Quality assessment of regulatory legal acts using the Mamdani algorithm

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Abstract. This article describes the relevance of the problem of assessing the quality of legislation. The algorithm for quality assessing of regulatory legal acts is proposed as a tool for resolving this problem. This algorithm uses methods of fuzzy math and processes the results of the expert group questionnaire with these methods. The result of the algorithm is a characteristic of the quality of a regulatory legal act in the form of a fuzzy term of a linguistic variable. "Automated system for quality assessing of regulatory legal acts" is variant of automation of the algorithm for quality assessing of regulatory legal acts, which is described in this article.

1. Introduction

The production of regulatory legal acts (RLA) is increasing but their quality deteriorates very much. Lawmakers allow incorrect use of concepts, contradictions to other laws and internal contradictions in laws and other errors, which do not allow the law to work for the good and in the interests of the social legal society. Therefore, the expertise of any RLA should be performed necessarily. This will allow the legislation to become more logical and fulfill its purpose to the full.

Currently, some expertise of the RLA is executed regularly. For example, anti-corruption expertise of RLA is executed most often. But this expertise is local and narrow. Therefore, lawmaking needs for RLA expertise that would consider RLAs more deeply on a much wider range of RLA quality criteria.

In this connection we need algorithms and techniques for more extensive and deep examinations of RLAs, which will allow to obtaining an overall quality assessment at different stages of the development of RLAs. This task is not solved today and requires finding a solution. Therefore, the topic of this article is of current interest.first paragraph after a heading is not indented (Bodytext style).

2. Ehe algorithm for quality assessment of RLA

The A survey of experts in this field is proposed to use for quality assessment of RLA. The results of survey transfer to the lot of fuzzy numbers and processed by the fuzzy algorithm that was proposed by the mathematician Mamdani. The scheme of a quality assessment of RLA is presented in the fig. 1.

Below we describe the blocks of the figure 1 in detail.

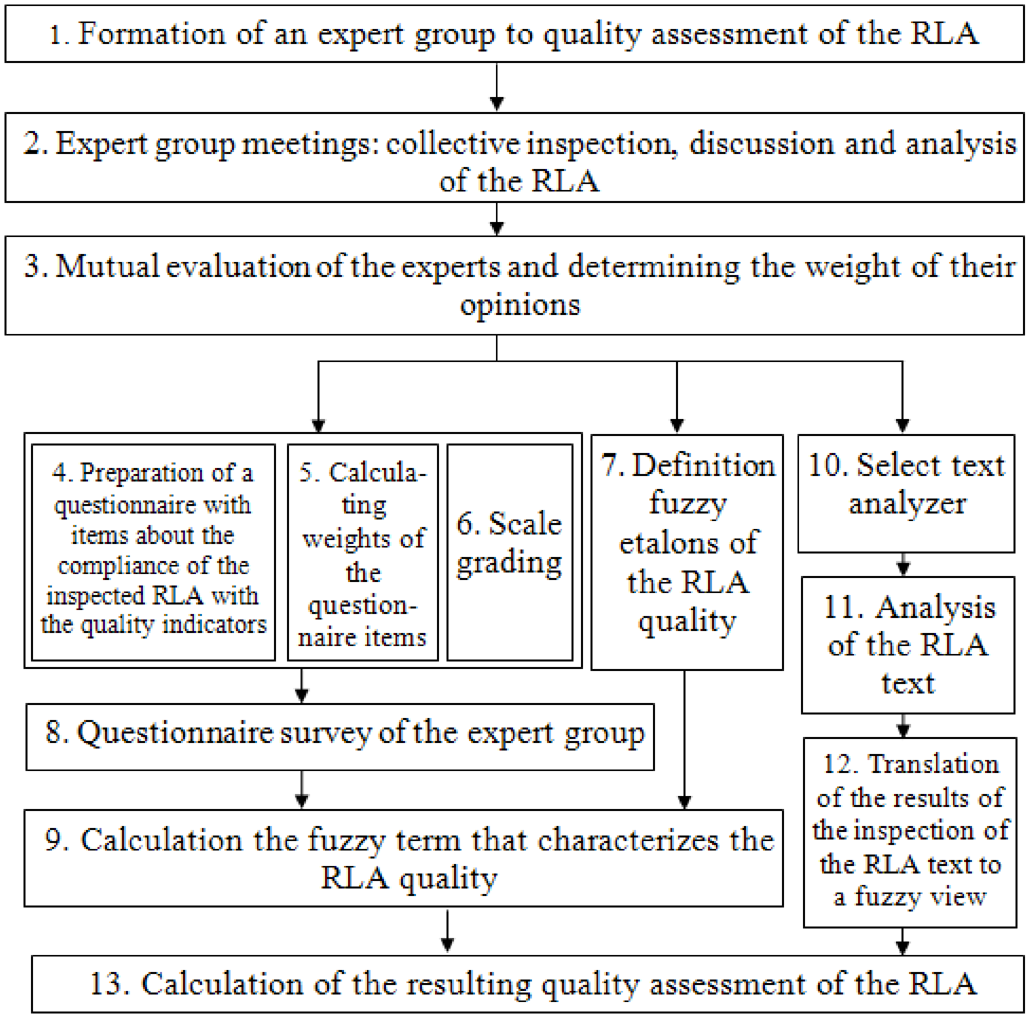

Figure 1. The scheme of a quality assessment of RLA

1. Formation of an expert group to quality assessment of the RLA

The algorithm of formation of an expert group to quality assessment of RLA is as follows:

