TECHNICAL AND ECONOMIC PARAMETERS OF EVALUATING THE LOGISTICS SYSTEM EFFICIENCY OF THE STATE FOOD AND GRAIN CORPORATION OF UKRAINE

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Abstract

The article identifies that the logistics system of the vertically integrated Public Joint Stock Company "State Food and Grain Corporation of Ukraine" is the most exemplary in the grain subcomplex of AIC. The work outlines the research phases of the casual dependencies of the technical and economic parameters of the corporate's logistics system efficiency and proposes a methodological toolkit for creating a common base for comparing the diverse activity of the corporation's affiliations through the use of logistical grain equivalent. It is substantiated to choose the operating profitability as an integral indicator of the logistics system efficiency for the enterprises of the grain subcomplex of AIC. The suggested integral indicator allows eliminating the investment and financial activity of affiliations from the evaluation orbit, in order to focus on the implementation of logistical functions related to the transition and modification of the grain flow. According to statistical study results of certain parameters dependencies the suggested regression models can be used to predict unknown values of the indicators of logistics systems efficiency as far as the enterprises of the grain subcomplex of AIC are concerned.

Key words: *Grain subcomplex of Agroindustrial Complex (AIC), logistics system, efficiency, correlation and regression analysis, integral evaluation*

INTRODUCTION

In order to develop the grain subcomplex of AIC there's a need for a strong theoretical foundation that actualizes scientific research, mainly in the sphere of scientific and methodological support of the functioning of all its structural elements. Logistic activity seems to be a powerful technology to increase the efficiency of producing grain and its process agrifood as it can integrate all elements of the grain subcomplex of AIC into a single chain and create potential not only for the internal production and consumption of its strategically important products, but also trigger powerful export grain flows. Scientist N.I. Chuhraj rightly remarks in [9, p. 236] that "...the major contradiction of integration processes can be solved by aligning vertical integration with strategic objectives of the state's economic policy..."

Foreign scientists such as C. Benson, R.H. Green [4], C. K. Eicher, J. M. Staatz [12], W. B. Eide [11] and others researched the economic problems of grain production in their works. Despite considerable scientific and practical achievements in the field of identifying the development problems of the grain complex were made by Ukrainian scientists such as V.I. Boyko [7], M.H. Lobas [21], P.T. Sabluk [24], L.M. Hudolij [14] and others, the issues of the effective functioning of integrated structures still remain unresolved, since these researches were mainly based on individual constituent elements of the grain subcomplex of AIC, or on fragmentary relations between the production and processing enterprises.

Comprehensive management of all elements of the researched subcomplex presupposes the use of a systematic approach viewing the grain flow in the context of logistics. The very logistics, in our opinion, is "…capable of consolidating individual components of the economic mechanism and ensuring a structural and functional balance and an effective institutional environment. By managing logistic flows, it is possible to create an optimal cause and effect relation of elements, which eventually will form an effective system ... " [16, p. 347].

Logistics systems were researched by foreign scientists such as D.J. Bowersox, D.J. Kloss [6], J.R. Stoke, D. Lambert [25], M.R. Linders [20] as well as Ukrainian scientists - O.P. Velychko [26], V.S. Kravtsiv [18], Ye.V. Krykavs`kyj [19], N.I. Chuhraj and others. Although such researches are mainly based on macro- and meso-levels, where logistics systems incorporate individual elements that are integrated in order to implement logistic or marketing functions, as, for example, presented in the work of N.I. Chuhraj [9]. In particular, the author dwelled on "…the ways to implement a vertical marketing integration strategy by entering the maritime industry", which, based on a situational analysis of NIBULON's experience of building an effective product supply chain, proved "…the possibility of implementing business projects in logistical maritime infrastructure at the agricultural markets in the conditions of Public-Private Partnership…" [9, p. 235].

Micro level researches are presented in the works of V.I. Perebyjnis [23], M.A. Oklander [22], who viewed internal logistics systems as a set of production units of an enterprise, interconnected by technological operations. The management of the logistics chain formed in such a way significantly differs from the management of corporate integrated structures in terms of content and characteristics.

