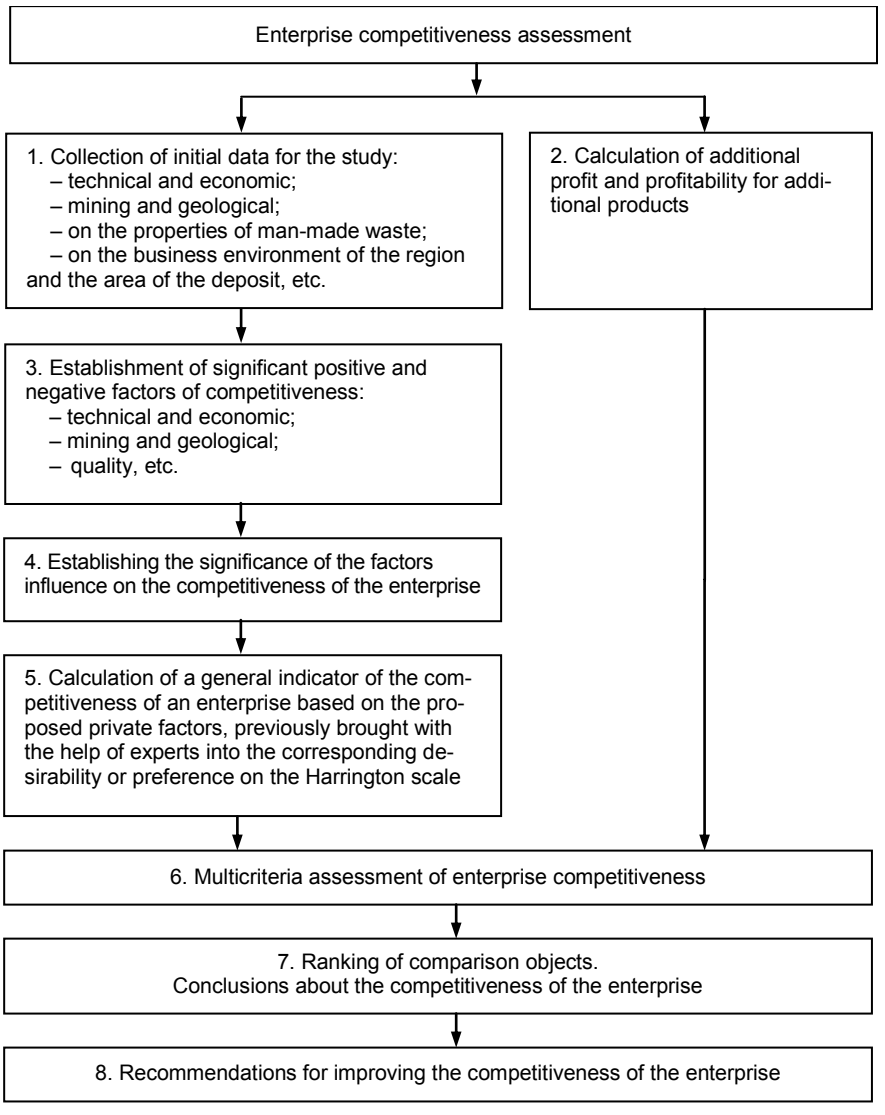

Figure 1. Algorithm for assessing the competitiveness of a mining enterprise
Рисунок 1. Алгоритм оценки конкурентоспособности горнодобывающего предприятия

coordinates of which are determined by the values of the target indicators involved in the comparison procedure. The selected solution is evaluated by the degree of remoteness of the latter from the reference point, which is characterized by the vector of the best values of partial indicators. The weighting of the target indicators is taken into account by the corresponding coefficients *k*, the value of which is established by an expert:

$$p_i = \sqrt{k_1\left(1-\frac{a_{i1}}{a_1^e}\right)^2 + k_2\left(1-\frac{a_{i2}}{a_2^e}\right)^2 + \ldots + k_n\left(1-\frac{a_{in}}{a_n^e}\right)^2}, \quad (2)$$

where p_i – the distance of each of the compared options to the reference point; a_1, a_2, … a_n – set of coordinates (numerical values of target indicators) of the *i*-th option in *n*-dimensional space; k_1, k_2, … k_n – weighting coefficients of targets; $a_1^э, a_2^э, \ldots a_n^э$ – reference point coordinate set.

According to the results of the analysis using the Harrington desirability function, the most competitive enterprise has undoubted competitive advantages that provide leadership in the market now and in the future, as it will have real financial opportunities to realize its innovative potential, to access advanced technologies, to move to new technological order [13, 14].

