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Determination of Labor Intensity of Research, Creative Work Types in Production Based on Complexity Theory Approaches and Fuzzy Logic

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ABSTRACT
The objective of this study is to create the methodology and methods of assessing the labor intensity in terms of time expenses for the conduct of research in the energy complex that has the creative component. For this purpose, the line of tasks was solved, including the following: the determination of creative labor as the norming object was given; the apparatus of the complexity theory, according to which, labor intensity is calculated under the labor product complexity, was adapted; fuzzy expert model, allowing to interpret the labor product linguistic assessments in numeric terms, was developed.
The relevance is connected with the high level of labor norming importance, both in economic terms, statutory regulation in the field of labor legislation, and in social terms. The worktime standards justified are not only a tool of labor productivity increase but also allow providing the fair labor remuneration and uniformity of load on staff. Nevertheless, the lack of work in the area of creative work norming and work with the unique result.
This paper describes the approach to assessing the labor intensity of creative work, which can include research work, in terms of the complexity theory, that is, based on the labor product complexity assessment. In connection with the fact that the product of creative and research work is the "new knowledge", the fuzzy expert model was developed for their complexity assessment. It enables the quantitative interpretation of the "labor product" - "new knowledge" qualitative assessments in terms of the required competences for implementation of the respective work, prospectivity and novelty of creative work results.
Based on the approach offered, the dependence of labor intensity in terms of work fulfillment duration on the complexity of the forecasted "labor product" for research, development, and engineering in the energy sector was obtained. The dependence obtained is an instrument for assessing interim labor costs for the fulfillment of unique projects. It determines the practical importance of this study. Its results can be used at planning research, development, and engineering, their labor intensity assessment, and the determination of compensation for labor.
Keywords: *creative class, labor norming, labor product, knowledge complexity, labor costs, competencies, linguistic variables, fuzzy expert model, energy*

1. INTRODUCTION

Recently, the importance of managerial and so called creative work has been increasing in the energy complex, similar to the other industry sectors. The latter can include both the activity of decision making top management and research labor. The representatives of the so-called creative class gradually displace the conventional middle class, the representatives of which, as a rule, are employed in the service sphere.
"The creative activity statistics has not formed completely yet, but its appearance is important. R. Florida (author's note: American economist, the author of the creative class theory) determined the creative economy branches and offered a new class structure, having assessed its composition and dynamics. He marks out the creative class, including its super creative core, and service class. Work class and agriculture were left from the previous segmentation. In the late 20th century, the qualitative shift occurred, including the high growth of the creative class and the decrease of the farmers' and workers' share. Since 1980, even the share of people engaged in service has been falling. This is how the innovation economy, in which most people earn by creative work, looks like", writes Ye.G. Yasin [1].
The efficiency of the activity of the so-called creative class greatly depends on the way in which the amount of specialists and workers fulfilling certain work meets this work labor intensity.

The Russian Labor Code has the state guarantees declared in the field of labor norming. In particular, it is specified in Article 159 of the Labor Code of the RF that workers are guaranteed state assistance to labor norming system organization. Nevertheless, there were almost no serious attempts to organize the regulatory, methodical and methodological basis for norming those types of labor activity that are subject to norming based on classic approaches.

Assessment of work labor intensity carried out in the process of research activity is one of the elements of assessing the efficiency of various economy sectors, including energy. At this, according to Petrusha Yu.S., the least developed is still the management organizational structure, which includes social factors, uncertainty of economic consequences, lack of development of managing technologies and the method base. The assessment of efficiency of separate events and projects in the whole is far from simple [2].

The increase of efficiency in energy is impossible without the labor resources and the human potential development. Respectively, assessment of efficiency of events implemented in energy bumps up against the staff efficiency assessment, and the assessment of labor intensity of works carried out by this staff. Selecting the ways of the industrial production efficiency increase depends on the objectivity of its assessment system. "The subjective assessment of efficiency will surely cause the incorrect determination of the ways of its increase. At the assessment of efficiency of energy production, the absolute production efficiency of the enterprise, its structural departments are assessed, or the efficiency at the choice of the economically reasonable solution option is compared. The generalizing indicator of economic efficiency is the growth of labor social productivity, measured by the ratio of final production results and full expenses of direct and embodied labor", writes Podyorgina L.I. [3].