It is recommended to use mathematical methods of statistical data processing to make criteria-based decisions on improving the efficiency of logistics systems in the grain subcomplex of AIC [2, 3, 5, 10, 13]. Knowing the degree of change in the summarizing indicator given the change in the actual indicator, it is possible to determine the scope of impact of the latter on the economic result. The same approach can be used for the calculation of reserves for improving the efficiency of vertically integrated structures in the grain subcomplex of AIC, however for the correct calculation of the consolidated indicators, it is necessary to take into account the peculiarities of accounting and analytical support of all integrated elements' activity.

MATERIALS AND METHODS

The purpose of the article is to develop a methodological toolkit enabling to research the dependencies of the technical and economic parameters of evaluating the logistics system efficiency through the scope of creating a common basis for comparing its elements and determining the integral indicator as based on the example of PJSC "State Food and Grain Corporation of Ukraine" (SFGCU), being a corporation that exemplifies the logistics system in the grain subcomplex of Ukraine's AIC.

To achieve this purpose, we had to solve the following tasks: to determine and evaluate the parameters and regularities of the grain logistics system functioning based on dialectical method of objective reality perception and using the general scientific methods of analysis and synthesis. With the help of monographic method we were also researching the structure and directions of the functioning of the most powerful vertically integrated state operator in the grain subcomplex of AIC - Public Joint Stock Company "State Food and Grain Corporation of Ukraine".

Criteria-based decision-making is preceded by the use of an economic and statistical method, which includes correlation and regression analysis to investigate the casual dependencies between the efficiency indicators of the logistics systems of corporations within the grain subcomplex of AIC as well as the formation of economic and statistical characteristics.

RESULTS AND DISCUSSIONS

The logistics system of the grain subcomplex of AIC [16] incorporates elements (subsystems) that ensure the transition of material (grain) flow by means of logistics chains from the primary source of raw material (the field) to the end consumers of finished products (sectoral enterprises of food

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industry, animal husbandry of AIC, etc.) and modify the grain flow by means of applying certain operations to it in the functional areas of the elevator and processing industries. Grain from the producer under the influence of spatial and time parameters undergoes certain stages on its way to the end consumers, involving in such a way a considerable number of infrastructure elements. A linearly ordered set of these elements, that is, participants of the logistics chain to strengthen their efforts to achieve the ultimate synergistic effect – acquisition of financial resources for sold finished products. Such condition of extended production reproduction is a common purpose and responsibility for each element of the logistics chain, since any failure in the discreteness of material flows and discrepancies in the specified time and space parameters will lead to a common loss of each participant, regardless of the quality and completeness of assigned to them functions.

In our opinion, the logistics system can be best demonstrated in the case of the most powerful state operator in the grain storage market - PJSC “SFGCU”, which encompasses 10% of all elevator capacities of Ukraine and provides port transshipment of 6% of grain for export. As a vertically integrated national operator, the corporation holds 10% of the domestic market share for cereals, flour and compound animal feed.

Based on the consolidated financial statements of the securities issuer, as announced by the object of the research on the official website *http://www.pzcu.gov.ua*, one can see that as of the beginning of 2019 the Company unites 55 branches and its elevator capacities are able to provide storage for cereals and oilseeds in the amount of 3.75 million tons. The State Food and Grain Corporation of Ukraine includes 16 processing enterprises, capable of processing about 700 thousand tons of cereals and producing seven types of flour per year with a total volume of 649.5 thousand tons, five types of cereals with an annual volume of 30.5 thousand tonnes and 160 thousand tonnes of compound animal feedstuff. The corporation also includes 2 port elevators based in Odessa and Mykolaiv with the total capacity of export transhipment comprising 2.75 million tons of grain cargo per year.

The activities of PJSC “SFGCU” include all stages of grain flow through the logistics chains, as the corporation purchases grain, ensures its processing, port transhipment for export, utilizing linear and port elevators, mills, compound feed mills and cereal factories. Therefore, by researching the efficiency of the logistics system of PJSC “SFGCU”, we will be able to develop appropriate criteria for efficiency enhancement in the whole grain subcomplex of Ukraine’s AIC, which incorporates 761 certified enterprises in the storage and food processing market alone [15].

