MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

SUMY STATE UNIVERSITY

Education and Research Institute of Business, Economics, and Management

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BACHELOR'S LEVEL QUALIFICATION THESIS

on the topic "Economic and Mathematical Modeling of Enterprise Management Quality Assessment"

Specialty 051 "Economics"
Study Programme "Business Analytics"

Student IV (course number) Course _____ (signature) Sydorenko A.A. (full name)

Group AB-71-8a.an (group's code)

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Bachelor's level degree qualification thesis contains the results of own research. The use of the ideas, results and texts of other authors has a link to the corresponding source _____ (signature) Sydorenko A.A. (applicant's full name)

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Sumy, 2021

SUMMARY

of Bachelor's level degree qualification thesis on the theme
"Economic and Mathematical Modeling of Enterprise Management Quality Assessment"

Student: Anastasiia Sydorenko

Enterprise management is a multidimensional complex feature based on internal indicators of financial and economic activities, level of management, employee education, coherence of teamwork, communication efficiency, level of technological equipment, and external factors of socio-economic and political environment. Effective management is not possible without understanding all the relationships that arise from the activities of the enterprise. The quality of the management decision on the future activities of the enterprise, its success, and competitiveness depends on how accurately and in detail the individual indicators, coefficients, and integrated characteristics of the project, production, financial, corporate, investment management will be calculated. Understanding all these aspects, comprehensive evaluation of their activities is a continuous, constantly relevant task for top management and business analysts.

The purpose of the qualifying bachelor's thesis is to assess the effectiveness of enterprise management based on the formation of a rating indicator and the development of regression models to describe the rate of increase in net profit as a key determinant of the efficiency of the enterprise.

The object of the study is the enterprises of the public sector of the economy, which belong to the sphere of management of the Ministry of Energy of Ukraine.

The subjects of the study are indicators of financial and economic activities that characterize the level of quality of enterprise management, international and domestic methods for assessing the level of efficiency of the enterprise, economic and mathematical methods of forming separate and aggregate indicators of quality of enterprise management.

The objectives of the study are: to justify the choice and relevance of quality indicators of enterprise management, the feasibility of their use; to analyze the quality factor of enterprise management; to review the current state of methodological approaches to assessing the effectiveness of the level of enterprise management, to carry out their comparative analysis; to determine the impact of stimulants and destimulants factors on the effectiveness of enterprise management; to make the normalization of indicators of management of the enterprise for their comparison and carrying out mathematical calculations; to develop multifactor regression models of rates of change the enterprise's net profit as the key characteristic of the enterprise management quality; to check the statistical significance of the developed regression models; to develop an aggregate rating indicator of the level of the enterprise management efficiency; to conduct a cluster analysis of the division of enterprises into the groups; to provide an interpretation of the results.

To achieve the goal and objectives of the study were used: fundamental concepts of theoretical and methodological research of domestic and foreign scientists on the importance of assessing the effectiveness of enterprise management; a set of general scientific and special research methods (analysis, synthesis, logical generalization, comparison, structural, functional analysis, bibliometric analysis); multidimensional statistical analysis (descriptive statistics, principal components analysis, cluster analysis), regression analysis; multiplicative convolution.

The information base of the bachelor's thesis consisted of the results of the pre-diploma practice, reporting materials of the Unified State Web Portal of Open Data, laws of Ukraine, reporting of public sector enterprises for 2020, scientific works of domestic and foreign scientists, indicators of enterprises activity and own calculations.

The main scientific results of the bachelor's thesis are the developed nonlinear regression model, which allows identifying reserves for improving the level of enterprise management and increasing the efficiency of its activities, and

the developed integrated indicator of the efficiency of Ukraine public sector enterprises.

Practical calculations were performed with Statistica package, Statgraphics Centurion package, and MS Excel software.

The obtained results can be used by economic-analytical departments and top managers of enterprises.

Keywords: indicators of financial and economic activity of the enterprise, efficiency of enterprise management, principal components analysis, integrated rating indicator, cluster analysis, nonlinear regression model.

The content of the Bachelor's level degree qualification thesis is set out on 47 pages, including a list of used sources of 35 titles placed on 5 pages. The work contains 9 Tables, 3 Figures, as well as 7 Appendices placed on 9 pages.

The year of Bachelor's thesis fulfillment is 2021.

The year of Bachelor's thesis defense is 2021.

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"__" _____2021 year

TASKS FOR BACHELOR'S LEVEL DEGREE QUALIFICATION THESIS

(specialty 051 "Economics" (Study Programme "Business Analytics"))
Student of IV course, group's code AB-71-8a.an.

SYDORENKO ANASTASIIA ANATOLIYIVNA
(student's full name)

1. The theme of the work is "Economic and Mathematical Modeling of Enterprise Management Quality Assessment" approved by the order of the university from "___"_____2021 year No ___
2. The term of completed paper submission by the student is "17" June 2021 year.
3. The purpose of the bachelor's thesis is evaluation of the efficiency of enterprise management based on the formation of a rating indicator and the development of regression models to describe the rate of increase in net profit as a key determinant of the enterprise efficiency.
4. The research object is the enterprises of the public sector of the economy belonging to the sphere of management of the Ministry of Energy of Ukraine.
5. The research subject is indicators of financial and economic activity that characterize the level of quality of enterprise management, international and domestic methods for assessing the level of efficiency of the enterprise, economic and mathematical methods of forming separate and aggregate indicators of the level of enterprise management quality
6. The qualification paper is carried out on materials of pre-diploma practice, and statistical data on the values of the enterprises' financial and economic activity indicators of the public sector of the Ukraine economy.
7. The indicative plan of qualification work, terms of submission of the chapters to

the research advisor, and the content of tasks for the performance of the set purpose is as follows:

Chapter 1 Theoretical and methodological aspects of the enterprise's quality management system – 04 June 2021 year

In chapter 1 it is necessary to substantiate the choice and relevance of indicators that characterize the quality of enterprise management, the feasibility of their use; to analyze the quality factor of enterprise management; to review the literature on the current state of methodological approaches to assessing the effectiveness of the level of enterprise management, to carry out their comparative analysis, to form a conceptual model for the formation of an integrated indicator of the enterprise efficiency.

Chapter 2 Development of models for evaluating the effectiveness of enterprise management – 11 June 2021 year

In chapter 2 it is necessary to determine the impact of stimulants and destimulants factors on the effectiveness of enterprise management; to make the normalization of indicators of management of the enterprise for their comparison and carrying out mathematical calculations; to develop multifactor regression models of rates of change the enterprise net profit as the key characteristic of the enterprise management quality; to check the statistical significance of the developed regression models; to develop an aggregate rating indicator of the level of the enterprise management efficiency; to conduct a cluster analysis of the division of enterprises into the groups; to provide an interpretation of the results.

8. Supervision on work:

Chapter	Full name and position of theadvisor	Date, signature	
		task issued by	task accepted by
1			
2			

9. Date of issue of the tasks: "01" March 2021 year

Research Advisor _____ _____
(signature) (full name)

The tasks has been received _____ _____
(signature) (full name)

CONTENT

INTRODUCTION

The quality of enterprise management directly determines the level of its competitiveness and financial stability, serves as a guarantee of economic development of the country as a whole. Understanding all aspects, comprehensive evaluation of their activities is a continuous, constantly relevant task for top management and analysts of public or private enterprises.

The purpose of scientific work is to assess the effectiveness of enterprise management based on the formation of a rating indicator and the development of regression models to describe the rate of increase in net profit as a key determinant of enterprise efficiency.

The object of the study is the enterprises of the public sector of the economy, which belong to the sphere of management of the Ministry of Energy of Ukraine.

The subjects of the study are indicators of financial and economic activities that characterize the level of quality of enterprise management, international and domestic methods for assessing the level of efficiency of the enterprise, economic and mathematical methods of forming separate and aggregate indicators of quality of enterprise management.

The main scientific results of the bachelor's thesis are the developed nonlinear regression model, which allows to identify reserves to increase the level of enterprise management and increase the efficiency of its activities, as well as developed integrated rating indicator of efficiency of public sector enterprises of Ukraine.

The objectives of the study are:

– substantiation of the choice and relevance of indicators that characterize the quality of enterprise management, the feasibility of their use;

– analysis of the quality factor of enterprise management;

– review of the current state of methodological approaches to assessing the effectiveness of the level of enterprise management, conducting a comparative analysis;

– determining the impact of stimulant and destimulant factors on the effectiveness of enterprise management;

– normalization of indicators that characterize the level of enterprise management;

– development of multifactor regression models of rates of change the enterprise's net profit as the key characteristic of quality the enterprise management;

– verification of statistical significance of regression models;

– development of an aggregate rating indicator of the efficiency level of an enterprise management;

– interpretation of the obtained results.

To achieve the goal and objectives of the study was used:

– fundamental concepts of theoretical and methodological research of domestic and foreign scientists on the importance of evaluating the effectiveness of enterprise management;

– a set of general scientific and special research methods (analysis, synthesis, logical generalization, comparison, structural, functional analysis, bibliometric analysis);

– multidimensional statistical analysis (descriptive statistics, principal components analysis, cluster analysis);

– regression analysis;

– multiplicative convolution.

CHAPTER 1. THEORETICAL AND METHODOLOGICAL ASPECTS OF THE ENTERPRISE'S QUALITY MANAGEMENT SYSTEM

1.1. The quality management system of the enterprise as a factor of its competitiveness

Enterprise management is a multidimensional complex feature based on the values of internal indicators of financial and economic activity, level of management, education of employees, coherence of teamwork, efficiency of communications, level of technological equipment and due to external factors of socio-economic and political environment [1]. Effective management is not possible without understanding all the relationships that arise from the activities of the enterprise. Thus, the quality of management is determined by the factors of project, production, financial, corporate, investment management, based on qualitative and quantitative indicators. The quality of the management decision on the further activity of the enterprise, its success and competitiveness depends on how accurately, in detail individual indicators, coefficients and integral characteristics of these factors will be calculated [2]. In the rapid development of digitalization processes, it is impossible not to emphasize that the level of quality management and operation of the enterprise depends on the introduction of innovative financial technologies, the ability to use them to achieve the main goal – to increase net profit.