a. Formation of a basic list of RLA experts;

b. Selection of the RLA experts from the basic list of RLA experts in the RLA expert group;

c. Formation of the RLA expert group.

The basic list of RLA experts is formed with the help of competent RLA experts. Any RLA expert reports several RLA experts known to him. Each of this RLA experts report other RLA experts. The process of searching for RLA experts is stopped when the list ceases to be replenished with new experts. Experts who participated in the development of the RLA are excluded from the base list. The resulting list is the desired basic list of the RLA experts.

Each of the RLA experts from in the base list is evaluated by the algorithm of the selection of an expert to the RLA expert group. The procedure for the selection of experts is described in other articles by the authors of this article [1].

The expert who have passed the selection procedure and who have a qualification level not lower than the “permanent qualification of the RLA expert” is stepped in the RLA expert group.

2. Expert group meetings

This algorithm does not set the rules for conducting expert group meetings and methods for detecting compliance of the RLA with the quality indicators from the questionnaire. This part is completely determined by the experts of the formed expert group.

3. Mutual evaluation of the experts and determining the weight of their opinions

The mutual evaluation of the experts within the group is performed to determine the weight of the opinion of a member of the expert group. The procedure for the selection of experts described in the article [1] is using for mutual evaluation too.

Mutual evaluations of the experts are performed to a matrix view $V = (v_{ij})$. The elements of the matrix are the terms of the linguistic variable “The qualification of the RLA expert”

The resulting linguistic terms of the mutual evaluations $V = (v_{ij})$ are matched to numerical values:

Very low RLA expert qualification → 1;

Low RLA expert qualification → 2;

Average RLA expert qualification → 3;

Steady RLA expert qualification → 4;

Normal RLA expert qualification → 5;

High RLA expert qualification → 6;

Very high RLA expert qualification → 7.

The weight of the opinions of each of the experts of the group is calculated by the formula:

$$W_i = \frac{\widetilde{W}_i}{\sum_{i=1}^{N} \widetilde{W}_i}, \tag{1}$$

where

$$\widetilde{W}_i = \sum_{j=1}^{N} v_{ij}; \ \sum_{i=1}^{N} \widetilde{W}_i = 1; \tag{2}$$

N – number of the RLA experts in the group; v_{ij} – elements of the matrix of mutual evaluations of the RLA experts.

The obtained values allow you to give more weight to the opinions of more qualified members of the group when calculating the quality assessment of RLA.

4. Preparation of a questionnaire with items about the compliance of the inspected RLA with the quality indicators

The list of quality indicators of RLA must be presented in the form of a questionnaire for a survey of the RLA experts. It contains sections and questions within them. The expert group develops this questionnaire and includes in it all the necessary indicators of quality, which the inspected RLA must conform.

The table of pairwise comparisons must be composed for items of the questionnaire in matrix form A_{ij} (i=[$1;n$], j=[$1;n$], n – number of items in the questionnaire). The matrix A_{ij} shows the importance of items regarding each other. The expert group builds it from assessments of significance (numbers). The assessments of significance are corresponding to the opinion about item from the questionnaire. It’s given in table I.

Table 1. Scale for composing a table of pairwise comparisons of questionnaire items

Assessments of significance	Opinion about questionnaire item	Comments
1	No superiority	Items have equal weight
3	Slight superiority	The superiority of one item over another is slight
5	Significant superiority	There are convincing arguments for the superiority of one item over another
7	Obvious superiority	There are many convincing arguments for the superiority of one item over another
9	Absolute superiority	The superiority of one item over another is absolute and undoubtedly
2, 4, 6, 8	Intermediate values	-

Coefficient of consistency *Io* and relation of consistency *Os* must be calculated after composing a table of pairwise comparisons of the questionnaire items for determine the consistency of the resulting matrix. The following formulas are used to calculate these values:

$$Io = \frac{\lambda_{\max} - n}{n-1}, \tag{3}$$

$$Os = \frac{Io}{M(Io)}, \tag{4}$$

where *M(Io)* – the average value of the coefficient of consistency for randomly composed table of pairwise comparisons (determined experimentally); λ_{max} –maximum eigenvalue of pairwise comparisons table; *n* – number of items in the questionnaire.

