A FUZZY LOGIC MODEL FOR EVALUATING THE MOTIVATION FOR HIGH-QUALITY PUBLICATIONS: EVIDENCE FROM A BULGARIAN UNIVERSITY

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Abstract

This paper proposes a fuzzy logic model for evaluating the level of stakeholder motivation for high-quality publications. Conceptually, the model is based on stakeholder theory and Vroom's expectancy theory of motivation. Instrumentally, tools of fuzzy sets, fuzzy logic, and expert evaluations are at its core. The model is suitable for any university. Further, it reflects university specificity, using specific motivational factors in one of the evaluation procedures. The model easily evaluates the level of motivation by processing vague, subjective perceptions. It was applied at a Bulgarian university through a comprehensive survey that included 106 participants and performed well. The model contributes to the advancement of management science by theoretically enriching research management and organizational behaviour and complementing their tools. Expected practical implications are improved university management and higher scientific results based on well-grounded decisions about research, people, and performance.

Key words: *research management, motivation, fuzzy logic, evaluation, model, high-quality publications, university*

1. INTRODUCTION

The quality of scientific publications is a crucial hallmark of academic excellence and prestige for researchers and universities (Atieno et al., 2021; Matveeva et al., 2021; Raitskaya & Tikhonova, 2020). Nowadays, quality publications have become the prime measure of research performance (Bak & Kim, 2019; Jaskiene & Buciuniene, 2021; Vogel & Hattke, 2018). Some authors designate research quality as a vital source of benefits for organizations, industries, economies and society (Belcher et al., 2020; McLean & Sen, 2019; Stoyanov, 2014; Vorontsova et al., 2020). Despite the undeniable importance of research quality, there is no agreement on what is meant by 'quality publications' (Belcher et al., 2016; Cruz-Castro & Sanz-Menendez, 2021; Matveeva et al., 2021; McLean & Sen, 2019). Kirillova (2021), Vogel & Hattke (2018) refer them to peer-reviewed journals, Raitskaya & Tikhonova (2020) to high-tier and well-established journals, Ebadi & Schiffauerova (2016) to high-quality journals. In this paper, publications in Web of Science (WoS)/Scopus-indexed journals are considered a key criterion for research quality and are entitled 'high-quality

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publications'. This designation distinguishes them from publications in journals from secondary databases (EBSCO, ProQuest, etc.), among which there are also quality ones. Besides, publications in the WoS/Scopus journals from quartiles Q1 and Q2 are considered top-quality ones.

A vital prerequisite for improving the quality of research production is motivating stakeholders (Kang et al., 2021) to contribute to high-quality publications. Modern management science has perceived the classic notion that "improvement cannot be achieved without measurement" (Cournot, 1847) as a guiding principle. In the social sciences, including management, measurement inevitably involves evaluating subjective perceptions. In this regard, the WoS and Scopus literature was reviewed on the topic of motivation for high-quality publications, looking primarily for evaluation models. What was found? First, there were few publications on this topic. Second, several motivational factor models were found, but not models for evaluating the level of motivation for high-quality publications. The researchers (Erez & Shneorson, 1980; Lambovska & Todorova, 2021; Lambovska & Yordanov, 2020; Lee et al., 2016) focused on motivational drivers, measuring their levels, but not the overall level of motivation. A fuzzy logic model for the motivation evaluation process was also found (Yeheyis et al., 2016). Based on an analysis, the model was considered inadaptable to the topic of motivation for high-quality publications. Third, stakeholder and process approaches were rarely applied to the topic. Therefore, the main conclusion is that it is necessary to create a model for evaluating the level of motivation for high-quality publications, consistent with the object of its application - the specific university.

Motivation is considered one of the most elusive concepts of the social sciences (Dörnyei & Ushioda, 2021). This specificity stems from subjective individual perceptions of quality motivational drivers. It predetermines several *requirements* for the evaluation model, most of which are methodological. The need to use expert evaluations comes *first*. It derives from the inability to generate statistical evaluations due to the lack of both objectivity and sufficient retrospective data. Some authors (Lee et al., 2016; Ramlall, 2004) believe that conventional (statistical) approaches are not suitable for motivation evaluation because of their strong methodological limitations. However, unequivocal perception of the level of motivation implies its description both quantitatively and qualitatively. Thus, the *second* requirement is the simultaneous generation/processing of qualitative and quantitative motivation evaluations. The second requirement results in the *third* - to establish quantitative and qualitative scales of variables and evaluation rules. In addition, expert evaluations are often accompanied by "subjective uncertainty" due to the experts' lack of confidence in these evaluations or lack of knowledge (Oberkampf, 2002). Thus, crisp (discrete) values are inaccessible and impossible to apply in human decision-making under uncertainty (Aggarwal, 2021). That presupposes an imprecise (interval or fuzzy) description of quantitative evaluations. This gives rise to the fourth and fifth requirements. The *fourth* is the need to consider the deviation intervals of expert evaluations. The *fifth* is the need to consider the degree of hesitation of experts on their evaluations. In addition, a prerequisite for generating well-founded motivation evaluations is taking into account the process of their formation, the *sixth* requirement for the model. In addition, the model should be simple and easy-to-use

in practice, the *seventh* requirement for the model.