It is important for any enterprise to compile comparative tables describing the absolute and relative deviations of financial performance indicators for the last periods of operation. During the pre-diploma practice at "LLC Vesela Torbynka" one of the tasks was to study the financial and economic indicators that characterize its activities. LLC "Vesela Torbynka" is engaged in purchase and sale of consumer goods, goods of industrial and technical purpose. Its economic

activity is aimed at making a profit and meeting social needs. Each service and employees act on the basis of regulations on departments and job descriptions of employees, which determine the place, role in the management system, the main tasks, responsibilities, rights, responsibilities for the work performed. The formation of indicators that determine the current state of the enterprise and, accordingly, the level of management economists-analysts carry out within two stages. At the first stage, a preliminary analysis of the enterprise, which is meaningfully described by a tuple of 8 coefficients: non-payment (loan arrears, repayment of liabilities to banks or other creditors), financial stability, independence (ownership), business activity, the efficiency of owner's equity, profitability, the total coverage ratio (shows how many times the company's working capital can cover current liabilities), the ratio of equity and long-term liabilities in inventories. These ratios are determined based on the Balance Sheet and the Statement of Financial Performance. The formulas for the calculation are given in the Table 1.1.

Table 1.1. Indicators of preliminary analysis of the enterprise's activity

Indicator of	**Formula for calculation**	**Interpretation**
Non-payment X_1	Row 620 (Balance Sheet)	Comparison of the amount at the beginning and end of the reporting period
Financial stability X_2	$\frac{\text{Owner's Equity} + \text{Long-term liabilities}}{\text{Currency of Balance Sheet}}$	$\geq 0{,}7$ – financial position is stable; $< 0{,}7$ – non-stable
Independence X_3	$\frac{\text{Owner's Equity}}{\text{Currency of Balance Sheet}}$	$\geq 0{,}5$ – independent state; $< 0{,}5$ – dependent state
Business activity X_4	$\frac{\text{Net profit}}{\text{Average annual Balance Sheet currency}}$	The lower the turnover, the worse the turnover of assets
The efficiency of owner's equity X_5	$\frac{\text{Income (}loss\text{)}}{\text{Owner's Equity (average value)}}$	The amount of net profit (loss) per 1 UAH of owner's equity

Continued Table 1.1

Indicator of	Formula for calculation	Interpretation
Profitability of enterprise X_6	$\frac{X_5(\%)}{\text{Average yield of securities (\%)}}$	The greater the value, the better
The total coverage ratio X_7	$\frac{\text{The amount of working capital}}{\text{Short - term liabilitie s}}$	The average allowable value is 2.0 - 2.5 times
The ratio of equity and long-term liabilities in inventories X_8	$\frac{\text{Owner's Equity} - \text{Non - current assets} + \text{Long - term liabilitie s}}{\text{Reserve fund}}$	The greater the value, the better (%)

If there are certain shortcomings in the activities of the enterprise only on the basis of the values of these coefficients, management has the opportunity to assess the degree of risk and quality of management. However, for a comprehensive assessment of financial aspects at the second stage, the calculation of coefficients in terms of 4 factors: the efficiency of financial resources, solvency, turnover of assets, potential of the enterprise. The factor of financial resources efficiency is formed by indicators of profitability: assets, equity, production funds, production and financial investments. The solvency factor includes the ratios of absolute liquidity, quick liquidity, total coverage ratio, net revenue ratio. The asset turnover factor is formed by turnover indicators: all assets, current assets, tangible current assets and non-tangible current assets. The fourth factor of the potential of the enterprise is determined by the values of the following indicators: the dynamics of the share of productive assets in total assets, the dynamics of the share of fixed assets in total assets, depreciation rate, dynamics of capital investments, use of financial investments. Of course, in the context of each enterprise, the content of the fourth factor is determined by the coefficients that characterize the specifics of its activities.

This methodics of assessment the prime state of the enterprise is based on the values of financial and economic indicators and comparative analysis with regulatory or basic for the last 2-3 years of activity. However, for a comprehensive assessment of the level of interprise management it is recommended to use

methods of multidimensional statistical analysis, such as factor analysis, descriptive analysis, cluster analysis, correlation-regression analysis, methods of generalizing rating indicators, which serve as an indisputable basis for forming management decisions on aspects of enterprise activity.

1.2. Review of methods and approaches to assessing the quality of enterprise management

An interesting approach to assessing the level of an enterprise efficiency is offered by the authors Coculova et al. in a study [3] using the determinants of talent-management. Human resources, considered as carriers of knowledge and innovation [4, 5], form a unique economic category. Realy an integral part of talent management is the support of education and self-development, support of innovative approaches and creative experiments of employees. This is dictated by the rules of globalization processes, structural transformation of all spheres of national systems (technological, economic, social, political). In [6] Kaya, H. D. considers the indicators of ease of doing business, ease of hiring employees, the level of business regulation, regional training and networking programs, the values of which determine the level of optimism of owners and business success in general. The study is based on the results of a survey conducted by the Kaufman Foundation of the companies owners in different regions of a particular country on their assessment of the current situation and optimistic forecasts for the future. The regression analysis showed that the growth rate of net profit mainly depends on the ease of starting a business (it’s described for small businesses) [7]. However, this approach can not adapt to all countries because different countries have their own characteristics regarding the conditions of registration of their own business. Also, the level of business regulation is an important factor in the

formation of the number of employees, the formation of the business climate, and the prosperity of the enterprise, which can not adapt to most countries.

Scientists around the world are constantly raising questions in their research on assessing the current state of enterprise management [8], efficiency and stability of its activity [9, 10], identifying reserves to increase profit growth [11, 12]. Thus, for the query "quality of enterprise management" in the Scopus database were found 6102 studies for the period from 2015 to 2020. Bibliometric analysis of these publications with the tools of the program VOSviwer 1.6.15 shows the relevance of the research issue for scientists. Based on 5 or more citations, we have 8 clusters covering publications of scientists from 64 countries and 132 universities and institutes. The total number of relationships and co-citations is 436 (Fig. 1.1).

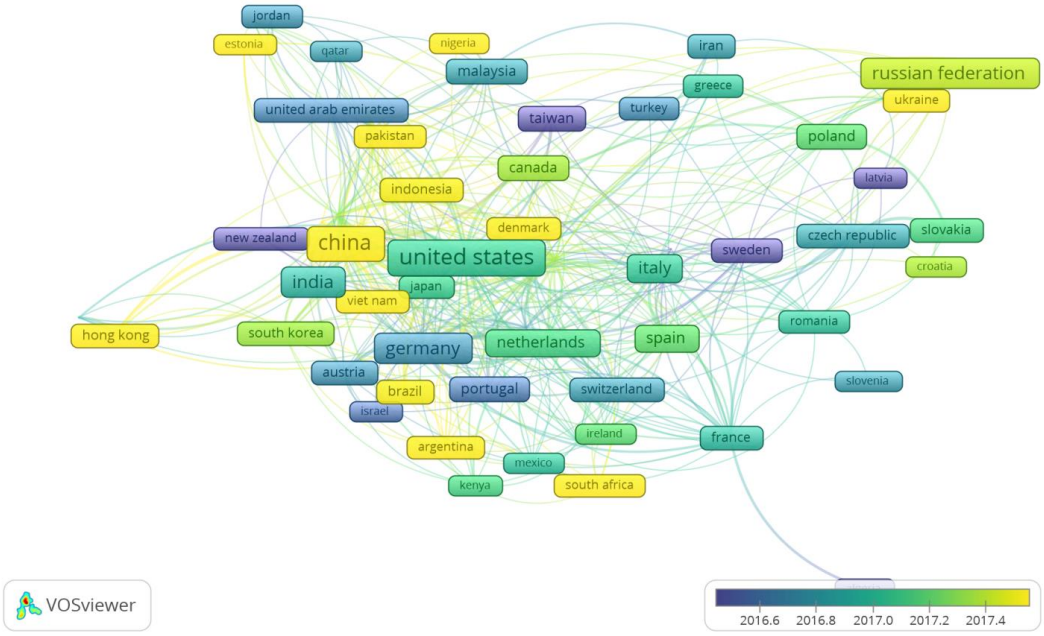

Figure 1.1. Bibliometric analysis of scientific publications on the assessment of the quality of enterprise management

Source: developed by the author on the Scopus data base and VOSviewer 1.6.15 tools

The largest cluster consists of 16 countries: Croatia, Chech Republic, Finland, Italy, Kazakhstan, Latvia, Lithuania, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Ukraine. The smallest 2 clusters form 4 countries: Algeria, France, Portugal, Tunisia, and China, Hong

Kong, Singapore, South Korea. This division of scientific research on evaluating enterprise management effectiveness emphasizes the relevance of this issue for the respective countries and their economies in general.

As we can see, Ukrainian scientists are actively cooperating and researching the issue of assessing the level of enterprise management as a key determinant of the financial stability of enterprises at the micro-level and the factor that shapes the level of competitiveness in the world.

1.3. Theoretical principles of the structural and functional content formation of the enterprise management quality assessment system of indicators

The basis for assessing the quality of enterprise management is to assess the results of its financial and economic activity.

To composite and complex assess aspects of the quality of enterprise management, factors are used that comprehensively characterize the results of financial and economic activities [13]. Such factors include four groups of complex features that form indicators: socio-economic (group 1), financial and economic activity and implementation of financial plans (group 2), indicators of assets, depreciation of fixed assets (group 3), financial stability ratios, coverage, solvency (group 4).

The generalized structural and logical scheme describing each group of indicators for evaluating the results of financial and economic activities of the enterprise is presented in Figure 1.2.

As a basis for the study, the data were used characterizing the results of enterprises' financial and economic activity in the public sector of the economy, which belongs to the sphere of management of the Ministry of Energy and Coal.

The quantitative and statistical database is formed based on official information published in the database of the Unified State Web Portal of Open Data [14].