Solving the issue of norming managerial, research and creative work is also highly actual in terms of society, which is related to adequate and fair labor remuneration []. But, despite the presence of studies in this field, the lack of practical tools, determined in the form of methods and recommendations, is observed in this field. It is also connected with the fact that it is hard to observe and, moreover, to "measure" the "creative labor" with classic approaches only.

2. DETERMINATION OF CREATIVE, RESEARCH LABOR IN TERMS OF NORMING

According to the Russian rule-making tradition, creative activity means creating cultural values and their interpretation [5]. Kushnir A. B. carried out the following creative work classification by types of activity:

- first type of creative work is the scientific activity having the nature of fundamental research;
- second type of creative work is the activity for the knowledge implementation into new technologies, which is traditionally called applied studies;
- third type of creative work - labor in the sphere of art for creating new cultural values;
- fourth type of creative work - activity, that is frequently classified as labor in the art serving to satisfy current, short-term people's needs, creation of mass culture works, as a rule, those of entertaining nature, the main task of which is providing the leisure versatility;
- fifth type of work - innovation enterprises, and entrepreneurial activity, based on ew marketing decisions [5].

Despite the wide range of activity classified as creative, it can be noted that they are related to the production of "new knowledge" or "new ways to apply old knowledge". This is some type of invariant uniting all types of creative work, without regard to direction, branch, genre "seriousness", starting from the work of managers and ending with scientific activity. According to the Russian scientific tradition, norming of creative work is possible through the assessment of this labor results. The line of papers, including ours, demonstrates that the "new knowledge" can be classified as such [6], [7]. Therefore, after assessing the complexity of the creative work product, it becomes possible to determine labor intensity for this product generation works.

3. LABOR NORMING THROUGH THE LABOR PRODUCT BASED ON THE THEORY OF COMPLEXITY

The method of assessing the foreseeable time expenses, based on determining the complexity of the labor product, or "Theory of complexity", was offered and time-tested on practice by the scientists of Izhevsk State Technical University. They solved an issue, actual for the modern stage of machine engineering, connected with the nomenclature change frequency for products being issued, heir uniqueness and increased complexity [8], [9], [10].

In accordance with this approach, labor intensity of a mechanical product manufacture is assessed based on the determination of the product structural and technical complexity, is carried out with the use of regression dependence of labor intensity on the product structural and technical complexity:

$$T_j = a_j + b_j C, \qquad (1)$$

where Tj – labor intensity of a mechanical product manufacture in the jth production system, min; C – complexity (structural and technical) of the labor product, units; aj, bj – regression factors of dependence of labor intensity of a mechanical product manufacture on the product structural and technical complexity for the jth production system. Moreover, by their nature, they are determined by the organization and technical level of the

jth production system, and can be determined by its direct inclusion. "Labor product complexity" complexity is an indicator which is "invariant" and immanent to the labor product, independent on external conditions, labor organization, cost indicators, staff qualification and competency, and other factors.

In terms of the work described, the automated expert data processing module, based on the multi-dimensional scaling method, was developed. It is intended for revealing the factors of organization and technical level of the production systems, greatly influencing the labor intensity of the machine product manufactured The developed expert data processing module allows automating the processing of expert, increasing the reliability of determining critical indicators because, during the expert information processing, coordination of experts' opinions is taken into account, and decreasing the labor intensity of the expert data processing.

Assessing the accuracy of results obtained with the use of the mathematical model, forecasting the labor intensity of the machine product manufacture in the conditions of multiproduct machinery production with the direct registration the organization and technical level of the production system, at its testing at FGUP GPO "Votkinskiy Zavod", Votkinsk, SOJSC "Izhevsk Instrument Plant "Izhmash", Izhevsk, OJSC "Zavod "Avtopribor", Vladimir, FGUP GPO "IEMZ "Kupol", Izhevsk, allowed determining that the value of error between the calculated values of the forecasted labor intensity and its actual value does not exceed 12% at the median of 4,5% [11].

The complexity theory formed a basis for assessment of labor intensity of creative work, including research and managerial. With regard of on the fact that the creative labor is, as a rule, connected with the information processing and logical operations, it is logical to assume that the dependence of labor intensity on complexity is the exponentiality, reflecting the rates of new information accrual:

$$T(C) = a \cdot e^{b \cdot C} \qquad (2)$$

This dependence is coordinated with the labor reduction law equation but has a different meaning. It can be concluded from it that the labor intensity of creative work grows exponentially at the labor product complexity growth.