Based on this background, the following *research questions* arise:

1. What is the reasoning behind the methodological framework of the model for evaluating the level of motivation for high-quality publications?

2. How can the tools of this model be applied to its conceptual basis, while also considering university specificity?

This paper provides answers to these questions. It aims to propose a model for evaluating the level of motivation for high-quality publications by applying the stakeholder approach, expert evaluations, and fuzzy logic to Vroom's expectancy theory. The model is of a general nature and is suitable for any university. At the same time, the model allows considering university specificity by using a specific motivational factor model in one of the evaluation procedures.

Conceptually, this model is based on Vroom's expectancy theory of motivation and stakeholder theory. Vroom's expectancy theory is the classic process theory of motivation. Its application meets the sixth requirement for the model. The logic, simplicity and quantification potential of Vroom's theory (Erez & Shneorson, 1980; Osafo et al., 2021) were paramount to shaping the conceptual framework of this model. These merits contribute to fulfilling the seventh requirement. The stakeholder approach makes it possible to determine and reckon the motivations of all stakeholders to increase the quality of publications. Research shows that relationships based on the stakeholder theory create more value for all participants, including in higher education (Langrafe et al., 2020; Nedelko et al., 2017; Perig, 2018).

Instrumentally, the theories of fuzzy sets and fuzzy logic and the method of expert evaluations are at the heart of this model. By applying tools of fuzzy set theory, the model reflects (subjective) uncertainty (fourth and fifth requirements), processing both quantitative and qualitative evaluations with immediate transitions between them (second requirement). Fuzzy logic is applied in this model as a tool for generating motivation evaluations, qualitative and quantitative (fuzzy/discrete), overcoming the inability to use statistical approaches. Thanks to it, this model meets all the requirements at once. The subjectivity of motivation predetermines the use of expert evaluations (first requirement).

This paper consists of seven sections. Section 1 presents the topicality and the research framework of this study. Section 2 analyses works related to this topic. Section 3 outlines the methodological frameworks of the proposed model. It also responds to research question 1. Section 4 describes the model, responding to research question 2. Section 5 presents the application of the model at a Bulgarian university. Section 6 discusses the contributions and advantages of this model. Section 7 covers concluding remarks and ideas for future research.

2. RELATED WORKS

Related works, identified in Web of Science (WoS) and Scopus before March 2022 are analysed here. Combinations of the following keywords were searched: 'motivation', 'Vroom/expectancy theory', 'research/science management', 'fuzzy', 'researcher', 'scientist', 'academic', 'scholar', 'evaluation', 'assessment', 'estimation'.

A total of 1725 papers were retrieved. They were analysed for compliance with the research topic, objectives and/or tools of this study, using the method of expert evaluation and the structural approach. As a result, 5 full-text papers were found relevant to the study (Table 1).

Table 1. Specifics of related research - in WoS and Scopus

Reference	Content	Motivation theory	Tools	Research object	Nature
	1	2	3	4	5
Erez & Shneorson (1980)	Explores the differences between the motivational drivers of academics and professionals in the same occupation	Holland's theory of personality type, Vroom's expectancy theory	MANOVA, Discriminant analyses	Israeli researchers in engineering and management	Specific, (country, community)
Lambovska & Todorova (2021)	A model for factors influencing researchers for top-quality publications	Several, including Vroom's theory	Expert evaluations, Analysis/ Synthesis, Induction/ Deduction	Bulgarian internal university stakeholders: Top management, Department heads, Researcher	Country specific
Lambovska & Yordanov (2020)	A systematic literature review on researchers' motivation for high-quality publications	None	Structured approach, Content analysis, Descriptive statistics	Researchers	General
Lee et al. (2016)	Explores levers to motivate knowledge workers to create organizational value within four organizational cultures	Several, including Vroom's theory	Fuzzy-set qualitative comparative analysis	American business college academics	Specific (country, culturally, community)
Yeheyis et al. (2016)	A fuzzy rule-based model for evaluating motivation of construction workers using their working pattern	Vroom's theory	Fuzzy logic	Canadian carpentry construction workers	Specific (country, community)

Source: Author.

Based on the content analysis, several *specifics* of the related works were identified (Table 1):

- Content (column 1): Related works address two topics: motivational factor models (Erez & Shneorson, 1980; Lambovska & Todorova, 2021; Lambovska & Yordanov, 2020; Lee et al., 2016) and the process of motivation evaluation (Yeheyis et al., 2016). The first topic concerns the application of this model as it generates evaluations on two input variables employing specific motivational factors. The second topic coincides with the topic of this paper.

