

## **MATHEMATICAL TOOLS FOR MONITORING EXPORT-IMPORT CAPACITY OF UKRAINIAN INDUSTRIAL ENTERPRISES**

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### **ABSTRACT**

Efficiency of using export-import potential depends on well-running operating system. Monitoring also takes a great part in operating system of institution's export-import potential because the results of its work provide quality and data support of the whole operating system and promptitude of problem solving. Based on specified meaningful essence of export-import potential and definition of monitoring as a Ukrainian industrial institution's component, it is offered for analytical support for monitoring the potential, in particular: total performance system, the complex of mathematical tools and procedures of monitoring. As a monitoring assessing export-import potential, forecasting its indicators, optimizing the indicator's values for strategies development and increasing the effectiveness of its use is offered.

**Key words:** mathematical methods, monitoring, management, export-import potential.

**Classification of JEL:** CO2, C61, L1.

### **INTRODUCTION**

Global economic development, the impact of which extends to the economy of all countries, including Ukraine, increases its export-import potential, one of the main elements of which is the export-import potential of industrial enterprises. Due to it, the capacity of national economy increases. Due to the official statistical data, export of the goods from January until July 2018 was \$ 26876.2 million or 112.7 % in comparing with the indexes of January- July 2017. The import was \$ 3093, 9 million or 115, 9%. Unfavorable balance was \$ 4063, 7 million (the same balance in 2017 year equaled \$ 2847, 5 million.) [1]. The export-import coverage ratio was 0, 87 (during the time from January till July 2017 the index was 0, 89), which holds down the economic growth. For moving it, faster Ukrainian's international

organizations give the financial backing. Therefore, the current portfolio of the International Bank for Reconstruction and Development's projects consists of eight investment projects totaling about \$ 2.5 billion and one guarantee for \$ 500 million. Ukraine and consequently entrepreneurship are in the face of new opportunities of growing up based on effective using of the ongoing free trade arrangements, in particular, with the EU, EFTA, CIS, Canada, Georgia, Turkey, Israel, and the accession to the Regional Convention on Pan-Euro-Mediterranean Preferential Market Access Rules. With reference to what was said above the management of the developing export-import potential requires constant monitoring, which should be carried out on a scientific basis. The efficiency of using export-import potential fully dependent on the current management system. Monitoring takes a big part in a managing system of export-import potential of an entrepreneurship since the results of its operation determine the quality and scope of information support for the entire management system, as well as the timeliness of eliminating the problems that come up.

## **1. LITERATURE REVIEW**

The scientific basis for solving such problem is the results of economist's researches in such areas as: modeling theoretical and methodical principles of export-import potential management, export-import activities of enterprises, exactly Spiridon Pralea (2012) [2], Minh Quang Dao (2014) [3], Cooke, S., & Watson, P. (2011) [4], Stoian, M., Rialp, A., & Rialp, J. (2012) [5], Draghescu, F. (2015) [6], Mishra, P. (2011) [7], Obešlo, F. (2017) [8] etc. The analysis of scientific and practical works of these and other well-known experts on the issues of potential, foreign economic and export-import activities of enterprises, attest to disambiguate insight of specified meaningful essence of export-import potential and forms of manifestation of export-import potential. The concept of export-import potential of the enterprise has been formed in scientific concepts not so far ago. The meaningful essence of export-import potential depends on its object, with help of which we can distinguish the export-import potential of the country, region and enterprise, in case that the export-import potential of enterprise is the basis of formation the previous ones. Based on the conceptual approach to distinguishing the components of the subjective (ability) and object (capability) potential, it is offered to determine the export-import potential of the enterprise as the ability to carry out export and import operations. Also, to ensure their positive balance, particularly carry out effective export- import activity for reproduction and forming the competitive position of the company in the external and internal markets.

## **2. OBJECTIVE**

The meaningful essence of export-import potential reside in the fact that it may represent different types of export-import potential of industrial enterprises, especially organizational capacity, management capacity and resource potential, which consists of labor resources, means of production (basic and reversible), natural, monetary, information resources, which provide labor, technic, finance, technological and informational potential. These types of potential are used to implement production, financial, innovation-investment, marketing, export-import activities of the enterprise.

Considering monitoring as a functional component of export-import potential of enterprises' management, analytical support should give an opportunity to do systematic monitoring, evaluation, control and forecast the states of the potential through instrumental, organizational and methodological ways.