The complexity of "new knowledge", as the creative work product, is a generalizing indicator including the assessment of the following factors:

- "competency complexity" of knowledge, i.e., presence of knowledge and skills in the contractor that are required for its generation;
- "knowledge prospectivity ", an indicator reflecting the labor product value;
- "knowledge novelty", i.e., their unique nature.

At the assessment of these factors, as a rule, the expert method is used, in the process of which, specialists in a certain area determine the approximate time labor costs for the implementation of work which is unique by its nature [12].

4. FUZZY LOGIC USE AT R&D STANDARDIZATION IN PRODUCTION

The expert assessment of creative work results, including that due to high uncertainty, and abstractiveness of creative work, includes linguistic quality assessments. For this reason, in order to solve the task of their quantitative interpretation, possibilities of the fuzzy logic mathematical apparatus were used. Moreover, the number of authors have already used these approaches at labor norming and assessment. In particular, N.B. Paklin in his dissertation in support of candidature for a technical degree [13] was the first one to offer a method of determining the forecasted labor intensity of machine products manufacture based on fuzzy logic, which allows assessing time norms operatively without the technology process design.

In terms of fuzzy logic, when determining the complexity of the labor product, in our case, knowledge, it is required to determine the target function describing the dependence of input and output variables of the creative work product complexity:

$$C(y_1, y_2, ...y_m) = F(x_1, x_2, ...x_n), \qquad (3)$$

where x1…xn – indicators assessed, y1…ym – output variables. In the determination of parameters or linguistic variables being assessed, it is required to proceed from the requirements to the creative project itself, to the assumed product, C – knowledge complexity, F – function, describing the fuzzy expert model.

Labor product complexity was assessed at each step on the basis of the following three parameters:

– knowledge competency complexity;
– knowledge novelty;
– use prospectivity.

Figure 1 shows the membership function μC of the linguistic term competence level (low level of the competency) built on the basis of this indicator expert assessment.

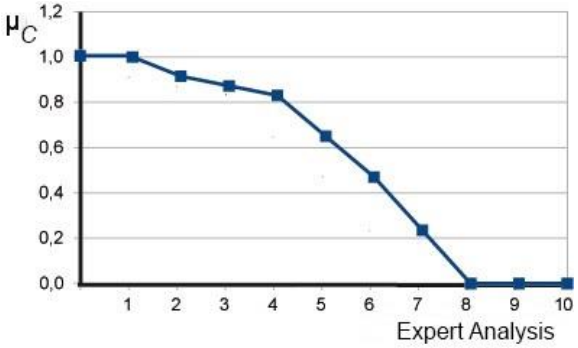

Figure 1 The Membership Function μC of the Linguistic Term Competence Level (Low Level of the Competency)

Rules for the assessment of new knowledge, obtained as the creative work product, according to the results of work with experts, have the following nature:

– if the knowledge complexity is low, the novelty is low, the prospectivity is low — "Labor product complexity" is low;

– if the knowledge complexity is medium, the novelty is low, the prospectivity is low, "Labor product complexity" is low;

– if the knowledge complexity is high, the novelty is high, the prospectivity is high, "Labor product complexity" is high, etc.

Figure 2 membership function of input parameters (competence complexity, novelty and knowledge prospectivity) and the output parameter (knowledge complexity).