- Motivation theory (column 2): Four papers refer to Vroom's expectancy theory, but two (Erez & Shneorson, 1980; Yeheyis et al., 2016) are based entirely on it. No motivation theory is used by the fifth paper (Lambovska & Yordanov, 2020) as it is a literature review.

- Tools (column 3): Two papers employ fuzzy data processing tools. Only one paper (Yeheyis et al., 2016) is relevant to this study, because it uses fuzzy logic as an evaluation tool.

- Research object (column 4): Only Lambovska & Todorova's (2021) paper addresses more than one stakeholder, namely three internal university stakeholders. Yeheyis et al.'s (2016) research object, carpentry construction workers, is outside the scope of this study. The other three papers cover only the researcher stakeholder.

- Nature (column 5): Except for theoretical ones, motivational factor models are usually (country, community-, culturally-) specific (Lee et al., 2016; Raitskaya & Tikhonova, 2020; Vogel & Hattke, 2018). In this regard, four papers were considered specific, and only the literature review by Lambovska and Yordanov (2020) - general.

Given these specifics and the research questions raised here, it is worth analysing only Yeheyis et al.'s (2016) model for applicability to this topic. The main advantage of Yeheyis et al.'s paper is the excellent argumentation of Vroom's theory and fuzzy logic, respectively, as a conceptual framework and instrumental basis of their model. Yeheyis et al. (2016, pp. 863-864) typify the basic idea of Vroom's theory about "the relationship between individual effort, individual performance, and the desirability of results" as a "logical, rigorously tested, and working conceptual base for understanding motivation". Yeheyis et al. (2016, p. 865) precisely formulate as a key advantage of fuzzy logic its applicability to "deal with real-world problems in complexities/uncertainties, describe nonlinear relationships using simple rules, formalize the reasoning process of human language using fuzzy tools, incorporate expert opinions with real data". Besides, these authors substantiate the combination of Vroom's theory and fuzzy logic very well, referring to the weaknesses of traditional tools and literature gaps.

In the context of this study, four shortcomings of Yeheyis et al.'s model were found. First, the motivational factors used in their model as input variables are community-specific to construction. Yeheyis et al. (2016, p. 870) argue that "other relevant input variables need to be identified for industries with very different work environments". Scientific publishing is one of these industries. Second, their model covered one stakeholder. Third, it is not clear how the

indicators of Vroom's theory (expectancy, valence, instrumentality) are integrated into their model. Fourth, factors influencing motivation, but not its level, are evaluated in their model, despite the authors' claims to the latter. The proof is the procedure 'selection of factors maximally influencing motivation'. Another proof is provided by Yeheyis et al. (2016, p. 870), defining their model as "…a complementary tool to EIV model and motivational analysis in construction". In summary, Yeheyis et al.'s model is not suitable for application to this topic.

Based on the analysis of related works, the following conclusions were drawn:

1. Vroom's expectancy theory is rarely applied to research management.
2. At present, fuzzy logic is not yet applied in research management to evaluate motivation.
3. On this topic, only motivational factor models were found in the WoS and Scopus literature.
4. Except for the review-based one, all models are country/community-specific.
5. Most of the models refer to one stakeholder, the researcher.
6. The WoS and Scopus literature lacks models for evaluating the level of motivation in research management, including for high-quality publications.

3. METHODOLOGICAL FOUNDATIONS

3.1. Conceptual foundations

Vroom's expectancy theory is widespread in management (Chopra, 2019) mainly due to its ability to clarify the process of motivating and easily measure motivation. It is based on the idea "that people choose in a way that maximizes subjective expected utilities" (Vroom, 1964, p. 19). In other words, "individuals have expectations for the outcomes of their behaviors in that they are motivated by the perceived probability of success and the incentive value of such success" (Chan et al., 2018, p. 3; Lewin, 1938). Therefore, motivation is a function of several variables describing elements of the 'effort-performance-outcomes' relation (Chan et al., 2018; Simeonov, 1997). Mathematically (equation 1), motivation (M) is determined by multiplying three indicators: expectancy (E), valence (V), and instrumentality (I) (Locke & Latham, 1990, p. 241; Vroom, 1964, p. 20-22):

$$M = E \times \sum_{k=1}^{n} (V_k \times I_k) = E \times PR,$$

where PR, k ($k \in [1, \cdots, n]$), $\times$, $\in$ denote respectively preference, outcome, product, 'belong'.

The role of these indicators in the process of motivation formation is explained by literature as follows:

- Expectancy addresses the 'effort-performance' relation and shows the expectations for the effectiveness of the individual's efforts, i.e. that the efforts will result in the intended performance.
- Instrumentality addresses the 'performance-outcomes' relation and reflects the belief that "the intended performance will lead to the desired outcomes" (Simeonov, 1997, p. 27).
- Valence refers to "individual's affective orientations toward particular outcomes" (Vroom, 1964, p. 15). It shows the anticipated satisfaction of an outcome.
- Preference describes desirability. The degree of preference is "the strength

of desire or aversion for outcomes" (Vroom, 1964, p. 15). The term 'preference', equation (1), is used here to denote "the algebraic sum of the valences of all outcomes weighted by the instrumentality to achieve these outcomes" (Erez & Shneorson, 1980, p. 99).