The monitoring of the EIPE (export-import potential of enterprise) should observe such requirements as monitoring which provides a methodological aspect of the construction of the EIPE management process, improves the economic structure of EIPE management, realizes the social structure of management process, and forms the organizational structure of EIPE management process. Monitoring is an active functional component of the management, which implements the functional structure of the management process and informally supports all management functions. It is carried out with the help of analytical tools, which we could find in its methodological support. Therefore, a new approach to the management of the export-import potential of the enterprise is provided theoretically.

## **3. DATA AND METHODS**

The effectiveness of management measures entirely depends on the data objectivity on which they were developed. Monitoring requires a system of indicators which, first of all, adequately describes and determines the potential, its structure and elemental composition [9]. The monitoring of EIPE system is described in terms of the analyze of methodological approaches to assessing the potential of industrial enterprises, their export potential, export-import activities and also of the relative frequency of recommendations for the use of a given indicator by leading experts. (tab. 1)

**Table 1. The system of indicators of monitoring of export-import potential of the enterprise**

Group	The name of indicators and denomination
Partial indicators of the state of EIPE and the overall potential of the company which provides it	$x_1$ – the export's quota in the volume of the sold output (Ex); $x_2$ – the export's quota in the volume of the sold output (IM); $x_3$ – export condensation of enterprise in the external market (EC); $x_4$ – the part of domestic market (PDM); $x_5$ – the rate of change in export supply (RCES); $x_6$ – the rate of change in import supply (RCIS); $x_7$ – the level of product diversification of exports (PDE); coefficient of use of working time (CUWT); $x_9$ – specific gravity of the employee with the academic institution; $x_{10}$ – specific gravity of the employee who were trained by a new profession
Partial indicators of the state of EIPE and the overall potential of the company which provides it	$x_{11}$ – specific gravity of the employee who improved their qualification in the reporting period; $x_{12}$ – turnover rate; $x_{13}$ – the work's productivity; $x_{14}$ – coefficient of renewal of basic funds; $x_{15}$ – capital productivity ratio; $x_{16}$ – capital-labor ratio; $x_{17}$ – current assets coverage ratio; $x_{18}$ – part of working capital financed by owner's equity; $x_{19}$ – ratio of capital turnover; $x_{20}$ – ratio of owner's capital turnover; $x_{21}$ – turnover ratio of productive supplies; $x_{22}$ – finished goods turnover; $x_{23}$ – turnover ratio of owners' equity; $x_{24}$ – equity-assets ratio; $x_{25}$ – coefficient of maneuverability; $x_{26}$ – the index of finance leverage; $x_{27}$ – coefficient of stock and cost maintenance of own funds ; $x_{28}$ – reserve supplies; $x_{29}$ – materials/output ratio; $x_{30}$ – total costs ; $x_{31}$ – depreciation charge; $x_{32}$ – labor payment expenses; $x_{33}$ – benefits-related deduction; $x_{34}$ – another operating expenses; $x_{35}$ – total production stock; $x_{36}$ – amount of work in progress; $x_{37}$ – amount of finished commodity
Partial indicators of EIPE usage	$y_1$ – economic efficiency of export; $y_2$ – economic efficiency of import; $y_3$ – profitability of export; $y_4$ – cost effectiveness of export operations; $y_5$ – rentability of import; $y_6$ – rentability of aggregate capital; $y_7$ – gross profit margin of solds; $y_8$ – operating margin of solds; $y_9$ – net margin of solds
Integral indicators	Integrated Development Index; EIPE, integrated Indicator of EIPE use, Integrated Indicator of General Condition of EIPE

This system is meeting all needed requirements, such as adequate reflection of the substantive essence of the EIPE, its state. Also being hierarchic which means to contain indicators, which define elementary, factor and complex signs. Next requirement is to be multidimensional, express metric and nonmetric values of signs. In addition, it is important to be limited by the main determinants, contain the information, which is compared in space and time. Conform to the principles of preparing statistical reporting and rely on data from primary accounting records and summary records of management accounting. Formed system of monitoring indicators is a tool, which floats the information support for managing the export-import potential of an industrial enterprise.