The system of performance indicators of PJSC “SFGCU” provides for calculating the partial efficiency of the use of certain production factors, the interaction of which generally forms an integral effect. Direct analysis of the use of production factors of the researched corporation involves the research of the quantitative and qualitative parameters of capital assets both in terms of their availability and degree of use, as well as the efficiency of the use of current assets and workforce.

The capacity of the logistics system is determined by the parameters of the technical means that ensure the transition and modification of the material flow all the way from the primary source of raw materials to the consumers of final products. On the other hand, the modification of the material flow and its origin complicates the integral evaluation of the logistics system efficiency, that is to compare different products of grain processing, as well as the conditions of its processing, in the situation when the owner of the grain uses only the services of the corporation (for storage, processing, etc.) and the cost of raw materials is not reflected in the corporate reporting. Therefore, in order to conduct the technical and economic evaluation of the logistics system efficiency, it is necessary to define a common basis for comparing the numerous and diverse

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affiliations of the corporation, and for this purpose we recommend the use a natural indicator, which we called ***the logistical grain equivalent***.

The use of logistical grain equivalent allows to figuratively convert all grain production into grain through the normative conversion factors of bread products into grain equivalent (Table 1). This natural indicator characterizes the annual quantity of all grain (in thousand tons) which passed through the logistics chains in the researched system, and in the calculation of partial indicators of its efficiency enables to rightfully take into account all grain production and grain in comparable units, regardless of their source of origin and designated purpose.

Table 1. Bread Products Conversion Factors

Bread products expressed in terms of flour, cereals	**Ratio**
Bread and flour products	0.736
Flour of all kinds	1
Cereals of all kinds	1
Peas, beans, other legumes	1
Pasta products	1.031
Semi-finished foods and culinary products from cereals and pasta	0.7
Bread products (flour, cereals) expressed in terms of grain equivalent	**1.330**
including semolina	1.368

Source: Based on data of industry enterprises.

In the process of analyzing the intrasystem factors' impact on improving the logistics systems efficiency in the grain subcomplex of Ukraine's AIC, it is recommended to use modern mathematical methods of statistical data processing, which provide for the necessary mathematical tool and appropriate software for PCs. This toolkit can provide computer support as the solution to a key problem in any research: how it is possible, based on partial results of statistical observation of analysed events or indicators, to identify and describe the relationships that exist between them [2]. The very problem of statistical study of dependencies is primary in analyzing dependencies of key performance indicators of the logistics systems that operate in the grain subcomplex of Ukraine's AIC.

In order to research the dependencies of the main technical and economic parameters of PJSC "SFGCU"'s logistics system efficiency, let's look at its functioning by means of a set of variables presented in Fig. 1.

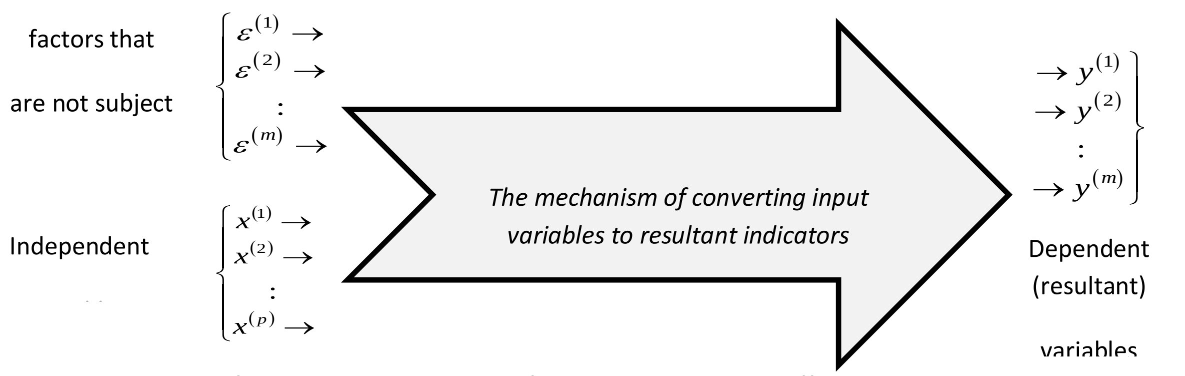

Fig. 1. General Diagram of Variables Dependencies of the Logistics Systems Efficiency During Statistical Research.
Source: Created by authors.