Mathematically, expectancy and instrumentality vary from 0 to 1 (E, I ∈ [0;1]), and valence, preference, and motivation from -1 to +1 (V, P, M ∈ [-1;1]).

The essence of *theory of stakeholders* is formulated by Freeman (2015, p. 32) as follows: "Organizations must bear in mind the different perspectives and expectations of a variety of constituents, called 'stakeholders', who can influence the outcome of the organization". Applying stakeholder theory to this topic stems from the different content of motivation for high-quality publications for individual stakeholders. For researchers, this is motivation to increase high-quality publications, and for all other stakeholders - motivation to influence researchers to increase high-quality publications. Consequently, motivational factors differ by stakeholder type, and models that describe them must be applied separately for each stakeholder.

In *response to research question 1*, the following arguments stand behind the *conceptual framework* of this model:

- Arguments for applying Vroom's theory:
  - It provides a clear and logical description of the process of motivating (sixth requirement).
  - It has a high quantification potential.
  - It is simple and easy-to-use (seventh requirement).
- Arguments for applying the stakeholder approach: It enables a simultaneous evaluation of the motivation level of all stakeholders, taking into account differences in their motivational factors.

3.2. Instrumental foundations

Fuzzy set theory was designed by Zadeh (1965, p. 339) as "a conceptual framework that provides a natural way of dealing with problems under the ambiguity of imprecision." It is considered an analogy of the theory of probabilities for processing subjective and qualitative information under uncertainty (Gil-Aluja, 2014). Fuzzy sets and numbers are its main *tools*. The fuzzy set is a "subset of the universal final set, characterized by a membership function which associates each element of the subset with a real number in the interval [0; 1], describing the degree of membership of each element to that subset" (Zadeh 1965, p. 339; 1975). The fuzzy set characterizes by a supporting (confidence) interval for each degree of membership in the range [0; 1] (Bojadziev & Bojadziev, 2007; Marasini et al., 2017). Fuzzy numbers are fuzzy sets with normalized and convex membership functions (Bojadziev & Bojadziev, 2007). In this model, the output (motivation evaluations) is described by fuzzy sets and the input data and possible scale values by fuzzy numbers. Algebraic operations with fuzzy numbers and confidence intervals are employed to quantify scales.

Fuzzy logic is a logical system based on fuzzy set theory. Zadeh (1975) developed fuzzy logic to create models for rational decision-making under uncertainty, subjectivity, and imperfection. To handle uncertainty, fuzzy logic extends the concept of Boolean logic (Yeheyis et al., 2016), wherein the value of logical variables is either 0 or 1.

According to Zadeh (2008, p. 2753), "fuzzy logic is a precise logic of imprecision and approximate reasoning," in particular, "a novel method for computing and reasoning with words." Linguistic variables, fuzzy (logical) rules and the fuzzy decision table are the fuzzy logic *tools* (Zadeh, 1975). Linguistic variables are "variables whose values are words and sentences in natural or artificial language" (Zadeh, 1975, p. 411). Their possible values (called 'labels' below) are quantified by fuzzy numbers, as people understand the meaning of words differently. Fuzzy rules use logical operations to describe imprecise dependencies between input and output variables (Zadeh, 1975). Each rule is a fuzzy conditional statement consisting of two parts: an antecedent ('if…,') and a consequent ('then…'). The former is a condition, and the latter is a conclusion. It is composed of input and output variables, respectively. Classically (Mamdani & Asilian, 1975), the antecedent includes at least two input variables and is conjunction-based ('min' function 'and' operation). The number of output variables predetermines the type of fuzzy inference model. The MISO (many inputs, single output) model is applied here. Depending on the conclusion quantification tool, fuzzy set or crisp value, Mamdani's and Sugeno's fuzzy logic systems are known. In a rectangle, the fuzzy decision table presents the outputs of all rules obtained by conjunctions of the fuzzy inputs.

