Essence of Measurers of Enterprise Activities Efficiency

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Objectiveness of measuring the efficiency of enterprise is entirely depends on the analytical tool through which this process is carried out, most of all by measurers. Nowadays, enterprises in many countries remain in difficult economic conditions, which depend on the social-political processes that are occur in the world. So, managerial decisions should be informed and justified, based only on a reliable information base that reflects and describes the processes, characteristics of the enterprise. Therefore, there is a necessity of improvement and development of reliable measurers in the economy. Adequate assessment of the state of a management unit in the economy is possible on the basis of complete and objective information, which is obtained not with the help of separate measurements, but in the case of large flows of measurement information in multichannel measurements of a system of values; measurements that rapidly change during time; multiple measurements in order to improve the accuracy and reliability of measurements; measurements on the background of different noises, uncertainties. The probabilistic nature of measurement information is only fully manifested in the flow of information, especially in the intensive flow. Introduced by K. Shannon, a quantitative measure of information was needed for economical coding in order to increase the speed of transmission of the flow of statements, for the transmission of the same separate statements, it would lose practical meaning. The same is observed in measurements in engineering, and furthermore in the social sciences, when the usefulness of information accessments is fully manifested only in the analysis of mass and complex measurements, although the transition to an information description of the measurement process is clearly connected with the necessity to evaluate the amount of information in the flow element - in one act of measurement [1, c. 4].

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Consequently, we need to review the information and analytical basis of measurement in economics. The carrier of information in the economy is the rate. The purpose of the rate in the economy is determinative and is explained by the essence of this concept. Rate is a separate distinct feature of an economic object expressed in numbers [2].

The rate in the economy is different from the rate in technology. There are different values in economic activity, which are measured on different scales. According to nature of features of objects in the economy, it is appropriate to distinguish the following indicators: technical, economic, statistical. In Fig. 1 the differences of these indicators are schematically depicted by the criteria of the characteristics that they express, values, method of measurement and forms of existence.

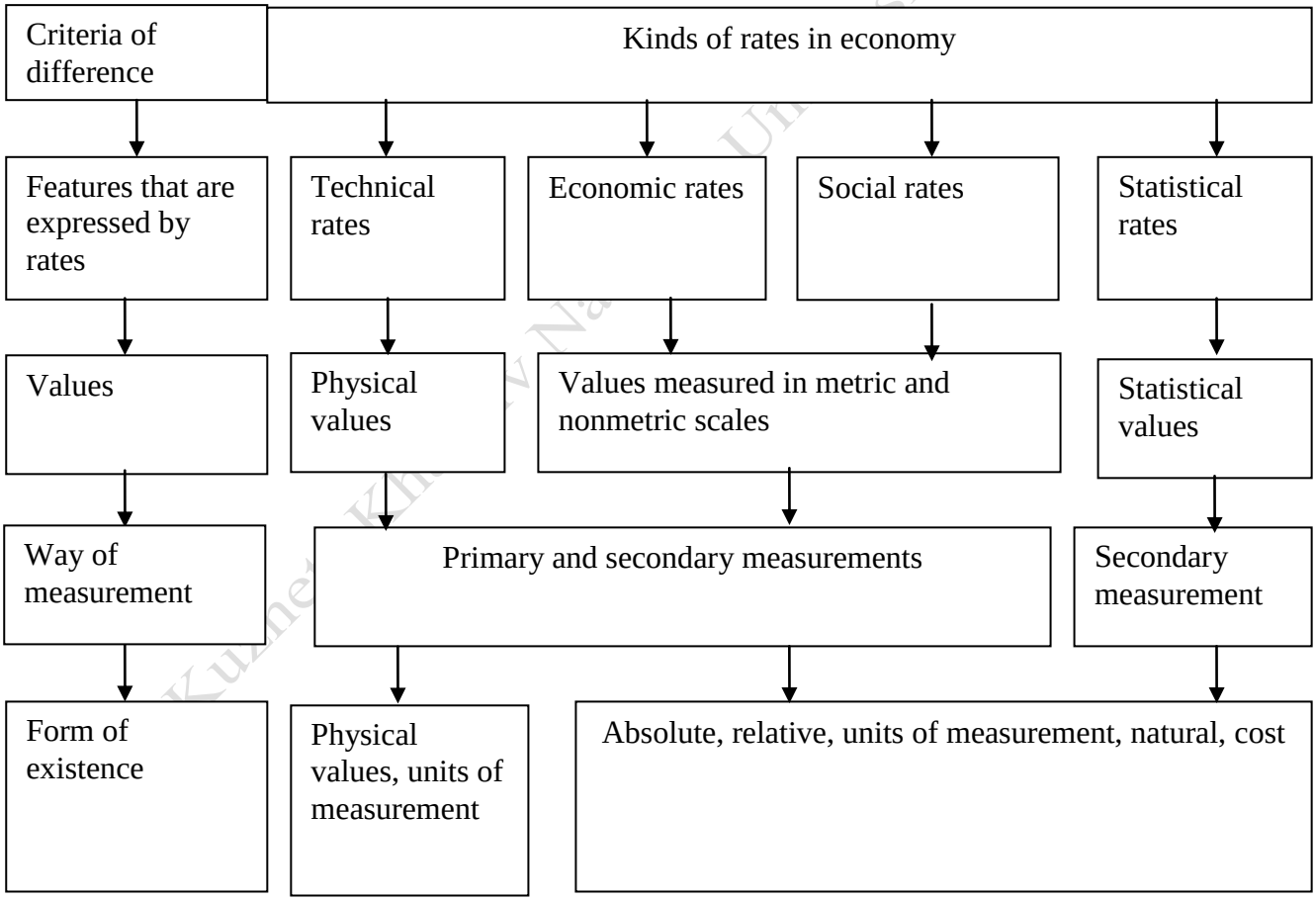

Fig.1. Kinds of rates in economy

Technical rate is considered by metrologists as a value of the physical property of an object, without calling it a rate [3]. Sometimes, they generally indicate the technical characteristics of an object, including values of its physical characteristics. The existence of physical and non-physical features of objects in the economy led to the existence of economic or socio-economic and

statistical rates. The economic rates include absolute (in natural units of measurement), relative, cost, labor indicators. Most often, absolute indicators reflect the physical properties of objects. If we transmit a physical value into cost, then we get cost rate. In society, physical value can take on its cost continuation and thus it becomes a variable cost value. Note that such a fact is absent in technology.