The significance of the items included in Fig.1 is the following one:

$x^{(1)}$, $x^{(2)}$, …, $x^{(p)}$ stand for input variables that describe the operation conditions of the researched object's logistics system, provided that some of them are usually subject to partial control (in economic and mathematical models they are called argument-factors, exogenous, independent),

$y^{(1)}, y^{(2)}, \ldots, y^{(m)}$ stand for output variables that characterize the efficiency of the functioning of the researched object's logistics system (in economic and mathematical models they are called endogenous, dependent, resultant),

$\varepsilon^{(1)}, \varepsilon^{(2)} ..., \varepsilon^{(m)}$ stand for latent random residual components, which reflect the influence of unaccounted "input" factors, as well as deviations during measurement of the resultant variables (in economic and mathematical models they are called residuals).

The task of the statistical research of dependencies of the technical and economic parameters of the logistics system efficiency at the PJSC "SFGCU" can be formulated as follows:

based on the results of *n* measurements of variables

$$\left\{x_i^{(1)}, x_i^{(2)}, \ldots, x_i^{(p)}; y_i^{(1)}, y_i^{(2)}, \ldots, y_i^{(m)}\right\}, \quad i = 1, 2, \ldots, n \tag{1}$$

to construct such vector-valued function on specific research objects

$$f\left(x^{(1)}, x^{(2)}, ..., x^{(p)}\right) = \begin{pmatrix} f^{(1)}(x^{(1)}, ..., x^{(p)}) \\ f^{(2)}(x^{(1)}, ..., x^{(p)}) \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ f^{(m)}(x^{(1)}, ..., x^{(p)}) \end{pmatrix}, \tag{2}$$

which could best reinstate the values of the resultant (predicted) variables $Y = \left(y^{(1)}, y^{(2)}, \ldots y^{(m)}\right)'$ based on the corresponding values of the independent variables $X = \left(x^{(1)}, x^{(2)}, \ldots, x^{(p)}\right)'$.

The line at vectors stands for their transportation operation. This means that *Y* and *X* are respectively *m*- and *p*-dimensional vector columns.

It is worth noting that the functions *f(x)*, which within the context of this general formulation of the matter describe the behaviour of the conditional average values $y_{cp}(X)$ of a specific predicted performance indicator, are called regression functions. Their model looks as follows:

$$y = f\left(x^{(1)}, x^{(2)}, ..., x^{(p)}; \theta\right) + \varepsilon, \tag{3}$$

where ε stands for a residual of the component, which causes a possible deviation in determining a specific indicator of the logistics system efficiency *y* based on known factor values $x^{(1)}, x^{(2)}, ..., x^{(p)}$,

$f(X;\theta)$ stands for a function of a specific known parametric family $F = \{f(X;\theta)\}$ for which, however, the numerical values of the parameters (constants included in its equation) are unknown.

Analysis of the scientific literature with regard to the solving of typical practical matters with the help of a tool for statistical research of dependencies [2, 5, 10, 13] allows to state that the whole process of statistical research of dependencies between the indicators of logistics systems efficiency can be decomposed into the following iteratively interconnected main phases:

(i)Preliminary

(ii)Information

(iii)Correlation analysis

(iv)Identifying of the general type of regression function (feature class) within the scope of which the relationship between variables will be investigated

(v)Analysis of multicollinearity of independent variables and selection of the most informative ones

(vi)Calculation of unknown parameters' estimates that are part of the researched regression equation

(vii)Accuracy analysis of the constructed equations of the statistical relationship between the researched variables.

It should be noted that:

-First of all, the research part that integrates phases 4-7 is called a regression analysis.