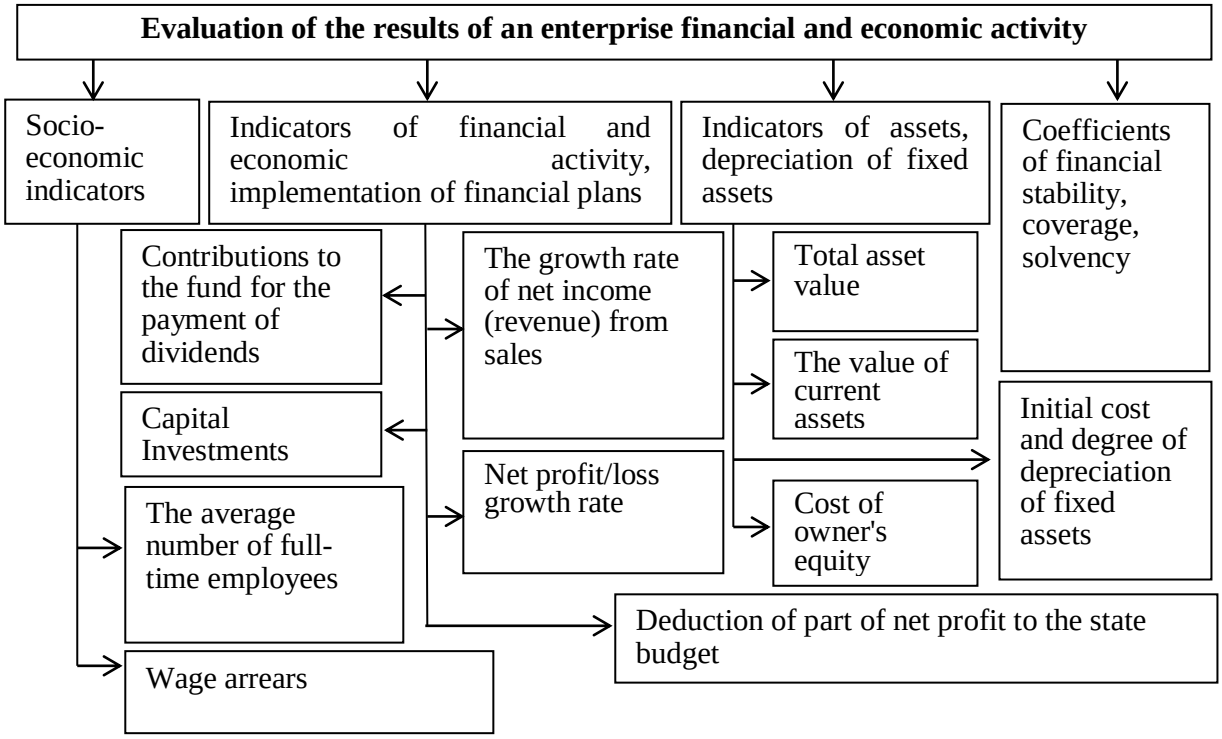

Figure 1.2. The generalized structural scheme of estimation the enterprise's results of financial and economic activity

Source: developed by the author

Particularly acute issues of quality management and efficient operation are for the coal industry. In 2021, Ukraine has chosen the European Green Course strategy, a new strategy for economic growth. Within the framework of this program, it is planned to transform the models of life, work, production, consumption. The key direction is a healthy lifestyle, innovative enterprises. Climate change, environmental degradation lies in the context of the green transition [13], the decarbonization of the economy, the transformation of coal mining regions, and the reform of the coal sector [16, 16].

Thus, the object of the study is 47 enterprises of Ukraine in the public sector of the energy sector. The research period is the first three quarters of 2020. As for

indicators that characterize the quality of management, it is proposed to use 7 indicators, namely: K1 – covering coefficient (at the end of the reporting period), K2 – firmness coefficient (financial stability ratio, at the end of the reporting period), K3 – solvency coefficient (at the end of the reporting period), K4 – salary debt mark (arrears of wages – number of points), K5 – financial outturn profit (implementation of the financial plan – net profit/loss, number of points), K6 – the degree of depreciation of fixed assets (amortization, at the end of the reporting period), K7 – profit changes (the rate of net profit/loss change) (Appendix B, Table B1).

At the same time, we are used only operating enterprises for the research. Those enterprises that work but are in bankruptcy proceedings – dispose of property, whether it is in bankruptcy, or the report is not submitted by enterprises, or enterprises are in the uncontrolled zone, are non-profit organizations [14], or enterprises do not submit a financial plan to the Ministry coal, whether they work but are in the process of liquidation by the decision of the authority, the study does not include.

The logic of determining the effectiveness of enterprise management consists of the formation of an integrated indicator and the development of statistically significant regression models. The integrated indicator, which allows determining the rating and, accordingly, the level of management quality of the studied enterprises, is formed based on indicators K1 – K6. The conceptual scheme for calculating the integrated indicator is presented in Fig. 1.3.

To develop statistically significant regression models that characterize the dependence of net profit (loss) as an indicator of the quality of enterprise management, from the influential indicators K1 – K6, it is advisable to conduct modeling in the context of three stages. At the 1st stage, normalization of input indicators should be carried out, as they are measured according to different scales and methods to compare them further and perform mathematical calculations. At the 2nd stage, it is necessary to substantiate the input information space on the

statistical significance of indicators using descriptive statistics and determine the optimal number of indicators based on the principal components analysis. At the third stage, develop regression models, check them for statistical significance.

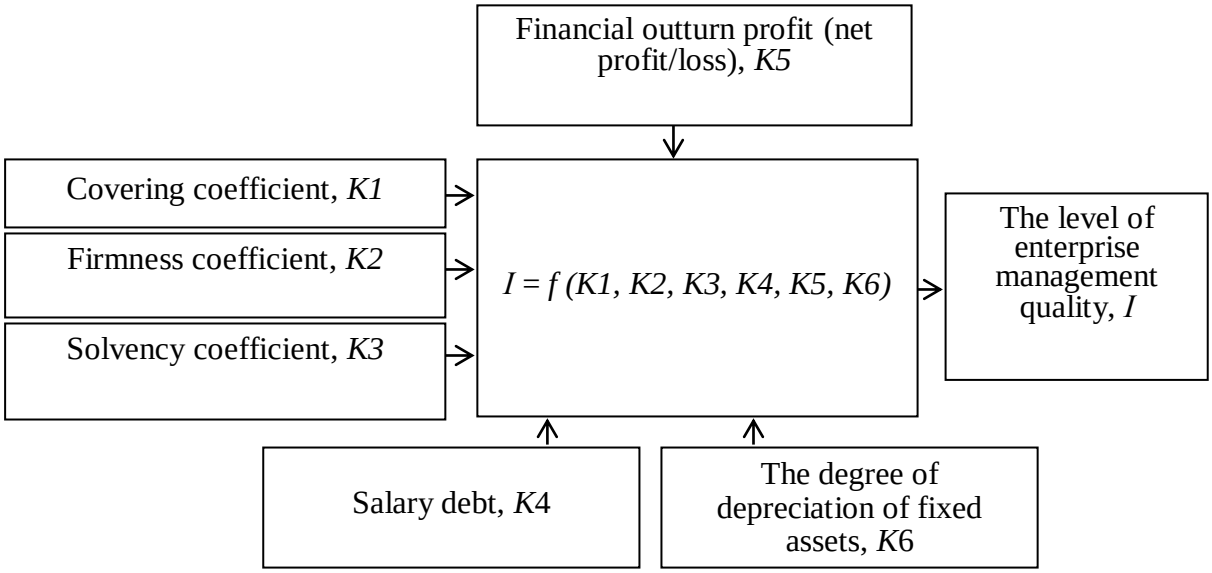

Figure 1.3. Conceptual scheme of an integrated indicator formation of the enterprise management quality level

Source: developed by the author

CHAPTER 2. DEVELOPMENT OF MODELS FOR EVALUATING THE EFFECTIVENESS OF ENTERPRISE MANAGEMENT

2.1. Formation of the feature space of indicators system for the enterprise management quality

Input indicators of the studied Ukrainian enterprises of the public sector of the economy are measured in various scales corresponding to coefficients (K1 - K3), point characteristics (K4), binary values (K5), numerical characteristics of the degree of depreciation of fixed assets measured on a scale from 0 to 100 (K6), numerical characteristics of the rate of change of net profit (loss) (K7), measured as a percentage. Therefore, for further mathematical calculations, the possibility of comparing and using the input indicators, it is necessary to carry out their normalization procedure.

The obtained values of input indicators were determined according to the calculation method approved by order of the Ministry of Economic Development No 253 dated 15.03.2013 [13] and Balance sheets (Statements of financial results) of the studied enterprises [14].

There is a great variety of normalization methods that use the functions of transformation of quantities. Still, for further development of an economic and mathematical model for assessing enterprise management quality based on these indicators, it is necessary to carry out such transformation considering numerical characteristics of distribution laws. Therefore, we propose to carry out the normalization procedure using a modified logistic conversion function, taking into account its obvious advantages (2.1):

$$y_{ij} = \frac{1}{1 + e^{-3\frac{x_{ij} - p_i}{q_i - p_i}}}, \tag{2.1}$$

where y_{ij} – the normalized value of the *i*-enterprise of the *j*-indicator, q_i – the value of the indicator x_{ij}, at which the conversion function takes a value not less than 0,95; p_i – the value of the indicator x_{ij}, at which the conversion function becomes 0,5 [18]. We emphasize that the level of the converted values according to the conversion criterion depends on the q_i and p_i.

First, it is necessary to start from the content of the relevant indicator, namely, whether it is a stimulus for assessing the effectiveness of enterprise management (i.e., the greater the value of this indicator, the better management manages the enterprise and ensures its reliable operation and stable competitiveness position), or is a de-stimulus factor. Second, take into account the value of the coefficient of variation (Table 2.1). For the statistical significance of the indicator, it should exceed 5%.

Table 2.1. Numerical characteristics of K1 – K7 indicators for studied enterprises

Numerical characteristics	Values of numerical characteristics						
	K1	K2	K3	K4	K5	K6	K7
Count	47	47	47	47	47	47	47
Average	5,49	8,23	-1,05	1,32	0,32	70,79	-111,27
Median	0,72	0,03	0,03	2,00	0,00	74,96	57,90
Variance	236,47	503,30	6,49	0,70	0,22	342,79	1581300,00
Standard deviation	15,38	22,43	2,55	0,84	0,47	18,51	1257,50
Coefficien of variation	2,80	2,73	-2,42	0,63	1,48	0,26	-1130,17
Standard error	2,24	3,27	0,37	0,12	0,07	2,70	183,43
Minimum	0,01	-0,94	-11,16	0,00	0,00	19,74	-5000,00
Maximum	75,86	96,41	0,99	2,00	1,00	97,57	3045,00
Range	75,85	97,35	12,15	2,00	1,00	77,83	8045,00
Standard skewness	10,52	8,51	-5,96	-1,88	2,24	-1,94	-5,28
Standard kurtosis	19,30	12,08	6,84	-1,73	-1,99	0,11	11,70

Source: developed by the author with Statgraphics Centurion 16.1.11.0. package

Third, use especially carefully indicators in which the values of the coefficients Standard skewness and Standard kurtosis go beyond the interval (-2; 2) because values of these statistics outside the range of -2 to +2 indicate

significant departures from normality, which would tend to invalidate any statistical test regarding the standard deviation. Thus, the values of the normalization parameters by the formula (2.1) are presented in Table 2.2.

