Integrative-cyclical Approach to the Study of Quality Control of Resource Saving by the Use of Innovation Factors

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Abstract

In this paper we investigate some problems dealing with quality control of some economic processes. It is well known, that while we do a quantitative evaluation of the quality control of some economic processes with help of innovation factors, there are three groups of problems: high uncertainty of indicators of the quality management, their considerable ambiguity, and high costs to provide a large-scale research. These problems appear because of usage of contradictory objectives of enhancing of the quality control in accordance with innovation factors and preservation of economic stability of the enterprise. In our opinion, the following two methods are to solve these contradictions most effectively: 1) the use of paradigms and concepts of evolutionary improvement of quality of resource-saving management in the cycle "from the project of an innovative product (technology) - to its commercialization and update parameters of customer value"; 2) the application of the so called integrative-cyclical approach which consistent with complexity and type of the concept, to studies allowing to get quantitative assessment of the stages of achieving of the consistency of these objectives. We have developed some new methods, based on the integrative-cyclical approach, that allow us to get consistent management solutions for reducing the severity of the above mentioned contradictions and increasing the validity of the choice of resource-development strategies in terms of parameters of quality management and sustainability of enterprise. In this paper it is shown that the use of the integrative-cyclical approach to the study and evaluation of the resulting and factor indicators will help raise the level of resource-saving characteristics up to the value existing in the developed economies of post-industrial type.

Keywords: *integrative-cyclical approach, quality control*

1. Introduction

Diversity and multidimensionality of statistical data in complex socio-economic systems determine the relevance of the tasks of building groups, classifications, and other methods for analyzing of information about the type of the distribution of observations. This leads to increased uncertainty in division into classes for most innovative factors and resulting indicators to measure the quality of resource-saving management. These classes are called clusters in this case.

Usually, the division of feature space into disjoint regions is carried out on the basis of cluster analysis. The procedure for calculating the distance between the objects of the study population is the least formalized in this analysis. Selection of the measure of proximity (metric) is defined by means of research objectives, the nature of the vector of observations, and information about the type of distribution of its probabilities. At that, types of metric mahalanobis distance are used, for instance, weighted Euclidean distances, and others [1]. There are proposals about the physically meaningful metrics and usage of principal component analysis, which is important for reducing of the dimension of feature space of indicators of quality of the management.

To test the hypotheses of the study, there were set the tasks to get a valid accuracy of the calculation of economic parameters for different methodological approaches:

- normative method that allows to achieve high level of verification under conditions of small discrepancies of initial data;
- correlation and regression method, that can process large amount of data;
- the method of fuzzy sets in which there is a possibility of processing initial data in interval values.

2. Research Methods

To improve the objectivity of ratings of the influencing indicators in expert fuzzy databases of the socio-economic systems, we need to have substantial managerial and economic numerical parameters of relations among the objects. Indeed, the usage of different modifications of the method of weighted sum of partial technical and economic indices assumes implicitly that the shortage of some indicators can be compensated by means of surplus of others. However, often the indicators of quality of management and innovation differ in several times (a manifestation of factor of heterogeneity) for compared enterprises. With such a spread of the indicators, sensitivity of the resulting factors can not be constant throughout the all factor space.

The aim of the study is to find possibilities for an array of statistics socio-economic parameters to increase the level of verification of the results of research, using a variety of methodological methods of processing initial information.

Not only statistically evaluated quantitative indicators affect the value of this performance indicator as quality control, but also parameters of qualitative relationship, which are poorly analyzable by immediate quantification. For this purpose, fuzzy expert assessments of verbal type are used, such as "irrational using of resources", "excellent level of training", "high team spirit," and so on. Such uncertainty of input data is due to the impossibility to do costly full-scale studies. It is clear, that these estimates have some degree of subjectivity and fuzzy boundaries, which are conveniently determined using the theory of fuzzy sets [2] and other methods in the integrative-cyclical approach.

In the context of the fifth and sixth technological structures, the urgency of overcoming the critical mismatch of innovation development of avant-garde countries of the world in comparison with the level of other countries increases. The lack of capacity in the development and management of the development of "human innovation" determines the severity and urgency of the problems of quality assessment of resource-saving management in a high-tech innovative development of enterprises.

