Designing an ERP Module for Assessing the Economic Status of Mining and Metallurgical Enterprises Based on Operating Leverage

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ABSTRACT
Demand fluctuation and increased competition in iron ore mining accompanied by increased total cost affect the economic status of mining and metallurgical enterprises. This can lead to either a significant increase or decrease of fixed costs in the total cost structure, which is characterized by operating leverage. The article is aimed at studying the structure of the total cost, which allows setting its marginal value necessary for assessing levels of theeconomic status at mining and metallurgical enterprises. The authors have applied such methods as economic analysis, systematization, generalization, correlation and regression analysis, economic and mathematical methods. Modern practices in the theory of the total cost formation indicate that existing methods and criteria of assessing the total cost structure do not allow determining their marginal structure and impact on the economic status of enterprises. To eliminate the revealed drawbacks, the authors suggest a methodical approach to assessing the economic statusof mining and metallurgical enterprises by means of the operating leverage criterion characterizing the marginal structure of total costs. The above-mentioned makes it possible to assess the economic status of mining and metallurgical enterprises by means of the operating leverage coefficient and determine the possible degree of the crisis.Theauthorssubstantiate the necessity to use management information systems of ERP (Enterprise Resource Planning) class in estimating the economic status of mining and metallurgical enterprises on the basis of operating leverage.
Keywords: *cost structure, factors, crisis levels, efficiency, information systems*

1. INTRODUCTION

Modern economic conditions make economists manage an enterprise efficiently, analyze available and potential threats, minimize current and consider possible risks of an enterprise's operation. Efficiency of control over an enterprise's total expenses is assessed by operating leverage which allows working out thorough economic analysis of an enterprise's activity.

Assessment of total cost control efficiency by means of operating leverage determines the degree of an enterprise's operating risk. Efficient control over total costs provides for determining limit values of the correlation of fixed and variable costs at mining and metallurgical enterprises to minimize their risks.

The practical implementation of the mechanism controlling cumulative costs through operating leverage at industrial enterprises involves the use of modern information systems and data processing technologies.

1.1. Literature Review

The issues of the economic mechanism of controlling operating costs have been raised by many Ukrainian and foreign economists, namely, I. A. Blank [1], F. Modigliani, M. Miller [2], P. Oghazi, Rad, F. Fakhrai, S. Karlsson, D. Haftor [3], O. A. Orlov, E. H. Ryasnykh [4], D. Ashraf, K. Felixson, M. Khawaja, S. M. Hussain [5], H.V. Savitskaia [6],A. M. Turylo, Yu. B. Kravchuk, A. A. Turilo[7], Z. Chen, J. Harford, A. Kamara [8], O. O. Tereshchenko [9], S. Sarkar[10] and others.

Yet, actual functioning of national mining and metallurgical enterprises reveals that the current system of operating costs control does not allow assessing their efficiency and possible bankruptcy risks.

Analysis of developing methods for determining efficiency of the operating costs structure aimed at preventing mining and metallurgical enterprises' crisis is of local and not always complex and system-based character.

Therefore, substantiation and development of the economic mechanism of controlling mining and metallurgical enterprises' operating costs becomes urgent.

2. PROBLEM STATEMENT

Considering the above, there arises a task of substantiating a criterion for assessing mining and metallurgical enterprises' economic status determined by the structure of their total costs that will result in reducing operating activity risks.

3. MATERIAL PRESENTATION AND RESULTS

To solve the set problems, the authors determine major factors of the operating leverage mechanism.

Economic and mathematical transformations should be based on determining the operating leverage coefficient as a ratio of the enterprise's marginal profit and the operating one (formula 1) [7].

$$DOL = \frac{V_{fixed} + P}{P}. \quad (1)$$

where *DOL*- is the operating leverage coefficient, unit fraction; V_{fixed} - is the value of fixed costs, MU; *P* - is the operating profit, MU.

To investigate characteristics of the operating leverage coefficient as the criterion of an enterprise's economic status, there are determined interdependencies of the operating leverage coefficient on factors determining its value. Modified formula (1) allows finding factors influencing the operating leverage like fixed costs, the critical (break-even) sales volume, sales profitability [11].