Physical values and their units of measurement from the qualitative side are characterized by the dimension treated as a conditional characteristic of a value that have a form of a power monomial with a coefficient equal to one. Dimension reflects the relationship of the magnitude with the values taken in this system as the primary. The dimension of the derived value is established directly from its expression through the basic quantities, and is also determined from a certain equation of a particular physical quantity.

Relative values obtained as ratios of two homogeneous values have zero dimension, that is, dimensionless. Often dimensionless units are called coefficients. In the economy there are many indicators are represented as coefficients. One more feature of relative indicators – is that most often they are resultive indicators or indicators of efficiency, that is, constructed as the ratio of the values of the results of the enterprise activities` to the amount of costs.

Particular importance in the measurement of values in the economy has statistical value. The study of mass social phenomena and processes is conducted as the study of groups of objects that combine into statistical combinations. Indicators define characteristics of individual objects that can be compared in magnitude by the same characteristics. Statistical combination is made up of objects that have relative statistical values. Determination of statistical values that have mass characteristics of objects in combination, is made by a special science - statistics. Thus, statisticsal rates determine the statistical value of the features of objects of statistical combination. Measuring the values of public features of objects in the economy is a process of measuring statistical features. Exactly according to values of statistical indicators an assessment, analysis of the functioning and development of business entities in the economy is performed. This is explained by the functions having statistical indicators: cognitive, managerial, control, stimulating. In the cognitive function stands out information function. It should be noted that the statistical rate approximate, inaccurate and subjectively reflect the public features of the objects. The subjectivity of the statistical value is conditioned by the presence, dependence on the subject, that is, the person who organizes the measurement, collection and transmission of information, notwithstanding that there is a science of statistics, which observes and controls the methods of accounting, calculation of the statistical value and its form - a statistical indicator. . Therefore, some part of statistical rates that display mass attributes on an individual object are a form of physical value that is initially measured. Statistical rates that defined by the mass characteristics of a set of objects (averages, variations, indicators of

connection characteristics, rates of structure and nature of distribution, rate of speed and growth rate, variability in dynamics, statistical generalization and integral rates) are forms of secondary non-physical values measured. The latter, firstly, reflect the comparative quantitative characteristics of the objects, secondly, provide spatial determinacy of these features, thirdly, demonstrate determinacy of features in time. In this way a quantitative reflection of the social feature embodided, the value of which is estimated by the degree of its development. Types of statistical rates that are formed from the values of non-physical features of objects, that is, from values that express mass, common features of objects, combined into groups, are divided into the following: values that describe the position of values of indicators of features of objects; values to measure the relationship between elementary and complex features of an object and to evaluate differences between objects. The conditional classification of statistical rates assignment is adequate to the mathematical methods and models already developed for solving practical problems. Often, in the economic literature, there are mistakes in the interpretation of the statistical values of the features of the objects, and thereforein statistical rates. To avoid such mistakes, you need to formalize the object by features in a proper way.

The defining feature of phenomena, processes, objects in the economy is their complexity, so they should be explored from the standpoint of system analysis, identifying elementary, complex features that are hierarchically placed in the system structure of the object [3]. The clear effect of the mechanism of causation of traits and types of traits themselves necessitate a distinction between the types of interaction between traits, as shown in Fig. 2.

