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ALECU IONEL CIPRIAN[1] Points of view

CONSIDERATIONS ON THE DEVELOPMENT OF THE QUALITATIVE TECHNIQUES IN MANAGEMENT PROCESSES BY USING TRIANGULAR NUANCED NUMBERS

Abstract

The knowledge-based society needs new methods and instruments for a superior processing of the increased amount of data. In the case of qualitative methods based on reasoning that are used in management in knowledge-based society, the accent is put on the experience and professional quality of top managers to be able to anticipate economic, social and technological events that impact the organization We consider the utilization of elementary nuanced numbers would represent a major step forward in the development methods for the evaluation of attributive characteristics. A new mathematics is needed based on fuzzy number classes, with complex presentations and specific operations. A special advantage for the knowledge-based society could be the development of decision-assisting software with fuzzy numbers

Keywords: *uncertainty, decision making, nuanced (fuzzy) numbers, Delphi technique*

1. Introduction

A complex strategic approach in the management of the knowledge-based organization involves a set of interactive methods and techniques aimed at eliciting forecasts from groups of experts intended to provide assessments and analyses of important transformations that may occur in a particular area and predict fundamental development trends of the broader environment.

In the knowledge-based society, many decisions rely on a database of information which tends to be ever more extensive and difficult to identify, obtain and fully control. The weaknesses of the underlying information database are transmitted as errors in short-term forecasting, at the research proposal stage, and are amplified as they aggregate at market level.

The quality of information in socio-economic research is also influenced by the fact that, on the practical level, rational situations coexist with situations characterized by various levels of irrationality, assessed from multiple perspectives.

Usually, in the activities of an organization management, two clear-cut directions are in focus: forecasting contextual developments (based on statistical and probabilistic analyses, the Delphi method, cross-impact matrix, scenario method, enterprise modeling, etc.) and preparing for decision-making situations (procedures for tracking changes in the environment, computer-based management systems, market research, etc.).

Increasingly, the focus is on a multidisciplinary and interdisciplinary approach to information management in order to enable an as vast as possible coverage of a topic according to the emerging necessities of socio-economic life. Moreover, there is particular interest in methodological borrowing from other sciences so as to enable the broadening of the examined phenomena.

[1] Researcher, PhD, Romanian Academy, Iasi Branch, "Gh. Zane" Institute of Economical and Social Researches, e-mail- aiciprian@yahoo.com

The focus on interdisciplinary approach results in the expansion of analysis tools by borrowing methodology and can be easily achieved by using fuzzy numbers. From an epistemological point of view, we can argue that fuzzy numbers play a distinct role owing to the contribution to the study of socio-economic phenomena, the laws that govern them, their uncertainty and risk of their occurrence, the analysis of the performance of strategies and implemented programs etc.

In this respect, from an epistemological perspective, a major step in developing qualitative assessment methods for residual uncertainties is the use of elementary nuanced/ fuzzy numbers

In this article, we will explore the use of elementary fuzzy numbers. By associating an elementary triangular fuzzy number[2] to an attributive characteristic that incorporates other complementary elements of the research we believe that it is possible to define/characterize a much more complex picture, with a high degree of comparability.

2. Considerations regarding the use of nuanced numbers in management of knowledge-based organizations

The major advantage of data organization in a knowledge-based society is that its underlying principles lead to a high level of accessibility of data for any person, even though sometimes it is provided for a fee. The main limitations observed consist in:

- it is a static image specific to a particular well-defined time and space
- high degree of specialization of results and difficult to extrapolate
- limited degree of applicability to research
- they provide a point of view most often grounded on extreme cases
- high degree of perishability, as data becomes vague and outdated.

In the knowledge-based society, a special place is occupied by formal information which is the result of various studies, reports or documents with a specific purpose within hyper-specialized research. Although such results are usually contingent and complementary, we would like to emphasize their importance because specialists consider them to be much more valuable and operational. At the same time, this category of information is difficult to secure, being much less public and accessible, and often available for a fee.

Furthermore, the degree of authenticity and the alethic character of information are directly influenced by the nature and quality of the channel through which it travels from the source to the end user.