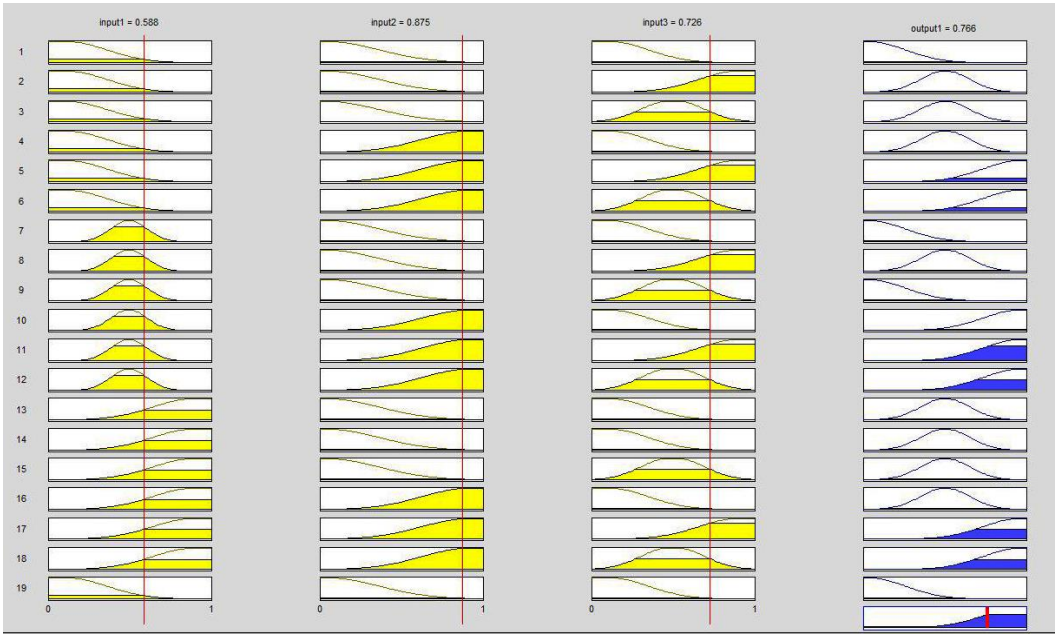

Figure 2 Fuzzy Expert Model to Define Complexity of the Creative Work Results (New Knowledge) in Dependence on their Competence Level, Prospective Capacity and Novelty

Defuzzification was carried out by the Mamdani method, assuming the use of the following formula for numeric interpretation of the linguistic variable "Labor product complexity" ("Knowledge complexity"). With regard to the assessment parameters, regulations base, by fuzzification of the use of logical operations set for the fuzzy parameter set, we receive the labor result forecasted "mode" given in Figure 3.

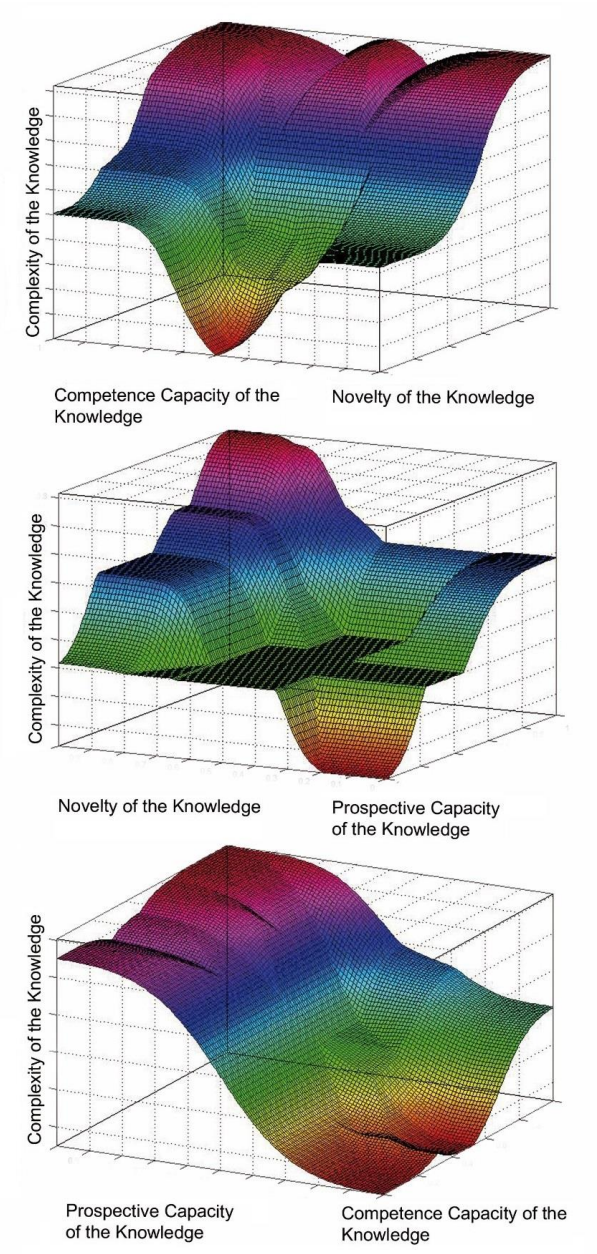

Figure 3 Fuzzy Expert Model which defines Complexity of the Knowledge with Dependence on Input Parameters

This fuzzy expert model was used for the assessment of labor intensity of research work in the energy sector. Initial data in the form of classification of R&D stages and duration (labor intensity) were obtained in the paper of R.A. Durbev, I.V. Zhdanenko [12]. They are given in table 1. It should be mentioned that in their time, A.M. Karyakin and Ye.O. Grubov developed a method of substantiation of the project cost connected with the conduct of research and development in the energy sector, even in case of its complexity considerable differences from the existing analogs [14].

