

Measurement of the Intensity of the Creative Works while RnD Projects are Carrying Out, on the Fuzzy Expert Model

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Abstract. The article describes fuzzy logic approach and theory of complexity in term of work measurement for brain- creative work bound to research and development intensity to be estimated. The idea that the intensity of the creative- and brain-work can be estimated through its product complexity is put forward. It is suggested that new knowledge is a product of creative work and its complexity can be evaluated by expert linguistic rating. To turn linguistic rating of new knowledge novelty, competency and business capacity into numerical data fuzzy logic expert system, which enables linguistic assessment on the product of labor to be quantified, was developed.

The relevance of this study follows from essential place of labor regulation for both economic vantage point, legal regulation and social fairness in HR-management. Reasonable labor standards for creative work not only enable productivity increasing, but also ensure fair salary and even staff loading by work pressure.

The paper describes an approach to the complexity of creative work as research and development, in terms of the theory of complexity proven before for machinery, that is, based on the assessment of the complexity of the product of labor. Due to the fact that the product of creative, research, work is "new knowledge", to assess their complexity was developed fuzzy expert model. It enables to quantify qualitative assessment of the product of creative or brain-work - "new knowledge" in terms of the necessary competencies to gain demanded gains, the prospects and novelty of the results of creative work.

On the basis of the proposed approach, the dependence of labor intensity in terms of the duration of work on the complexity of the designed "product of labor" for research and development work was obtained. This dependence is a tool for assessing the time spent on the implementation of unique research and development projects which include "invisible" and undetectable brain-work. This determines the practical usage of this work's results which could be used for the planning of research and development works, the assessment of their complexity, duration and costs. This work is supported by the Kalashnikov Izhevsk State Technical University (Izhevsk, Russia) under grant 38.04.01/18GRA.

1. Creative work definition and issues of its estimation

A research is an integral part of the Russian educational system. Since Russia's accession to the Bologna process, when so called "specialitet" ("specialists training"), soviet tradition education system, turns into two-staged baccalaureate and magistracy, this issue has been getting more crucial. It because that, taken after USSR system graduate qualification work, in contrast to the master thesis, is not necessarily should contain scientific novelty.

While this goes on the rationing and estimating research creative work effort and time study get more essential. At least it is useful to determine the time-frame of scientific-research for thesis to be prepared to defense. Problems associated with this issue are similar to those that occur when fixing the so-called creative brain-work for new knowledge generation. Talking about research intense estimation, we mean and use term “creative work”.

Russia has several hundreds of regulatory legal acts, departmental recommendations and other doc and papers defining the time amounts for given work, labor standards, personnel capacity rate in of various brunches of the economy. However, despite the growing importance that acquires creative work from the point of view of enterprises or even national economies efficiency these specific activities remain actually out of state or even corporate regulation, if we are talking about work measurement.

And the very notion of “creative work” is presented in the Russian legal framework too scanty. It is indirectly presented in State Labor Code of the Russian Federation. Along this way, this provision of the low is limited by mass media, film making, TV, video shooting, different kinds of troupes. circuses, performance folks and showmen. Labor Code 52.1 Chapter defines the special features governing the scientists, heads of scientific organizations and their deputies working, whose activities can be described as “creative”.

In addition, creatives copyrights are governed by Russian legislation. In recent years different departmental rules and codes that establish professional standards and requirements to creative workers employed come into life. But, at the same time, creative work measurement and intensity are beyond the Russian legal system till now-days.

Obviously, it is a serious omission while creative work importance keeps rise up. According to some researchers, creative class representatives are gradually replacing the so-called traditional middle-income employers, who are working in service.

While new technology penetrates every side of human activities creative work is becoming more essential to gain commonwealth for society and individual prosperity. According to some researchers, creative class is gradually replacing the so-called traditional middle-income employers, who are working in service and other convenient branches of economy.