#### 4. RESULTS

The procedure for assessing the export-import condition is one of the obligative components of its monitoring tool. In order to designate the assessment objectively, you must have the correct conceptual representation of this concept. It is suggested to determine the rate as a management function that provides a description of the object in the economy by its features. Besides managing function provides the formation of indicators' system, the establishment of the trends to change the values of indicators based on the analysis of their dynamics and the comparison of achieved values' levels with planned, normative or reference that usually accompanied by search and detection of reserves, diagnosis of critical situations. Especially in the dynamics of observing the change in the values of the EIPP indicators, the establishment of their tendencies to change, the comparison with the laws, the identification of internal based on causal relationships mechanisms is carried out well . First of all, the most important impact indicators of EIPP, which stay in dense causal relationships and form interconnection mechanisms in the process of using EIPP, should be monitored. For managing the potential, it is necessary to determine both direct and indirect factors' influence of the internal environment. Due to this goal it is recommended to identify the causal relationships monitoring system of EIPE indicators based on the use of cluster, factor and canonical analysis [10]. The practical check-over of the proposed EIPP evaluation procedure was carried out at the Ukrainian industrial enterprises such as: PJSC "KhMZ" Svetlo Miner ", PJSC" Turboatom ", PJSC" Ukrelectromash ", PJSC" Zavod im. Frunze ", PJSC" Kharkiv Bearing Plant ", State Enterprise" Kharkiv Machine-Building Plant "FED" using the statistical package Statgraphics Centurion. The system of indicators that describe the state of the EIPE and its use with cluster analysis should be structured at first. It makes it possible to systematize indicators by groups. On the Figure 1 the results of cluster analysis of EIPP state indicators and their us are presented.

An analysis of the composition of each cluster of indicators allows to establish the relationship between these indicators. To determine the internal causation mechanisms in the export-import activity of the investigated enterprises and to identify the most influential indicators that determine the state of the EIPE and its use, should be used the factor analysis and canonical analysis in each of the four groups of indicators.

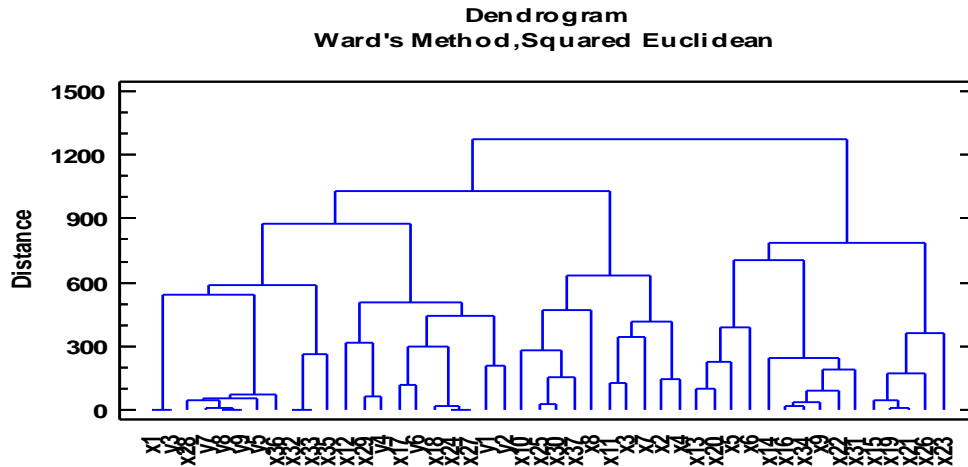


Figure 1. Dendrogram of the system of indicators describing the state of the EIPE and its use at the investigated enterprises

Thus, for the first group of EIPE indicators that was obtained by cluster analysis, the first system of equations of general variables  $U_i V$  in in the model of the relationship between the indicators of the development of EISP and indicators of its use has the form:

$$r_{U_1(1)V_1(1)} = 0,949, \quad p\text{-value} = 0,000;$$

$$\begin{cases} U_1(1) = 0,28x_1 + 0,419x_{28} + 0,993x_{32} - 0,687x_{33} - 0,139x_{35} + 0,258x_{36}, \\ V_1(1) = 0,676y_3 + 0,24y_5 + 0,543y_7 + 0,297y_8 - 0,461y_9, \end{cases} \quad (1)$$

From where the  $r_{UV}$  is the coefficient of canonical correlation.

The most influential determined indicators allowed to reveal internal factors of the EIPE development and to carry out an objective assessment of its use at the investigated enterprises. The most influential indicators include the level of product diversification of exports. Based on the benefits of defining a taxonomic development indicator for building integral indicators in the economy, this integral indicator is recommended for measuring EIPP levels (Table 2). Analysis of the dynamics of values of integral indicators expands the possibilities of monitoring EIPP.