Conflicting goals of the effective resource-saving management and maintaining stability of an enterprise in the long term can be achieved only in conditions of balance of interests in the process of the resource-saving management and compliance parameters of the dynamic compliance of the enterprise development with environment characteristics. At the same time, the systems of resource management in many Russian enterprises do not provide yet the timely development and implementation of strategies in accordance with the innovation factors, which are relevant to conditions for sustainable development of post-industrial society.

In the transition to a cyclic model of development it is necessary to ensure the possibility of creating of breakthrough innovation products and resource-saving technologies at the stages of realization of projects. This creation is differ by using of the modern methods of economy of knowledge, potential and results of the basic sciences to achieve innovative solutions through the development of competencies of staff of an enterprise. The new paradigm and the concept of the quality resource-saving management suggest that its increasing is necessary to consider in terms of innovation and technological cycle changes, providing a preponderance of growth rate of level of quality of the products over the growth rate of the cost of their creation.

Implementation of the new concept is more effective under conditions of integration of different tools for quantitative and qualitative analysis into a single algorithm that will take advantage of existing methods and reduce their disadvantages. The application of quantitative methods of probabilistic assessment of the impact of factors on result indicators can be evaluated on the basis of regressions. Using coefficients of the closeness of liaisons will reduce the subjectivity of logical assessments of the impact of factors on predicted behavior of objects. Furthermore, it gives opportunity for experts to correct more precisely their estimations taking obtained results into account. The weighted factors in the toolbox of fuzzy sets are used in the method of multi-dimensional matrix analysis [3] and methods of risk assessment and boundary values of the probabilities of qualitative characteristics.

As a criterion of quality of resource-saving management in an enterprise according to innovative factors we will take the number $Q \in [0,10]$. The higher the value of this criterion, the greater the stability of the company and its investment attractiveness. Such kinds of resultant parameters are influenced by many industrial, social, economic, and other characteristics of the factors of the innovation development. We denote them by $X_1, X_2, \ldots, X_n$. Then the integral indicator of the performance will be a functional mapping of the form: $\bar{X} = (X_1, X_2, \ldots, X_n) \to Q \in [0,10]$, where $\bar{X}$ is a

vector of influencing characteristics in the function $F(\overline{X})$.

When we have a large number of characteristics in analysis, their influence can be conveniently classified as a hierarchical tree of logical form. Factor values will be expressed as deviations from the average values of similar parameters of compared enterprises. For their modeling it is used so called Mamdani's expert fuzzy knowledge bases, such as "low", "medium", and "high" [2].

For some factors, the number of independent characteristics can be significant. Mapping rules of fuzzy characteristics into fuzzy values of such factors can be cumbersome, making it difficult to process the comparative evaluation of options for sustainable resource-saving development of companies. Therefore, making such an assessment, we propose to combine the techniques of fuzzy modeling with the well-known methods of statistical data, such as regression analysis, index-factor analysis, multidimensional scaling. Thus, the methods of factor analysis and principal component can significantly reduce the number of baseline characteristics, using the substitute characteristics or latent variables. Reducing the number of baseline characteristics will greatly simplify the formation of a set of rules.

We develop the integrative and cyclical approach, which is proposed for inclusion in the general tools of economic-and-mathematical modeling of developing of complex systems. To do this, we have to take these features of the resulting estimates their (dependent) and explanatory variables into account. Therefore, the following method of applying of the integrative-cyclical approach for the analysis and planning is suggested:

1. It needs to do regression analysis of total multidimensional data sets (by means of correlation analysis, a meter of statistical relationship is chosen and estimated, the hypothesis about its significance is tested). For example, the meter can be established in accordance with factor indicators of the level of innovation, defining measures of productivity, the level of resource-saving as target or dependent variables of estimation of quality control (output parameters of the model).
2. In identifying that indicators of input and output of the model are measurable, regression equations of connection are found by standard methods [1]. If we can not directly measure the properties of a complex system, which are under consideration, the problem of estimating of the composite indicator $F(\overline{X})$ up to an arbitrary monotonic transformation is solved. The meaningful interpretation (economic and administrative) of the objective function under conditions of a sufficient homogeneity of the investigated objects and limited time of application of the model can be mathematically represented by a linear approximation in the form of a Taylor series expansion or with help of index-factor method.
3. Organization of training and interviewing of experts for scoring estimation of output parameters of the resulting indicators F_i.
4. Statistical evaluation of the explanatory variables X_j, supplemented, if necessary, expert scoring estimations of statistically immeasurable indicators.
5. Building of the desired objective function $F(X_n)$ with quantitative estimates F_i and X_j.
6. Quantification of the elements of antecedents of fuzzy rules in points or fractions of a unit in order to replace the fuzzy verbal indicators for multivariate prediction or deeper analysis.
7. Adjustments to the parameters of selection of strategies and innovative development scenarios in accordance with the criterion of minimum imbalance of interests in resource efficiency of the innovation factors and preserve the stability of the company. The criterion is assessed by nonparametric statistics.