The algorithm for assessing the competitiveness of a mining enterprise is shown in fig. 1:

1. Collection of data on the deposit or deposits under study, based on the geological information available to subsoil users about the subsoil, the location of the subsoil plot and the results of calculations of technological and economic indicators for the development of the reserves of the subsoil plot;

2. Calculation of the main economic indicators, taking into account the receipt of additional products of the mining enterprise;

3. Establishment of a list of the most significant technical and economic, mining and geological and other factors that positively and negatively affect the competitiveness of mining enterprises using the expert method;

4. Determining the significance of the influence of factors on the competitiveness of mining enterprises using an ordinal scale with points according to the degree of influence of factors;

5. Calculation of a general indicator of the competitiveness of an enterprise based on the proposed private factors, previously brought with the help of experts into the corresponding desirability or preference on the Harrington scale (formula (1));

6. Multi-criteria assessment of the level of enterprise competitiveness (formula (2));

7. When assessing the competitiveness of several enterprises, ranking enterprises according to the level of competitiveness, choosing the best option;

8. Substantiation of ways to increase the competitiveness of a mining enterprise and practical recommendations.

Approbation of methodological tools was carried out for the enterprise "Peshchernoye", which develops a gold deposit, in comparison with three other enterprises ("Altyntash", "Yagodnoye" and "Shilovskoye") [15].

Determination of the competitiveness conditions of the assessed mining enterprises in terms of positive and negative factors is presented in table 2.

During the evaluation, the experts were guided by the materials of pre-project studies on the listed gold deposits (feasibility study of conditions, environmental impact assessment, development project). When assessing, the experts took into account general practical recommendations and the specific features of each field. The calculation of the generalizing indicator of competitiveness is presented in table 3.

Table 2. Determining the conditions for the competitiveness of mining enterprises
Таблица 2. Определение условий конкурентоспособности горнодобывающих предприятий

Enterprise	Factors					
	a_1	a_2	a_3	a_4	a_5	a_6
	In terms of positive factors					
Altyntash	0,7	0,8	0,5	0,5	0,5	0,9
Peshchernoye	1,0	0,3	0,5	0,2	0,9	0,9
Shilovskoye	0,9	0,6	0,5	0,2	0,5	0,5
Yagodnoye	0,8	0,3	0,7	0,5	0,5	0,7
Enterprise	Factors					
	b_1	b_2	b_3	b_4	b_5	b_6
	In terms of negative factors					
Altyntash	0,5	0,3	0,7	0,3	0,9	0,7
Peshchernoye	0,5	0,5	0,3	0,3	0,5	0,7
Shilovskoye	0,3	0,3	0,3	0,3	0,5	0,5
Yagodnoye	0,9	0,3	0,9	0,3	0,5	0,5

Table 3. Calculation of the general indicator of competitiveness
Таблица 3. Расчет обобщающего показателя конкурентоспособности

Enterprise	Positive factors	Negative factors	Total *d*
Altyntash	0,7; 0,8; 0,5; 0,5; 0,5; 0,9	–0,5; –0,3; –0,7; –0,3; –0,9; –0,7	0,5
Peshchernoye	1,0; 0,3; 0,5; 0,2; 0,9; 0,9	–0,5; –0,5; –0,3; –0,3; –0,5; –0,7	1,0
Shilovskoye	0,9; 0,6; 0,5; 0,2; 0,5; 0,5	–0,3; –0,3; –0,3; –0,3; –0,5; –0,5	1,0
Yagodnoye	0,8; 0,3; 0,7; 0,5; 0,5; 0,7	–0,9; –0,3; –0,9; –0,3; –0,5; –0,5	0,1

Table 4. Economic indicators of additional products
Таблица 4. Экономические показатели дополнительной продукции

Enterprise	Products from tailings[1], kg	Cost, million rubles	Refining costs[2], million rubles	Products from off-balance reserves, kg	Cost, million rubles	Refining costs[3], million rubles	Rock building materials[4], million m^3	Cost, million rubles	Costs, million rubles	Total cost, million rubles	Total costs, million rubles	Total additional profit, million rubles	Return on costs, %
Altyntash	1101,6	2477,5	1085,0	1119,1	2516,8	2243	1,877	844,6	523,6	5838,3	3644,0	2184,2	60
Peshchernoye	792,0	1781,2	646,0	–	–	–	1,988	894,8	567,0	2676,0	1213,1	1462,7	120
Shilovskoye	261,3	465,6	185,2	639,6	1463,0	1241	0,380	171,1	105,7	2099,0	1532,0	5 67,0	37
Yagodnoye	684,0	1577,3	565,0	637,5	1438,0	1217	1,167	525,1	320,0	3536,0	2213,0	1323,0	60

Note:
1. Extraction of metals from tailings using the most promising methods (for example, chlorinated roasting) accepted 80% (practically can reach 95%), losses 10%;
2. The cost of processing 1 ton of sand from the tailing dump is 750 rubles (by analogues);
3. The development and processing of off-balance reserves is identical to the processes of development and processing of reserves, due to the low metal content, the increased consumption of reagents is taken into account by a factor of 1.1;
4. Processing is possible in the amount of 70% of the volume of rock overburden, bulk density (bulk weight) 1380 kg/m^3, price 450 rubles/m^3, self-delivery.