An American researcher Florida R. analyzed new class structure of the social, its components and dynamics. He enlightens creative class and its super-creative core as well as maintain class. Working class and farming are the only ones of previous classifications. At the end of the twentieth century there was a qualitative shift, including the boom of the creative class and the decline in farmers and workers numbers. Since 1980 the share of the service employment has been getting down. That is how current innovative economy in which a growing number of people earn through creativity seems”, - noted Yasin E.G., former the Minister of economy of the Russian Federation [1].

Over the last century in the developed countries economies the proportion of creative and brain workers increased from 10% to at least 90%. For the near future, this indicator can leave behind 95 percent [2, 3].

For employers rationing and measurement creative work effort and time expenses for creative and highly intelligent projects are getting more significant. At least it is useful to determine the time-frame for research, creative project or decision making if it is about top-tier employees’ activity.

Problems associated with this issue are similar to those that occur when fixing the so-called creative brain-work for new knowledge generation goes on. Despite the growing importance that acquires creative work from the point of view of enterprises or even national economics work measurement remains actually out of state, corporate regulation, and even theory.

Thus, it can be concluded that intensive estimation and creative work measurement are really crucial issues for today and it is a basis of the relevance of the topic. Creativity can be viewed as the first stage of an innovation process [4]. This might create a scientifically grounded basis for time study and creatives motivation to be carried out. The latter aspect is directly related to the fair and adequate compensation for work.

1.1. Definition of the creative work

Since creative research process or act of creation may not always be observed and is beyond the direct measurement, it often lacks the repeatability principle. Brain work is so unique that sometimes its results is just a product of “insight”. Since that some authors, as it is shown below, come to the creative work measurement nor through time study neither doing physiological research but basically on the assessment and estimation of the results gained through creative work. Hence, the definition of “creative work” and “results of creative work” in the term of norm-fixing and time expenditure is getting more crucial.

A.B. Kuschnir, representative of heading Russian scientific school which focused on labor research [5], put forward an idea to define “creative work” as an activity with progressive element of novelty, when qualitatively new inventory items and cultural wealth come up, and these new products enable to meet just emerged needs of society. Thus, the creative work generates some results for society needs to be boosted. In other words, new product bears along new needs to meet ones.

According to A.B. Kushnir complex intellectual creative work aimed to gain new knowledge. This is the essence of the creative activities. He defines the content of the creative work as an intellectual activity, which includes the fruitful thinking. It should be added that not only fruitful but purposeful.

On that basis the creative work can be defined as creation and interpretation new knowledge which are able to meet new needs of society and generate new requirements to meet ones which derive itself from new knowledge which have be generated.

A.B. Kushnir carried out creative work classification by type of activity, which is summarized in this article:

- the first type of creative work is a scientific activity dedicated to basic research;
- the second type of creative work refers to applied research to transform knowledge into new technologies;
- the third kind of creative work is art and cultural values creation;
- the fourth type of creative work is an activity, which is often referred to art for short-term needs of the people to be met through entertaining pop-culture performance;
- the fifth creative work is an innovative enterprise and entrepreneurial activities, based on the new marketing tricks.

B.M. Genkin, Russian labor economist, classifies “creative work” as follows: regulated or α -work, creative - β -work and spiritual - γ -work [6]. Serbinovsky B.Yu. and Churin A.S. adjusted this classification separating β -work into two distinct components [7]: β_1 -work or creative change regulated processes based on conventional knowledge and β_2 -work, which involves creativity for the creation of new knowledge and new ways of management. As the authors note, the result of this work category is knowledge and different kind of stuff with high level of novelty for use in business practices and on the market with intellectual rights protection.

It would be appropriate to determine what we mean by the term “new knowledge”, but we leave it outside the study, focused on intuitive understanding what is it. In this paper, we use this term as the identification of creative work result or product. Either way, the generation of new knowledge requires high level of knowledge, competencies in certain brunches of activity and creativity either way.