3. Analysis Results

In this context and in example, sustainability is understood as the ability of the company to maintain a given level of output parameters of quality control when the external and internal factors of innovation are changing. Agreed solution is reached in integrative-cyclical approach to application of the methodology in three following sub-cycles [6]:

- there is a process of implementation of innovative management solutions while ignoring the problems of preserving the stability of the company (there is a high level of imbalance of interests in the evaluation of strategic objectives);
- there is a process of joint implementation of the tasks of efficiency of resource saving with help of innovation factors and maintaining of stability in the long term work in the area of trade-offs of interests;
- there is a process of providing a positive synergy of action to achieve a high level of consistency of management decisions by consensus of interests in the long run (perfect quality control).

Mathematically, the quality control is assessed by means of non-parametric statistics. For this purpose, direction

and strength of links of rank indicators as criteria of imbalance interests of innovative resource efficiency and sustainability are established by means of known coefficients of Spearman's and Kendall's rank correlation [1]. Thus, for example, the factor (-1) corresponds to a high feedback, characterizing unbalance zone of interest, and (1) denotes the presence of high direct coupling into the zone of their consensus, then strategy adjustment is not required.

Testing of the integrative-cyclical method has been conducted to evaluate the influence of factors of innovation on a such indicator of quality control as labor productivity of an enterprise of food industry. Modeling based on the index-factor method has been carried out with help of the following innovative resource factors: dynamics of the process of creating of added value; intensity of financial flow and resources consumption; effectiveness of using of work time; availability of materials for staff; and resource consumption per unit time. The designations of input characteristics of the index-factor model are given in Table 1.

Table 1 – Designations of input characteristics of index-factor model of analysis of the quality control of resource saving in estimation of labor productivity

№	Name and designation of characteristic	Assigning of characteristic
1.	Intensity of financial flow (I_{FF})	Dependence of the cash flow from the innovative attraction of a strategy of resource saving
2.	Coefficient of effective using of time (C_{ET})	It shows the level of loss of working time in production systems
3.	Availability of materials for staff (AM)	Factor of material resources per worker depending on the level of innovation of technology
4.	The intensity of the processing of material resources (I_{MR})	It determines the amount of material resources used per unit of time, decreasing in high-tech processes
5.	Productivity of staff (PS), as an indirect indicator of the quality of control	The accelerated growth rate of the indicator in comparison with the growth of income determines the quality of its management

In each of these sub-cycles a functional deterministic model of analysis of such important indicator of the quality of management as labor productivity has been used:

$$PL = \frac{I_{FF} \cdot C_{ET} \cdot AM}{I_{MR}}. \quad (1)$$

The obtained results of the analysis and application of innovative organizational factors have improved level of the use of working time by 6.78%. The result was achieved on the base of the use of international and domestic experience of organization of business processes, better organization of working places of staff [3]. Taking into account the reduction of losses on 6.2% according to the project "Lean production" it has provided the staff productivity growth by 7.2%.

At the same time, the accuracy of the analysis is reduced due to the rigid determinism of factors. Besides, it does not use the variability of experts' opinions in relation to a particular scenario of resource saving while the sustainability of the enterprise is maintained. Therefore, the method of determining of the regression for target indicator depending on the quality of management of the innovation factors was used:

$$PL = -10.432 + 1.886 I_{FF} - 74.635 C_{ET} + 1.025 AM - 1.307 I_{MR}. \quad (2)$$

Variation ranges of indicators were defined by company's employees, consultants, leading experts in the area of data analysis and evaluation of productivity. Identification of relationship between indicators and the target value allowed us to specify the fuzzy database.