Why nuanced numbers and not fuzzy numbers or fuzzy sets? We will not embark on an epistemological debate, but rather a more pragmatic one, which we argue will be required, in time, due to the technology transfer of basic fuzzy numbers into various fields. This trend is very topical and aims to expand classical techniques by means of interdisciplinary approaches.

The choice of the concept of nuanced numbers is closely linked to the idea of nuanced assessment. Most experts in different fields exhibit a distant attitude to the use of the concept of fuzzy numbers, both in theoretical and practical terms. This is due to several reasons, which include the following:

• Difficulties in grasping the concept of fuzzy numbers itself;

• Psychological reservations in using fuzzy numbers;

• Difficulty understanding basic operations with fuzzy numbers;

• Reservations regarding the advantages of using elementary fuzzy numbers in the analysis of uncertainty;

[2] Ovidiu Gherasim, *Matematica numerelor fuzzy triunghiulare (The Mathematics of the Triangular Fuzzy Numbers)*, Editura Performantica (Performantica publishing house), Iasi, 2005

• Difficulty in identifying the opportunity of using fuzzy numbers, although they may view current techniques as insufficient;

• Reservations regarding the theoretical correlation between the need for multiple, varied and nuanced assessment with the use of elementary fuzzy numbers;

• Failure to implement theoretical and practical advances achieved through the use of fuzzy numbers over the last decade.

In scientific conferences, greater openness has been noted to phrases such as "vague estimates", "nuanced assessment", "multiple appraisals" etc. One could argue that the same specialists exhibit particular affinity to the concept of nuanced numbers, overcoming most of the reservations listed above.

The main proposed stages in the use of fuzzy elements in the assessment of the examined quality characteristics are: defining the framework of the problem to be analyzed, identifying alternative characteristics, assessing data and formalizing information using basic fuzzy numbers (which involves identifying alternative ways of quantitative and qualitative data assessment, of their uncertainty and subjectivity, determining the best method of coding information based on fuzzy numbers, formalizing the uncertainty of information), determining the criteria to be used in information processing (identifying the best methods for establishing an optimal level, ranking criteria), selecting the mode of consolidating knowledge and the delivery of conclusions, feedback on the results.

The representation of the qualitative characteristics through fuzzy (nuanced) numbers is not exactly a novelty. In this regard we shall remind the fact that various proposals (as shape and operability) were developed by Zadeh (1975), V. Georgescu (1995), Tamura Hatono and M. Umano (1998), Gil Aluja and Teodorescu (1998), Lazzari and Martinez Panero (2001), Garcia-Lampresta and L. Lamazares (2003), O. Gherasim (2006).

One of the most engaged representations of the qualitative assessments structured on a scale of 1 to 5 by employing elementary triangular fuzzy numbers has the following pattern[3]:

Very little	VL	0.0	[0.00, 1.00, 3.00]
Little	L	2.5	[1.00, 3.00, 5.00]
Medium / Moderate	M	5.0	[3.00, 5.00, 7.00]
Big	B	7.5	[5.00, 7.00, 9.00]
Very big	VB	10.0	[7.00, 9.00, 10.00]

Extremely useful in the case of the economic processes is also the representation of the imprecision through fuzzy numbers as Left/Right[4]. However we regard this point of view as non-applicable in the case of multiple qualitative assessments, unless it is undertaken a further encoding and editing process[5].

[3] Ciprian Ionel Alecu, „*Error analisysis in Management Processes Using Fuzzy Numbers",* in N. Gavriluta and P. Dunca (ed.) *Knowledge and Action within the Knowledge Based Society*, Institutul European (European Institute publishing house), Iasi , 2011, 231

[4] Antonio Maturo, „Alternative Fuzzy Operations and Social Sciences," *International Journal of Intelligent Systems*, Vol. 24 (2009): 1234-1264

[5] Ioan Tofan, Tehnici de matematica nuanţată (Techniques of Gradated Mathematics) ,Iaşi, 2011

Considering the particularity of the matter we shall apply to the definition way of the operations developed by Gherasim through the elementary fuzzy arithmetic[6].

