EFFICIENCY ESTIMATION OF ANTI-CRISIS DESISIONS IN THE MANAGEMENT OF UP–TO-DATE RAW ENTERPRISES

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Abstract. The article deals with modern ways of anti-crisis management at the raw enterprises taking into account different aspects of ecological problems, extensive production and exhaustion of resources, economic crises and globalization. The authors have described fundamental stages of assessment of economic efficiency of anti-crisis projects and proposed a common mechanism and mathematical model of assessment of anti-crisis solutions efficiency in the management of the iron ore company. The mechanism involves optimum reserves delineation for the best economic benefits. The authors have substantiated economic efficiency of partial extraction of unconditioned iron ore as a profitable way of anti-crisis management in modern conditions of economy development.

Keywords: efficiency, raw enterprise, anti-crisis management, optimization, economic modeling.

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Introduction

Modern business-world is extremely dynamic. Such dynamism provokes different risks, economic problems and crises at various levels of human life. Despite the fact that global progress has developed rapidly, many economic and social problems remain unresolved. This is especially true for industrial enterprises that intensively use raw materials and material resources of the planet, affecting the environment and degrading the environmental situation. However, these enterprises are of primary importance for the society and business. They use a variety of resources involved in the creation of wealth and even have considerable portion of power, which is very important. Business enterprises are closely related not only to economics, but also to the development of societies, social changes and technological advances. Thus, one of the most important challenges today is to ensure a balance between business interests, the needs of production, depletion of resources and the environment. Management of up-to - date industrial enterprise has become both science and art nowadays that allows providing such important equilibrium. This task is complicated by economic instability, risks, world crises and limitation of resources in the raw markets. Due to this fact modern business needs up-dated anti-crisis decisions.

A brief overview of research and publications

On the one hand, each industrial enterprise is a functional part of business and public environment, and on the other hand it is its driving force. So, the enterprise depends on the

external environment and at the same time influences it by production, using raw, material and human resources.

Professor Booth S. describes crisis-management of industrial enterprise as a set of elements, each of which can be a source of risk and danger (Fig. 1).

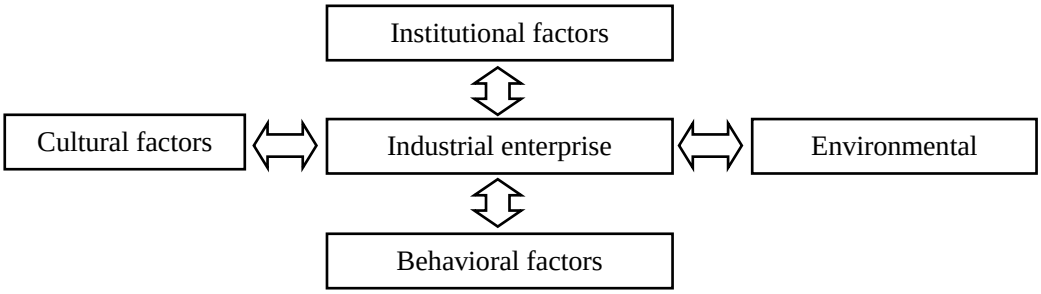

Fig.1. Environment of modern industrial enterprise
Resource: research by Booth S. (Booth, 2015: 4)

These main factors determine the strategy and management style, based on the perspective of the crisis. Thus, anti-crisis decisions need to be based on such aspects (Booth, 2015: 85):

- environmental factors that cause the most significant effects leading to the survival of the enterprise;
- institutional influences including the regulatory forms, within which the company operates, and formal relationships that affect the trajectory of the company activities;
- cultural factors that create the climate, which is the basis of risk management and the style of decision-making;
- behavioral factors that relate to individual employees and groups in the enterprise and outside it.

According to the study of Booth S. A. and others (Booth, 2015; Tietenberg, Lewis, 2016; Baxter, 2013; Lam, 2014), environmental factors are very important for enterprise management. They include the external environment and ecology, resource availability, technologies, economic and political situation in which the enterprise operates.