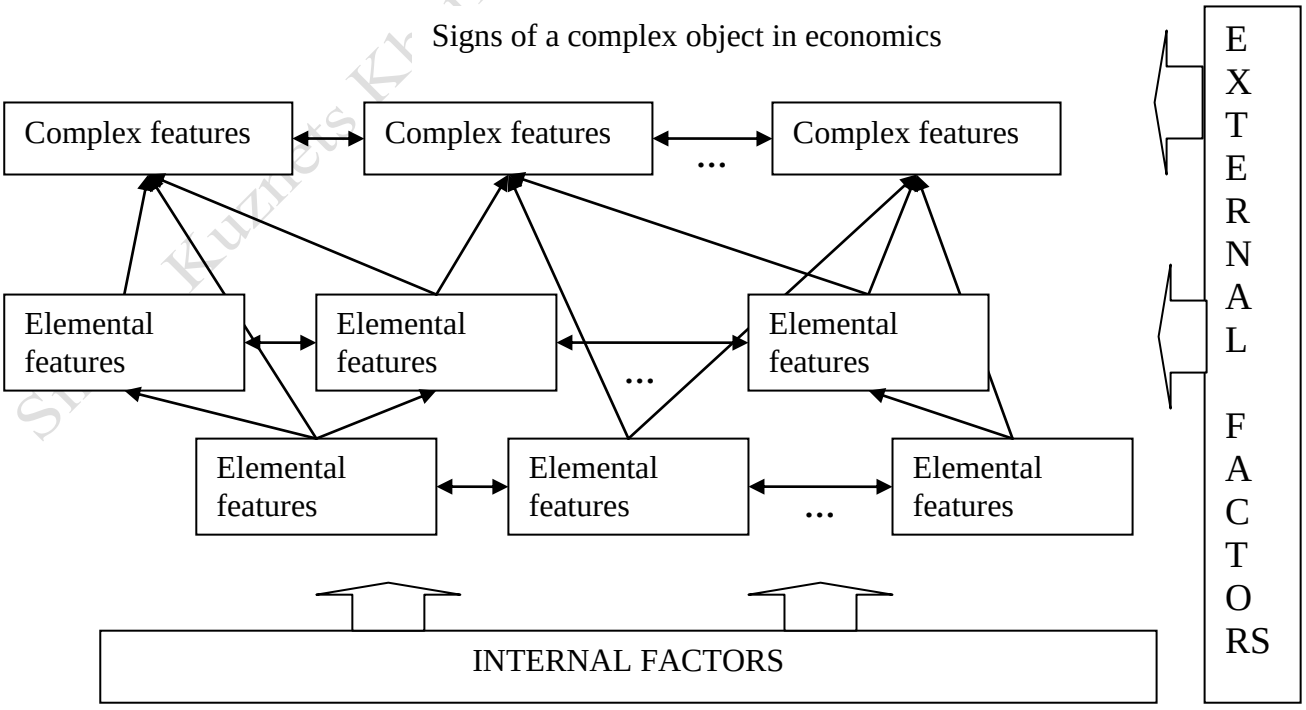

Fig. 2. The system of signs and their relations of complex object in economy

It is known that cause and effect relationships prevail in economy, that is, all features are distinguished by cause and effect, in other words, factor and resultive. When we calculate the value of a relative indicator, we often call features of values, on which calculations are conducted, as factors. We believe that such a factor should be called functional, since changing the value of such feature functionally causes a direct change in the value of the calculated indicator. Therefore, the value of functional factors is previously known when we calculate the value of the indicator of the resultive feature and research aimed at the purposeful action of changing the values of one feature to another. Undoubtedly, the study should be subjected to features that are being factors towards others. If there are several causative features, they may have a cumulative effect (multiplicative) and should also be considered as an action factor or a compatible action (perhaps even synergetic), and then they are referred to latent factor. If the interaction of complex features is evaluated, then the system of factors that usually determine the current state of functioning and development of phenomena and processes in the economy is considered. The listed (not functional) factors can be called statistical because their effect is mediocre and stochastic. Special mathematical methods of multidimensional statistical analysis have been developed to calculate the statistical rates of the relationship of elementary, complex features of an object, and more precisely the action of statistical factors

To measure the complex features of phenomena, processes it is used a system of indicators in the economy that comprehensively describe them. Scientists are often in discussions about the issue of formation of a system of indicators that should describe the phenomenon or process that are being analyzed. We believe that the specificity of measurement objects determines the composition of the system of indicators that characterize it, but it is necessary to observe the general methodological requirements developed by qualimetry, metrology, mathematics, economy, statistics to the system of indicators: adequately, holistically, conceptually describe the object; be hierarchical, that is, it contains indicators that determine elementary characteristics, factor characteristics, complex features; be multi-dimensional and multicriteria; express metric and non-metric values; be limited by the main determinants; have information comparable in space and time. Of course, this list of requirements can be detailed separately according to the recommendations of different sciences. It is appropriate to include those rates in the system that are not functionally duplicate but quantitatively reflect the different qualities of the object.

An effective information-analytical method of management in the economy of enterprise is a Balanced Scorecard. A common disadvantage of classical economic management methods is their focus only on financial performance, which has led to a weakening of strategic management at enterprises and a vision of them as holistic systems, the development of which is ensured by various areas of enterprise activity. The existing problems of management of efficiency and its

measurement are the insufficient considering of specific desires and needs of the enterprise itself, the satisfaction of which depends on the stakeholders, namely: investors, customers, intermediaries, enterprise staff, suppliers, regulatory bodies, influential groups and various partner alliances . Problems also include: inconsistency of efficiency criteria with enterprise strategies, processes and capabilities aimed at meeting the needs and desires of the parties. A disadvantage of the existing efficiency measuring system, is a random separation of some internal efficiency criteria, abstracting from the fact that it is only part of a whole, unified system. To eliminate the shortcomings of the old economic management practices, many new management methods have emerged in recent decades.

Peter Drucker also spoke about the role of new information and analytical management methods that they provide the enterprise with the information that the manager really needs [4, p. 11–31]. There are four types of analytical information: basic information, performance information, specialization information, and resource allocation information. This is the kind of information that is needed to develop the concept of enterprise management and its effective tools. Basic information includes the values of financial indicators and cost accounting by type of activity. For objective performance information, we recommend that you use the latest benchmarking tool to compare your performance against the best in the industry. The provision of information in the field of specialization is accompanied by an evaluation of the results of innovative activity, as it specifies the relevance of the results of the enterprise to its goals, the direction of market development, market position, etc. The fourth type of information relates to the allocation of scarce resources within the enterprise, namely financial and human resources. Experts believe that the most limited and valuable type of resources in the enterprise are the people who work for it. This quality and structure of information provides a holistic vision of the company in the development of management decisions.

The fact that directors exaggerate the meaning of the profit indicator casts doubt on the key performance indicators of enterprise on which the market is oriented. Robert J. Eccles, who proves this in his work "The Manifest of the Revolution in Accessment of the Activity of Companies" , is sure about this [5, p. 32-51]. Implementation of an activity-based costing method - the ABC method - at an enterprise allows it to become an example for the rest. This method gives a possibility to identify problems at the enterprise in terms of the cost of the manufactured products; specify types of activities that, without increasing the value of products, lead to increased costs for its production; determine how much the price of a product should be lowered to increase its sales. But cost management allows not only catch up with the best companies, but also to become the leader. The introduction of the ABC method in large companies, such as Chrysler and Safety-Kleen, has contributed to significant success, making profit and using market opportunities. The direct cost

accounting does not provide a breakthrough in the efficiency of thecompany, it made possible only accounting by separate processes, thereby distinguishing different types of activities. The practical recommendations for the implementation of this method at enterprises are the integration of the ABC method in the financial system of the enterprise and in its evaluation system, at the same time this method can be used for a one-time analysis of the cost of production, which gives a significant, but also a one-time effect. The disadvantage of this management method is labour-intensive collecting of the information that is necessary to create the ABC system, since this method is much more complex and detailized than the usual cost accounting. The ABC method uses much more indicators when dividingg overhead costs between different product types, processes, distribution channels, customers and markets.

Bob Phelps, who heads the British analytical group at McKinsey and was a consultant of the CCN Decision System in financial risk issues, believes that the secret of company's success is based on an understanding of the small details achieved through the old manager method – system of measuring of enterprise efficiency [6]. The “right” measurement systems support three basic principles of management: clarity (clear definition of purpose and reward for progress), objectivity (understanding the key factors of the value creation mechanism), teamwork (concentrating the efforts of all employees in one direction). Clarity is the key factor to reduce costs and increase efficiency. Bob Phelps says that problem of implementation is that many businesses recognize the neccessity of usage measurers` system, but that does not mean that they have been able to implement a system that works effectively. Financial indicators reflect the effectiveness of decisions made in the past and do not focus on factors that ensure the effectiveness of the enterprise in the future.