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1.2. Issues which turn up while creative work is being estimated

Nevertheless, despite the presence of a large number of studies on creative work measurement and time study, there are more questions than answers. In most areas of creativity there are lack of generalized, reasonable and statutory labor standards, methods for intensity of creative brain-work to be estimated. The causes of the methodological problems of rationing creative work are following [5]:

- high variety of jobs to do and rare occurrence;
- considerable dependency costs and result from the employee's personal merits and diverse conditions of creative work;

- the specific nature of the creative work, for example, the creativity involuntary goes on beyond working time;
- high risk of getting a negative result due to the high novelty studies and project objects;
- collective work management when interdisciplinary knowledge to be used and moral-psychological climate have significant impact on outcomes.

In the Western traditions of rationing of the indirect labor, which is becoming increasingly important knowledge economy is developing and impact on the economy of enterprises assets and direct costs are decreasing, are identified long time ago. The based on the preliminary assessment of the time spent for manufacturing operations watch-clock method which works proper well while repetitive operations are measured, loses its adequacy and “economic viability” when it comes to indirect labor.

It was noted by W.J. Richardson [8]. Assuming a linear dependence between the quantity of labor actions and time expenses for their execution, he developed a method for standardizing indirect jobs, based on multiple regressions. The complexity of implementation of these evaluations and correlation of these accounting indicators, labor intensity and the immediate task during the abstract activity or “compound” labor-intensiveness of the thermodynamic description of systems akin to the deterministic methods.

Some researchers suggested that there are three assessment techniques for creativity measurement: first, creativity tests; second, objective analysis of products; and last, subjective judgements [9]. Mark Batey notes that measurement of the creativity may be made objectively (e.g., hard data). A subjective measure may be taken from the focal point of analysis (e.g., an individual, team, etc.). In the context of the investigation of an individual, this would involve scores on a self-rating of creativity [10]. He presented heuristic model that takes into account the who or level of analysis (individual, team, organization, or culture), the what or facet (trait, process, press, or product) and also the how or measurement approach (objective, self-rated, or other-rated).

In this regard, among three main methods of norm-fixing, neither computationally-analytical nor experimentally-statistical method but judgmental method is proper for creative work estimation. The constraints of the first two approaches arise from the fact that they rely on the monotony of work and frequent repeatability of the operations. At the same time, as noted by Kushnir A.B. [5], creative work or brain-work estimation is possible only through their result or product. He states: “The existing experience of complex brain-work measurement lets us highlighting specific norm features of the creativity. One of these is a possibility to norm a set of time standards of creative work only through one's result estimation and evaluation”.

Hence, the norm regulation of creative work is done through evaluation of the result, or in above defined terms “creative work” and “product of creative work”, it is the complexity of “new knowledge” should be estimated to define intensity of creative work and carry out time study.

1.3. Creative work measurement through complexity attribute

The concept of “complexity” in the context of the valuation and measurement of labor-intensiveness appeared in “complexity theory” [11]. The authors suggested this indicator for estimating effort of an intricate piece of machinery manufacturing. The “complexity” is “invariant” and inherent features of product, which is not affected by external conditions, labor management and it not bound to cost, qualification of personnel, and other subjective categories.

The authors of “complexity theory” have developed the theoretical apparatus for this indicator to be calculated and how to use it while technology and economics issues are sorted out. This method work measurement was named as method of evaluating complexity of the produced item.

The “complexity” of the product of labor is determined regardless of the technological process, its definition does not require preliminary manufacturing procedure development. “It can be defined at the design stage on the basis intricate piece of machinery manufacturing draft studying. The designer while draft running and being essentially an expert, shall identify complexity of its. Indicator of complexity is versatile” – say authors of this methodology [11].

Despite the fact that the above-mentioned work involved is mostly about solid of revolution and pressurized craft pieces, universality of theory enables to adapt it for time study and estimating intensity of the creative work. Indeed, in this case, the result of the creative work or “new knowledge” can be considered as complex piece of knowledge which is evaluated by experts like it is done for intricate piece of machinery manufacturing.