Summing up the aforesaid, it is worth noting that today, many scientists from different countries develop theoretical and empirical tools necessary for understanding and analyzing problems in management of environmental and resource economies (Tietenberg, Lewis, 2016; Hanley, Shogren, White, 2013; Callan, Thomas, 2013; Lowe, 2012; Heutel, 2012; O'riordan, 2014). It is important to note that these General economic concepts such as benefit-cost analysis, discounting, valuation techniques, externalities, property rights, and market failures can be applied to a number of environmental and natural resource Economics issues such as air pollution, the management of non-renewable resources, sustainable development and management of industrial enterprises.

Callan S., Thomas J. and Hanley N. (Hanley, Shogren, White, 2013; Callan, Thomas, 2013) propose their own methodology and analytical tools for the assessment of anti-crisis decision-making and planning with regard to the environmental component. So, modern anti-crisis management assumes:

- environmental risk analysis;

- assessing benefits for environmental decision making;
- assessing costs for environmental decision making;
- benefit-cost analysis for environmental decision making (Hanley, Shogren, White, 2013:126).

According to scientific works (Tietenberg, Lewis, 2016; Nusinov, Burkova, 2015; Khorolskyi, Khorolskyi, Gayday, 2015; Yellishetty, Mudd, 2014), nowadays great attention should be paid to management of such industrial raw enterprises as mining companies, because they extract ore raw materials which are very important for steel production, mechanical engineering, construction and other spheres.

Professors L. Lewis and T. Tietenberg (Tietenberg, Lewis, 2016:46,122) define such tasks of anti-crisis management and efficiency assessment of mining projects:

- finding criteria of efficiency;
- finding optimal outcome for the enterprise;
- risk estimation;
- cost-effectiveness analysis for the N-period of time;
- increasing marginal extraction cost.

Also they specify that such "decision-making metrics" is important for mining enterprises because today they are in need of effective anti-crisis solutions. Thus creation of methodology for assessing the effectiveness of various anti-crisis projects is a challenge for mining companies.

Task and its relevance

As shown earlier, today the key line of many studies concerns the development of anti-crisis decisions for the industrial raw enterprises and assessment of their efficiency. Mining companies are striking examples of such raw enterprises.

At the modern stage of industrial and economic development the economic efficiency of underground extraction requires the solution of actual issues related to their resource base expansion, production performance optimization, reducing the pace of deepening mining operations while maintaining the quality and competitiveness of iron ore products. This is particularly important for mining companies of Ukraine whose activity provides a significant contribution to the economic development of the entire industry. At present, the economic efficiency of underground mining is significantly reduced due to achievement of significant production depth (more than 1400 m), dynamic growth in energy and materials prices, an increase of dumping costs and complexity of the conditions of ore extraction.

Under these conditions, involvement in the development of the reserves, which have so far been classified as off-balance and not mined, can become the production strategy of a mining enterprise. Such a significant amount of the off-balance reserves is present at any mine. However, the complexity of the study of economic feasibility and efficiency of the off-balance reserves extraction is explained by the fact that, in some of their parameters, they may differ significantly from the standards for iron ore. Today, off-balance reserves of enterprises are being lost by enterprises almost in full due to the lack of the overall economic mechanism for the substantiation of their extraction expediency. Based on the above, the formation the mechanism of the economic justification of the off-balance reserves development expediency is an urgent task. Its solution is important for the growth of economic efficiency of mining, expansion of the resource base and the development of the mining enterprises of Ukraine in crisis conditions.

Highlights of the research

As a result of our study, we have arrived at the conclusion that in modern conditions of industrial and economic development, attracting part of the off-balance reserves of iron ores to the operation cycle is a means of enhancing the economic efficiency of underground mining. It contributes to the solution of such important management issues as:

- the expansion of the raw material base of the mining companies;
- the growth of its revenue by attracting additional sources of raw materials;
- maintaining stable production capacity of mines;
- the extension of period of cost-effective operation of mines;
- reducing the rate of costly deepening of mining operations;
- reducing the cost of mining;
- the growth of ecological and economic efficiency by reducing the intensity of heaps formation;
- compliance with the state program of mineral resources base development in Ukraine for the period until 2030, which provides for the need of economically and technologically optimal, integrated and comprehensive use of mineral resources.