It is known that a breakthrough in the development and implementation of new methods of management of enterprise was Balanced Scorecard, developed by R. Kaplan and D. Norton [7; 8]. Necessity to resolve two important issues - the problem of effective accessment of business performance and the problem of successful strategy implementation - prompted the authors to move away from traditional accessment procedures that focus only on financial results, which are lagging indicators and supplement them with outperformance indicators. Balanced scorecard provides execution of management functions such as analysis, planning, organization, regulation, incentives, training, coordination and control. The BSC can be considered as a component of the management system or as its basis.

The BSC takes into account almost all main types of activities of the enterprise in the complex of interdependent balanced indicators, which evaluate the determining factors not only of the current but also the future development of the enterprise, quantitative and qualitative aspects of its activity. The main advantage of this system of balanced indicators is the synthesis of financial

and non-financial indicators, internal and external view of the enterprise, ensuring the relationship between indicators and goals and a comprehensive assessment of prospects.

The founders of the method justified the structure of a balanced scorecard, which contained components: financial, customer, internal business processes and training and development. The customer component must determine the purchase value of the manufactured product and its service for operational improvement at the enterprise, providing leadership of the goods and close communication with customers. The goals of the customer component is product development, respond quickly to changing consumer needs, and strive to become the main suppliers for their customers and to be partners for them. The internal business processes component defines key enterprise processes that need to be refined to continue functioning and creating value for both customers and the enterprise itself. The goals of internal business processes are to improve technology, production, increase productivity in designing, updating the product range. The goals of component learning and development are technology leadership, production process improvement, product orientation, and time-to-market. The financial component indicators show how effectively the enterprise is operating by implementing the chosen strategy provided by the other components. The financial component ensures the successful functioning and development of the enterprise [7-15].

Progressive modern performance measurement models include the SMART pyramid, which is a method of strategic analysis of measurements and reporting, a system of results and determinants, but it has not been properly recognized among effective management methods at domestic enterprises [6].

The concept of a balanced scorecard has been developed into a concept of method for building a prism of efficiency, which has been expanded to take into account external stakeholders, forming a high-level system of enterprise activity along with a list of general criteria.

The founders of the "prism of efficiency" method, Andy Neely, Chris Adams and Mike Kennerley, believe that the advantage of this method is its focus on critical issues of the enterprise [9].

Therefore, efficiency measurement systems are based on four procedures. The first procedure is connected with development of criteria; the second - with the preparation for implementation of the measurement system, namely the planning of the process of access to the required data, the construction of the measurement system, the development of configuration processing and distribution of data; the third procedure is connected with the work of criteria-based management to understand the processes that occur during the functioning of the enterprise; the fourth procedure is the management of the measurement system itself, which includes checking its updating and improvement, monitoring compliance with the criteria of the organization.

In terms of strategies, the measurement system should be such that: 1) management is able to monitor whether the chosen strategies are implemented or not; 2) inform the whole enterprise about the implementation of the strategy; 3) could be used as a system to encourage and stimulate strategy implementation; 4) make conclusions as to how well the chosen strategy is implemented.

In order to make the measurement system correct, the following requirements must be observed: 1) a clear definition of a strategy based on contrasting the current results with the factors-incentives of future activity; 2) developing metrics based on data and facts; 3) conducting analysis to determine the effective factors that stimulate the enterprise; 4) understanding the impact of measurement systems on changes in behavior patterns. Experts consider that the system of measurers is effective if it is designed taking into account the peculiarities of the activity of a particular enterprise. The correct system of measuring instruments allows to understand functioning and development of the enterprise as a whole, to abstract from subjective prejudices in the development of management decision, to consolidate the interests of managers and the enterprise, combining them with the driving operating factors. Analysis of measurers system is based on the principles of variation, correlation detection, benefits and dynamics [17].

Fig. 3 represents a meaningful model of a balanced scorecard as part of the enterprise management system and the place of measurers in it.

Consequently, modern economic management methods become more and more based on analytical provision, which allows them to be assigned to a new class of economic management methods: economic-analytical methods. At the same time, in the process of setting up new management methods in an enterprise in the current environment, first of all, attention should be paid to the state and level of development of the measuring instruments, performance criteria and key factors of efficiency, since management functions directly use them.