Let's take 2 triangular fuzzy numbers X, Y $\in F_{TR}$, given by $X=[L_x, M_x, R_x]$, respectively $Y= [L_y, M_y, R_y]$.

The centre of weight associated with a triangular nuanced number is being defined:

$$G(X) \ = < V > = \frac{L_x + 2 * M_x + R_x}{4}$$

The main operations with triangular nunaced numbers

- Addition : $X (+) Y= [L_x+L_y, M_x+M_y, R_x+R_y]$
- Multiplication: $X (*) Y= (X* <Y> +<X> * Y)/2$
- Subtraction: $X (–) Y = X+(-1)*Y=[L_x-L_y, M_x-M_y, R_x-R_y]$
- Division: $X (/) Y= (X* <Y> +<X> * Y)/(2<Y>^2)$

Observations:

- The laws of composition are stable;
- By composing 2 triangular fuzzy numbers a triangular fuzzy number will be obtained (even by multiplication);
- It can also be obtained a group of assumed properties as reduced

3. General remarks regarding developing Delphi technique by using nuanced triangular numbers

The Delphi technique is an interactive group method, partially uncontrolled, in our view, that is used to determine the grounds for long-term strategies, based on the principle of intuitive thinking[7] and its improvement.

We should emphasise that practice has practice has turned it into a leading practice in modern management, particularly useful in making innovative decisions involving medium and long-term timeframes and third and fourth-degree uncertainties. Furthermore, it has been the object of methodological borrowing and interdisciplinary approaches in various fields such as marketing, sociology, psychology, politics, etc.

The method was initially devised within the RAND Corporation by Olaf Helmer and Nicholas Rescher (in order to deal mainly with strategic problems, including some related to the cold war) and subsequently developed for the broader use by international companies. Some observers argue that the name of the method (after the Oracle in Delphi) has slight ironic undertones, while others claim it is somewhat commercial.

[6] Ovidiu Gherasim, *Matematica numerelor fuzzy triunghiulare (The Mathematics of the Triangular Fuzzy Numbers),* Editura Performantica (Performantica publishing house), Iasi, 2005

[7] Yvan Allaire, Mihaela Fîrşirotu, *Management strategic*, Editura Economică, Bucharest, 1998, p. 418.

We can emphasise that the basic principles of the method[8] are considered to be achieving *mediated interaction* (through a group leader) among participants (who do not interact directly with each other), and *carrying out the process through successive iterations*, triggered by the recorded feedback on the views expressed, *filtered and mediated* through the leader's interventions (which is why we consider the process to be partly uncontrolled).

The development of the Delphi method by nuanced triangular numbers requires that the method meets certain general challenges of foresight[9] methods: organisation, divergence, convergence, assessment and achieving consensus.

It aims to achieve a degree of consensus on future events among specialists who hold expert roles or have significant experience in the analysed decision-making situation. This convergence is achieved over several stages. Certain authors focus on a condensed form entailing three or four stages, while others, for the sake of optimal explanation, develop it over seven stages.

We present below the following logically ordered structure of the Delphi method:

- The first stage consists in identifying the directions of the analysis by means of a survey of experts' opinions on the unfolding of events likely to have a marked influence on the future developments in an field of activity, and on the likelihood of these events occurring; in this respect, it is worth clarifying some key points:
  - at this stage, the group leader is established along with the decision-making problem the technique is intended to tackle;
  - the major issues that specialists from various fields need to address are defined;
  - the group of specialists providing expert opinions through the questionnaire is formed;
  - a pilot questionnaire is developed.
- The second stage (II) involves applying the questionnaire among specialists and identifying the optimal solution.

A. Issuing the questionnaire to the n experts who will provide a triple nuanced estimate regarding the decision-making problem, structured as follows:

L- representing the minimal estimate

M – the most likely estimate

R – the maximum estimate based on the data collected and own experience.

A fuzzy triangular estimate will result, expressed as $E_i = [L_i, M_i, R_i]$, i=1-n, number of experts involved in responding to the questionnaire.