The core issue of the “complexity theory” is calculation of the correlation between “complexity” of the product (C), and the time frame (T) for this product manufacturing:

$$T=f(C) \quad (1)$$

The authors offer to study dependence by statistical method. To determine the complexity indicator of the model was proposed:

$$C = C_s \cdot K_1 \cdot K_2 \dots \cdot K_n \quad (2)$$

Here C_s is the structural complexity of the product, and K_i - coefficients which enable the impact of different factors to be taken into account.

According to the theory of complexity time expenditure T is determined on the statistic fetched of manufacturing data. Thus, in the studied paired values of T and C , the first one is labor intensity in term of time expenditure, and C , respectively, calculated in accordance with formula 2.

It seems fair that complexity theory can become the basis for estimating effort of creative work, including researches and brain-works. For this purpose, it is necessary to make some generalizations. For creative work product, as we defined above “new knowledge”, its complexity defines through “novelty”, “business benefits-to-be” and a “level competence”. These ideas are very close to Subramaniam and Youndt classification of the creative work result: “developed ideas that imply substantial departures from existing product and service lines”; “developed ideas that make existing knowledge about current products/services obsolete”; “developed breakthrough ideas—not minor changes to existing products/services” [12].

For creative or brain-work measurement instead of “structural” complexity we consider C which is “complexity of new knowledge”. It includes following indicators:

- C_c - “competence complexity” of knowledge which indicates the lowest level of professional training of team members to gain fruitful results;
- K_n – coefficient for “novelty of knowledge” which indicates uniqueness of the knowledge obtained;
- K_b – coefficient for “business benefits-to-be” or “the knowledge perspectives” which indicates commercial value of the brain-work results.

By the way the indicator C_c indicates performers’ level of skills, time of training and volume of knowledge required to meet an issue of creative project. This seems reasonable because consumers, are not interested in the process but in value that makes them pay.

1.4. Definition of competence complexity of the creative work results

Typically, when creative work is estimated experts in a particular brunch of knowledge try to approximate time of work. These approaches are well described in the academic references. However, due to the uniqueness of each issue, specialists opt the method and means to gain results, which can seriously reduce or increase the time expenditure.

In our opinion time frames for work on the accumulation of experience and competencies necessary for successful performance should be taken into account. Anyway, independent expertise implies a certain fuzziness, non-strict reasoning, linguistic characteristics and quality estimating of creative challenges and logistical means. To meet this challenge, the mathematical apparatus, known as fuzzy logic was suggested. It enables quantify the linguistic judgments.

Principles of fuzzy logic first were completely formulated by American scientist Lotfi Zadeh [13]. Currently fuzzy logic is applied in the automotive, aerospace and transportation industries, robotics, risk assessment, management, including staff assessment. In the Ph. D thesis of Packlin N.D. fuzzy logic ideas have been used to define time expenditure of engineering products manufacturing, that enables to estimate time norms without designing engineering process [14].

In this article we do not point out the nuances of fuzzy logic. They are well known in described in numerous works. We just note, that complexity of the results of creative work (C) defines through a set of input and output variables which are named linguistic terms:

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

Here $\{x_1 \dots x_n\}$ are evaluated indicators and $\{y_1 \dots y_m\}$ are output variables.

Output values, fuzzification and de-fuzzification parameters in accordance with linguistic rules, determine C ("complexity") of the results of the creative work or "new knowledge" and this is an intensity measure of the creative work.

1.5. An algorithm for creative work intensity estimation

On the basis of the above described ideas the algorithm of creative work estimation can be developed.

The first step includes statistics accumulation, including information on creative projects and time expenses for their realization.

The second step is a rating of "complexity" of creative work results, including, for example, such categories as the complexity novelty and market significant of knowledge,

The third step includes quantitative interpretation of qualitative assessments with the approaches of fuzzy logic and complexity of new knowledge definition C through parameters of estimation C_c , K_n and K_b .