The typical *fuzzy logic system* consists of three major components: fuzzification, fuzzy inference, and defuzzification (Yeheyis et al., 2016). Fuzzification means transforming crisp (non-fuzzy) sets into fuzzy ones (Zadeh, 1975). In it, labels of variables are fuzzified. Accordingly, logical rules also become fuzzy based on these labels. Fuzzy inference, also called "fuzzy decision-making" (Hilletofth et al., 2019), is the process of determining outputs using a fuzzy inference engine (FIE). The FIE maps connections between inputs and outputs based on fuzzy rules. The classic FIE applied here is based on a max-min logical operator. The inference process comprises two procedures: rules evaluation and aggregation. The first procedure consists of three activities. First, in the 'inputs coding' activity, the input data meanings are matched with the fuzzy membership functions of all labels on the respective input scales. As a result, the degrees of membership of input meanings to these functions, called 'fuzzy readings,' are determined (Bojadziev & Bojadziev, 2007). Second, in the 'firing' activity, the fuzzy rules are applied to the fuzzy readings. The outputs are determined by selecting the minimum fuzzy readings for each rule. Third, these outputs are systematized in a fuzzy decision table. In the aggregation procedure, the fuzzy outputs of all active rules (with non-zero values) are combined by disjunction ('max' function 'or' operation) into one fuzzy set. Finally, the fuzzy aggregate output is transformed into crisp by defuzzification, the opposite of fuzzification (Bojadziev & Bojadziev, 2007). Various defuzzification methods are known. Centre of gravity and maxima methods are used the most (Hilletofth et al., 2019; Yeheyis et al., 2016).

The *method of expert evaluations* allows "fast and easy extraction of in-depth knowledge by experts" (Kirova & Velikova, 2016, p. 505). It is employed in this model, along with surveys and focus groups, to collect data and develop logical rules.

In *response to research question 1,* here are the arguments behind the *instrumental framework* of this model:

- Arguments for applying the fuzzy set theory:

- It is a tool for the quantitative description of qualitative categories, processing both qualitative and quantitative data, and providing immediate transitions between them (second requirement).
- Through the fuzzy description of the input variables, this model reckons with (subjective) uncertainty, including the deviation intervals of expert evaluations (fourth requirement) and the degree of hesitation of experts (fifth requirement). These refer to the supporting intervals and the degrees of membership of the fuzzy membership functions, respectively. This model uses fuzzy sets' output to reflect (subjective) uncertainty in stakeholder motivation evaluations.
- The defuzzification function allows for an easy transition to crisp values (seventh requirement).

- Arguments for applying fuzzy logic:
  - It considers the subjectivity of motivation and uncertainty, allowing the usage of expert evaluations (first requirement) and fuzzy indicators (fourth and fifth requirements), respectively.
  - It processes and generates qualitative and quantitative evaluations (second requirement) with immediate and easy transitions between them. To this aim, it introduces/uses linguistic and quantitative variables, scales, and logical rules (third requirement).
  - It enables one to reflect on the process of motivation formation (sixth requirement), including connections and interactions between its building blocks (expectancy, instrumentality, valence, preference).
  - There are no strong methodological requirements for its implementation. It is easy to use and allows quick and easy change of logical rules and scales of variables (seventh requirement).
- Arguments for applying the method of expert evaluations: Expert evaluations reverberate the subjective nature of motivation (first requirement).

4. RESEARCH MODEL

This section describes the content, stages, and procedures of the model proposed here, responding to *research question 2*, accordingly.

4.1. General model description

This model evaluates the level of stakeholder motivation for high-quality publications by applying the stakeholder approach and fuzzy logic to Vroom's expectancy theory (Figure 1). It considers university specificity, using a university-specific model for motivational factors in instrumentality and valence evaluation. Instrumentally, this is a fuzzy logic-based MISO model, employing the classic FIE by Mamdani to evaluate motivation.

Qualitative and quantitative (fuzzy/crisp) motivation evaluations of the university stakeholders are a *product* of this model. Together they form the university motivation map, *the other product*.

This model has four *limitations*:

1. The same scales and logical rules are employed for all stakeholders.

2. The same conditions are used to evaluate the motivation of researchers in all subject areas.
3. A ready-made model for stakeholder motivational factors is required to be developed or used.
4. Each stakeholder is represented by one focus group.

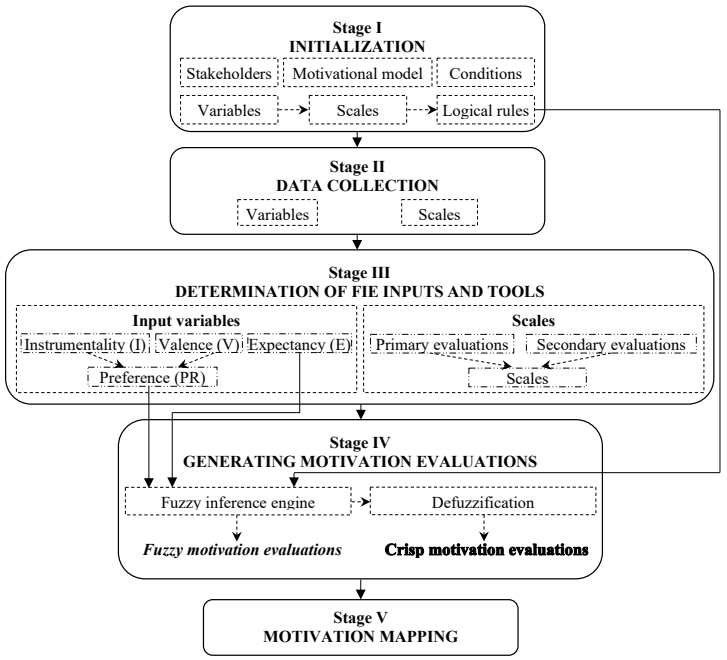

Figure 1. The fuzzy logic model for evaluating the motivation for high-quality publications

Source: Author.