Table 2.2. The values of parameters q_i and p_i for standardization of initial indicators

Parameter	Indicator						
	K1	K2	K3	K4	K5	K6	K7
q	75,86	96,41	0,99	0	1	19,74	3045
p	0, 72	0,03	0,03	1,32	0,32	74,96	57,9

Source: developed by the author

Standardized values of indicators that characterize the financial and economic activities and allow to make an assessment o the effectiveness of the management level of the studied Ukrainian enterprises of the public sector of the economy are given in Appendix B, Table B2.

Principal components analysis of the input data array allows reducing the initial space R^6 and identifying latent features [19]. At the same time, its representativeness is not lost. The method of the principal components analysis is implemented by the procedure "Multivariate Exploratory Techniques, Principal Components&Classification Analysis" of the program Statistica 10.0.1011.0 (Table 2.3).

Table 2.3. Eigenvalues of correlation matrix for indicators K1 – K6

Value number	Eigenvalues of correlation matrix, and related statistics Active variables only			
	Eigenvalue	% Total variance	Cumulative Eigenvalue	Cumulative %
1	2,293671	38,22784	2,293671	38,2278
2	1,081199	18,01998	3,374869	56,2478
3	1,028658	17,14430	4,403527	73,3921
4	0,759261	12,65435	5,162788	86,0465
5	0,523826	8,73043	5,686614	94,7769
6	0,313386	5,22310	6,000000	100,0000

Source: developed by the author with Statistica 10.0.1011.0 package

The substantiation of the number of the most influential factors is based on Kaiser's rule [20]: leave those factors which eigenvalues are greater than 1. These are the first three factors F1, F2, and F3, with eigenvalues $\lambda_1 = 2{,}294$, $\lambda_2 = 1{,}081$,

$\lambda_3 = 1{,}029$. The first factor explains 38,23% of the total variance, the second and third – 18,02% and 17,14%, respectively. Cumulative dispersion is 73,39% (Table 2.3; Appendix C, Figure C.1). The table of factor loadings (Appendix C, Table C1) contains values that characterize the influence of each indicator on the corresponding factor. To identify the most representative indicators, it is necessary to calculate the weights for each indicator based on the variances of the influence of factors and factor loads using the weighted average [18]:

$$w_j = \frac{\sum_{i=1}^{n} F_{ji} \cdot \sigma_i^2}{\sum_{i=1}^{n} \sigma_i^2}, \qquad (2.2)$$

where w_j – j-indicator's weight, $j = \overline{1,m}$; F_{ji} – j value of the factor load of the i factor, $i = \overline{1,n}$; σ_i^2 – the value of the variance of the i factor, $i = \overline{1,n}$. The results of the calculation of each indicator's weight are presented in the Table 2.4. The verification criterion that directly follows from the calculation formula (2.2) is the sum of the values of the weights equal to 1.

Table 2.4. Weighted impact of the indicators

Indicator/Factor Loading	Factor1	Factor2	Factor3	Indicator's weight
	38,22784	18,01998	17,14430	w_j
K1	0,236729	0,139090	0,002511	**0,158043**
K2	0,292575	0,006486	0,056321	**0,167143**
K3	0,264739	0,022764	0,000932	0,143702
K4	0,195524	0,022505	0,007583	0,10914
K5	0,008577	0,186959	0,732565	**0,221498**
K6	0,001855	0,622195	0,200087	**0,200474**
			$\sum_{j=1}^{m} w_j$	**1**

Source: developed by the author

Therefore, for further development of multiple regression models that identify the impact of the studied indicators on the rate of change of profit (loss) in terms of its analysis of the quality of enterprise management, we use indicators K1 – covering coefficient, K2 – firmness coefficient, K5 – financial outturn profit,

K6 – the degree of depreciation of fixed assets (amortization). These indicators have the highest values of weights.

2.2. Development of nonlinear regression models of enterprise management quality

The linear regression models formed due to modeling, describing the influence of indicators K1, K2, K5, K6 on the resulting depending indicator K7 – the rate of change of net profit (loss), were statistically insignificant. Therefore, it is advisable to develop nonlinear multifactor regression models.

Substantiation of the choice of nonlinear approximation functions for influential indicators is carried out based on the maximum value by the absolute value of the parameter T-statistic [21]. Calculations were performed using an MS Excel package with procedure Data/Data Analysis/Regression (Table 2.5).

Table 2.5. T-statistics regarding the significance of functional dependence specification of the quality of enterprise management on nonlinear factor characteristics

Function/Indicator	Covering coefficient (K1)	Firmness coefficient (K2)	Financial outturn profit (K5)	Amortization (K6)
cos K	0,864611	0,761179	**65535**	-0,972386408
K^3	-4,24108	**0,765636**	65535	-0,829105484
sqrt K	**4,507347**	-0,74018	11,37203	1,120584593
ln K	-3,43902	0,736138	-7,05931	**-1,201011437**

Source: developed by the author

Therefore, we use nonlinear functions to develop nonlinear regression models: square root for K1, cubic parabola for K2, cosine for K5, and natural logarithm for K6. The model was developed in Statgraphics Centurion 16.1.11.0 package.

The model (2.3) is statistically significant according to the coefficient of determination R2, Student's Test, and Fisher's Test (Appendix D).

$$K7 = 0{,}0759 \cdot K1 + 0{,}4799 \cdot K2 + 0{,}0356 \cdot K5 - 0{,}5055 \cdot K6 \quad (2.3)$$

where K7 – profit changes; K1 – covering coefficient; K2 – firmness coefficient; K5 – financial outturn profit; K6 – the degree of depreciation of fixed assets (amortization).

However, the p-value exceeds the maximum allowable 5% [22]. Therefore, it is needed to carry out the rigid screening of multicollinear indicators using the Backward Stepwise Selection method. As a result, we obtained a statistically significant model that determines the impact of firmness coefficient (K2) and amortization (K6) on the dependent indicator of the change rate in net profit (loss) (K7) (Appendix E):

$$K7 = 0{,}5816 \cdot K2 - 0{,}5891 \cdot K6 \quad (2.4)$$

Tables 2.6–2.7 show the statistical characteristics of the model (2.4).

Table 2.6. Statistical characteristics for the regression model

Parameter	*Estimate*	*Standard Error*	*T-Statistic*	*P-Value*
K2	0,58163	0,125401	4,63816	0,0000
K6	-0,598056	0,0446769	-13,3863	0,0000

Source: developed by the author

Table 2.7. Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	10,9761	2	5,48805	201,11	0,0000
Residual	1,22798	45	0,0272884		
Total	12,2041	47			

Source: developed by the author

When developing the model (2.4), the free member (constant) is omitted. This is due to the choice of nonlinear approximation functions and their domains of definition and ranges: for the cosine function for K5 indicator range is [-1; 1], and for the natural logarithm for K6 indicator range is $(-\infty;+\infty)$, and axis *Oy* is the vertical asymptote. There are many examples of regression models in economics in

which the constant is zero. In the theory of cost analysis, the variables of production costs are proportional to the output [23]. The Cobb – Douglas production function is widely used to represent the technological relationship between the amount of two or more resources invested (physical capital and labor) and the amount of output these inputs can produce [24].

Since the value of the P-value in the ANOVA Table 2.7 (Analysis of Variance) is less than 5%, there is a statistically significant relationship between variables at the level of 95% confidence. R-Squared statistics – the coefficient of determination, indicates that the model explains 89.938% of the variability of the dependent indicator of the change rate of net profit (loss). The standardized value of the R-Squared statistics is 90.7368% and indicates the adequacy and static significance of the econometric multiple nonlinear regression model (2.4). There is no constant in the model due to the choice of nonlinear approximation functions. However, the coefficient of determination, which explains the fraction of the variance of the dependent variable in the regression model and is calculated as the ratio of regression sum of squares (SSR) to the total sum of squares (SST), allows us to estimate how well the theoretical model agrees with real data if even dependent variable does not have a normal distribution. Thus, the developed model (2.4) agrees very well with the initial data. The standard error of the estimate has the standard deviation of the residuals 0,165. The mean absolute error (MAE) is equal to 0,083 and characterizes the average value of the residuals. The Durbin-Watson (DW) test checks the residuals to determine whether there is a significant correlation between the independent variables in the order in which they are entered in the model. The calculated value of the Darbin-Watson test (1.94) is in the range from 0,584 to 2,464, which indicates compliance with the uncertainty zone. Further study of autocorrelation of residues using the John von Neumann test shows its absence, $DW \approx 2$ – no autocorrelation [25, p. 289]. In addition, the value of the P-value is less than 5%, which confirms the absence of serial autocorrelation of residues at the confidence level of 95.0%.

Thus, the developed econometric model (2.4) is statistically significant, which confirms the Student's criteria [21] (the absolute actual value of the Student's t-test is greater than the theoretical value of the Student test, which equals 2,012), F-statistic and DW-statistic (Appendix E).

Consider the interpretation of model (2.4) from an economic point of view. The firmness coefficient (K2) directly proportionally affects the performance indicator and is a stimulus factor to increase the level of management efficiency of the enterprise as a whole. It is defined as the ratio of the sum of owner's equity and long-term liabilities to the balance sheet currency (Table 1.1). If the value of the firmness coefficient is less than 70%, the financial condition of the enterprise is unstable. Thus, according to model (2.4), when the firmness coefficient increases by 1%, the enterprise's net profit will increase by the value of $0,5816 \cdot 0,01 = 0,005816$, about 0.6%, which is significant in terms of the activities of each surveyed enterprise.