The fourth step is about $T=f(C)$ calculation with exponential regression analysis when $T(C)$ is an exponent function (4):

$$T(C) = A \cdot e^{B \cdot C} \quad (4)$$

Here T is the time expenditure; A and B are regression coefficients.

This function allows evaluating the laboriousness of creative work, with the expected complexity of the result in the term of "new knowledge". The exponential dependence fits creative work measurement because creative work generate knowledge, new information which decreases with exponential rate.

The advantages of this model are following: a relatively simple mathematical model and initial statistics data can be gathered concern to relatively non-unique creative projects, including studies of masters, postgraduate, journalistic inquiry when novelty, viability and competence complexity can be estimated very easy.

Function $T(C)$ has universal nature, regardless of industry and "genre" of creativity because it explains the dependence of the laboriousness from invariant indicator that describes the product of labor.

1.6. Intensity of creative work dependence from the complexity of the product of creative work based on statistical model

The survey was conducted regarding piece of creativity of ordinary research and development. As a parameter of the labor intensity of creative work at every stage of research and development can be taken its average duration.

The complexity of the creative work product at each stage is assessed on the basis of the three following options: the competence complexity, novelty and prospect of application of the new knowledge on the basis of linguistic assessments under fuzzy logic.

To determine the complexity of the “new knowledge” at every stage of research and development is necessary to determine rating interval with a maximum and minimum points value of the following coefficients: C_c is the competency level; K_n is the novelty of knowledge; K_b is the knowledge commercial capacity and perspectives.

The above-mentioned coefficients and output function C are described through a multitude of linguistic variables with its membership function with values range from 0 to 1. Figure 1 presents as an example the membership functions for “low level” novelty of knowledge based on expert assessments.

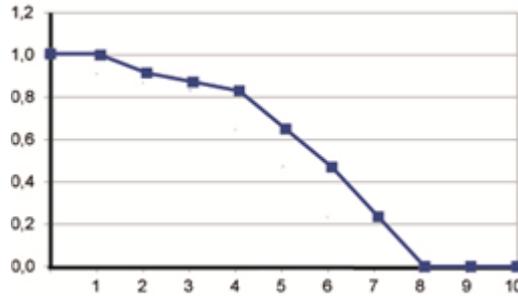


Figure 1. The Membership Function of Low Novelty of “New Knowledge”.

Rules for assessing new knowledge obtained as a product of creative work should be like follows:

- if the competence complexity of knowledge is low, prospect is low and novelty is low — the complexity is low;
- if the competence complexity of knowledge is fair, novelty is low and the prospect is low then complexity is fair;
- if the competence complexity is great, novelty is low and perspectives is low, the complexity can be low, can be fair or can be high;
- if the competence complexity of knowledge is low, prospect is low and novelty is low — the complexity is low;
- if the complexity of knowledge is great, novelty is the fair and the prospect is high then competence complexity is great;
- if the complexity is great, novelty is fair and perspectives is great, the competence complexity is great.

These rules were defined in the basis of the survey carried out among experts.

The quantitative interpretation of fuzzy “new knowledge” was implemented with Mamdani method:

$$C = \frac{\int_{xl}^{xu} \mu(x) x dx}{\int_{xl}^{xu} \mu(x) dx}, \tag{5}$$

where $\mu(x)$ – is a function which describe the “model” of new knowledge obtained as a result of the creative work,

The surfaces of knowledge complexity (C) as dependencies on the complexity of knowledge, novelty of knowledge and knowledge perspectives in the figures 2-4.

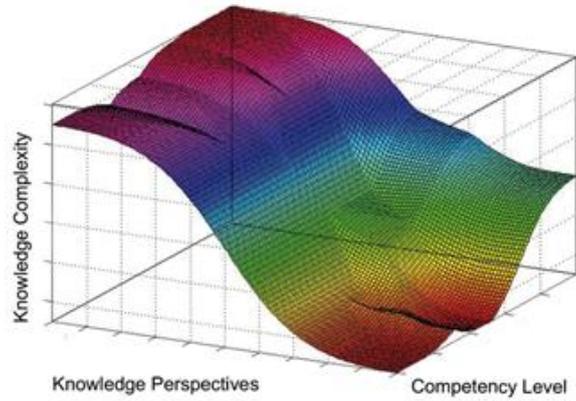


Figure 2. Dependence of the Knowledge Complexity on “Competency Level” and “Knowledge Perspectives”.