The above factors can be presented by:

$$Vcritical = \frac{V_{fixed} \times V}{MP}, \quad (2)$$

where $Vcritical$ - is the critical sales volume, MU; *MP* - is the marginal profit, MU; V_{fixed}- is fixed costs for the whole sales volume, MU; *V* - is the net operating income, MU;

$$Cp = \frac{P}{V}, \quad (3)$$

where *Cp*- is the sales profitability coefficient, unit fraction.

Then formula (1) will look like:

$$DOL = \frac{V_{fixed}}{Vcritical \times Cp} \quad (4)$$

Sales profitability is also affected by balance assets. Thus, considering the formulae determining the asset profitability coefficient *CpA*and the asset turnover coefficient *CpT*:

$$CpA = \frac{P}{A}, \quad (5)$$

$$CpT = \frac{V}{A}, \quad (6)$$

where *A* - is the balance asset, MU,formula (4) will look like

$$DOL = \frac{V_{fixed} \times Cpt}{Vcritical \times CpA}. \quad (7)$$

As a result of economic and mathematical transformations in calculating the operating leverage coefficient, one should consider four factors – fixed costs, the asset turnover ratio, the critical sales volume and the asset profitability coefficient.

Further transformations allow expanding a range of influential factors. Taking into account the fact that the ratio of the operating profit to equity capital forms equity profitability (*CpEC*), the leverage coefficient (*Cf*) is determined by the ratio of the balance asset to equity capital EC [6, 9], presented by formulae 8, 9:

$$\frac{EC}{P} = \frac{1}{CpEC}, \quad (8)$$

where EC - equity capital, MU,

$$\frac{A}{EC} = Cf, \quad (9)$$

Then, formula (7) will look like:

$$DOL = \frac{V_{fixed}}{Vcritical} \times \frac{1}{CpEC} \times Cf \times CpT. \quad (10)$$

Similarly, we introduce debt capital (DC) into formula (10) that will enable us to expand the number of influential factors:

$$DOL = \frac{V_{fixed}}{Vcritical} \times \frac{DC}{EC} \times \frac{V}{P} \times \frac{A}{DC} \times \frac{EC}{A}. \quad (11)$$

We expand the number of influential factors by introducing financial leverage, the sales profitability coefficient, the debt capital coefficient and the equity-assets ratio. The ratio of the debt capital to the equity capital forms financial leve7, rage [6, 7, 12]:

$$\frac{DC}{EC} = C_{FL}. \quad (12)$$

where C_{FL}- is the financial leverage coefficient, unit fraction.

The ratio of the operating profit to an enterprise's sales volumes is determined as the sales profitability coefficient [6, 7, 9]:

$$\frac{V}{P} = \frac{1}{Cp}. \quad (13)$$

The debt capital coefficient is determined by the ratio of the debt capital to an enterprise's balance assets [8, 9]:

$$\frac{A}{DC} = \frac{1}{Cdc}, \quad (14)$$

where *Cdc* - is the debt capital coefficient, unit fraction.

The ratio of the equity capital to the balance assets determines the equity-assets ratio [6, 7, 9]:

$$\frac{EC}{A} = Ceq, \quad (15)$$

where *Ceq* -is the equity-assets ratio, unit fraction.

Then, considering the above factors, formula (11) will look like:

$$DOL = \frac{V_{fixed}}{Vcritical} \times C_{FL} \times \frac{1}{Cp} \times \frac{1}{Cdc} \times Ceq. \quad (16)$$

We introduce the indices of the aggregate capital (*AC*) and an enterprise's net profit (*Pnet*).

The ratio of the net profit to the debt capital determines the profitability coefficient of the debt capital [6, 7, 11]:

$$\frac{Pnet}{DC} = Cp\ dc, \quad (17)$$

where $Cp\ dc$ - is the profitability coefficient of the debt capital, unit fraction.

The ratio of the aggregate capital (*AC*) to the equity capital forms the capital multiple [6, 7, 12]:

$$\frac{AC}{EC} = CM, \quad (18)$$

where *AC* - is the aggregate capital, unit fraction; *CM* - is the capital multiple, unit fraction.