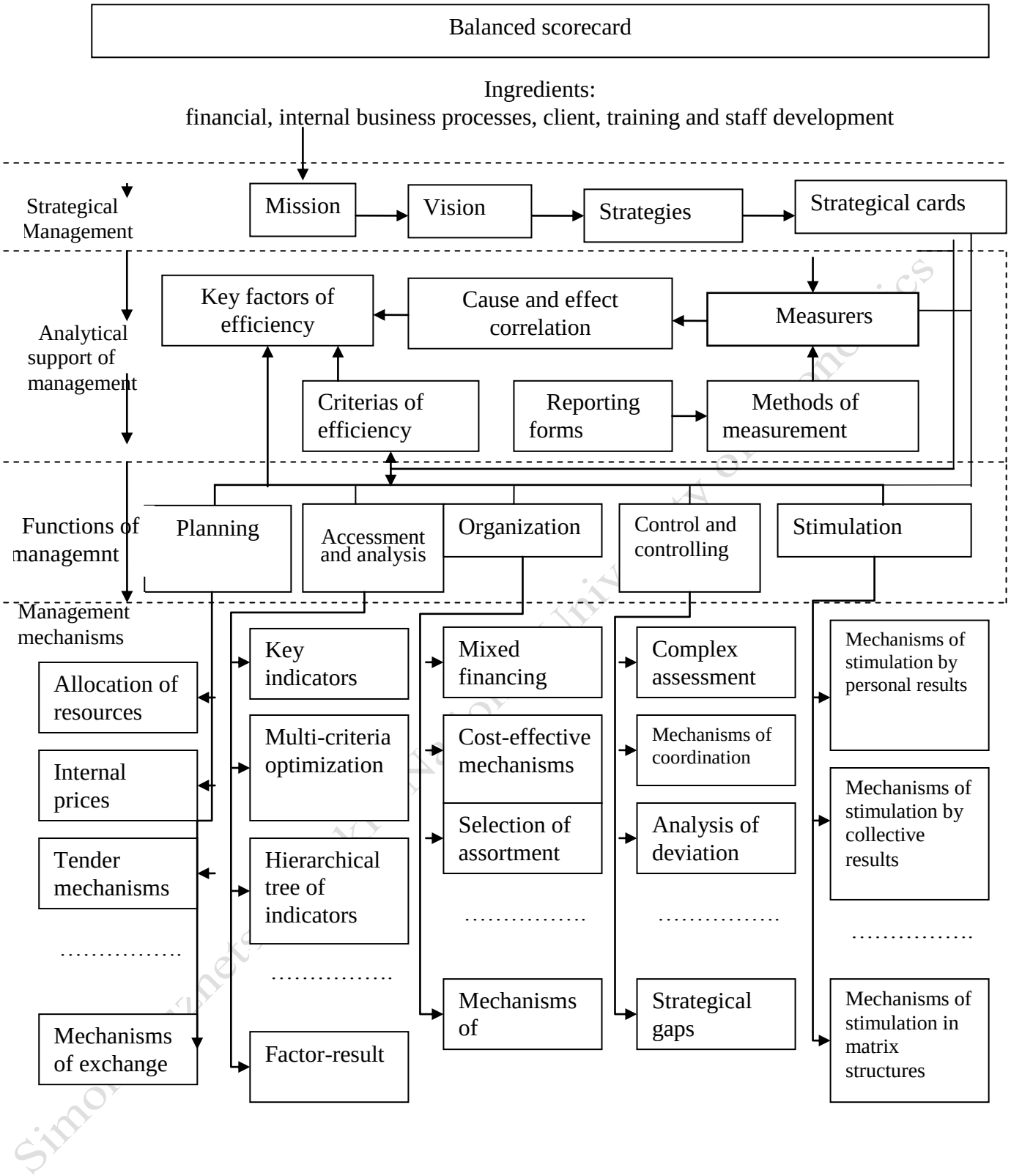

Fig. 3. Model of a balanced scorecard as part of the enterprise management system and place of measurers in it

FMCs measure the basis for an objective assessment that is consistent with the system of principles and capable of performing current functional tasks (Table 1).

Table 1. Tasks and principles of assessment the effectiveness of the enterprise on the basis of BSC

Tasks of assessment the effectiveness of the enterprise on the basis of BSC	Principles of assessment the effectiveness of the enterprise on the basis of BSC
1) to study the nature of economic laws, determine the patterns and trends of economic development on microlevels; 2) comprehensive substantiation of all processes and strategies of the enterprise; 3) control over achievement of targets of activity, efficiency of use of resources; 4) search for reserves for improving the efficiency of the enterprises` economic system; 5) improving the efficiency of current enterprise management; 6) development of the enterprise development plan; 7) comparative assessment in the dynamics and in the aggregate of enterprises; 8) identifying strategic gaps; 9) simultaneous achievement of many criterias in the activity; 10) construction of an indicative control panel based on a hierarchical system of indicators	Integration into the overall system analysis (assessment system should be targeted and organically combine the specifics of the business and the priorities of the owners); Scientific nature of the research (assessment process should focus on using modern, enough theoretically justified methods and measures); Complexity (evaluation of only one or two business processes cannot reflect the overall performance of an enterprise, that usually formed in two or three interrelated areas; in addition, the final conclusions should take into account the full range of factors affecting the research object); System approach (creating of measuring system of enterprises` activity isprofitable only if it is conducted on an ongoing basis); Objectivity (only accurate, real facts, methods and measures that minimize the subjectivity of researchers or the inaccuracy of assessments should be used to build an evaluation system); Concreteness (each stage of economic phenomena must have a specific target); Accuracy (the system should reproduce real economic processes); Timeliness (it is necessary to take into account the dynamic of economic activity and static character (latency) of assessments); Effectiveness (it`s necessary to compare the positive effects of systems` existence and current costs of maintaining it)

The analytical function of the BSC and its informative function are interrelated. The informative aspect forms the basis of analytical research and objective evaluation of the activity of the enterprise. Amount, content and timeliness of obtaining information determine the quality of the decisions taken and, ultimately, the effectiveness of the enterprise. As a management tool, assessment puts some demands to the quality of information.

In the system of measurers of efficiency of activity it is possible to take into account its multidimensionality and multicriteria. The criterion is a measure of the reliability of the assessment of an object's feature for objective reality. This definition is consistent with the understanding of the criterion in various areas of human activity. It is another matter how this criterion will be measured and displayed in models. Thus, for the most part, the criteria for the development of economic and

mathematical models are the features, both elementary and complex, which are measured by metric scales. This understanding of the criterion takes into account the dimensionality, hierarchy of features, their quality, which is reflected in the levels of values. Therein lies the peculiarity of the existence of criteria in the economy. Therefore, criterias in development of economic and mathematical models are complex and elementary features that reflect the properties, that is, the characteristics of the object, and express the quality for their evaluation. There are general and partial criterias in economic and mathematical modeling. The general criteria is usually constructed and is a function in economic and mathematical modeling, that is, it is represented as a goal function, which is investigated for the optimum to establish the quality level of a complex feature of an object. General criteria can be a vector function which concept is a generalization of the concept of a function. This understanding of the problem of multicriteria in the economy a little bit contradicts the statement that in practice multicriteria problems arise when it is possible to formulate and formalize in the form of criteria only a number of individual requirements that are put forward to an optimal solution and combine these individual criteria into one opportunities [20]. Such a statement is true in mathematical modeling of objects in engineering, in economics are different. As a rule, the economy mathematically models business entities and their complex characteristics, which are signs, so for the most part the general criterion is known, as well as the partial criteria that must be taken into account in order to achieve fullness, complexity, systematic presentation. Another matter is that there is indeed a problem of contradiction between the criteria and the establishment of a compromise between them, which is known to be achieved on the basis of the Pareto optimality principle. Establishing functionality allows you to find all alternatives, that are optimal by Pareto principles, but it does not provide a basis for choosing one of them as the optimal solution to the problem. This is true even when experts recommend weight, the alternative sought can only be considered an optimal solution when the functional is presented as a global target function, that is, as a function of the utility of partial criteria. But, as we know, in vector optimization, the ordering of partial criteria is usually not specified, only the properties are known. If enough information about the object of modeling in the economy, namely about its features, actual and regular tendencies of changes of their values, reference levels of quality, causal relationships between the traits, dependence of the productive traits on the factor, develop economic and mathematical model should be given this information, not abstract from it. Otherwise, there is a probability of obtaining the result of solving a multicriteria optimization problem that is far from true, and most importantly, it will be found in completely ignoring the cause and effect relationships in the economy. This view in the study and problem solving of multicriteria is not contradictory to the general theory of optimization, only confirms the peculiarities of presentation of objects and their characteristics in the economy and the need to take them into account in the development of multicriteria optimization

models. Thus, limits of usage of multicriteria optimization problems in economy are expanded on the basis of taking into account tcorrect content model of the object in the economy, reflecting it by relevant features, taking into account features of measuring the values of the features, quality criteria for the evaluation of elementary and complex features. This is important in the conditions of rapid development of both mathematical methods and their implementation in the software environment, in particular data mining techniques [16].