In most cases, the cost of the off-balance reserves production is lower, because they occur with the advancing of the mining front and on the upper floors which are already passed, which makes it possible to involve them in the production process through the use of already passed mining developments and constructed lifting systems.

Production strategy of mining companies on off-balance reserves attraction can be effectively realized through a combination of the following components: on the one hand - the presence and availability of the off-balance reserves for mining (their amount is usually up to 20-30% of the mine reserve), and on the other hand - introduction of the economic mechanism of feasibility study for such reserves mining.

For economic assessment of reserves at a mining company we propose to introduce the concept of "economically promising off-balance reserves" – this is part of the sub-standard ores which, on the basis of their economic value, cost of production and technologically acceptable locations are economically viable for mining in the current economic and geotechnical conditions of the enterprise. Involvement of these stocks is profitable for a company and contributes to obtaining an additional economic benefit to it.

Economic efficiency of the off-balance reserves development is explained, on the one hand – with the cost of production and processing, and on the other hand - with the income that mining company can receive from the sale of marketable ore seized from each ton of the off-balance reserves. These rates differ for different mining units depending on the characteristics of their development, which ultimately determines the economic expediency of the off-balance reserves attraction to the production process.

The first step is creation of model of efficiency estimation of anti-crisis decisions at the management of iron ore companies. Given the above, the system of economic efficiency indicators of the off-balance reserves development it formed.

We have developed an analytical criterion - the index of economic efficiency, which allows comparing the development of the main indicators of the balance and off-balance reserves, namely, the volume of commodity ore produced by the company, conditioning the amount of income and the economic value of reserves and the cost of their mining and processing.

$$I_E = \frac{Q_{m2.}}{C_2} / \frac{Q_{m1}}{C_1} = \frac{Q_2 \cdot \left[c_2 \cdot \frac{l_2}{f_2} \cdot k_{r2} \cdot (1 - q_{l2} \cdot k_{leach}) \cdot (1 - q_{r2} \cdot k_{rich}) \cdot k_{T2} \right]}{Q_1 \cdot \left[c_1 \cdot \frac{l_1}{f_1} \cdot k_{r1} \cdot (1 - q_{l1} \cdot k_{leach}) \cdot (1 - q_{r1} \cdot k_{rich}) \cdot k_{T1} \right]} \cdot \frac{C_1}{C_2}, \quad (1)$$

where I_E is the index of economic efficiency of the off-balance reserves development, the proportion of units; Q_{m1}, Q_{m2} is the volume of marketable ore, produced from balance reserves and off-balance reserves correspondingly, t; C_1, C_2 is the cost of mining and processing balance reserves and off-balance reserves correspondingly, UAH; Q_1, Q_2 is the volume of balance reserves and off-balance reserves correspondingly, t; c_1, c_2 is the iron content in the ore from balance reserves and off-balance reserves correspondingly, %; l_1, l_2 is loss factor for the development conditions of the balance reserves and off-balance reserves, the proportion of units;. f_1, f_2 is contamination factor for the development conditions of the balance reserves and off-balance reserves, the proportion of units. k_{r1}, k_{r2} is recovery factor of marketable ore for the processing of the balance reserves and off-balance reserves at crushing-screening plant, the proportion of units;. q_{l1}, q_{l2} is the specific density of the leached ore, respectively, in off-balance reserves and balance reserves, the proportion of units;. k_{leach} is the reduction factor of commercial ore output during processing due to the presence of leached ore in the reserves, proportion of units, q_{r1}, q_{r2} is the proportion of rich martite ores and hematite-martite ores respectively in balance and off-balance reserves, the proportion of units;. k_{rich} is the reduction factor of commercial ore output in the presence of rich martite ores and hematite-martite ores, proportion of units;. k_{T1}, k_{T2} is the coefficient of technological losses during the processing of the balance reserves and off-balance reserves at crushing-screening plant, the proportion of units.