The ratio of the net profit to the aggregate capital is the profitability coefficient of the aggregate capital multiple [6, 8, 12]:

$$\frac{Pnet}{AC} = Cp_{AC}, \quad (19)$$

where Cp_{AC}-is the profitability coefficient of the aggregate capital, unit fraction.

Finally, as a result of economic and mathematical transformations, formula (16) looks like:

$$DOL = \frac{V_{fixed}}{Vcritical} \times \frac{1}{Cp} \times \frac{1}{Cdc} \times Ceq \times \frac{1}{Cp\ dc} \times CM \times Cp_{AC}. \quad (20)$$

Thus, we obtain a complex index, which considers eight factors and allows assessing their influence on the investigated index. Most analyzed factors belong to indices of assessing an enterprise's economic status. It may be concluded that the operating leverage coefficient integrates a set of economic characteristics of an enterprise's activity [8].

The functional character of interrelated factors influencing the operating leverage coefficient can be investigated by means of factor analysis taking mining and metallurgical enterprises' economic indices as an example.

Thus, using expanded formula (20) for calculating the operating leverage coefficient, basic factors forming a resultant index are found. The conducted research allows formulating new basic characteristics of the operating leverage coefficient including the following. The operating leverage coefficient is the indicator of an enterprise's economic status which comprises basic economic characteristics. The feedback of the operating leverage coefficient and the financial robustness determines the characteristics of the operating leverage coefficient as an indicator of an enterprise's financial potential under stable economic conditions.

Diagnostics of crisis-like phenomena is one of the necessary stages of management. The diagnostics results are a tool of anti-crisis management which allows not only determining the degree of crisis-like phenomena, but also substantiating steps for their overcoming, estimating an enterprise's potential as for this and forecasting consequences of further development [12].

Foreign economists' research works also deal with investigation and diagnostics of crisis phenomena in an enterprise's functioning: S. H. Archer, G. M. Choate and G. Racette [12],K. J. Arrow [13], E. Altman [14], Merton H. Miller [2]. Such leading scholars as Altman E. A., Beermann K., Lis R., Springate K., Taffler R., Tishow H. and others developed methods and criteria of forecasting a crisis, formulated basic methodological approaches and approbated them at various enterprises [1, 2, 12, 14].

In spite of the great amount of research conducted, a set of problems is left unsolved including those associated with application of these models to assessing mining and metallurgical enterprises' possible bankruptcy. Considering this, it is advisable to analyze advantages and disadvantages of known models, and their acceptability for being applied in mining and metallurgical enterprises' practices.

Methodological approaches to crisis phenomena diagnostics have a common disadvantage – they have been created on the basis of other countries' economies. Most models do not take into account the impact of the external environment, the level of the state control of the national economy and its industries, specific features of separate industries' functioning, capital intensiveness of products, taxation, development stages of an enterprise, its market and national economy. It should be noted that application of such models requires caution. Their application is limited in assessing national economic entities' bankruptcy risks as they do not consider the capital structure in different industries while considering financial and operating components of enterprises' functioning. The plus of the models is their simplicity and possibility of interpreting model results as possible bankruptcy or its absence.

Significant contribution to development of this trend of financial analysis was made by Tereshchenko O. O. [9], who substantiated a new methodological approach to diagnostics of national enterprises' bankruptcy on the basis of multivariant discriminant analysis [9]. Consideration of the industry-specific features of research objects is an important advantage of the above approach in creating discriminant models of bankruptcy diagnostics.

Tereshchenko O.O. developed corresponding models for various Ukrainian industries. His discriminant model for mining and metallurgical industries has the following advantages. It is simple in calculation, based on national statistical data and considers industry-specific features. Due to application of various modifications of the basic model at enterprises of different activity types, it solves the problem of determining critical index values, which indicate possible bankruptcy of an enterprise in a certain industry [9].

Thus, both in foreign and national practices, there are many methods of determining an enterprise's possible bankruptcy, both separate indicators and models of factors with weight coefficients. Yet, the other scholars' models do not consider operating and financial components of crisis appearance. O. O. Tereshchenko's model considers specific diagnostics of national mining and metallurgical enterprises' bankruptcy [9].