It is recommended to use conversion functions to convert indicators into measurers. Harrington function (Harrington, 1965) is a well-kown conversion function, which implies the development of a desirability scale. In the scale of desirability, it is necessary to establish a correspondence between the relations of advantages in the empirical and numerical (psychological) systems [21]. Harrington's scale of desirability sets benchmarks that divide the whole scale into intervals, namely: - very bad, - poor, - satisfactory, - good, - very good. Due to existence of scales the level of efficiency is taken into account in its measurers. It is necessary to correlate these intervals correctly with the actual intervals of changes of values of each indicator. The Harrington conversion function looks like:

$$Y_{ij} = e^{-e^{-x'_{ij}}}, \qquad (1)$$

x'_{ij} − - the calibrated value of the i-th criteria in the j-th period of time. This function is recommended by many scientists and has advantages such as continuity, monotony and smoothness, and at intervals that are close to [0; 1], its sensitivity is much lower than in the middle zone.

There are also other types of transformation function, such as the logistic function suggested by the American biologist, demographer, and economist Raymond Pearl (Kingsland, 1982):

$$Y(t) = \frac{Y_0}{1 + ae^{-bt}}, \qquad (2)$$

where $Y(t)$ – quantity in unit of volume of population in time moment t; Y_0 – initial quantity of production; a, b – constants.

There are regular tendencies of change of values of indicators which reflect normal activity of the enterprise. For example, regular changes in the values of efficiency indicators of an enterprise are increasing, that is, when you choose the conversion function, you must take into account $x_{ij} \geq x_{j\,min}$. If regular tendencies to change of values of the criteria are declining, such as, for example, indicator of costs on the enterprise, namely the cost of production, then it is taken into account $x_{ij} \leq x_{j\,max}$.

It should be said that there is a third type of economic criteria that has bilateral constraints $x_{j\,min} \le x_{ij} \le x_{j\,max}$.

The paper (Ponomarenko, Malyarets, 2009), dedicated to complex assessment of the quality of objects in the economy, offers simple and flexible conversion functions [2]:

Symmetrical bilateral :

$$Y_{ij} = exp\left(-k \cdot \left(\frac{x_{ij} - a_i}{b_i - a_i} \right)^2 \right); \quad (3)$$

Symmetrical unilateral:

$$Y_{ij} = \frac{1}{1 + exp\left(-k \cdot \left(\frac{x_{ij} - c_i}{a_i - c_i} \right) \right)}. \quad (4)$$

Where a_i – value of feature x_{ij}, for which the bilateral conversion function is equal to 1 (100%) and unilateral function is not less than 0.95; b_i – value of feature, for which quality is low, lower than 0,05 (5%); c_i –level, with the help of which we gain 50% of quality or 0,5. Parameter k controls the shape of curve. It should be mentioned that in accordance with economist` assessments and conducted experiments of authors, the best value of this parameter is equal to $k = 3$ nearly in all solved economic problem for both unilateral and bilateral dependencies.

On the basis of generalization of the results of model experiments on the building of conversion functions to solve real problems in the economy, the authors obtained the most common features of conversion of features of socio-economic systems that have one defining characteristic - flexibility. For bilateral asymmetrical tendencies of development of the system the following conversion functions are suitable:

$$Y_{ij} = \begin{cases} exp\left(-3 \cdot \left(\frac{x_{ij} - a_i}{b_i - a_i} \right)^2 \right) \; for \; x_i \le a_i, b_i < a_i, \\ exp\left(-3 \cdot \left(\frac{x_{ij} - a_i}{c_i - a_i} \right)^2 \right) \; for \; x_i \ge a_i, c_i > a_i, \end{cases} \quad (5)$$

where a_i, b_i , c_i – defining points: a_i – best value of indicator x_{ij}, for which conversion function reashes the biggest value 1 (100%); b_i, c_i $(b_i < c_i)$ – unsatisfactory value of indicator x_{ij} (on opposite sides of the best one), for which conversion function reaches the value that is not bigger than 0,05 (5%).

Under condition of symmetric tendencies of the development of features, the conversion function reaches 1 (100%) when

$$a_i = \frac{b_i + c_i}{2}.$$

Form of function is becoming simplier:

$$Y_{ij} = exp\left(-3 \cdot \left(\frac{x_{ij}-a_i}{b_i-a_i}\right)^2\right) \quad (6)$$

Or (this is equivalently)

$$Y_{ij} = exp\left(-3 \cdot \left(\frac{x_{ij}-a_i}{c_i-a_i}\right)^2\right). \quad (7)$$

For unilateral types of regular changes in the values of efficiency of activities` criteria, it is recommended to use modified monotone functions of conversion of the type of logistics function:

$$y_{ij} = \frac{1}{1+e^{-3\frac{x_{ij}-p_i}{q_i-p_i}}}, \quad (8)$$

where q_i – value of indicator x_{ij}, for which conversion function reaches value that is not smaller than 0,95 (95 %); p_i – value of indicator x_{ij}, for which function reaches 0,5 (50%). It should be noted that level of integral indicator of quality depends on q_i and p_i. So, it`s necessary to assign values very thoroughly and rely on well-known patterns in the economy of enterprise.

To determine performance metrics of a large industrial enterprise, a balanced scorecard is recommended, which is structured into four components and is presented in Table. 2 [23 – 29].