4.2. Motivation stages and procedures

The proposed model evaluates motivation in five stages:

- Stage I "Initialization";
- Stage II "Data collection";
- Stage III "Determination of FIE inputs and tools";
- Stage IV "Generating motivation evaluations";
- Stage V "Motivation mapping."

In the *first stage*, specifics of the model application and qualitative characteristics of the tools are determined. This stage covers two *procedures*:

- Model initialization,
- Toolkit initialization.

One focus group and the expert evaluation method were employed in this stage. The focus group is common to all stakeholders. It performs all activities at this stage.

The model initialization requires defining conditions, subjects (stakeholders), and the university-specific motivational model. '*Condition*' is the indicator against which stakeholder motivation is evaluated. Here

it denotes the number of high-quality articles per researcher to be published annually. *Stakeholders* are internal and external. In this context, the main stakeholders are researchers, non-academic staff, university management, government, publishers, and bibliographic databases (Perig, 2018).

Regarding universities, the first three are internal stakeholders, and the others are external. The '*motivational model'* incorporates factors inciting stakeholders to contribute to increasing high-quality publications, usually by influencing researchers. Developing such a motivational model is beyond the scope of this study (limitation 3).

The toolkit initialization means selecting and qualitatively describing variables and rules. Following (1), the model employs five *variables* (Figure 2): four inputs and one output (MISO model). The input variables of instrumentality and valence are components of the 'preference' input variable. Thus, three variables describe the FIE: two inputs (preference and expectancy) and one output (motivation for high-quality publications). A qualitative description of the variables is performed by defining linguistic labels on their scales. The motivation and expectancy scales have five labels each, differing in content. Based on Vroom's theory, the preference scale has three labels (positive-neutral-negative), denoting satisfaction/acceptance, neutrality/indifference, and rejection/non-preference. This scale is relative (Hilletofth et al., 2019) and bipolar (Liu et al., 2018) and is very rarely used by researchers (Eccles & Wigfield, 2020). Regarding logical *rules*, the model employs the complete set of fifteen *'if ... and ..., then ...'* rules (Table 2). For comparability purposes, the motivation of all stakeholders is evaluated under the same conditions, scales, and rules (limitations 1 and 2).

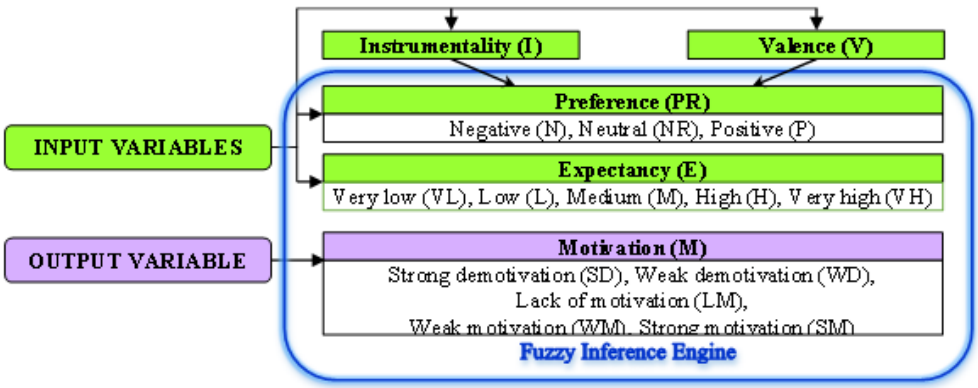

Figure 2. Variables and labels in the research model
Source: Author.

Table 2. Exemplary logical rules for evaluating the motivation for high-quality publications

Motivation		Expectancy				
		VL	L	M	H	VH
Preference	N	SD	WD	LM	LM	LM
	NR	WD	LM	WM	WM	WM
	P	LM	WM	WM	SM	SM

Source: Author.

In the *second stage*, data are collected. Its *products* are expert quantitative evaluations on three input variables and scale labels. This stage covers two *procedures*:

- Evaluation by input variables;
- Evaluation of scales.

Methods of expert evaluation, survey, and focus groups are used. Evaluations by input variables refer to expectancy, valence, and instrumentality. Focus group experts generate evaluations by each variable for each condition. Each expert generates an evaluation of expectancy and, for valence and instrumentality, an evaluation per factor of the motivational model applied. Both fuzzy trapezoidal numbers and crisp values describe the evaluations. The crisp ones are calculated using the normalized Hamming distance (Zhou et al., 2020). The common focus group evaluates the scales. Each expert generates two evaluations per label on each scale: primary and secondary. Primary evaluations are described by fuzzy numbers, and secondary ones by four-point confidence intervals.