The influence of indicator K6, which characterizes the degree of depreciation of fixed assets, on the performance indicator is inversely proportional. It is also a stimulus factor to increase the level of enterprise management: the lower the degree of depreciation, the better for the company, of course, with stable operation and increased production, compliance with technological requirements for operation. Model (2.4) shows that with a decrease in the degree of depreciation of fixed assets by 1%, the increase in profit will change by an amount of $0,5891 \cdot 0,01 = 0,005891$ that is a significant factor for the company.

2.3. The development of a generalized rating indicator of enterprise quality management

Generalized indicators serve as an aggregation of the initial feature space and determine the level of quality, rating position of certain factors related to the formed research tasks [26]. To do this, use a wide variety of methods of additive convolution and multiplicative. Determining the generalized rating indicator that characterizes the level of quality management for 47 studied enterprises of the public sector of the economy of Ukraine, it is proposed to use a multiplicative convolution using the formula of the weighted geometric mean. This convolution procedure allows calculating the average rate of dynamics [27, 28]:

$$I_p = \Sigma \sqrt[n_j]{\prod_{j=1}^{6} K_j^{n_j}}, \tag{2.5}$$

where I_p – generalized rating assessment of the enterprise management quality *p*; Σn_j – the sum of the frequencies; K_j – the studied indicator ($j = \overline{1,6}$); n_j – the frequency of the studied value (variant) for the j-indicator.

The convolution of the input indicators using the geometric weighted average (2.5) for all enterprises of the study is presented in Appendix F, Table F1.

To interpret the results of generalized rating values of enterprises, we offer the following scale: $0{,}5 \le I_p \le 0{,}7$ – the level of management is high, the activity of the enterprise is effective; $0{,}25 \le I_p < 0{,}5$ – he level of management is average, the company's activity is satisfactory; $0 \le I_p < 0{,}25$ – the level of management is low, the company's activity is unsatisfactory. The choice of the highest value of the integrated indicator, equal to 0.7, due to the values of the original statistical information for all enterprises (Appendices B, C).

Thus, 9 enterprises have a high level of management: Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin, Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti, Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin, PJSC "UKRHYDROENERGO," Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya," Dp "Kalus`ka Teploelektrocentral`-Nova," L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin, Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa," State Foreign Trade Company "Ukrinterenergo." The average level of management is typical for 26 studied enterprises, i.e., 55.32%. This only confirms the hypothesis that the management of enterprises has something to work on to improve their activities, to re-evaluate their reserves and capacity of fixed assets. For 13 enterprises, the level of management is low, and the activity is inefficient (Appendix F, Table F1). The problem is especially acute for the enterprises Dp "Voly`n`vugillya," Dp "Torecz`kvugillya," Akcionerne Tovary`Stvo "Ly`sy`chans`kvugillya." The values of the integrated indicators are 0,0014, 0,0133, and 0,0145, respectively. Management urgently needs to conduct a comprehensive assessment of its activities from the standpoint of identifying reserves in terms of financial and economic activities and all the factors that shape it, to analyze the profit and profitability of production, production, and sales, labor indicators [29-32].

Similar results of the division of enterprises into groups that characterize the level of quality of enterprise management at high, medium, and low and indicate effective management, satisfactory and unsatisfactory we receive as a result of the clustering procedure using the Ward method in Statgraphics Centurion 16.1.11.0 (Table 2,8; Appendix G). This method is used because, unlike other methods of cluster analysis (Nearest Neighbor, Furthest Neighbor, Centroid, Median), it uses methods of analysis of variance [33, 34]. The distance between the clusters is the

increment of the sum of the squares of the distances of the objects to the center of the cluster resulting from their merging:

$$V_I = \sum_i \sum_j (x_{ij} - \bar{x}_{jI})^2, \qquad (2.6)$$

where I – the cluster number; i – the object number (i = 1, 2, …, n_I); n_I – the number of objects in the I cluster; j – feature number (j = 1, 2, …, k); k – the number of features that characterize each object.

At each step of the algorithm, the following two clusters are grouped, the combination of which leads to a minimal increase of the variance: the smaller the value of intragroup variance and the greater the value of intergroup variance, the better the feature characterizes the membership of a particular cluster and the better the clustering results [34, 35]. That is, those objects (clusters) that have the smallest increment of V_I are combined.

Table 2.8. The results of cluster analysis of enterprise quality management indicators with Ward's Methods

Cluster 1	**Cluster 2**	**Cluster 3**
Dp "Poltavs′ke Upravlinnya Heofizychnykh Robit"	Vos`my`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	Dp "Novovolyns′kyy Remontno-Mekhanichnyy Zavod"
Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	SE Institute "UKRNDIPROEKT"	Dp "Specializovany`J Centr "Vugleizotop"
Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	Dp "Dyrektsiya Po Budivnytstvu Ob'yektiv"	Dp "Specializovany`J Centr Pidgotovky` Kadriv"
Dp "Upravlinnya Vidomchoyi Voyenizovanoyi Oxorony`"	Dp "Dniprodiproshakht"	SE "Ukr R&D Institute for IndTech"
State Foreign Trade Company "Ukrinterenergo"	Dp "Kry`ms`ky`j Naukovo-Inzhenerny`j Centr"	Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya"
Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti	Dp "Skhidnyy Hirnycho-Zbahachuval′nyy Kombinat"	Dp "Bar'yer"
Dp "My`rnogradvugillya"	Dp "Dy`my`trovs`ky`j Uchbovo-Kursovy`j Kombinat"	Dp "Voly`n`vugillya"
SE "Pervomays'kvuhilla"	SE "NNEGC" Energoatom "	Dp "UKRSHAXTGIDROZAXY`ST"
Dp "L`vivvugillya"	Dp "Chornoby`l`promenergobud"	Dp "Torecz`kvugillya"
Dp "38 Viddil Inzhenerno-Tekhnichnykh Chastyn"	Dp "OS "MASMA-SEPRO"	Dp "Shaxtoupravlinnya "Pivdennodonbas`ke No1"
Dp "SELY`DIVVUGILLYa"	Derzhavny`J Koncern "UKRTORF"	Dp "Peredpuskova dy`rekciya shaxty` No10 "Novovoly`ns`ka"

Continued Table 2.8

Cluster 1	Cluster 2	Cluster 3
L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin	Derzhavny`j Koncern "Yaderne paly`vo"	Dp "Ob`yednana Kompaniya "UKRVUGLERESTRUKTURY`ZACIYa"
Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa"	Dp "Kremenecz`ke upravlinnya z postachannya ta realizaciyi gazu"	Dp "Shaxta No1 "Novovoly`ns`ka"
Dp "Kalus`ka Teploelektrocentral`-Nova"	PJSC "NY`ZhN`ODNISTROVS`KA GES"	Dp "DERZhVUGLEPOSTACH"
PJSC "UKRHYDROENERGO"		Dp "ShAXTA "ZARIChNA"
		Dp "Shaxta im. M. S. SURGAYA"
		PJSC "SHAHTA NADIYA"
		Akcionerne Tovary`Stvo "Ly`sy`chans`kvugillya"

Source: developed by the author with procedure Describe/Multivariate methods/Cluster Analysis and Statgraphics Centurion 16.1.11.0 package.

Enterprises in cluster 1 have a high level of management, in cluster 2 – medium, in cluster 3 – low. For most companies, cluster analysis results coincide with the division into groups on the proposed scale according to the developed methodology for calculating the integrated indicator and determining the levels of management effective, satisfactory, inefficient, which indicates the quality and accuracy of the analysis.

CONCLUSIONS

As a result of the study on assessing the level of management of public sector enterprises of the Ministry of Energy and Coal Industry, enterprises were divided into three groups that are efficient (have a high level of management), satisfactory (medium level of management), and inefficient (low level of management). Construction of the aggregate generalizing indicator is carried out based on standardized values of the enterprise quality management indicators using the logistic function of transformation. For its formation, the multiplicative convolution by a method of the weighted average geometrical of six indicators (covering coefficient, firmness coefficient, solvency coefficient, salary debt, financial outturn profit, the degree of depreciation of fixed assets) characterizing the enterprises' management quality and efficiency in 2020 is applied. The division into groups was made based on the proposed scale to interpret the values of the integrated indicator and the results of cluster analysis by the Ward method.

The analysis showed that only 9 enterprises out of 47 studied have a high level of management: Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin, Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti, Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin, PJSC "UKRHYDROENERGO," Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya," Dp "Kalus`ka Teploelektrocentral`-Nova," L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin, Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa," State Foreign Trade Company "Ukrinterenergo." The average level of management is typical for 26 studied enterprises, which is 55.32%. This confirms the hypothesis that the management of enterprises has something to work on to improve their activities, re-evaluate their reserves and capacity of fixed assets, implement innovative technologies. For 13 enterprises, the

level of management is low, and the activity is inefficient. The problem is especially acute for the enterprises Dp “Voly`n`vugillya,” Dp “Torecz`kvugillya,” Akcionerne Tovary`Stvo “Ly`sy`chans`kvugillya.” The values of the integrated indicators are 0,0014, 0,0133, and 0,0145, respectively.

Also, the research developed a nonlinear regression model of the dependence of the dynamics of growth (decline) of net profit as a key determinant of the quality of enterprise management on two factors, firmness coefficient, and amortization. The modeling was performed in three stages. At the 1st stage, the procedure of normalization of input indicators for the purpose of their further comparison and mathematical calculations is carried out. At the 2nd stage, the input information space on the indicator’s statistical significance is substantiated with the help of descriptive statistics tools, the optimal number of indicators is determined based on the principal components analysis. In Stage 3, the choice of nonlinear functions is substantiated using the Student’s test. The developed regression model is statistically significant, as confirmed by statistical verification criteria (value of the coefficient of determination, p-value, Durbin-Watson Statistic, F-Statistic, T-Statistic) and can be used by the economic-analytical department, management to improve the efficiency of its activities.

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APPENDICES

Appendix A

Summary

Sydorenko A.A. Economic and Mathematical Modeling of Enterprise Management Quality Assessment. – Bachelor's thesis. Sumy State University, Sumy, 2021.

The work determines the algorithm of performing an integrated rating indicator on the level of quality of management of public sector enterprises of the Ministry of Energy and Coal Industry, the division of enterprises into three groups based on the proposed scale and cluster analysis, which have a high level of management and are effective, medium and has satisfactory management status, low level and are inefficient. A statistically significant nonlinear multifactor model for estimating the dynamics of changes in net income from factor characteristics of the financial stability ratio and the degree of depreciation of fixed assets has also been developed. The developed model can be used by the management of the enterprise.