Table 5. Multicriteria assessment of competitiveness
Таблица 5. Многокритериальная оценка конкурентоспособности

Enterprise	Calculation formula	Multicriteria assessment indicator
Altyntash	$p_{\text{А}} = \sqrt{0,7\left(1-\frac{0,5}{1}\right)^2 + 0,15\left(1-\frac{60}{120}\right)^2 + 0,15\left(1-\frac{2184,2}{2184,2}\right)^2}$	0,46
Peshchernoye	$p_{\text{P}} = \sqrt{0,7\left(1-\frac{1}{1}\right)^2 + 0,15\left(1-\frac{120}{120}\right)^2 + 0,15\left(1-\frac{1462,7}{2184,2}\right)^2}$	0,13
Shilovskoye	$p_{\text{Sh}} = \sqrt{0,7\left(1-\frac{1}{1}\right)^2 + 0,15\left(1-\frac{37}{120}\right)^2 + 0,15\left(1-\frac{567}{2184,2}\right)^2}$	0,39
Yagodnoye	$p_{\text{Ya}} = \sqrt{0,7\left(1-\frac{0,1}{1}\right)^2 + 0,15\left(1-\frac{60}{120}\right)^2 + 0,15\left(1-\frac{1323}{2184,2}\right)^2}$	0,79

Additionally, the profit and profitability of additional products is calculated. The costs of obtaining it are calculated taking into account the extraction of metal from ore processing tailings, off-balance reserves, processing of rock mass for building materials (where adjustments for the price of the metal are taken into account). The extraction of silver from tailings and off-balance reserves, due to its low content and insignificant price compared to gold, will be obviously unprofitable. The results of calculations for the economic indicators of additional production are presented in table 4. The effectiveness of the development of compared enterprises is evaluated by the degree to which a given combination of target indicators is achieved.

Each solution variant is considered as a point in the *n*-dimensional Euclidean space, the coordinates of which are determined by the values of the criteria indicators involved in the comparison procedure. The selected solution is evaluated by the degree of remoteness of the latter from the location of the reference point, which is characterized by the vector of the best values of the indicators. The weighting of the criteria indicators is assumed to be 0.7; 0.15; 0.15 (table 5).

According to the set of target indicators, the Peschernoye deposit has the highest level of competitiveness.

Conclusions

The developed methodology and algorithm for assessing the competitiveness of mining enterprises, which are sectoral in nature, involve the combination of scoring and cost approaches and the use of a multi-criteria assessment of decisions made, which increases the reliability of the results and provides sufficient information support for making managerial decisions. Approbation of the proposed methodological approaches on the example of a number of enterprises in the gold mining industry has demonstrated the possibility of their practical application for solving applied problems related to assessing the com-

petitiveness of enterprises and the rational use of mineral resources. This technique can also be presented as a technique for assessing the investment attractiveness of a mining enterprise.

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Методический инструментарий оценки конкурентоспособности предприятий горнопромышленного комплекса

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Аннотация

Актуальность. Минерально-сырьевой комплекс России остается базисом устойчивого развития государства и его конкурентным преимуществом в мировой торговле. По-прежнему до 70 % валютной выручки РФ формируется благодаря его продукции, включая металлургию. Горнодобывающая отрасль являются системообразующей для национальной экономики, определяя эффективность и характер развития смежных секторов, обеспечивает решающий вклад в формирование стабилизационного фонда и золотовалютных резервов страны. Конкурентоспособность страны (национальная конкурентоспособность) складывается из конкурентоспособности регионов, отраслей, предприятий и организаций, способности их завоевывать и укреплять ведущие позиции на внутренних и зарубежных рынках. Управление конкурентоспособностью требует постоянно оценки этого параметра.

Цель исследования – разработка методического инструментария оценки конкурентоспособности горнодобывающих предприятий с учетом отраслевого подхода.

Методы исследования. В работе использованы общенаучные методы анализа и синтеза, программно-целевого подхода, экономического, логического и логико-структурного анализа, методы сравнения, аналогии, экспертных оценок.

Результаты. В статье приводятся результаты анализа методов, используемых для оценки конкурентоспособности, и обоснование необходимости отраслевого подхода к выполнению оценочных процедур. Предлагается система частных оценочных факторов, характеризующих конкурентоспособность горнодобывающих предприятий с учетом специфики их производственной деятельности. Доказывается целесообразность обращения к сравнительной оценке по шкале желательности Харрингтона, введения в процедуру оценки показателей прибыли и рентабельности дополнительной продукции и расчета интегрального показателя. Предлагаемый методический инструментарий апробирован для условий четырех золоторудных предприятий.

Выводы. Предлагаемый методический инструментарий позволяет получать наиболее достоверные оценки конкурентоспособности горнодобывающих предприятий, учитывающие специфику производственной деятельности последних. Особо следует отметить возможность использования разработанного методического инструментария для оценки инвестиционной привлекательности предприятий горнопромышленного комплекса.

***Ключевые слова*:** конкурентоспособность, горнодобывающие предприятия, методический инструментарий, факторы, интегральный показатель, алгоритм.

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