In the *third stage*, the FIE input data and tools are determined. Its *products* are the final quantitative evaluations of FIE inputs and labels of all scales. They are described with fuzzy numbers (triangular/trapezoidal). This stage covers two *procedures*:

- Determination of FIE inputs;
- Determination of FIE scales.

Algebraic operations with fuzzy numbers and confidence intervals are used. FIE inputs are determined for each condition and stakeholder. For the expectancy variable, the focus group evaluation is the arithmetic mean of its experts' evaluations. For the valence and instrumentality variables, three activities are performed for each condition and focus group. First, following equation (1), the previous stage evaluations of these variables are multiplied, resulting in an evaluation of the 'preference' variable. This calculation is by factors and experts. Aggregation by motivational factors is then performed, calculating the arithmetic mean of the experts' preference on each factor. Finally, the focus group preference evaluation is calculated as the arithmetic mean of the eponymous evaluations for all factors.

Scale labels are determined based on primary and secondary expert evaluations. Secondary evaluations address the quality of the primary evaluations. Precisely, scale labels are calculated by multiplying the arithmetic mean of the primary label evaluation and the mathematical expectation of its secondary evaluations. The membership functions of expectancy evaluations and their scale labels vary in the range [0; 1], while those of the preference and motivation variables in the range [-1; 1].

In the *fourth stage*, evaluations of stakeholder motivation for high-quality publications are generated. They are described with

both fuzzy sets and crisp values. This stage covers two *procedures*:

- Fuzzy decision-making;
- Defuzzification.

These procedures are applied repeatedly, separately for each stakeholder and each condition. Fuzzy logic *tools* and fuzzy set operations are used here. Fuzzy motivation evaluations are the product of the fuzzy decision-making procedure, e.g., Figure 3. It is performed using the classic FIE by Mamdani, FIE fuzzy inputs of expectancy and preference, the scales of FIE variables, and the logical rules of the model. The functioning of the FIE refers to the procedures of rules evaluation and aggregation (see section 3.2 and Figure 3). The defuzzification procedure generates crisp motivation evaluations. Their number is calculated by multiplying the number of stakeholders and the number of conditions.

In the *fifth stage*, the motivation for high-quality publications of the university stakeholders is mapped. Its *product* is the university motivation map. It graphically presents motivation evaluations of all university stakeholders for all conditions considered when applying the model (see Figure 4).

5. MODEL APPLICATION AT A BULGARIAN UNIVERSITY

The proposed model was applied in 2021 at the Todor Kableshkov University of Transport (TKUT) in Sofia. There were two main reasons for choosing TKUT. First, TKUT's motivational factor model is proven in practice (Lambovska & Todorova, 2021). Second, the crucial importance of high-quality publications for TKUT as a public university. Following the current Bulgarian regulations, these publications strongly influence the university rating/accreditation, student influx, and state subsidies (Todorova, 2019).

5.1. Research design

- Data collection tools: Expert evaluation method, focus groups, comprehensive survey.
- Participants: 106 individuals, including 89 researchers, 10 department heads, and seven university managers.
- Specifics of the model application at TKUT:
  - Three internal stakeholders: Researcher, Department Head, and Top University Management. The researcher stakeholder covered TKUT researchers with the most and least papers in WoS and Scopus in 2014-2020. TKUT researchers in technical and natural sciences had the most papers and the least in social sciences.
  - Conditions: Four. They were determined based on TKUT articles in WoS and Scopus in 2019-2020. Conditions 1, 2, 3, and 4 correspond to 1, 1.5, 2, and 3 articles per researcher annually in WoS/Scopus-indexed journals (Figure 4).
  - Labels of variables and logical rules: in Figure 2 and Table 2, respectively.
  - Motivational factor model: Lambovska & Todorova's (2021) model.
  - Defuzzification method: The center of gravity method (Hilletofth et al., 2019).

5.2. Results and findings

The *final results* for the motivation of TKUT internal stakeholders for high-quality publications in 2021 are the following:

- Motivation evaluations (qualitative, fuzzy, and crisp quantitative) in condition 2 (in Figure 3). Condition 2 is used here for illustrative purposes due to diverse evaluations.
- In all four conditions, motivation evaluations (qualitative and crisp quantitative) (in Table 3).
- TKUT motivation map for high-quality publications (in Figure 4).