The results of calculations are shown (Fig. 1) by graph of the indicator of quality management of development in the evaluation of PL depending on the analyzed factors.

Analysis of the application of the methods showed that discrepancy between the results of calculations of labor productivity was not more than 2-3% for those methods. This is evidence of sufficient reliability of the estimates and it confirms the need for the integrative approach for improving of the quality of management. Indeed, a variety of factors causes to do variation of the composition of the management functions in each sub cycle, replacing their action. Therefore, assessment of the possibilities of substitution is suitable.

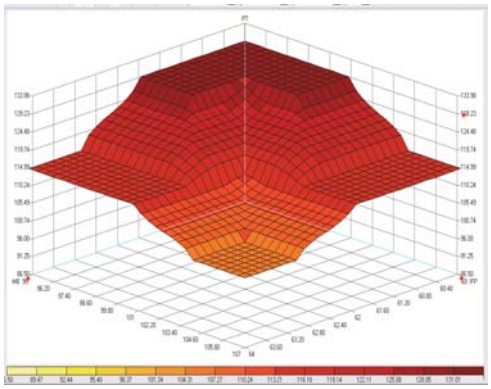

Figure 1. Quality management in assessing of productivity depending on innovation factors of resource saving

The idea of the management substitution of action of innovation factors emerged in conditions of post-industrial development of economy. It is based on complexity of technical systems and the further growth of physical capital, which makes it necessary to increase investment in staff competencies and other innovations. Additional need in the replacing arose in connection with the tasks of providing of value of added growth in conditions of modernization of the productive capacity of the enterprise mainly based on the development of intellectual resources.

Resource usage of obsolete equipment, whose average age exceeds 15 years, may be partially offset by innovations in the management of resource saving based on innovative management functions and resource saving forms of work organization (Fig. 2). Range of possible outcomes of substitution of technical and technological factors by factors of higher quality of resource saving management is shown by a family of curves.

Instrumentation of the substitution is realized in a special mechanism by changing of functions and control structures in the second and the third sub-cycles. This helps to reduce the level of conflict among opposite goals of the innovative resource saving. These goals significantly change the situation and reduce the stability of enterprise.

The areas OA and OB show the results of possible replacement of technical and technological factors by intangible factors-functions of high quality resource saving management. This approach is advisable to implement in the short and long term in these sub-cycles [4].

The transition from the preemptive usage of short-term factors of quality management to long-term logistics can exacerbate internal contradictions. Therefore, regulation of the replacement processes should be based on a compromise, as practically acceptable level of balance between interests of owners, executives, and personnel of the enterprise, which can be reached on narrow (point M), average (point N), and high (point D) levels of achievement of the goals or if there is consensus (perfect balance) of interests (point C). This consensus can be reached in the sub cycle 2 of the solving of the resource saving problem.

On stages 1-6 of the technique in sub cycles 2 and 3 theoretically sound set of the most significant factors of coordinated actions is formed. It will improve the accuracy of the estimation of the parameters to select strategies and scenarios of innovation development in respective matrices. Established in this study were the factors of innovation resource saving, affecting the growth of quality management in the estimations of labor productivity, depending on the degree of balance between the interests of resource factors and sustainable development.

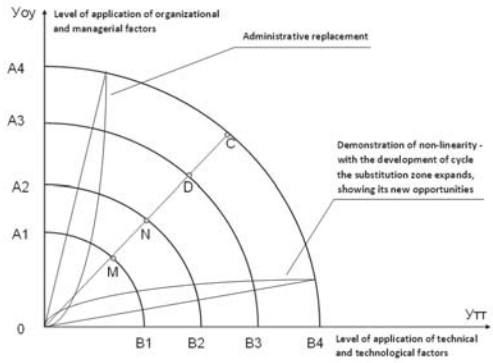

Figure 2. Curves of choice of possible replacement of factors

These factors can be grouped into two sets as interchangeable organizational-managerial and technical-technological ones. In turn, the first factors can also be represented in set of options for purely managerial substitution (for example, some control functions by others). The necessary tools for assessing of possibilities of the substitution are developed [5,6].