Components of the mentioned model comprise financial and operating factors of an enterprise's activity that allows assessing the degree of bankruptcy threat. The model complexity can be considered a serious drawback in anti-crisis management as it does not allow distinguishing positive or negative impacts of the financial and operating activity on the value "Z".

Under current conditions of national economy development, there arises a necessity of more system-based approach to assessing an enterprise's economic status by results of its operating and financial activity.

The conducted research allows substantiating the operating leverage coefficient as an indicator of an enterprise's economic status. Distinguished peculiarities are confirmed by correspondence of the changed values of the operating leverage coefficient to the changed values of "Z". It is proven graphically (Figure 1, 2).

As Fig. 1-2 indicate, higher values of "Z" correspond to lower values of the operating leverage coefficient. In other words, the increased threat of the crisis according to "Z" values corresponds to the increased risk according to the operating leverage coefficient. Thus, the given factors have a reverse connection. We can also indicate a partial

discrepancy of increasing rates of the operating leverage coefficient and those of "Z" values. It is explained by a complex character of "Z" values assessing an enterprise's activity results (financial, operating, etc.).

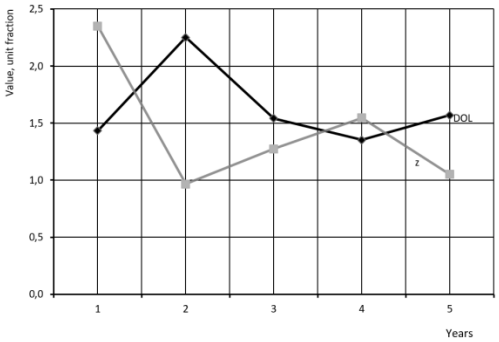

Figure 1 Dynamics of values of "Z" and the operating leverage coefficient (*DOL*) at the PJSC«Tsentralnyi GZK»

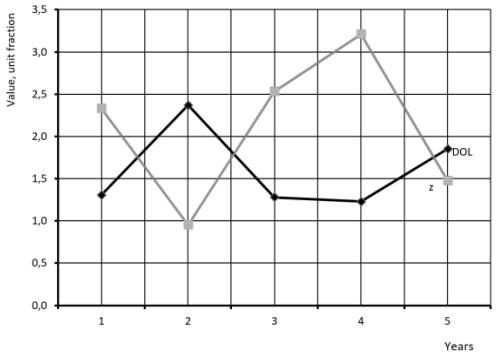

Figure 2 Dynamics of values of "Z" and the operating leverage coefficient (*DOL*) at the PJSC «Kryvbaszalizrudkom»

To assess the efficiency of forming the total costs structure and identification of crisis reasons we distinguish financial and operating components of the value "Z".

By means of the debt capital coefficient, we assess the financial component of an enterprise's economic status:

$$Cdc = \frac{DC}{EC}, (21)$$

where *DC* - is the debt capital, MU;*EC* - is the equity capital, MU.

As it has been indicated, we should distinguish either a positive or a negative impact of the operating activity on the value "Z" in order to assess efficiency of forming the structure of total costs and identification of the crisis reasons.

For further analysis, the authors have chosen O. O. Tereshchenko's model of assessing possible bankruptcy, which considers peculiarities of diagnostics of mining and metallurgical enterprises. The model components comprise financial and operating indices of an enterprise's activity that makes it possible to distinguish an operating component analytically.

Theoperatingcomponentisassessedbymeansoftheoperatingleveragecoefficient. Formula (1) modification allows determining the impact of the specific weight of fixed costs on theoperatingleveragecoefficient:

$$DOL = 1 + \frac{\partial V_{fixed} + CostT}{P} (22)$$

where *DOL* - is theoperatingleveragecoefficient, unit fraction;∂V_{fixed}- is the specific weight of fixed costs in total costs, MU;CostT - are total costs for product manufacturing and sales, MU;*P* - of the operating profit, MU.

As is known, the ratio of the operating profit to total costs in product manufacturing determines the coefficient of an enterprise's costs profitability that determines initial factors affecting the operating leverage:

$$Cpc = \frac{P}{costT}, (23)$$

$$DOL = 1 + \frac{\partial V_{fixed}}{Ccp}, (24)$$

where *Ccp* - is the coefficient of costs profitability, unit fraction.