The analysis of the EIPP's integral indicators provide evidence of an aggregate downward trend of concern, as this trend will affect the level of potential use in subsequent periods of time. The exception is PJSC "Turboatom", where there is a tendency to increase both the level of use and development of EIPE.

**Table 2. Integral indicators of export-import potential of the investigated enterprises**

Enterprises	2012 year	2013 year	2014 year	2015 year	2016 year
Integral indicator of the current state of development of EIPP					
PJSC "KhMZ" The Light of a Miner "	0,211	0,126	0,156	0,237	0,171
PJSC "Turboatom"	0,302	0,397	0,449	0,465	0,597
PJSC "Ukrelectromash"	0,208	0,308	0,181	0,186	0,198
PJSC "Zavod im. Frunze »	0,200	0,318	0,169	0,274	0,248
PJSC "KhPZ"	0,222	0,410	0,288	0,405	0,380
SE "KhMZ" FED "	0,299	0,273	0,349	0,232	0,179
Integral indicator of EIPP usage					
PJSC "KhMZ" The Light of a Miner "	0,380	0,571	0,539	0,351	0,356
PJSC "Turboatom"	0,379	0,596	0,622	0,633	0,789
PJSC "Ukrelectromash"	0,658	0,439	0,446	0,401	0,374
PJSC "Zavod im. Frunze »	0,672	0,322	0,570	0,519	0,550
PJSC "KhPZ"	0,461	0,430	0,678	0,372	0,457
SE "KhMZ" FED "	0,427	0,411	0,668	0,707	0,569

Assessment of the EIPP level will be objective if it is carried out according to the proposed rules. For example – the formation of a system of partial indicators, definition of causal relationships in the system of indicators, determining the rating of the most influential indicators. The analysis of trends in changing indicators to identify critical states and reserves for the development of EIPP. Determination and analysis of the current state and use of EIPP. In addition, the last rule is expressed as a modelisation of management measures for the development and use of EIPP.

In the process of monitoring, in order to understand deeply the trends in the state of EISP, it is necessary to predict the significance of its indicators. It is recommended to carry out a procedure for forecasting the EIPP monitoring indicators based on the calculation of growth curves. Therefore, the equation of the growth curve of the export density of PJSC "KhMZ" Light Miner "in the foreign market has the form:

$$x_3 = \sqrt{-1,58E8 + \frac{5,44E9}{t}} . \quad (2)$$

The model is qualitative according to statistical criteria that characterize the quality of this calculated model, namely the determination coefficient  $R^2 = 0,8596$ , Fisher's criterion  $F = 18,37$  and the Durbin-Watson criterion  $DW = 2,039$ . The predicted values of this indicator for 2017-2019, namely 27374.2; 24894.3; 22858.5, represent the change in values. Therefore, the company should urgently develop measures to correct this situation. Loss of

market share and business partners will instantly lead to a reduction in the efficiency of the entire business activity. Thus, the calculated forecast of the key indicators' values of the enterprises' export-import potential led to conclusions about its status and use. Their analysis makes it possible to timely develop management measures to prevent the emergence of critical situations in the development and use of EIPP. The assessment and analysis of the impact of environmental factors on the level of development ( $I_s$ ) and the level of use of EIPP ( $I_v$ ) have been made for PJSC Turboatom on the basis of computing multifactor regression dependencies on macroeconomic factors (market, technological, social, international), represent to their different influence. In particular, the equation of the level of development of the enterprises' export-import potential from the environmental macroeconomic factors has the form:

$$I_s = 0,4872 + 0,0000355 X_2 + 0,0000022 X_4 \quad (3)$$

The level of the EIPP development of this enterprise depends very heavily on two macroeconomic factors, such as: the increase of the average salary per one employee ( $X_2$ ), the increase of total exports in Ukraine ( $X_4$ ). It does not depend from the rest of the economic factors of the environment such as the level of GDP in actual prices) ( $X_1$ ), capital investments ( $X_3$ ), import volumes ( $X_5$ ). The model is statistically qualitative, the evidence for it are the determination coefficient  $R^2 = 0,5156$  and Fisher's criterion -  $F = 4,62$ . The significance of the regression parameters is also confirmed by Student stats. According to the model of increase of wages average per one employee per 1 UAH will result in an increase in the level of EIPP development of the company by 0,0000355, and the increase in total exports in Ukraine by 1 million USD. The US will increase the EIPP by 0,0000022.