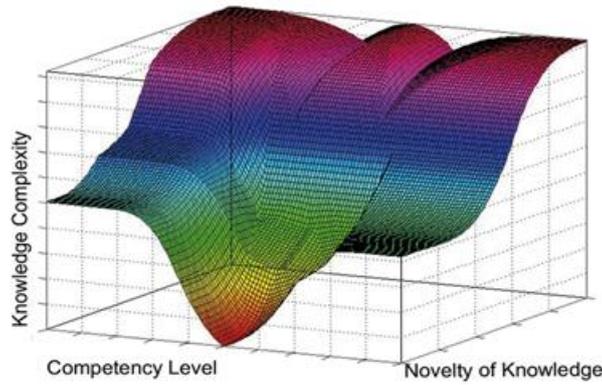


Figure 3. Dependence of the Knowledge Complexity on “Competency Level” and “Novelty of Knowledge”.

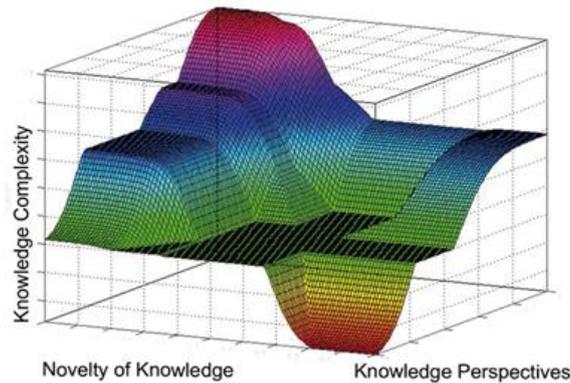


Figure 4. Dependence of the Knowledge Complexity on “Novelty of Knowledge” and “Knowledge Perspectives”.

The scatter plot $T - C$ brings an assumption about positive correlation between these parameters. The correlation coefficient is equal 0,711, which means a strong connection between time expenditure and results of creative work.

Function $T = f(C)$ developed on the regression technique basis with accordance to well-known approaches. The following function in accordance with the exponential dependence has been calculated:

$$T = 8.501 \cdot e^{0.358C}, \quad (6)$$

Here T is labor intensity in terms of time expenditure, expressed as a weighted average of the average time length of creative phase.

For example, if a peer review, after appropriate procedures fuzzification and de-fuzzification gives the value of competence complexity C of the creative project equal 6.5, the time expenditure to implement project will be 86,458 days, within ± 8.5 days confidence intervals. Thus, we get an approximation for creative work dependence of the labor intensity dependence on competence complexity of the product, which can be used to determine the labor intensity of the creative project, depending on the complexity of the expected product.

2. Conclusions

The creative work was defined as a willful human activity to gain new knowledge. New knowledge, its novelty, business prospective and competence complexity, enables creative work measurement in norm-fixing terms. Creative work measurement is an essential issue for new economics based on creative work penetration into real world.

The basic concept and approaches of the complexity theory were developed for norm fixing and measurement of the creative work to be carried out. Under principles of the fuzzy logic were defined basic terms to take into account the specifics and structure of creative issues that enable to quantify expert estimation.

The obtained dependence $T - C$ enables estimation of the time expenditure of creative project and can be used for the dependence of labor intensity in terms of the duration of work on the complexity of the designed "product of labor" for research and development work was obtained. This dependence is a tool for assessing the time spent on the implementation of unique research and development projects which include "invisible" and undetectable brain-work. This determines the practical usage of this work's results which could be used for the planning of research and development works, the assessment of their complexity, duration and costs.

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