Keywords: indicators of financial and economic activity of the enterprise, efficiency of enterprise management, principal component analysis, integrated rating indicator, cluster analysis, nonlinear regression model.

АНОТАЦІЯ

Сидоренко А.А. Економіко-математичне моделювання оцінювання якості управління підприємством. – Кваліфікаційна бакалаврська робота. Сумський державний університет, Суми, 2021 р.

В роботі сформовано інтегральний рейтинговий показник щодо рівня якості управління підприємствами державного сектору економіки сфери Міністерства енергетики та вугільної промисловості, здійснено розподіл підприємств на три групи на основі запропонованої шкали та проведеного кластерного аналізу, що мають високий рівень управління та є ефективними, середній рівень та мають задовільний стан управління, низький рівень та є неефективними. Також розроблено статистично значущу нелінійну багатофакторну модель оцінювання динаміки змін чистого прибутку від факторних ознак коефіцієнту фінансової стійкості та ступеню зносу основних засобів. Розроблена модель може бути використана керівною ланкою підприємства.

Ключові слова: показники фінансово-господарської діяльності підприємства, ефективність управління підприємством, аналіз головних компонент, інтегральний рейтинговий показник, кластерний аналіз, нелінійна регресійна модель.

Appendix B

Initial indicators and data

Table B1. Initial statistical characteristics of the studied enterprises of Ukraine public sector economy

No	Company name	Company_code	Covering coefficient_end (K1)	Firmness coefficient_end (K2)	Solvency coefficient_end (K3)	Salary debt_mark (K4)	Financial outturn_profit_mark (K5)	Amortization_end (K6)	Profit_changes (K7)
1.	Dp Poltavs′ke Upravlinnya Heofizychnykh Robit	00147921	5,28	5,24	0,84	2,00	1,00	96,67	2804,5
2.	Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159367	5,14	5,49	0,55	0,00	1,00	75,93	7,70
3.	Vos`my`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159427	63,74	70,26	0,63	2,00	0,00	72,80	-30,0
4.	Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159462	44,43	45,34	0,64	2,00	1,00	74,96	290,80
5.	SE Institute "UKRNDIPROEKT"	00174125	0,62	0,60	0,38	2,00	0,00	83,46	54,50
6.	Dp "Novovolyns′kyy Remontno-Mekhanichnyy Zavod"	00179000	0,09	-0,56	-1,26	2,00	0,00	96,53	3045,0
7.	Dp Dyrektsiya Po Budivnytstvu Ob'yektiv	00179737	6,59	12,95	0,04	2,00	0,00	35,24	0,00
8.	Dp "Specializovany`J Centr "Vugleizotop"	00186022	0,59	-0,23	-0,30	1,00	0,00	87,99	-837,50
9.	Dp "Upravlinnya Vidomchoyi Voyenizovanoyi Oxorony`"	02072239	1,20	0,04	0,03	2,00	1,00	82,08	127,90
10.	Dp "Specializovany`J Centr Pidgotovky` Kadriv"	04642416	0,24	0,39	0,28	0,00	0,00	97,57	-2791,3
11.	Derzhavne Pidpryyemstvo "Dniprodiproshakht"	05410777	1,31	3,99	0,80	2,00	0,00	65,59	526,20
12.	Dp "Kry`ms`ky`j Naukovo-Inzhenerny`j Centr"	13790848	3,13	2,15	0,68	2,00	0,00	79,55	-89,10
13.	Dp "Skhidnyy Hirnycho-Zbahachuval′nyy Kombinat"	14309787	0,83	0,01	0,00	2,00	0,00	33,52	103,80
14.	SE "Ukr R&D Institute for IndTech"	14310483	0,72	0,03	0,03	0,00	0,00	80,63	163,90
15.	State Foreign Trade Company "Ukrinterenergo"	19480600	1,08	0,12	0,11	2,00	1,00	57,59	8,80
16.	Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti	20335814	4,15	-0,24	-0,04	0,00	1,00	74,04	-5000,0
17.	Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya"	24249112	1,89	1,28	0,55	0,00	0,00	49,76	97,30
18.	Dp "Dy`my`trovs`ky`j Uchbovo-Kursovy`j Kombinat"	24319172	0,28	1,43	0,54	2,00	0,00	76,62	-4500,0
19.	SE "NNEGC" Energoatom "	24584661	1,13	2,42	0,57	2,00	0,00	68,73	-125,00
20.	Dp "Chornoby`l`promenergobud"	25301719	10,87	1,52	0,14	2,00	0,00	87,61	59,70
21.	DP "OS "MASMA-SEPRO"	31107102	15,04	38,30	0,97	2,00	0,00	86,61	-1192,9
22.	Dp "Bar'yer"	31330051	0,04	-0,70	-1,64	1,00	0,00	62,16	97,00
23.	Dp "My`rnogradvugillya"	32087941	0,12	-0,91	-2,68	1,00	1,00	76,28	92,80
24.	SE "Pervomays'kvuhilla"	32320594	0,10	-0,82	-3,08	1,00	1,00	54,83	57,90
25.	Dp "L`vivvugillya"	32323256	0,24	-0,70	-1,60	1,00	1,00	65,88	-31,80
26.	Dp "Voly`n`vugillya"	32365965	0,03	-0,94	-11,2	1,00	0,00	89,58	61,10
27.	Dp "UKRSHAXTGIDROZAXY`ST"	32442405	0,01	-0,82	-2,12	0,00	0,00	48,47	17,30
28.	Dp "38 Viddil Inzhenerno-Tekhnichnykh Chastyn"	33127487	1,24	0,15	0,05	2,00	1,00	75,04	149,50
29.	Dp "SELY`DIVVUGILLYa"	33426253	0,10	-0,78	-2,26	2,00	1,00	68,72	59,00
30.	Dp "Torecz`kvugillya"	33839013	0,06	-0,88	-6,63	2,00	0,00	55,13	167,40

Continued Table B1

No	Company name	Company_code	Covering coefficient_end (K1)	Firmness coefficient_end (K2)	Solvency coefficient_end (K3)	Salary debt_mark (K4)	Financial outturn_profit_mark (K5)	Amortization_end (K6)	Profit_changes (K7)
31.	L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin	33839804	75,86	18,85	0,19	2,00	1,00	82,47	73,00
32.	Dp "Shaxtoupravlinnya "Pivdennodonbas`ke No1"	34032208	0,18	-0,60	-1,24	0,00	0,00	70,20	142,80
33.	Derzhavny`J Koncern "UKRTORF"	35633030	1,39	0,03	0,02	2,00	0,00	96,00	-41,00
34.	Dp "Peredpuskova dy`rekciya shaxty` No10 "Novovoly`ns`ka"	35671961	0,22	-0,79	-3,59	2,00	0,00	84,73	37,50
35.	Derzhavny`j Koncern "Yaderne paly`vo"	36282830	1,54	96,41	0,99	2,00	0,00	46,69	1,00
36.	Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa"	37770008	0,84	-0,13	-0,15	0,00	1,00	96,98	-6,30
37.	Dp "Ob`yednana Kompaniya "UKRVUGLERESTRUKTURY` ZACIYa"	39244468	0,11	-0,74	-0,67	1,00	0,00	82,78	5,70
38.	Dp "Kremenecz`ke upravlinnya z postachannya ta realizaciyi gazu"	39460902	0,65	0,82	0,45	2,00	0,00	40,00	50,20
39.	Dp "Shaxta No1 "Novovoly`ns`ka"	39806601	0,16	-0,83	-4,94	1,00	0,00	92,36	127,10
40.	Dp "DERZhVUGLEPOSTACH"	40225511	0,71	-0,16	-0,19	0,00	0,00	61,85	94,80
41.	Dp " Shaxta "ZARIChNA"	40578553	0,11	-0,82	-4,04	1,00	0,00	81,46	325,60
42.	Dp "Shaxta im. M. S. SURGAYA"	40695853	0,20	-0,37	-0,51	0,00	0,00	48,99	-194,20
43.	Dp "Kalus`ka Teploelektrocentral`-Nova"	40885849	1,03	0,71	0,41	2,00	1,00	49,91	7,90
44.	PJSC "SHAHTA NADIYA"	00178175	0,07	-0,89	-6,19	0,00	0,00	75,42	115,10
45.	PJSC "UKRHYDROENERGO"	20588716	1,26	2,96	0,74	2,00	1,00	19,74	130,60
46.	PJSC "NY`ZhN`ODNISTROVS`KA GES"	30149623	3,28	89,15	0,99	2,00	0,00	70,27	4,50
47.	Akcionerne Tovary`Stvo "Ly`sy`chans`kvugillya"	32359108	0,02	-0,89	-6,84	1,00	0,00	67,67	501,70

Source: developed by the author on the basis of [14]

Table B2. Standardized values of indicators of quality management assessment for the studied enterprises of Ukraine public sector economy

No	Company name	Company_code	Covering coefficient_end (K1)	Firmness coefficient_end (K2)	Solvency coefficient_end (K3)	Salary debt_mark (K4)	Financial outturn_profit_mark (K5)	Amortization_end (K6)	Profit_changes (K7)
1.	Dp Poltavs′ke Upravlinnya Heofizychnykh Robit	00147921	0,545	0,540	0,926	0,175	0,953	0,235	0,940
2.	Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159367	0,544	0,542	0,835	0,953	0,953	0,487	0,487
3.	Vos`my`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159427	0,925	0,899	0,867	0,175	0,197	0,529	0,478
4.	Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159462	0,851	0,804	0,871	0,175	0,953	0,500	0,558
5.	SE Institute "UKRNDIPROEKT"	00174125	0,499	0,504	0,749	0,175	0,197	0,387	0,499
6.	Dp "Novovolyns′kyy Remontno-Mekhanichnyy Zavod"	00179000	0,494	0,495	0,017	0,175	0,197	0,237	0,953
7.	Dp Dyrektsiya Po Budivnytstvu Ob'yektiv	00179737	0,558	0,599	0,508	0,175	0,197	0,896	0,485
8.	Dp "Specializovany`J Centr "Vugleizotop"	00186022	0,499	0,498	0,263	0,674	0,197	0,330	0,289
9.	Dp "Upravlinnya Vidomchoyi Voyenizovanoyi Oxorony`"	02072239	0,505	0,500	0,500	0,175	0,953	0,404	0,518