It is shown that the most indicative for the evaluation of the economic feasibility of the off-balance reserves development are the following values of the index (2). In terms of $I_E \geq 1$ or $I_E \rightarrow 1$ the off-balance reserves can be regarded as a cost perspective. These index values indicate that the amount of commercial ore, now received as a result of the off-balance ores mining, and the cost of their production and processing is sufficient to provide the same effectiveness as in the development of balance reserves of the mine. When $I_E \geq 1$, the off-balance reserves can be involved in the development as an alternative to balance mine reserves that will not only expand the raw material base, but will also contribute to the prolongation of the effective operation of mining horizons. When $0.9 < I_E \leq 1$, off-balance reserves mining is more efficient than the mining of balance reserves in the lower producing horizons. When $I_E < 0.9$, off-balance reserves mining is not economically viable in the current economic and geotechnical conditions of the enterprise. However, off-balance reserves index in the range $0.7 < I_E \leq 0.9$ may eventually go into the category of economically promising in case of reducing the quality requirements to raw materials, technology development and cost reduction.

At the level of the mining enterprise the overall economic effect of the off-balance reserves mining is studied as an integral component, which is formed from such partial effects:

$$\Delta E = \sum_{t=1}^{T} E_{\Delta V} \cdot \alpha_t + \sum_{t=1}^{T} E_{\Delta C} \cdot \alpha_t + \sum_{t=1}^{T} E_{\Delta Cp} \cdot \alpha_t + \sum_{t=1}^{T} E_{\Delta I} \cdot \alpha_t + \sum_{t=1}^{T} E_{ecol} \cdot \alpha_t, \quad (2)$$

where ΔE is economic impact of mining off-balance reserves, UAH / t; T is the period during which the mining company involves in the operation the off-balance reserves, years; αt is the coefficient for raising multi-temporal costs and benefits to the calculated year t, the proportion of units;. $E_{\Delta V}$ is the effect (loss) from changes in the economic value of the remote reserves in attracting off-balance ore to the production, UAH / t; $E_{\Delta C}$ is the effect (loss) obtained by reducing or increasing the cost during the reserves mining, UAH / t. $E_{\Delta Cp}$ is the effect (loss) obtained by reducing or increasing the cost of ore processing at the processing plant, UAH / t; $E_{\Delta I}$ is the effect (loss) obtained by changing the efficiency of investment, UAH / t; E_{ecol} is the effect obtained by saving the cost of the environmental tax payment, UAH / t.

Studies of peculiar features of economic outcomes and costs formation when developing off-balance reserves led to the conclusion that the overall effect of such engagement will have ecological-economic component (E_{ecol}). The E_{ecol} effect will be obtained if instead of storing off-balance reserves on the surface, the company will involve part of them to the production process and thus eliminate the need for environmental tax payment for dumps formation and maintenance. Otherwise economic efficiency of this ore development in the future is reduced due to the fact that in the dumps, under the influence of natural factors, iron ore irreparably loses much of its economic value.

Determination of the integral economic effect by the formula (2) allows you to explore its structure and determine whether the correlation between the obtained economic results and costs is sufficient to ensure the economic feasibility of the off-balance reserves mining.

Implementation of economic mechanism of feasibility study for the efficiency and expediency of the off-balance reserves development is shown by the example of JSC "EVRAZ Suha Balka" (mine “Yuvileyna”, mine named after Frunze). The study showed that part of the off-balance reserves is economically viable for mining at the enterprise. The index of economic efficiency of such off-balance reserves is usually in the range (I_E = 0.9..1), and in some cases even $I_E > 1$.

We have determined gradation of changes in the profit that can be obtained by mining company through the development of the off-balance reserves, as well as the optimal values of indicators such as iron content in ore and production costs, ensuring cost-effectiveness of the off-balance reserves mining (Fig. 2).

According to the calculations we have studied the dynamics of fluctuations in profit (P, UAH / ton), depending on the performance of iron content in the ore (Fe,%) and production costs (C, UAH / ton), which made it possible to define the following graduation in its changes:

I, II are the off-balance reserves which are economically feasible to involve in the mining process, as the profit from their development exceeds the average profit indicator for the balance reserves of the mine. These reserves can be involved not only as an additional production volume, but also as an alternative to part of balance reserves, which will ultimately extend the term of the mine effective functioning.