-Secondly, the basic phases of correlation and regression analysis have powerful computer support by means of existing statistical packages of applications, so they can be fully automated [2].

-Thirdly, given the proper software use phases 5-7 can be implemented simultaneously.

During the preliminary phase in terms of our research object O_1 (PJSC "SFGCU") we identify a corresponding set of "input" (explanatory) and "output" (resultant) variables according to type (1) (Table 2).

During the second phase of the research, using the information resource http://www.smida.gov.ua, we received a full statistical overview of the type (1) about the activity of our object of interest. As a result of this work, a specific vector of "input" and "output" indicators was identified for PJSC "SFGCU", which characterize its activity based on a sample selection of 48 observations:

$$\mathrm{O}i \longleftrightarrow \left(x_{it}^{(1)}, x_{it}^{(2)}, \ldots x_{it}^{(5)}; y_{it}^{(1)}, y_{it}^{(2)}, \ldots, y_{it}^{(5)} \right),$$

$i = 1;\quad t = 1,2,\ldots,48.$

Table 2. Set of Variables Necessary to Evaluate the Logistics System Efficiency

Analyzed variables	Identification of a variable	Name of a variable
$x^{(1)}$	*X1_VOF*	Average monthly value of capital assets, USD
$x^{(2)}$	*X2_CHP*	Number of employees, persons
$x^{(3)}$	*X3_FOP*	Payroll, USD
$x^{(4)}$	*X4_MAZ*	Material costs, USD
$x^{(5)}$	*X5_FOZ*	Capital equivalent, USD / per unit of labour
$y^{(1)}$	*Y1_LZE*	Logistical grain equivalent (annual amount of grain that passed through the logistics chains in the researched corporation), thousand tons
$y^{(2)}$	*Y2_PLS*	Estimated capacity of the logistics system, thousand tons / month
$y^{(3)}$	*Y3_FMP*	Capitalization ratio, USD / t
$y^{(4)}$	*Y4_PRP*	Workforce productivity, t / person
$y^{(5)}$	*Y5_KLP*	Coefficient of logistics capacity utilization

Source: Created by authors.

Please note that the linear dependencies of the type (3) are the simplest for econometric researches. In many cases, with the help of taking logarithms nonlinear dependencies can go along with the linear type (3). This approach to data modification during regression analysis helps avoiding problems associated with the lack of normal distribution for the analyzed variables, which may result in distortion of the regression results.

Our task is to minimize the impact of such data, preferably without excluding them. The most common way to do this is to take logarithms of variables. This research uses decimal logarithms and as a result of such transformation equal distances on the logarithmic scale at the point of output correspond to equal percent increases rather than equal increases in values.

The phases (3-7) of researching dependencies of the technical and economic parameters of evaluating the logistics system efficiency were implemented on a personal computer using StatSoft's *STATISTICA* package.

Based on the results of the research, the following conclusions can be drawn:

(a)There exist quite a strong correlation between the researched variables of the PJSC "SFGCU"'s logistics system efficiency based on the data of paired correlation coefficients. The graphical analysis of paired correlation fields (data visualization) using a matrix scatter diagram (Fig. 2) allows, first and foremost, to determine the class of linear regression functions $\left(f(x) = \theta_0 + \theta_1 x^{(1)} + \ldots + \theta_p x^{(p)} \right)$ necessary to investigate the correlations of the analyzed variables, and secondly, to identify and remove anomalous observation points (emissions) from the statistical data pool.

(b)The presence of multicollinearity between the independent variables implies the selection of the most informative of them using *Forward stepwise* (multistep inclusion method).

(c)Calculation of unknown parameters' estimates of regression equations allows us to identify the most significant independent variables that have impact on the performance indicators of the logistics system functioning in PJSC "SFGCU" as well as to present the regression models given below.