If calculated value *Os* is *≤0,1* then the table of pairwise comparisons is consistency and can be used for further calculations in the algorithm. Else errors were made when the table of pairwise comparisons was composing and it can't use for further calculations in the algorithm. The table of pairwise comparisons must be recomposed to improve of consistency.

5. Calculating weights of the questionnaire items

The modified table $A' = a_{x'y'}$ is use for calculation the weights of the questionnaire items. *A'* must be calculated by virtue of the table of pairwise comparisons by the following formula:

$$a'_{x'y'} = \begin{cases} \dfrac{100}{a_{xy}+1} \cdot a_{xy} & \forall x < y : x' = x, y' = y \\ 1 & \forall x = y : x' = y' = x = y \\ \dfrac{100}{a_{xy}+1} & \forall x < y : x' = y, y' = x \end{cases}, \tag{5}$$

where $x=y=[1;n]$, *n* – number of items in the questionnaire.

The weights of the questionnaire items P_x ($x=[1;n]$) must be calculated by the following formula:

$$P_x = \frac{\widetilde{P}_x}{\sum_{x=1}^{n} \widetilde{P}_x}, \tag{6}$$

where

$$\widetilde{P}_x = \sum_{y'=1}^{n} a'_{x'y'}, (x' \neq y'); \qquad \sum_{x=1}^{n} \widetilde{P}_x = 1 \,. \tag{7}$$

6. Scale grading

The five-point numerical scale is proposed to be used in this algorithm to questionnaire survey the expert group on the quality indicators of RLA. The selected five-point grading scale is easy to use and the obtained measurement results are informative enough. A smaller grading of scale does not provide sufficiently complete information about the concordance of the RLA with the quality indicator. A bigger grading of scale encumbers, complicates and slows down the calculation of the algorithm for the quality assessment of RLA. But in practice in specific situations the grading scale can be expanded or narrowed if experts will deem it necessary.

7. Definition fuzzy etalons of the RLA quality

The experts should determine the semantic content of the result of the quality assessment of the RLA. It should characterize the RLA as a whole. Obviously, it is not enough to say that the RLA is "bad" or "good." The semantic load of a linguistic variable is inversely related to the accuracy from the formulation of its terms and it must be taken into definition of fuzzy etalons.

The base term-set $T_{RLAQuality} = \{T_i\}$ (i =[1;L]; L – the number of terms that are used as fuzzy etalons) must be defined directly to define the linguistic variable “RLA Quality”. After defined the linguistic variable the universal set $X_{RLAQuality}$ must be defined for define these fuzzy etalons and build their membership functions.

It is proposed to set the base term-set of the linguistic variable “RLA Quality” in following terms:

$T_{RLAQuality} = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7\}$ ={“very low quality of RLA” (VLQ RLA), “low quality of RLA” (LQ RLA), “average quality of RLA” (AQ RLA), “steady quality of RLA” (SQ RLA), “normal quality of RLA” (NQ RLA), “high quality of RLA” (HQ RLA), “very high quality of RLA” (VHQ RLA)}

The construction of the etalon fuzzy numbers is performed using one of the methods for constructing the membership function. As a result, we obtain the following etalon fuzzy numbers:

VLQ RLA = {1/1; 2/0,8; 3/0,1; 4/0; 5/0};

LQ RLA = {1/0,8; 2/1; 3/0,2; 4/0,1; 5/0,1};

AQ RLA = {1/0,6; 2/0,7; 3/0,6; 4/0,3; 5/0,2};

SQ RLA = {1/0,2; 2/0,4; 3/1; 4/0,6; 5/0,4};

NQ RLA = {1/0,1; 2/0,2; 3/0,6; 4/0,9; 5/0,7};

HQ RLA = {1/0; 2/0,1; 3/0,2; 4/1; 5/0,9};

VHQ RLA = {1/0; 2/0; 3/0,1; 4/0,9; 5/1}.

Thus, in accordance with the Mamdani algorithm, a fuzzy subset is obtained. It allows you to fuzz each input value – expert assessment in five-point scale. The output variable is also defined. It contains 7 fuzzy terms.

8. Questionnaire survey of the expert group

In the questionnaire survey of the expert group each expert of the group must indicate in points from 1 to 5 the compliance of the inspected RLA to each of the items from the questionnaire. Questioning can be conducted in person or in absentia. Both paper and electronic questionnaire can be used.

9. Calculation the fuzzy term that characterizes the RLA quality

In the next step some fuzzy number is calculated. It characterizes the combined assessment of the experts group from N people on the i-th indicator of the RLA quality. It must be calculated by the following expression:

$$X_i = \sum_{j=1}^{N}(X_{ij}W_j), \tag{8}$$

where X_{ij} – assessment of the j-th expert of compliance with the RLA to the i-th quality indicator; W_j – weight of opinion of the j-th expert of the group (*j=1..N*); *N* – number of members of the expert group.