Table 2. Balanced Scorecard for assessment the efficiency of activity of enterprise

Components	Partial indicators and their symbols
Financial component	ROI – return on investment (x_{11}); net income from export sales (x_{12}); accounts payable turnover(x_{13}); return on equity (x_{14}); cash ratio (x_{15}); financing coefficient (x_{16}); equity ratio (x_{17})
Component of internal business processes	Growth rate of labor productivity (x_{21}); growth rate of costs per 1 UAH of goods (x_{22}); utilization rate of average annual production capacity (x_{23}); capital productivity (x_{24}); coefficient of depreciation of current assets (x_{25}); relative weight of costs on modernization of production in general costs` structure ($x_{26}$); capital-labor ratio ($x_{27}$); share of owners` technic in assets structure (x_{28}); share of new production in total output (x_{29}); product replacement rate (x_{30})
Customers` component	ratio of production price to fixed price for current production (x_{31}); specific weight of costs on promotion of goods in structure of cost value (x_{32}); correspondence of planned resources and needs in them (x_{33}); share of costs on warranty service (x_{34}); share of production that is subject to warranty service in structure of total volume of manufactured production(x_{35}); economic effectiveness of export (x_{36}); specific weight of supplies by direct contracts among total amount of supplies (x_{37}); share of violations of supply contracts in total amount of contracts (x_{38})
Component of staff training	Growth rate of amount of workers (x_{41}); specific weight of workers, that upgraded

and development	their qualification in current year in their total number(x_{42}); specific weight of employees under 50 in their total number (x_{43}); specific weght of employees who perform scientific and technical work in their total number (x_{44})

On the example of net income from export sales (mln. UAH) Join-stock corporation TURBOATON, which belongs to leading turbine building eterprises in the world, specializing in the production of steam turbines for thermal power plants, nuclear power plants and thermal power plants and hydroelectric power plants, gas storage plants and steam and gas installations for thermal power plants and other energy equipment (official site Join-stock corporation TURBOATON) [22]. It is believed that the higher the value of this criteria of financial activity, the more efficient the entire activity of the enterprise is. For net export revenue, function parameters are as follows: $q_2 = 1964{,}7$, $p_2 = 1144{,}4$. On Fig. 1 results of calibration of net income from export sales are shown. It was necessary to configure conversion functions. The procedure for configuring the conversion functions should be done individually for each indicator.

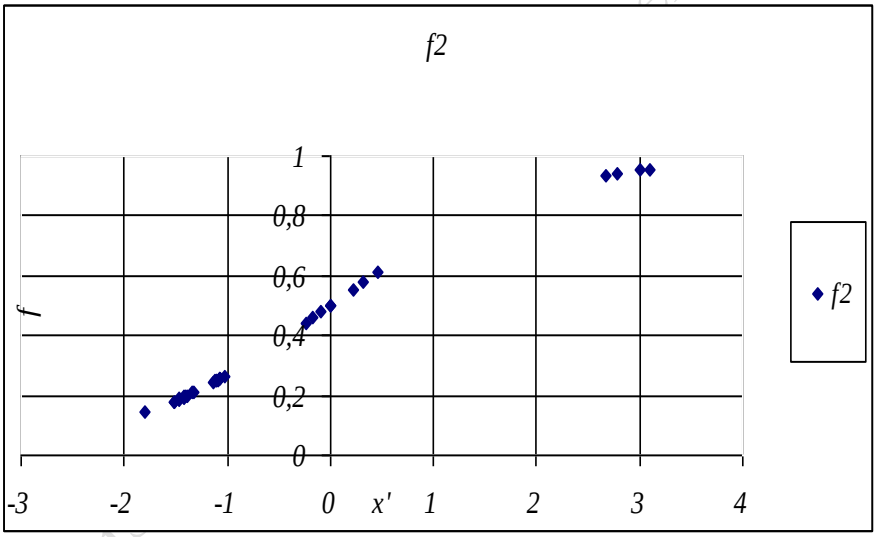

Fig. 1. Criterion calibration results x_{12}

When the conversion scale is chosen and the conversion functions are calculated for the indicators, there is another problem in the calculation of the integral measurer, namely the choice of the form of function of the convolution of the converted values into one value - the integral measurer (Fig. 2). Regarding the form of the generalized function of convolution of converted values of meters in integral, there is no unanimity in the views of experts in economic and mathematical modeling.

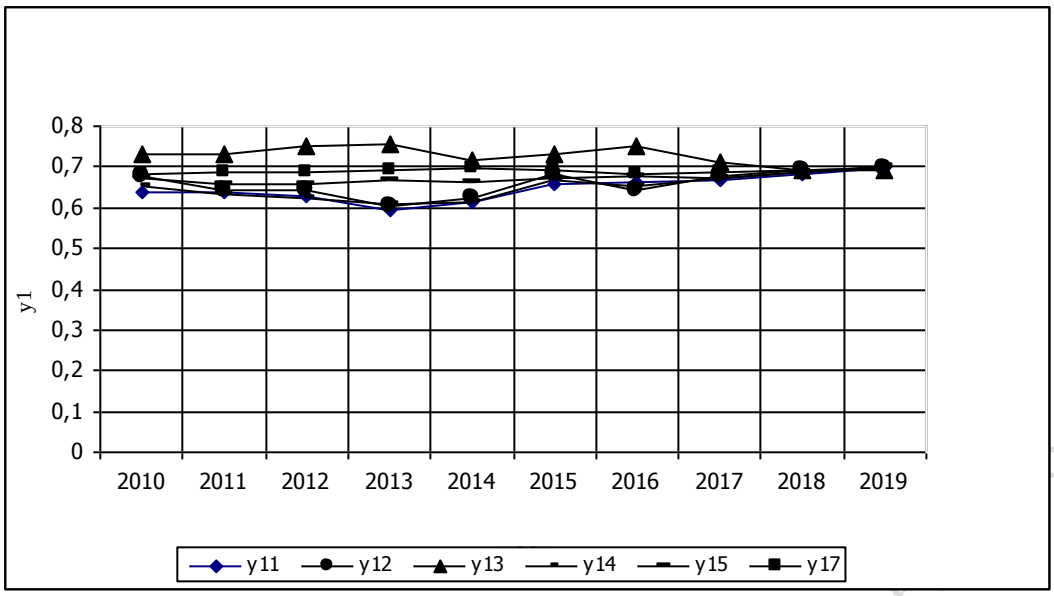

Fig. 2. Dynamics of values of financial instruments of the financial component of a balanced scorecard of Join-stock corporation TURBOATON

As a result of the practical check of these ratios, it is recommended to use average geometric mean formula (Us et al., 2018) when calculating the overall level of enterprise activity. In the process of calculating the integral measurer by average geometric mean of transformed values of measurers there is a situation of rigid consideration of zero values or values close to zero, which in product of numbers leads to zero value of the integral measurer. In this case, it should be taken into account that generalization function is sensitive to small transformed values of the measurers.