(d)The analysis of the obtained regression equations accuracy on the basis of the values of the determination coefficients of (R^2), *F*-criterion and its significance level *p*, as well as the research of the residuals of the regression models with graphical visualization of the scatter diagram of the residuals give us grounds to claim that the linear regression models describe conclusive correlations between variables.

$$
\begin{aligned}
&Y1\_LZE = -1{,}055 + 0{,}631 \times X3\_FOP + 0{,}222 \times X4\_MAZ;\\
&Y2\_PLS = 1{,}363 + 0{,}097 \times X4\_MAZ + 0{,}373 \times X2\_CHP - 0{,}11 \times X3\_FOP;\\
&Y3\_FMP = 0{,}17 + 0{,}443 \times X5\_FOZ - 0{,}066 \times X4\_MAZ - 0{,}154 \times X3\_FOP;\\
&Y4\_PRP = 0{,}066 - 0{,}182 \times X4\_MAZ + 0{,}403 \times X3\_FOP - 0{,}335 \times X5\_FOZ;\\
&Y5\_KLP = -1{,}646 + 1{,}851 \times Y1\_LZE - 0{,}252 \times X4\_MAZ - 0{,}574 \times X5\_FOZ.
\end{aligned}
\quad (4)
$$

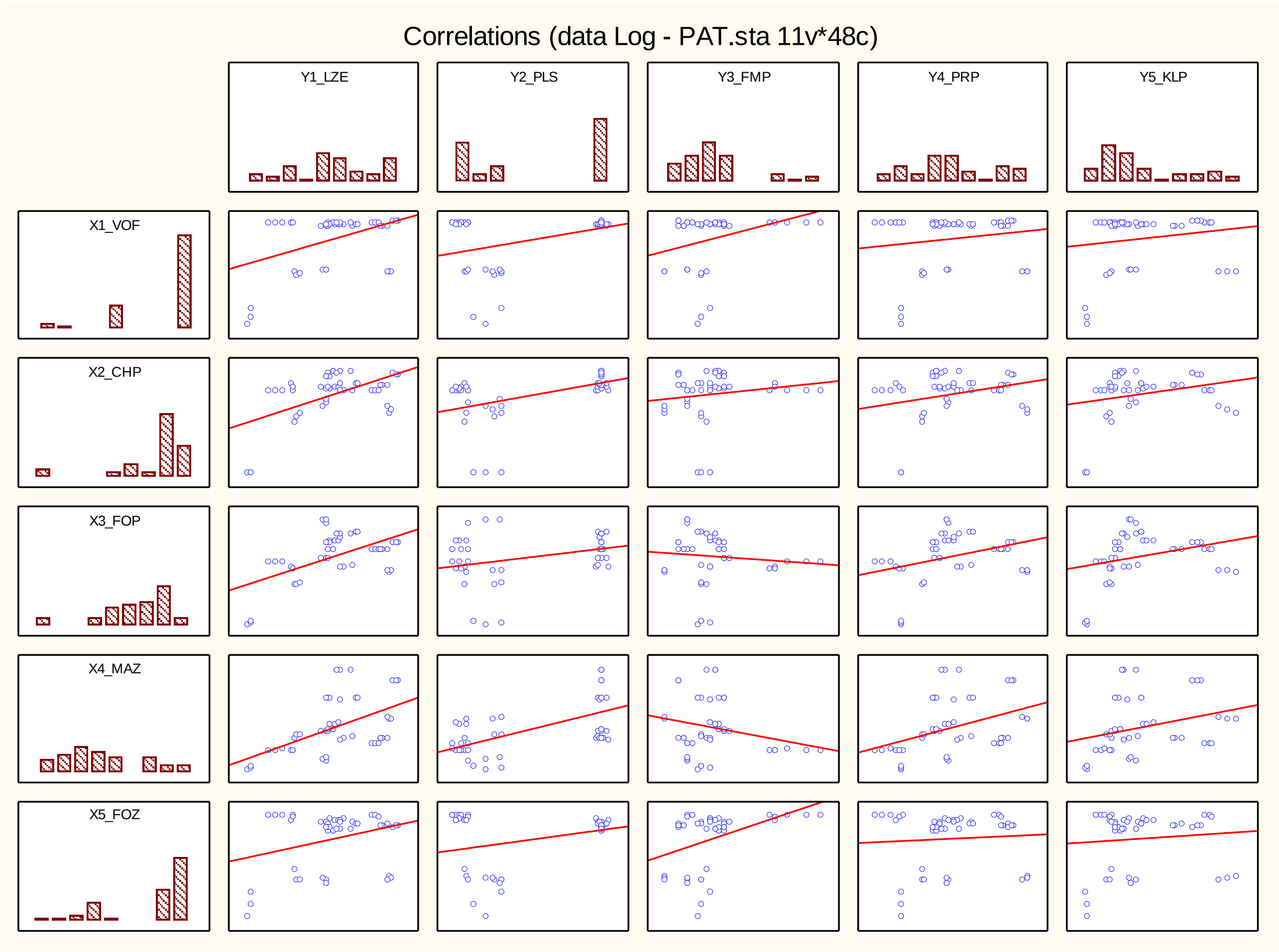

Fig. 2. Matrix Scatter Diagram
Source: Created by authors.

In particular, the linear regression functions indicate that the logistical grain equivalent developed by us is most influenced by the payroll and material costs (Table 3, Fig. 3).