The resulting values $X_i \in [\underline{X}_i, \overline{X}_i]$ are converted into the corresponding elements $X_i^* \in [0, L-1]$ by the following expression:

$$X_i^* = (L-1)\frac{X_i - \underline{X}_i}{\overline{X}_i - \underline{X}_i}. \tag{9}$$

where $[\underline{X}_i, \overline{X}_i]$ – parameter X_i (*i*=[*1..q*]) range; $\underline{X}_i = 0, \overline{X}_i = M_i$; M_i – maximum possible score on a scale; L – number of etalons.

Such the calculation makes it possible to present the obtained values in projection to the etalon numbers.

Further, in accordance with the Mamdani algorithm, the composition of fuzzy numbers, which correspond to the answers of the expert group, is calculated by following expression:

$$\mu = \bigcap_{i=1}^{q} X_i^*. \tag{10}$$

Note that the defuzzification of the obtained fuzzy number is not required, because the final result is required to be obtained in a fuzzy form. The resulting fuzzy term is calculated as the minimum difference between the found fuzzy number μ and the etalon fuzzy numbers by the following expression:

$$\sigma = \bigvee_{j=1}^{L}(\mu - T_j), \tag{11}$$

where $j = [1, L]$ – term number from base term-set *T*.

Choose the minimum from the differences between fuzzy number μ and the etalon fuzzy numbers. The term, which corresponds to this minimum difference, determines the quality of the inspected RLA.

10-11. Using a text analyzer to inspect the RLA text

The choice of a text analyzer to inspect of the RLA text is made by the expert group. Every present text analyzer has drawbacks. Therefore, it is better to use all available text analyzers to find the maximum amount of text errors.

12. Translation of the results of the inspection of the RLA text to a fuzzy view

After analyzing the RLA text using a text analyzer, the result of the analysis should be presented in the form of a fuzzy term. This is necessary to compare the result of the inspection of the RLA text with the fuzzy term, which was obtained from the results of the questionnaire survey of the expert group and which characterizes the RLA quality on the quality indicators. This is done by projecting the result of the analysis of the RLA text on the corresponding value of the linguistic variable that characterizes the RLA quality. The chosen projection method depends on the form of presentation of the result of the analysis of the RLA text. If several analyzers are used, the results of each analyzer are projected separately. Thus, the number of obtained linguistic terms is equal to the number of analyzers used to analyze the RLA text.

13. Calculation of the resulting quality assessment of the RLA

The resulting quality assessment of the RLA is calculated from the assessment of the RLA quality, which was calculated from the results of the questionnaire survey of the expert group, and the results of the inspection of the RLA text by text analyzers.

To find the resulting quality assessment of the RLA, each term of the linguistic variable, which characterizes the quality assessment of the RLA, is matched with an integer number V_i (i=1..7) by the following scheme:

V_1 (VHQ RLA) = 3;

V_2 (HQ RLA) = 2;

V_3 (NQ RLA) = 1;

V_4 (SQ RLA) = 0;

V_5 (AQ RLA) = -1;

V_6 (LQ RLA) = -2;

V_7 (VLQ RLA) = -3.

We find such a number for each of the quality assessment of the RLA obtained earlier.

V^0 – the assessment of the RLA quality, which was calculated from the results of the questionnaire survey of the expert group;

V^i – the results of the inspection of the RLA text by text analyzers ($i=1..K$; K – the number of text analyzers that were used to analyze the RLA text).

The resulting number V is calculated as the arithmetic average of the numbers V^j ($j=0..K$) and rounded to an integer. The resulting number is found among the numbers V_i. The linguistic term that matches to the found control number is the resulting quality assessment of the RLA.

3. Automation of the proposed algorithm

The quality assessment of the RLA in accordance with the proposed algorithm is a long, time-consuming process and requires processing a huge amount of data. Therefore, it is necessary to automate it. For this purpose, the software “Automated system for quality assessing of RLA” [2] (ASQAofRPA) was created. This software allows you to conduct a comprehensive quality assessment of the RLA on the required indicators of the RLA quality and evaluates qualification of the RLA expert by the algorithm of the selection of an expert to the RLA expert group. In detail ASQAofRPA and the example of its use are described in the work [3].

4. Conclusion

The proposed algorithm allows the processing of a large amount of fuzzy information, which is presented in the form of the results of the questionnaire survey of the expert group, and as a result gives a clear concise text result in the form of a fuzzy term. This is achieved by using the tools of fuzzy mathematics and processing the opinions of experts in this field with their help.

The algorithm described in this article was developed in the framework of a new scientific discipline – jurismetreo [4]. The task of jurismetreo is to measure legislation, its quality and completeness.

References

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