The forecast of the key indicators of enterprises' export-import potential gave an opportunity to make conclusions about its state tendencies and trends of use (Table 3).

The analysis of the 3d table shows that there are negative trends in the forecast for changes in the values of EIPP indicators, which are opposite to the logical progressive changes in its condition and use.



**Table 3. Forecast of the changes directions in values of key indicators of export-import potential of PJSC "KhMZ" Svit Miner "**

Forecast of change in indicators' values growth	Forecast in the values indicators' change
forecast of change in indicators' values growth; Productivity; recovery factor of fixed assets; coefficient of capital turnover; coefficient of own working capital turnover; turnover rate of inventories; coefficient of finished products` turnover; return on equity ratio; financial leverage indicator; salary expenses; deductions for social events; profitability of export operations;	enterprise`s export density in the foreign market; the pace of import changes; the export's product diversification level; the share of employees trained in new professions; the share of employees, which have increased qualification in the reporting period; share of own current costs in assets; coefficient of autonomy; coefficient of maneuverability; coefficient of stock and cost maintenance of own funds; the amount of accrued depreciation; volume of work in progress; volumes of finished products; net profitability of sales

There are the tendencies of such indicators as: financial leverage; export density of the enterprise in the foreign market; import change rate; the level of exports' product diversification ; the proportion of workers trained in new professions; the share of workers who have increased qualification in the reporting period; share of own working capital in assets; coefficient of autonomy; coefficient of maneuverability; coefficient of stock and cost maintenance of own sources of formation; net profitability of sales. These indicators contribute to the immediate development of a measures system to prevent negative critical trends in changing the state of export-import potential of the enterprise, which will lead to loss of financial stability and the spread of the crisis situation.

The search for compromise alternatives to solve the problems with many criteria, such as the level of development of export-import potential and the effectiveness of its use, is based on the solution of the multicriteria optimization problem. An mathematical methods' analyze for solving these problems proves the feasibility of using the fminimax procedure, which is programmed in the MatLab environment. The partial criteria in the multicriteria problem of optimization of EIPP indicators is the level of its development ( $F_1 \rightarrow max$ ), which is reflected by the relevant indicators, and the level of effectiveness of its use  $F_2 \rightarrow max$ .

While developing partial criteria it should be taken into account the impact of each individual EIPP factor. To do this, it is necessary to calculate the paired dependencies of the respective levels on each individual factor. In this multicriterion optimization problem, the intervals of changes in the values of factors based on their numerical characteristics, namely the standard error, are used as constraints. Partial criteria should be constructed with taking into account the dependencies of the level of use of export-import potential in the enterprise from its

factors with the established weighting factors, which are based on the priority of the decision of tasks in functional strategies.

In the multicriteria task of optimization of development indicators and use of EIPP for PJSC "Turboatom". Partial criteria, such as the level of EIPP development ( $F_1$ ) and the level of effectiveness of its use ( $F_2$ ) are maximized. And the second criteria looks like:

$$\begin{aligned}
 F_2 = & 0,2 \frac{1}{6,0467 - 3,6403 y_1} + 0,15 \left( \frac{1}{-0,3987 + \frac{3,1784}{y_2}} \right) + 0,2 \sqrt{0,1276 + \frac{0,2952}{y_3}} + \\
 & + 0,15 \left( 0,9465 - \frac{505,31}{y_4} \right) + 0,1 \left( \frac{1}{1,3329 - 0,4465 \ln y_5} \right) + 0,05 \left( \frac{1}{1,0803 + \frac{0,0507}{y_6}} \right) + \\
 & + 0,05 \sqrt{0,079 + 2,2857 y_7^2} + 0,05 e^{0,251 - \frac{0,1957}{y_8}} + 0,05 \left( \frac{1}{0,8448 + \frac{0,1751}{y_9}} \right) \rightarrow \max
 \end{aligned} \tag{4}$$