The efficiency of the logistics system as an integral performance indicator is the ratio of the obtained synergetic effect of the whole system to the total costs of all elements of the logistics chain [17]. The efficiency of the logistics system is determined by synergies, which, due to the integrative properties, lead to the appearance of an additional effect in the form of logistical synergy.
Profitability is the most general characteristic of the enterprise's operating efficiency [1, 8]. The whole life of a business entity in a competitive environment depends on profitability. Herewith the following

indicators are important: profitability of property, profitability of production funds, product profitability (e.g. total sales or individual types), etc. (Table 4).

	Regression Summary for Dependent Variable: Y1_LZE (data Log - PAT.sta) R= .62767486 R?= .39397573 Adjusted R?= .36704132 F(2,45)=14,627 p<,00001 Std. Error of estimate: ,18663					
N=48	Beta	Std.Err. of Beta	B	Std.Err. of B	t(45)	p-level
Intercept			-1.055	0.803297	-1.31340	0.195705
X3_FOP	0.382838	0.134137	0.631	0.221025	2.85409	0.006503
X4_MAZ	0.341176	0.134137	0.222	0.087134	2.54350	0.014481

Source: Created by authors.

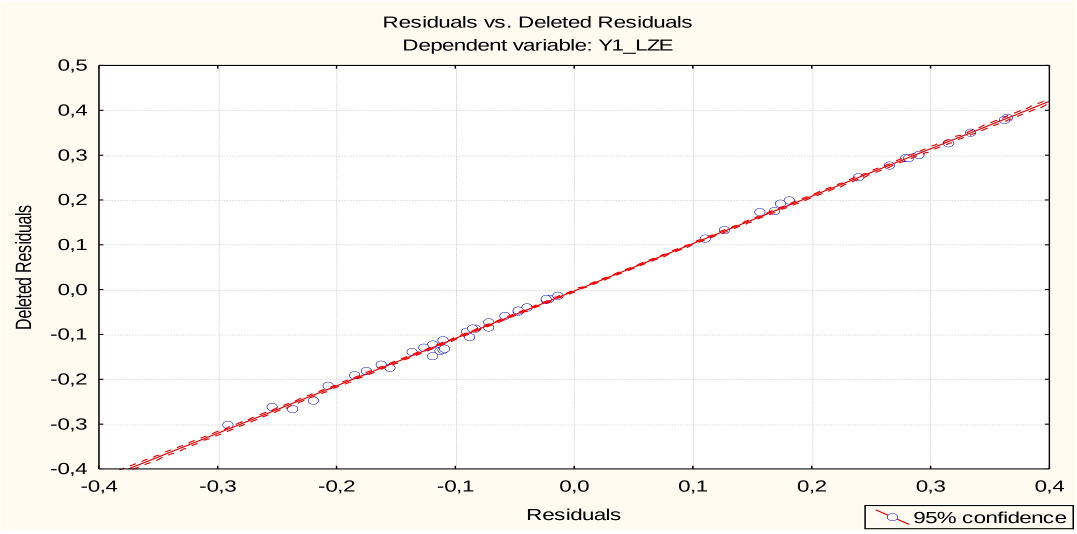

Fig. 3. Residuals and Deleted Residuals Scatter Diagram Y1_LZE.
Source: Created by authors.