As the parameter of the labor intensity of creative work at each stage of projects implemented, its duration has been considered. Group expert assessment of typical research projects and their duration are given in Table 1. The column "Labor product complexity" represents the results of the application of the fuzzy expert model, in which "Competency knowledge complexity", "Knowledge novelty" and "Knowledge prospectivity" are output variables, representing the expert assessment of the result of the respective R&D stage. Based on the fact that the project "Labor intensity" or "Average duration" is an interpretable variable, and "Labor product complexity", an interpreting variable, the regression equation in the form of exponent function was obtained.

Table 1: Expert Analysis of the Time Expenditure of the Creative R'n'D Stages and their Results

R&D stages	Expert assessments of the "Labor product"				Labor intensity (mean arithmetic duration) (T, day)
	Knowledge competency complexity	Knowledge novelty	Knowledge prospectivity	Labor product complexity (C)	
Understanding the R&D objective and tasks, requirements to scientific and practical results	0.136	0.731	0.098	0.500	61.71
Formulation of the research issue, scientific tasks, subject, object, limits	0.811	0.290	0.327	0.519	64.60
Substantiation of the issue resolution diagram, tasks, master plan, and work program development	0.513	0.524	0.471	0.527	67.64
Protective stock and sci-tech market state analysis	0.875	0.678	0.178	0.553	100.19
Improvement, adaptation of the existing scientific and methodical apparatus	0.556	0.614	0.625	0.638	140.04
Development of the new scientific and methodical apparatus	0.918	0.827	0.799	0.804	363.00
Development of the method of the initial data collection and processing for the use in the apparatus	0.327	0.811	0.285	0.614	106.65
Initial data collection and processing	0.854	0.699	0.689	0.776	219.62
Development of the special apparatus-based software	0.652	0.843	0.790	0.773	289.67
Conduct of calculations with the use of applied applications, special software	0.721	0.684	0.965	0.771	146.79
Developing the method of conduct of observations, machine, laboratory and natural tests	0.779	0.503	0.556	0.635	130.52
Experiment conduct	0.556	0.566	0.859	0.632	118.81
Conduct of observations, laboratory and natural experiments, tests	0.907	0.816	0.604	0.790	315.39
Development of methods of conducting expert polls	0.428	0.641	0.785	0.668	92.79
Conduct of expert polls	0.758	0.582	0.769	0.728	141.80
Processing of observation results, experiments, tests, expert polls	0.593	0.801	0.561	0.736	119.31
Assessment of technical or social and economic efficiency of scientific and practical results	0.779	0.503	0.556	0.635	95.14
Preparation of reporting materials	0.199	0.641	0.785	0.747	121.65

As a result of the regression analysis, the following correlation relation between the labor intensity of research work and the forecasted complexity of the labor product – new knowledge, was obtained:

$$T = 6.567 \cdot e^{4.468 \cdot C} \qquad (4)$$

The T on C exponentiality built can be used as a tool of defining the labor intensity of creative, and in this case, of research labor, at the presence of the expert assessment of the forecasted complexity of the planned product of creative, and in this case, of research labor, as new knowledge.

5. CONCLUSION

This paper describes the approach to assessing the labor intensity of creative work, which can include research work, in terms of the complexity theory, that is, based on the labor product complexity assessment. In its time, this approach was developed and time-tested for assessing time

expenses for the manufacture of the unique machining complex products.

The definition of creative work, one of types of which can be considered research work, in terms of norming, was given. It was offered to consider the "New knowledge" the result of such activity.

In connection with this, the fuzzy expert model was developed for its complexity assessment. It enables the quantitative interpretation of the "labor product" - "new knowledge" qualitative assessments in terms of the required competences for implementation of the respective work, prospectivity and novelty of creative work results.

Based on the approach offered, the dependence of labor intensity in terms of work fulfillment duration on the complexity of the forecasted "labor product" for research, development, and engineering in the energy sector was obtained. The dependence obtained is an instrument for assessing interim labor costs for the fulfillment of unique projects.

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