After mathematical transformations of Tereshchenko's model, we obtain:

$$Z = 0{,}213 \times X1 + 2{,}208 \times (1 - Cdc) + 0{,}67 \times$$

$$\times X3 + 1{,}13 \times X4 + 1{,}48 \times X5 + 0{,}515 \times$$

$$\times \frac{\partial V_{fixed} \times CostT}{DOL - 1} + 0{,}467 \times X7 - 2{,}599, (25)$$

where X1 is current assets / current debts, MU/MU;Cdc - is the debt capital coefficient, unit fraction.X3 - is net proceeds from sales/ balance currency, MU/MU;X4 - is the sum of the net profit and depreciation / the sum of net proceeds and other operating profits, MU/MU;X5 - is the sum of the net profit and depreciation / balance currency, MU/ MU;∂V_{fixed}- is the specific weight of fixed costs in total costs, MU;CostT - is total costs in product manufacturing and sales, MU; *DOL*- is the operating leverage coefficient, unit fraction;X7 is net proceeds from sales / average remains of floating assets, MU/ MU.

The resulted dependency (formula 25) contains the financial component (*Cdc*) and the operating one (*DOL*), that confirms consideration of the operating risk while assessing the crisis analytically. This conclusion allows distinguishing the impact of the operating risk on the value "Z".

Statisticanalysis results indicate essential connection between the model factors: the multiple coefficient of determination R is 0.851 and the determination coefficient $R^2$is 0.725 under the standard $R^2$of 0.708.

The conducted research allows determining the type of dependency of the value "Z" on the leverage coefficient (*DOL*) and the coefficient of the debt capital (*Cdc*) for mining and metallurgical enterprises:

$$Z = a - b \times Cdc - c \times DOL, (26)$$

where Z - is "Z-assessment", unit fracture;a, b, c - are approximationcoefficients, unit fraction; *Cdc* - is the debt capital coefficient, unit fraction;*DOL*- is the operating leverage coefficient, unit fraction.

According to dependency (26) we determine the regression equation of dependency of "Z" on the operating leverage

coefficient (*DOL*) and the debt capital coefficient (*Cdc*) for mining and metallurgical enterprises:

$$Z = 3{,}587 - 2{,}379 \times Cdc - 0{,}497 \times DOL,$$

under $R^2 = 0.851$. (27)

Validation of model (27) for adequacy reveals high adequacy of the analyzed equation and presence of essential interrelation of function Z and factors (*Cdc*) and (*DOL*).

The model obtained (formula 27) allows determining mining and metallurgical enterprises' possible bankruptcy on the basis of the debt capital coefficient and the operating leverage coefficient, positive and negative impacts of the operating risk on the value "Z" in forming an enterprise's total costs.

Managing the structure of cumulative costs of mining and metallurgical enterprises on the basis of the obtained model (formula 27) involves the use of a flexible information system. The module of the management system of operating leverage should include dynamic blocks for processing financial information, scheduling productive, operating, and other enterprise resources. In the context of the need to process large data sets of mining and metallurgical enterprises, the most appropriate for optimizing the structure of enterprise costs is the use of ERP systems.

Enterprise resource planning (ERP) systems, represent an important backbone of the business which can control all organizational resources and transactions through one system. ERP systems are standardized, off-the-shelf software packages which build on best practices based on different industries. Furthermore, ERP systems respond to the need for integrated solutions by replacing legacy systems to avoid incompatible silo structures and data redundancy, reducing maintenance costs and contributing to the establishment of a common platform for the enterprise [15].

Adopting ERP systems is, however, a complex organizational and technical undertaking. Technically, the systems are challenging to implement in terms of configuration, adaptation, and data conversion from legacy systems. Organizationally, for optimal use, the system introduces changes in business processes, working routines, and roles of the employees. ERP systems are well-suited for implementation in multinational enterprises (MNEs) due to their wide range of functionalities and expected benefits, such as standardization, efficiency, and better communication.

Formation of the structure of mining and metallurgical enterprises' total costs is aimed at reducing operating activity risks, which requires setting limits of operating leverage values with the established risk level. Fixed costs affecting the operating leverage coefficient do not change if production increases in a relevant range. They generate greater dynamics of profits determining risks of an enterprise's operating activity.