As a result of solving this problem in the MatLab environment, taking into account the limitations of the change in the values of the indicators, the following optimal values of the EIPP indices were obtained as:  $x_1 = 0,4671$  ;  $x_2 = 0,1227$  ;  $x_3 = 10301,27$  ;  $x_4 = 0,9055$  ;  $x_5 = 0,8929$  ;  $x_6 = 1,0918$  ;  $x_7 = 0,8267$  ;  $x_8 = 0,8543$  ;  $x_9 = 0,2967$  ;  $x_{10} = 0,0602$  ;  $x_{11} = 0,1953$  ;  $x_{12} = 0,0291$  ;  $x_{13} = 26,9076$  ;  $x_{14} = 0,019$  ;  $x_{15} = 1,5143$  ;  $x_{16} = 43,3698$  ;  $x_{17} = 0,4036$  ;  $x_{18} = 0,2309$  ;  $x_{19} = 0,3102$  ;  $x_{20} = 1,0012$  ;  $x_{21} = 0,9501$  ;  $x_{22} = 2,008$  ;  $x_{23} = 0,3989$  ;  $x_{24} = 0,6556$  ;  $x_{25} = 0,3486$  ;  $x_{26} = 0,2803$  ;  $x_{27} = 0,4346$  ;  $x_{28} = 401596,0$  ;  $x_{29} = 3,053$  ;  $x_{30} = 0,4774$  ;  $x_{31} = 0,0244$  ;  $x_{32} = 0,1998$  ;  $x_{33} = 0,0775$  ;  $x_{34} = 0,086$  ;  $x_{35} = 0,1792$  ;  $x_{36} = 0,1275$  ;  $x_{37} = 0,0643$  ;  $y_1 = 1,0865$  ;  $y_2 = 1,0537$  ;  $y_3 = 2,5947$  ;  $y_4 = 1000,963$  ;  $y_5 = 0,0537$  ;  $y_6 = 0,0324$  ;  $y_7 = 0,2805$  ;  $y_8 = 0,1653$  ;  $y_9 = 0,1043$  .

The value of the partial criteria, in particular, the maximum level of development of the EIPP of PJSC "Turboatom" is 0,4004 , while the maximum level of use is 0,4392. Comparison of

the obtained levels refers to greater possibilities of the enterprise to use its EIPP. The obtained optimum values of monitoring indicators should be used in the process of strategy development for PJSC Turboatom.

## CONCLUSION

In conclusion to monitor the export-import potential of an industrial enterprise, it is recommended to use the complex of mathematical instruments. Tools of mathematical statistics and multi-factor regression analysis, which are to monitor environmental factors that affect export and import potential, as well as to evaluate and analyze trends in the development of export-import activities of industrial enterprises in Ukraine and in the world. Factor and canonical analysis methods are to determinate the rating of the indicators' influence and causal relationships between the state of export-import potential and its use at the enterprise. Method of constructing a taxonomic indicator of development is to elaborate integrated indicators of development and use of export-import potential of industrial enterprises. Models of growth curves - for forecasting trends of potential indicators and multi-objective optimization method - to determine the optimal values of export-import potential indicators in developing strategies for its development and use.

## REFERENCES

1. Publication of documents of the State Service of Statistics of Ukraine. Retrieved from <https://ukrstat.org/uk>
2. Pralea, S. (2012). References Of The New Theory Of Trade And Economic Growth. *CES Working Papers*, 4(4), 824-836.
3. Minh Quang Dao, M. (2014). Exports, imports, government consumption and economic growth in upper-middle income countries. *Progress in Development Studies*, 14(2), 197-204.
4. Cooke, S., & Watson, P. (2011). A Comparison of Regional Export Enhancement and Import Substitution Economic Development Strategies. *Journal of Regional Analysis and Policy*, 41(1), 201-215.
5. Stoian, M., Rialp, A., & Rialp, J. (2012). International marketing strategy and export performance in Spanish SMEs: a contingency approach. *International Journal of Entrepreneurship and Small Business*, vol. 15(2), 213-236.

6. Draghescu, F. (2015). The Analysis Of Flat Glass Exports For Romania Using The Gravity Model. *Annals of Faculty of Economics*, 1(1), 1224-1235.
7. Mishra, P. (2011). The Dynamics of Relationship between exports and economic growth in India. *International Journal of Business and Economic Sciences Applied Research*, 4(2), 53-70.
8. Obešlo, F. (2017). Export and Import Functions - Empirical Analysis on the Example of the Czech Republic. *European Financial and Accounting Journal*, 2017(3), 5-16.
9. Malyarets L., Draskovic M., Proskurnina N., Dorokhov O., Vovk V. Analytical support for forming the strategy of development of export-import activity of enterprises in Ukraine. *Problems and Perspectives in Management*, Volume 16, Issue 3, 2018, 423-431.
10. Ponomarenko, V., & Malyarets, L. (2009). *Analysis of data in studies of socio-economic systems*. Kharkiv, INZHEK.