Continued Table B2

No	Company name	Company_code	Covering coefficient_end (K1)	Firmness coefficient_end (K2)	Solvency coefficient_end (K3)	Salary debt_mark (K4)	Financial outturn_profit_ mark (K5)	Amortization_ end (K6)	Profit_changes (K7)
10.	Dp "Specializovany`J Centr Pidgotovky` Kadriv"	04642416	0,495	0,503	0,686	0,953	0,197	0,226	0,054
11.	Derzhavne Pidpryyemstvo "Dniprodiproshakht"	05410777	0,506	0,531	0,917	0,175	0,197	0,625	0,615
12.	Dp "Kry`ms`ky`j Naukovo-Inzhenerny`j Centr"	13790848	0,524	0,516	0,884	0,175	0,197	0,438	0,463
13.	Dp "Skhidnyy Hirnycho-Zbahachuval′nyy Kombinat"	14309787	0,501	0,500	0,477	0,175	0,197	0,905	0,512
14.	SE "Ukr R&D Institute for IndTech"	14310483	0,500	0,500	0,500	0,953	0,197	0,424	0,527
15.	State Foreign Trade Company "Ukrinterenergo"	19480600	0,504	0,501	0,562	0,175	0,953	0,720	0,488
16.	Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti	20335814	0,534	0,498	0,446	0,953	0,953	0,512	0,006
17.	Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya"	24249112	0,512	0,510	0,835	0,953	0,197	0,797	0,510
18.	Dp "Dy`my`trovs`ky`j Uchbovo-Kursovy`j Kombinat"	24319172	0,496	0,511	0,831	0,175	0,197	0,477	0,010
19.	SE "NNEGC" Energoatom "	24584661	0,504	0,519	0,844	0,175	0,197	0,584	0,454
20.	Dp "Chornoby`l`promenergobud"	25301719	0,600	0,512	0,585	0,175	0,197	0,335	0,500
21.	DP "OS "MASMA-SEPRO"	31107102	0,639	0,767	0,950	0,175	0,197	0,347	0,222
22.	Dp "Bar'yer"	31330051	0,493	0,494	0,005	0,674	0,197	0,667	0,510
23.	Dp "My`rnogradvugillya"	32087941	0,494	0,493	0,000	0,674	0,953	0,482	0,509
24.	SE "Pervomays'kvuhilla"	32320594	0,494	0,493	0,000	0,674	0,953	0,749	0,500
25.	Dp "L`vivvugillya"	32323256	0,495	0,494	0,006	0,674	0,953	0,621	0,477
26.	Dp "Voly`n`vugillya"	32365965	0,493	0,492	0,000	0,674	0,197	0,311	0,501
27.	Dp "UKRSHAXTGIDROZAXY`ST"	32442405	0,493	0,493	0,001	0,953	0,197	0,808	0,490
28.	Dp "38 Viddil Inzhenerno-Tekhnichnykh Chastyn"	33127487	0,505	0,501	0,516	0,175	0,953	0,499	0,523
29.	Dp "SELY`DIVVUGILLYa"	33426253	0,494	0,494	0,001	0,175	0,953	0,584	0,500
30.	Dp "Torecz`kvugillya"	33839013	0,493	0,493	0,000	0,175	0,197	0,746	0,527
31.	L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin	33839804	0,953	0,642	0,622	0,175	0,953	0,399	0,504
32.	Dp "Shaxtoupravlinnya "Pivdennodonbas`ke #1"	34032208	0,495	0,495	0,019	0,953	0,197	0,564	0,521
33.	Derzhavny`J Koncern "UKRTORF"	35633030	0,507	0,500	0,492	0,175	0,197	0,242	0,475
34.	Dp "Peredpuskova dy`rekciya shaxty` #10 "Novovoly`ns`ka"	35671961	0,495	0,494	0,000	0,175	0,197	0,370	0,495
35.	Derzhavny`j Koncern "Yaderne paly`vo"	36282830	0,508	0,953	0,953	0,175	0,197	0,823	0,486
36.	Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa"	37770008	0,501	0,499	0,363	0,953	0,953	0,232	0,484
37.	Dp "Ob`yednana Kompaniya "UKRVUGLERESTRUKTURY`ZACIYa"	39244468	0,494	0,494	0,101	0,674	0,197	0,395	0,487
38.	Dp "Kremenecz`ke upravlinnya z postachannya ta realizaciyi gazu"	39460902	0,499	0,506	0,788	0,175	0,197	0,870	0,498
39.	Dp "Shaxta #1 "Novovoly`ns`ka"	39806601	0,494	0,493	0,000	0,674	0,197	0,280	0,517
40.	Dp "DERZhVUGLEPOSTACH"	40225511	0,500	0,499	0,335	0,953	0,197	0,671	0,509
41.	Dp " Shaxta "ZARIChNA"	40578553	0,494	0,493	0,000	0,674	0,197	0,413	0,567
42.	Dp "Shaxta im. M. S. SURGAYA"	40695853	0,495	0,497	0,156	0,953	0,197	0,804	0,437
43.	Dp "Kalus`ka Teploelektrocentral`-Nova"	40885849	0,503	0,505	0,766	0,175	0,953	0,796	0,487
44.	PJSC "SHAHTA NADIYA"	00178175	0,494	0,493	0,000	0,953	0,197	0,494	0,514
45.	PJSC "UKRHYDROENERGO"	20588716	0,505	0,523	0,902	0,175	0,953	0,953	0,518
46.	PJSC "NY`ZhN`ODNISTROVS`KA GES"	30149623	0,526	0,941	0,953	0,175	0,197	0,563	0,487
47.	Akcionerne Tovary`Stvo "Ly`sy`chans`kvugillya"	32359108	0,493	0,493	0,000	0,674	0,197	0,598	0,610

Source: developed by the author

Appendix C

Principal Components Analysis

Table C1. Factors loading

Variable	Variable contributions, based on correlation Active variables only					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
1	0,236729	0,139090	0,002511	0,189875	0,116762	0,315033
2	0,292575	0,006486	0,056321	0,138697	0,000593	0,505328
3	0,264739	0,022764	0,000932	0,056658	0,565233	0,089674
4	0,195524	0,022505	0,007583	0,486305	0,284575	0,003508
5	0,008577	0,186959	0,732565	0,000451	0,009003	0,062444
6	0,001855	0,622195	0,200087	0,128014	0,023834	0,024014

Source: developed by the author with Statistica 10.0.1011.0 package

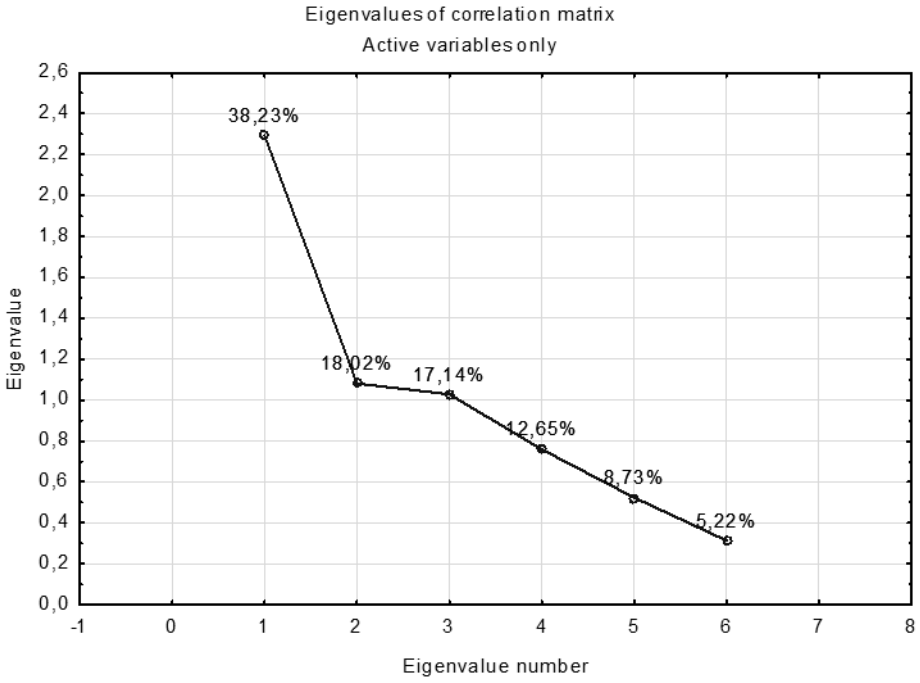

Figure C.1 – Plot of eigenvalue

Source: developed by the author with Statistica 10.0.1011.0 package

Appendix D

Multiple regression model of the dependency of the rates of change in net income (loss) from factors indicators covering coefficient (K1), firmness coefficient (K2), financial outturn profit (K5), and the degree of depreciation of fixed assets (amortization, K6)

Dependent variable: K7
Independent variables: K1, K2, K5, K6

Parameter	*Estimate*	*Standard Error*	*T-Statistic*	*P-Value*
K1	0,0758601	0,383531	0,197794	0,8441
K2	0,479799	0,79422	0,604113	0,5489
K5	0,0355758	0,508395	0,0699766	0,9445
K6	-0,505545	0,825828	-0,612168	0,5437

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	10,9833	4	2,74584	96,72	0,0000
Residual	1,22074	43	0,0283893		
Total	12,2041	47			

R-squared = 89,9973 percent
R-squared (adjusted for d.f.) = 89,2994 percent
Standard Error of Est. = 0,168491
Mean absolute error = 0,0840837
Durbin-Watson statistic = 1,94835
Lag 1 residual autocorrelation = -0,0678818

The StatAdvisor
The output shows the results of fitting a multiple linear regression model to describe the relationship between y and 4 independent variables. The equation of the fitted model is

K7 = 0,0758601*K1 + 0,479799*K2 + 0,0355758*K5 - 0,505545*K6

Since the P-value in the ANOVA table is less than 0,05, there is a statistically significant relationship between the variables at the 95,0% confidence level.

The R-Squared statistic indicates that the model as fitted explains 89,9973% of the variability in K7. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 89,2994%. (Note: since the model does not contain a constant, you should be careful in interpreting the R-Squared values. Do not compare these R-Squared values with those of models which do contain a constant.) The standard error of the estimate shows the standard deviation of the residuals to be 0,168491. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,0840837 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file.