Thus, there arises an issue of determining risk limits of an enterprise's operating activity. To calculate risk limits and systematize the operating leverage coefficients according to variants of developing events for mining and metallurgical enterprises we apply the regression equation of dependency of "Z" on the operating leverage coefficient (*DOL*) and the debt capital coefficient (*Cdc*) (formula 27).

Marginal values of the operating leverage coefficient in risk zones are calculated on the basis of values within the possible bankruptcy assessment according to. Tershchenko's model, which provides for three zones of possible bankruptcy – a financial crisis, additional analysis and financial stability. Comparison of results of analyzed indices of possible bankruptcy allows obtaining corresponding risk zones if the operating leverage coefficient is applied. It should be noted that "Z" has a reverse connection with the operating leverage coefficient.

The conducted research allows applying the operating leverage coefficient as a criterion of assessing mining and metallurgical enterprises' economic status. Obtained marginal values of the operating leverage coefficient in conformity with "Z" determine limits of the risk scale. Considering the obtained results, we distinguish three degrees of a crisis (critical, medium and low) as it is presented in Table 1.

Table 1 Degrees of crisis identification at mining and metallurgical enterprises according to the operating leverage coefficient

Values of the operating leverage coefficient (*DOL*), unit fraction	**Crisis degree**
$DOL \geq 1.788$	critical
$1.788 > DOL \geq 1.085$	medium
$DOL < 1.085$	low

Marginal degrees of crisis identification at mining and metallurgical enterprises by means of the operating leverage coefficient allows planning operating activity steps aimed at reaching the zone of lower risks than the current one. In doing so, one considers not an enterprise's financial status, but the efficiency of its operating activity. Increased values of the operating leverage coefficient cause the increase of an enterprise's crisis degree.

Crisis limits established by the operating leverage coefficient allow determining the achieved level of application of an enterprise's operating potential, identifying the current crisis degree and finding possible threats for an enterprise as a whole.

If the value of the operating leverage coefficient corresponds to the critical crisis degree, a substantial excess of fixed costs and a low level of costs profitability are observed. In this case, some steps are to be taken to reduce the crisis degree to the medium one.

The second crisis degree is also characterized by a negative impact on the specific weight level of fixed costs (excess of fixed costs) and costs profitability and requires some steps to reduce the crisis degree to the low one.

The third crisis degree determines the low risk by the operating leverage coefficient values, which leads to the stock of fixed costs at an enterprise.

Practical results of assessing the crisis degree by the operating leverage coefficient values in the analyzed period at mining and metallurgical enterprises reveal that the PJSC «Tsentralnyi GZK», the PJSC «Pivnichnyi GZK», the PJSC «Pivdennyi GZK», the PJSC «Kryvbaszalizrudkom» and the PJSC «EVRAZ Sukha Balka» have the medium crisis degree while at the PJSC «ArcelorMittal Kryvyi Rih» and the PJSC «Inhuletskyi GZK», the critical crisis degree is observed.

4. CONCLUSION

Thus, crisis degrees for mining and metallurgical enterprises are obtained on the basis of the operating leverage coefficient. They allow determining the achieved level of using an enterprise's operating potential, identifying the current risk level and finding potential threats for an enterprise as a whole.

Marginal degrees of crisis identification at mining and metallurgical enterprises by means of the operating leverage coefficient allow planning some operating activity steps aimed at reaching the zone of a lower risk degree than the current one. At the same time, one should consider not only an enterprise's financial status, but the efficiency of its operating activity as well.

Results of assessing the crisis at mining and metallurgical enterprises by the operating leverage coefficient values characterize the available structure of total costs, determine the achieved level of using an enterprise's operating potential, identify the current crisis degree and find potential threats of a possible crisis for an enterprise as a whole. The increased operating leverage coefficient causes the increase of an enterprise's crisis degree.

In order to prevent crisis phenomena at mining and metallurgical enterprises or reach its acceptable level, the operating leverage coefficient values can be changed by forming an effective structure of total costs with respect to the operating leverage coefficientin the context of ERP system implementation.

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