Thus, the set of the factors for analysis on the stage 7 of the second and third sub cycles of the technique forms adjustable sets of options to design matrices of strategic choice. In this case, from the results of the above mentioned quantitative analysis it is possible to identify the ranges of the factor-matrix parameters and to establish quantitative estimates of these parameters (e.g. low level in a particular range of managerial and technical-technological characteristics). Differences in obtained results make it possible to develop a multi-dimensional matrix to assess the competitive position of the company at each sub cycle of the cycle of resource saving in innovative development.

Equal benefit value of the results of the management of substitution at the points M, N, D, and C means that at different levels of intensity of the use of managerial and technological factors, there are equal opportunities for improving of effectiveness of resource saving according with innovation factors. And in the short term it may be more effective to provide management substitution interpreted by movement in the direction to point C. But this direction of development has its limits in contrast to the well-known approach in which manual labor is replaced by machines and mechanisms (based on the Cobb-Douglas production function).

We offer to supplement existing techniques of planning with matrix of identification and selection of strategies for effective resource saving according to innovative factors. In quadrant 1 it should be indicated spontaneous actions on a slow and uncontrolled movement towards a situation of crisis (Table 2). In this case, indicators of quality management in the estimation of productivity in resource saving on the innovation factors are decreasing.

Strategy of "survival" of the enterprise in quadrant 2 is characterized by increasing complexity and intensity of the use of basic (existing) control functions. This corresponds to work in conditions of low-innovative development. Usage of experience allows us to keep existing levels of resource efficiency indicators and quality control in the short term.

In quadrant 3 it can be defined strategy of projects and conservation development processes at high levels of innovation and quality control. This corresponds to abrupt (breakthrough) changes in the quality management on the basis of the new features of control strategies based on highly innovative resource factors.

Strategies and processes, corresponding to the parameters of the quadrant 4, are possible with the creation of the conditions of self-organization processes of resource-saving management. They are realizable in frame of organizational culture such as a type of task or innovation-leadership personality in structure of matrix or project type.

Degree of achievement of target parameters of efficient resource saving development and quality control in the estimates of labor productivity and balance of interests of innovative resource-saving and sustainable development			
	High	Strategies of survival based on the experience of resource planning backup and low innovative products using basic functions of control	Revolutionary strategy of effective resource development according to innovative resource-factors based on proactive and breakthrough methods of management
		2	3
	Low	1	4
		Evolutionary advancement to crisis situation in terms of inactivity or spontaneous self-organization	Evolutionary strategies in resource saving to respond to external factors
		Low	High
		Level of innovation	

Table 2 - Matrix of selection of resource-development strategy according to innovation factors

4. Conclusions

Thus, the integrative-cyclical approach has the following advantages: a large variability of values; cross-estimation of intervals of values; hierarchy levels of evaluation; taking into account deterministic, probabilistic and functional relationships; a big variety of variant values; scenario-based approach to assessment, taking into account their own opinion and the opinion of outside experts; endogenous and exogenous variables. Reduction of subjectivity in the analysis requires the development of core competencies in resource saving. It is necessary to involve experts on innovative management practices and to improve resource efficiency.

The use of the system of interconnected mathematical methods increases the stability of outcome evaluations in conditions of high uncertainty factors. Inclusion in the feedback the methods for the quantitative criterion of consistency for the balance of interests of substantial management decisions increases the objectivity of mathematical estimates.

References

Ayvazian, S. A. (1998). Basics of Applied Statistics and Econometrics: Textbook for economical departments of universities. Higher School of Economics (State University). Moscow: UNITI.

Kim, J. O., Mueller, Ch. W., & Klecka, W. R. (1989). Factor, Discriminant, and Cluster Analysis. Beverly Hills. CA, Sage Publications.

Alabugin, A. A., Topuzov, N. K., & Aliukov, S.V. (2010). Complex method of investigation resource saving management systems. CSU Herald, Chelyabinsk State University, 26 (307), 112-120.

Alabugin, A. A. (2005). Management balanced development of an enterprise in dynamic environment. Book 1: Models and methods of effective management of the development of enterprise. Monograph, Chelyabinsk, SUSU.

Alabugin, A. A. (2005). Management balanced development of an enterprise in dynamic environment. Book 2: Models and methods of effective management of the development of enterprise. Monograph, Chelyabinsk, SUSU.

Alabugin, A. A. (2014). Management the development of an industrial enterprise in terms of the imbalance of between-group and organizational interests: Theory and Practice. Monograph, Chelyabinsk.