Table 4. Profitability Estimation Indicators

No.	Indicator	Indicator description
	Expenditure-Related Indicators	
1	Product profitability	Shows how much gross profit is earned from USD 1 of expenses
2	**Operating Profitability**	**Shows how much operating profit is earned from USD 1 of operating expenses**
3	Profitability of ordinary operations	The amount of ordinary activity profit from USD 1 of ordinary expenses
4	Production costs coverage ratio	Shows the amount of production costs covered by UAH 1 of net income
5	Production costs return ratio	Shows the amount of production costs necessary to earn USD 1 in net income
	Income-Related Indicators	
6	Gross profit margin from product sales	Gross margin from USD 1 of product sales
7	Net profit margin from product sales	Net profit from USD 1 of net sales revenue
8	Income profit margin from operating activity	Profit from USD 1 of operating income
	Resources-Related Indicators	
9	Company profitability	Net profit from USD 1 of assets
10	Return on capital assets	Profit from USD 1 of capital assets
11	Return on Equity	Profit from USD 1 of equity
12	Profitability of the raised capital	Profit from USD 1 of raised capital

Source: Created by authors.

Having analyzed numerous approaches to generalized efficiency evaluation, we can conclude that it is most acceptable to use the operational profitability indicator as an integral indicator of the logistics system efficiency, which is calculated as follows:

$$Io = \frac{Po}{Cs + Ac + Sc + Oc} \times 100\% \qquad (5)$$

where *Io* – income from operational activity (integral indicator)

Po – profit from operational activity

Cs – cost of sales (of works, services)

Ac – administrative costs

Sc – sales costs

Oc – other operational costs.

The integrated assessment of the logistics system efficiency in the grain subcomplex of AIC based on the use of operational profitability indicator will enable us to:

-Determine the profitability of the logistical functions, excluding capital assets and financial investments that are not part of cash equivalents

-Evaluate the efficiency of logistical functions of enterprises, eliminating the influence of the size and composition of equity and loan capital (financial leverage)

-Determine the profitability of services regardless of the origin of raw material (own or donor) based on the publicly available consolidated financial statements of the corporation

-Take into account the structure and range of all grain processing products.

Thus, in evaluating the logistics system of a vertically integrated corporation, an integral indicator stands for the operational profitability, which allows to compare the synergetic effect of the logistical functions implementation with the total costs of all elements of the logistics chain.

CONCLUSIONS

The suggested methodological toolkit for researching the dependencies of the technical and economic parameters of evaluating the efficiency of PJSC "SFGCU"'s logistics system presupposes the use of a logistical grain equivalent that allows to figuratively convert all grain production (flour, cereals, compound animal feed) into grain through the normative conversion factors of bread products into grain equivalent. This natural indicator characterizes the annual quantity of all grain (in thousand tons) which passed through the logistics chains in the researched system, and in the calculation of partial indicators of its efficiency enables to rightfully take into account all grain production and grain in comparable units, regardless of their source of origin and designated purpose of the grain masses.

The efficiency of the logistics system as an integral performance indicator is the ratio of the obtained synergetic effect of the whole system to the total costs of all elements of the logistics chain. The suggested integral indicator – operational profitability – allows to eliminate the investment and financial activity of affiliations from the evaluation orbit, in order to focus on the implementation of logistical functions related to the transition and modification of the grain flow.

Based on the results of the analysis of the statistical research of the dependencies of certain identified performance indicators of PJSC "SCPCU"'s logistics system, it is safe to state that our proposed regression models can be used for prediction (recovery by antilogarithmization: the results are being by inverse logarithm of the function of exponentials) of unknown or average values of certain indicators of the corporate's logistics system efficiency. In its turn, this research provides for a prospective analysis of the logistics systems efficiency in related enterprises of the grain subcomplex of Ukraine's AIC.

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