In determining whether the model can be simplified, notice that the highest P-value on the independent variables is 0,9445, belonging to K5. Since the P-value is greater or equal to 0,05, that term is not statistically significant at the 95,0% or higher confidence level. Consequently, you should consider removing K5 from the model.

Appendix E

Multiple regression model of the dependency of the rates of change in net income (loss) from factors indicators covering coefficient (K1), firmness coefficient (K2), financial outturn profit (K5), and the degree of depreciation (amortization, K6) with the application of procedure backward stepwise selection

Dependent variable: K7
Independent variables: K1, K2, K5, K6

Parameter	*Estimate*	*Standard Error*	*T-Statistic*	*P-Value*
K2	0,58163	0,125401	4,63816	0,0000
K6	-0,598056	0,0446769	-13,3863	0,0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	10,9761	2	5,48805	201,11	0,0000
Residual	1,22798	45	0,0272884		
Total	12,2041	47			

R-squared = 89,938 percent
R-squared (adjusted for d.f.) = 89,7144 percent
Standard Error of Est. = 0,165192
Mean absolute error = 0,0831454
Durbin-Watson statistic = 1,94288
Lag 1 residual autocorrelation = -0,0721784

Stepwise regression
Method: backward selection
P-to-enter: 0,05
P-to-remove: 0,05
Step 0:
4 variables in the model. 43 d.f. for error.
R-squared = 90,00% Adjusted R-squared = 89,07% MSE = 0,0283893
Step 1:
Removing variable K5 with P-to-remove =0,944537
3 variables in the model. 44 d.f. for error.
R-squared = 90,00% Adjusted R-squared = 89,31% MSE = 0,0277472
Step 2:
Removing variable K1 with P-to-remove =0,615547
2 variables in the model. 45 d.f. for error.
R-squared = 89,94% Adjusted R-squared = 89,49% MSE = 0,0272884
Final model selected.

The StatAdvisor

The output shows the results of fitting a multiple linear regression model to describe the relationship between y and 4 independent variables. The equation of the fitted model is

K7 = 0,58163*K2 - 0,598056*K6

Since the P-value in the ANOVA table is less than 0,05, there is a statistically significant relationship between the variables at the 95,0% confidence level.

The R-Squared statistic indicates that the model as fitted explains 89,938% of the variability in K7. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 89,7144%. (Note: since the model does not contain a constant, you should be careful in interpreting the R-Squared values. Do not compare these R-Squared values with those of models which do contain a constant.) The standard error of the estimate shows the standard deviation of the residuals to be 0,165192. This value can be used to construct prediction limits for new observations by selecting the Reports option from the text menu. The mean absolute error (MAE) of 0,0831454 is the average value of the residuals. The Durbin-Watson (DW) statistic tests the residuals to determine if there is any significant correlation based on the order in which they occur in your data file.

Appendix F

Integrated rating index

Table F.1. Integrated rating index (I_p) of the enterprise's quality management

No	Company_name	Company_code	I_p
1.	Dp Poltavs′ke Upravlinnya Heofizychnykh Robit	00147921	0,4696
2.	Drugy`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159367	0,6910
3.	Vos`my`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159427	0,4860
4.	Desyaty`j Voyenizovany`j Girny`choryatuval`ny`j Zagin	00159462	0,6065
5.	SE Institute "UKRNDIPROEKT"	00174125	0,3688
6.	Dp Novovolyns′kyy Remontno-Mekhanichnyy Zavod	00179000	0,1807
7.	Dp Dyrektsiya Po Budivnytstvu Ob'yektiv	00179737	0,4170
8.	Dp "Specializovany`J Centr "Vugleizotop"	00186022	0,3767
9.	Dp "Upravlinnya Vidomchoyi Voyenizovanoyi Oxorony`"	02072239	0,4520
10.	Dp "Specializovany`J Centr Pidgotovky` Kadriv"	04642416	0,4400
11.	Derzhavne Pidpryyemstvo "Dniprodiproshakht"	05410777	0,4177
12.	Dp "Kry`ms`ky`j Naukovo-Inzhenerny`j Centr"	13790848	0,3918
13.	Dp "Skhidnyy Hirnycho-Zbahachuval′nyy Kombinat"	14309787	0,3938
14.	SE "Ukr R&D Institute for IndTech"	14310483	0,4636
15.	State Foreign Trade Company "Ukrinterenergo"	19480600	0,5073
16.	Central`ny`j Shtab Derzhavnoyi Voyenizovanoyi Girny`choryatuval`noyi Sluzhby` u Vugil`nij Promy`slovosti	20335814	0,6169
17.	Dp "Derzhavny`J Naukovo-Inzhenerny`J Centr Sy`Stem Kontrolyu ta Avarijnogo Reaguvannya"	24249112	0,5651
18.	Dp "Dy`my`trovs`ky`j Uchbovo-Kursovy`j Kombinat"	24319172	0,3890
19.	SE "NNEGC" Energoatom "	24584661	0,4055
20.	Dp "Chornoby`l`promenergobud"	25301719	0,3571
21.	DP "OS "MASMA-SEPRO"	31107102	0,4211
22.	Dp "Bar'yer"	31330051	0,2209
23.	Dp "My`rnogradvugillya"	32087941	0,1584
24.	SE "Pervomays'kvuhilla"	32320594	0,1385
25.	Dp "L`vivvugillya"	32323256	0,2900
26.	Dp "Voly`n`vugillya"	32365965	0,0014
27.	Dp "UKRSHAXTGIDROZAXY`ST"	32442405	0,1882
28.	Dp "38 Viddil Inzhenerno-Tekhnichnykh Chastyn"	33127487	0,4707
29.	Dp "SELY`DIVVUGILLYa"	33426253	0,1627
30.	Dp "Torecz`kvugillya"	33839013	0,0134
31.	L`vivs`ko-Voly`ns`ky`j voyenizovany`j girny`choryatuval`ny`j (avarijno-ryatuval`ny`j) zagin	33839804	0,5422
32.	Dp "Shaxtoupravlinnya "Pivdennodonbas`ke #1"	34032208	0,2799
33.	Derzhavny`J Koncern "UKRTORF"	35633030	0,3183
34.	Dp "Peredpuskova dy`rekciya shaxty` #10 "Novovoly`ns`ka"	35671961	0,0580
35.	Derzhavny`j Koncern "Yaderne paly`vo"	36282830	0,4855
36.	Dp "Naukovo-Texnichny`j Centr "VUGLEINNOVACIYa"	37770008	0,5171
37.	Dp "Ob`yednana Kompaniya "UKRVUGLERESTRUKTURY`ZACIYa"	39244468	0,3300
38.	Dp "Kremenecz`ke upravlinnya z postachannya ta realizaciyi gazu"	39460902	0,4260
39.	Dp "Shaxta #1 "Novovoly`ns`ka"	39806601	0,0343
40.	Dp "DERZhVUGLEPOSTACH"	40225511	0,4679
41.	Dp "Shaxta "ZARIChNA"	40578553	0,0585
42.	Dp "Shaxta im. M. S. SURGAYA"	40695853	0,4237
43.	Dp "Kalus`ka Teploelektrocentral`-Nova"	40885849	0,5439
44.	PJSC "SHAHTA NADIYA"	00178175	0,0208
45.	PJSC "UKRHYDROENERGO"	20588716	0,5796
46.	PJSC "NY`ZhN`ODNISTROVS`KA GES"	30149623	0,4574
47.	Akcionerne Tovary`Stvo "Ly`sy`chans`kvugillya"	32359108	0,0145

Source: developed by the author

Appendix G

Cluster analysis of enterprise quality management indicators with Ward's Method and Statgraphics Centurion package

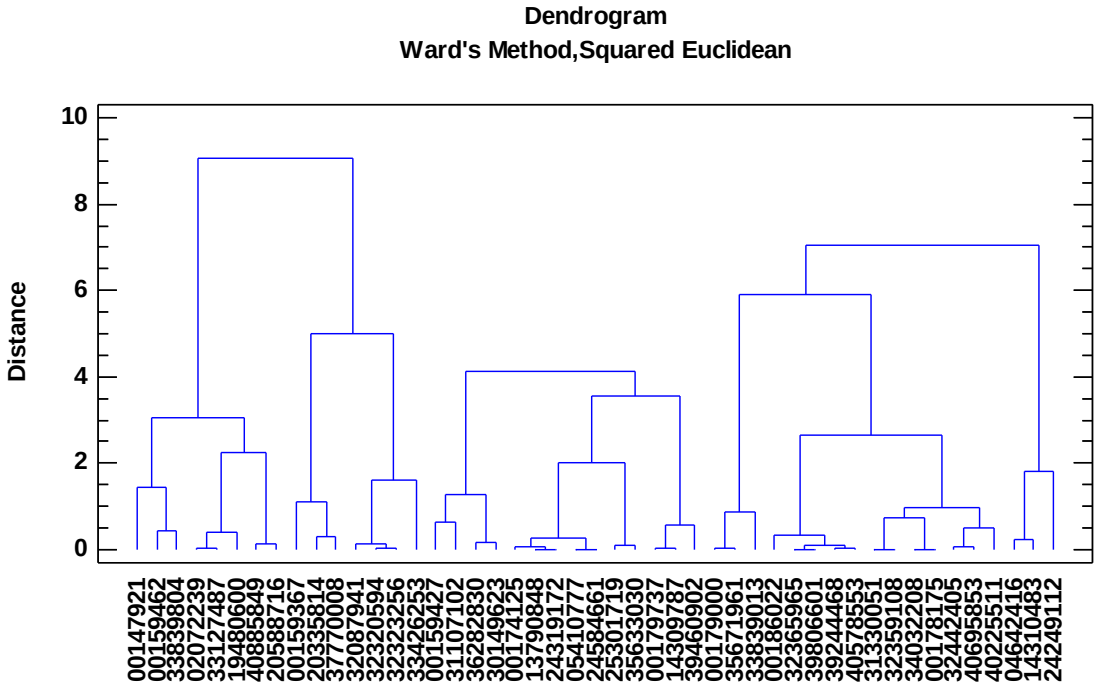

Figure G1. Dendogram for the clusrers (Axis X – the company code)
Source: developed by the author