B. The main convergences and divergences are calculated and identified, using the average of estimates:

- the average of iteration is determined: $M_j = (L_m, M_m, R_m)$

- the minim of iteration: $min_j = [L_{min}, M_{min}, R_{min}]$

[8] Florin Gheorghe Filip, *Decizie asistata de calculator. Metode si tehnici de asistare a deciziilor centrate pe judecata umana*, Revista Informatica Economica, nr. 3 (15)/2000.

[9] Zamfirescu Bala, C., F.G. Filip Metode de foresight in identificarea riscurilor si asistarea gestionarii lor cu calculatorul. în : Fenomene si procese cu risc major la scara nationala (Filip, F.G., B. C. Simionescu coordonatori). Ed. Academiei Romane. 2004

- the maxim of iteration : max_j= [L_{max}, M_{max}, R_{max}]

.where :

$$L_{min} = \min_i L_i \qquad L_{max} = \max_i L_i \qquad L_m = \underset{i}{Average}\, L_i$$

$$M_{min} = \min_i M_i \qquad M_{max} = \max_i M_i \qquad M_m = \underset{i}{Average}\, M_i$$

$$R_{min} = \min_i R_i \qquad R_{max} = \max_i R_i \qquad M_m = \underset{i}{Average}\, M_i$$

- the individual distances from the average expressed opinions is calculated

$$d_i = A_i - M = 1/3(|\ L_i\ - L_m| + |\ M_i\ - M_m| + |\ R_i\ - R_m|)$$

- The third stage (III) retroactively brings into discussion the points of view at the extreme opposite ends of the spectrum of expertise, based on results gathered through the pilot questionnaire, accompanied by the necessary explanations and comments.

Also, taking account of uncertainty absorption strategies at the organization level, coordinator of the group may propose for discussion an optimal solution with the following form: $M_\alpha = (L_\alpha, M_\alpha, R_\alpha)$, where α is the indicator of absorption of uncertainty[10]

The extreme points of view are analysed, being filtered and moderated by the coordinating group.

- In this stage (IV), the first steps are subsequently reiterated until the opinions on the odds of certain future events converge to a high degree; most group leaders estimate that the cycle can stop when at least 50%[11] of group members agree on the views included in the questionnaire.

For our method, if the distance between the fuzzy estimates M_{j-1} and M_j is considered to be small (meeting the objectives of the analysis), the decision is to stop the process. Otherwise, steps II and III are reiterated.

- The process is finalized and the conclusions are delivered.

The quality of decision-making options derived through this method is influenced by a range of factors, including:

- The objectivity and comprehensibility of the problem that experts are asked to analyse;
- The quality and heterogeneity of the team;
- Team members' motivation;
- The duration of stages;
- The experience and summarizing capacity and insight of the head of the investigation.

Study Case

Given the nature of the economic problems it addresses, we consider it particularly useful to use nuanced (fuzzy) triangular numbers with associated centroid[12].

By using nuanced numbers, we will cover largely the same stages as in the classical model, directly influenced by the processes of assessment and achieving consensus within the

[10] Alecu Ionel Ciprian , *Laplace Method Development using Basic Rectangular Fuzzy Numbers*, in „Economics, Management, and Financial Markets", Addleton Academic Publishers, New York, Volume 6(1), pages 487-497, 2011

[11] Ovidiu Nicolescu, Ion Verboncu, *Management*, Editura Economică, Bucharest, 1999, p. 386.

[12] Ovidiu Gherasim, *Matematica numerelor fuzzy triunghiulare*, Iasi: Editura Performantica, 2005.

method. As such, we will focus on the iterative steps and the use of nuanced triangular numbers.

Within the organization "Y", the management decided to develop a new product in the near future. This issue is sent to the development department.

We decided to use Delphi techniques. We identified a panel of experts consisting of 15 people and we sent questionnaires for assessing the indicators using a Likert scale.