III - off-balance reserves, profits from which are lower, but for the company their development is economically more efficient than mining of balance reserves in the lower mining horizons. Consequently, the reserves of this zone are also economically promising, and they should be involved in the development with a view to the overall increase in production volumes.

IV, V - off-balance reserves, profits from which are significantly lower than in case of balance reserves mining. These reserves are not economically feasible to develop at present.

However, with technological development and changing market conditions, the reserves of group IV can go to the III, and their economic value will be revised.

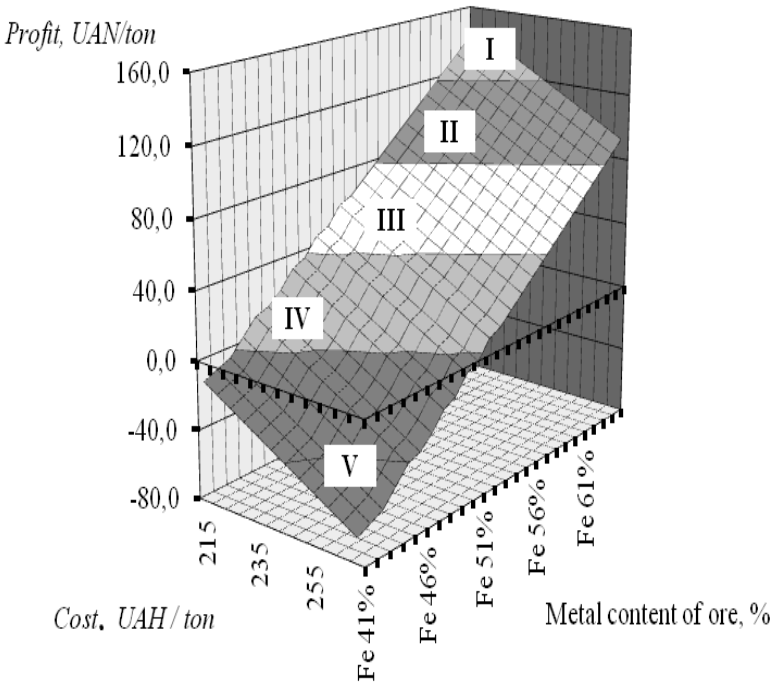

Fig.2. 3D model of profit
Resource: own research and calculations

Conclusions and suggestions

The study led to the conclusion that the anti-crisis and cost-effective production strategy for the company is involving off-balance reserves of higher and current mining horizons in the mining process with the purpose of obtaining additional economic benefits and reduction in the rate of mining operations deepening. This production strategy can also be proposed in order to increase overall performance, achieve the original design capacity of the mines, reduce the production cost and achieve the growth of economic efficiency of underground mining. At the level of the mining enterprise, the strategy can be considered in two dimensions:

1. Obtaining significant additional economic benefits by increasing production volumes subject to the availability of free reserves of production capacity of mines.

2. Off-balance reserves involvement at a constant performance of the mine in order to reduce the rate of mining operations deepening. In this case, the company will receive economic benefit comparing to mining in the underlying horizons. The time for the development of the mining horizon increases. We have found out that the expansion of the resource base by 20% due to the off-balance reserves extraction will provide ore mining

company with an extra year of cost-effective operation of the mine for every 5 years of development of the reserves.

By the example of Kryvyi Rih Basin, we have shown that withdrawal of the off-balance reserves from some mining blocks, totalling 400 thousand tonnes (up to 20% of annual mine production), will enable the company to obtain additional economic benefit of 19.8 million UAH (15% of the mine profits) with a corresponding increase in productivity and production volumes. At the sustainable annual productivity, economic benefits, compared to mining reserves in the lower horizons, will amount to 8.56 million UAH, and the intensity of the lowering of mining operations will decrease by 1.2 times. Thus, the production cost of mining off-balance reserves is by 17.5% lower than in the process of balance ore extraction at the underlying mining horizons.

Under these conditions, the involvement of the off-balance reserves in production cycle is economically and ecologically viable for the mining enterprise.

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