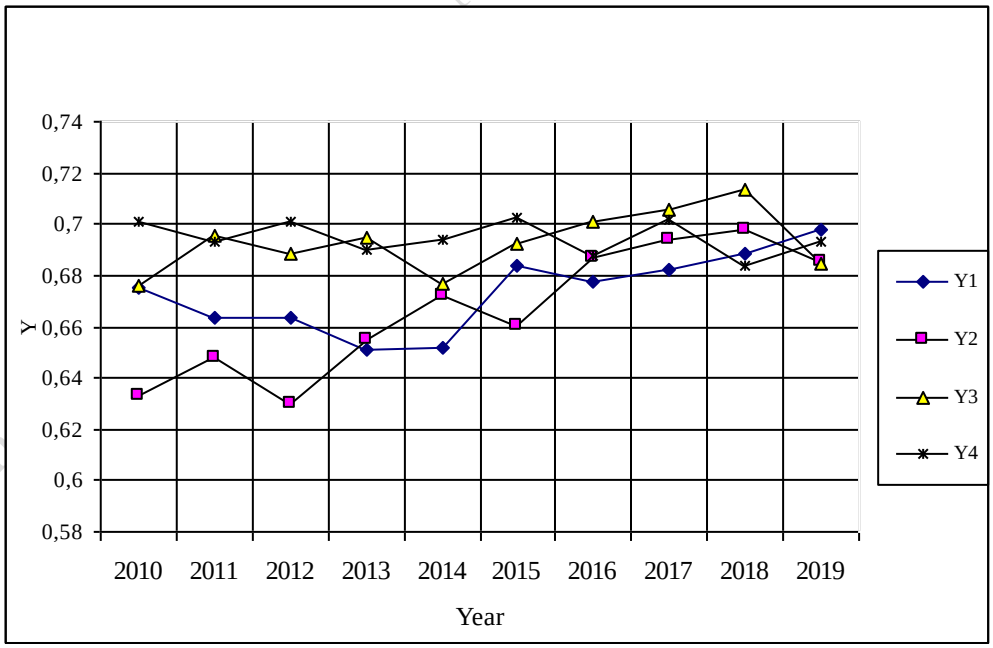

Fig. 3. Values of TURBOATON Join-Stock Corporate Components in dynamics, where Y1 is the integral component of the financial component; Y2 - client; Y3 - internal business processes; Y4 - staff training and development

The generalization function is a quantitative, unambiguous, single and universal measure of effectiveness. Its value increases when you add properties such as adequacy, efficiency and statistical sensitivity, it can be used as a partial criteria in multicriteria optimization. Fig. 3 emphasizes dynamics of measurers of each component of BSC (Y_j), that were calculated as average geometric means of measurers, that are being a coverted values of partial indicators (y_{ij}) by formula:

$$Y_j = \sqrt[n]{\prod_{i=1}^{n} y_{ij}} \ . \quad (9)$$

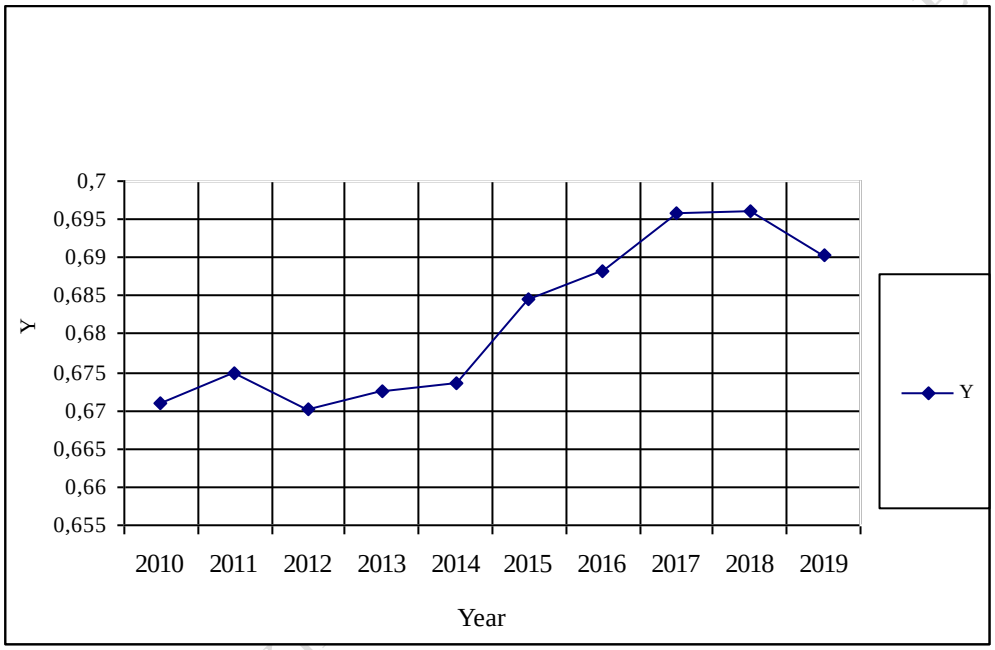

Fig. 3. The value of the measure of the effectiveness of the activity based on the AFS Join-stock corporation TURBOATON

To sum up, the effectiveness of the Join-stock Corporation TURBOATON is not significant, but increased during the observed period until 2018 but decreased in 2019. The reason for this is the decline of efficiency of internal business processes and customers` component. Even growth in the efficiency of the financial component and the training and staff training and development component does not compensate the decline in the overall level of efficiency of activity. Consequently, the enterprise should urgently develop thoughtful management measures to increase the levels of efficiency of internal business processes and the client component.

So, measurers of efficiency of enterprise` activity have advantages, as follows: 1) comparable among themselves, in contrast to the indicators measured in different units of measurement; 2) allow measurement of efficiency at different hierarchical levels; 3) allow to

monitor trends of changes of various components of efficiency; 4) allow to identify the problem in low levels of efficiency; 5) allow you to determine the relationship between the cause of the problem and other components of efficiency.

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