After establishing the coordination group, the decision-making situation to be analysed, the expert group, the mode of interaction (issuing the questionnaire, data collection, feedback), the pilot questionnaire, we aim to develop the following iterative steps:

II. The second stage (II)

A. Applying the questionnaire among specialists

A triple nuanced estimate regarding the decision-making problem will result.

After this step we obtain the following estimate:

Table 1.

Nuanced estimation of expertise in Iteration 1

Expert E_i	The minimal estimate L_i	The most likely estimate M_i	The maximum estimate R_i
E1	44	48	54
E2	44	48	62
E3	47	51	63
E4	40	54	69
E5	56	58	64
E6	40	51	57
E7	42	48	74
E8	52	56	59
E9	55	62	66
E10	44	48	60
E11	39	53	69
E12	57	59	65
E13	41	52	58
E14	39	46	63
E15	42	48	56

B. *The main convergences and divergences*

- the average of iteration is determined: $M_1 = [45.47; 52.13; 62.6]$

- the minim of iteration: $min_1 = [39; 46; 54]$

- the maxim of iteration : $max_2 = [57; 62; 74]$

- the individual distances from the average d_i :

Table 2.

Determination of differences of opinion from the average

Expert A_i	***Distances*** **$d_i = E_i - M_1$**	*Distances* $E_i - min_1$	*Distances* $E_i - min_1$
E1	4.73	2.33	15.67
E2	2.07	5.00	13.00
E3	1.02	7.33	10.67
E4	4.58	8.00	10.00
E5	5.93	13.00	5.00
E6	4.07	3.00	15.00
E7	6.33	8.33	9.67
E8	4.67	9.33	8.67

E9	7.60	14.67	3.33
E10	2.73	4.33	13.67
E11	4.58	7.33	10.67
E12	6.93	14.00	4.00
E13	3.07	4.00	14.00
E14	4.33	3.00	15.00
E15	4.73	2.33	15.67

It is noted that the more moderate views are expressed by the experts E3, E2, E10 and E15. Major differences are obtained for E9, E12, E 7 and E5.

III. The third stage (III) - the extreme points of view are analyzed, being filtered and moderated by the coordinating group.

Then it repeats the questionnaire, repeating step II and III.

We obtain the following evaluation of the second iteration:

Table 3.

Nuanced estimation of expertise in Iteration 2

Expert E_i	The minimal estimate L_i	The most likely estimate M_i	the maximum estimate R_i
E1	44	48	54
E2	44	48	62
E3	47	51	63
E4	40	54	69
E5	56	58	64
E6	40	51	57
E7	42	48	74
E8	52	56	59
E9	55	62	66
E10	44	48	60
E11	39	53	69
E12	57	59	65
E13	41	52	58
E14	39	46	63
E15	42	48	56

Based on the current iteration, we obtain the average M_2 = [40.00; 44.87; 54.07].

Compared to M_1, we observe significant changes in the assessments provided by experts. Values for individual distances decreased in iteration 2.

Performing calculations for the 3rd iteration, we get an average M3 = [41.12; 43.54; 51.31], which can be considered by group coordinator approximately equal to M2. This may go to completion of the data transmission.

The simultaneous analysis of unfavorable views, of optimistic opinions and respectively of estimates regarded as the most plausible provide management with a more complex analysis entailing rather equal effort.

Conclusions

As can be noted, by using fuzzy numbers, the process is not a demanding compared to the classical form, but enables a more detailed snapshot of the decision-making process.

By using fuzzy numbers it can provide numerous advantages as follows:

- Leveraging the professionalism and experience of a sizeable team and of a panel of specialities within the organisation;
- Reducing a large number of uncertainties and information incompleteness;
- Engaging in decision-making and raising the interest of an increasing number of specialists;
- Formulating innovative medium and long-term decision-making directions and analysing them thoroughly by reviewing at various aspects.

The limitations of this method stem from the effort made in terms of the material and financial resources involved, the time it requires, and ensuring the major commitment of the participating professionals, on the one hand, and from the difficulty to precisely definition of the problem, the gap between the actual and ideal situation, on the other hand.

We consider that this addresses more optimally the need to absorb uncertainties which occur in the case of strategic decisions.

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