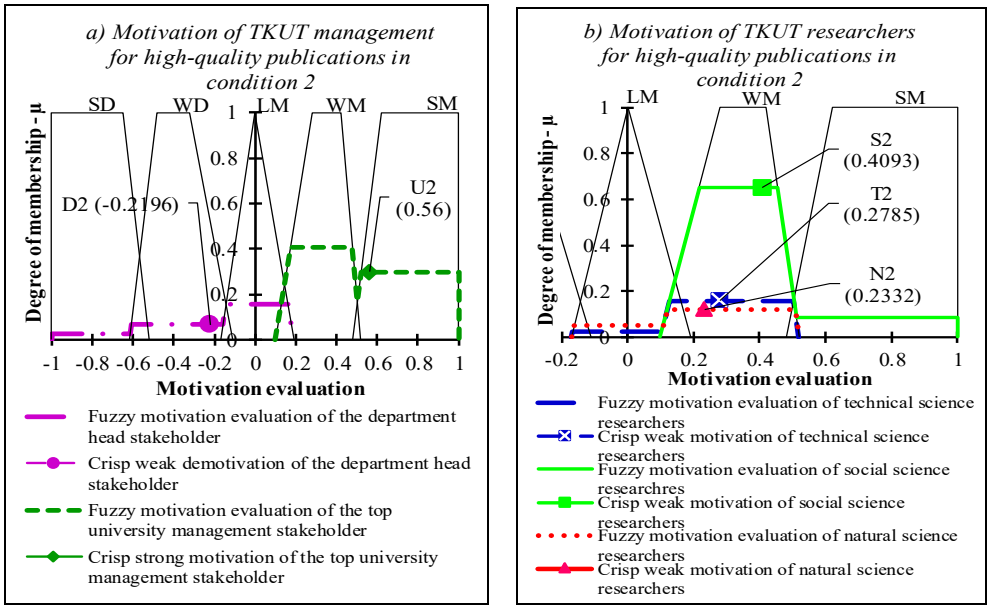

Figure 3. The motivation of TKUT internal stakeholders for high-quality publications in condition 2

Source: Author.

Table 3. Motivation evaluations of TKUT internal stakeholders for high-quality publications

Stakeholder	Quantitative and qualitative motivation evaluations in condition											
	1			2			3			4		
1. Researchers in natural sciences	0.0079	(N1)	LM	0.2332	(N2)	WM	0.6745	(N3)	SM	0.7836	(N4)	SM
2. Researchers in social sciences	0.1475	(S1)	LM-WM	0.4093	(S2)	WM	0.7456	(S3)	SM	0.3193	(S4)	WM
3. Researchers in technical sciences	0.0144	(T1)	LM	0.2785	(T2)	WM	0.7331	(T3)	SM	0.7503	(T4)	SM
4. Department heads	-0.764	(D1)	SD	-0.2196	(D2)	WD	0.287	(D3)	WM	0.0048	(D4)	LM
5. Top university management	0.3167	(U1)	WM	0.56	(U2)	SM	0.7767	(U3)	SM	0.7853	(U4)	SM

Note: The corresponding point in Figure 4 is in brackets.
Source: Author.

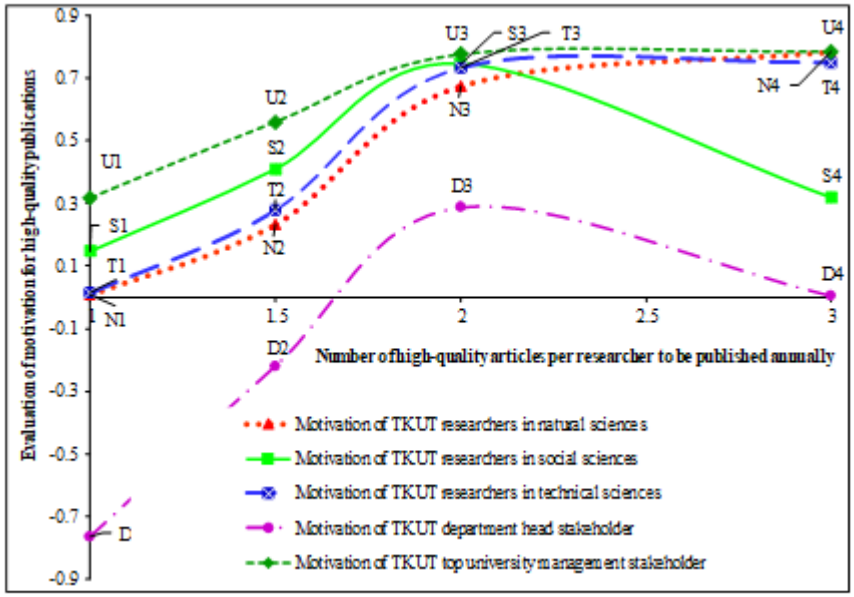

Figure 4. Motivation map for high-quality publications of TKUT internal stakeholders
Source: Author.

The main *findings* on the motivation of TKUT internal stakeholders (Figure 4, Table 3) are:

For the top management stakeholder: It was the most motivated with the highest evaluations in all four conditions. Besides, there was an upward trend in motivation in terms of these conditions (row 5). The reason for this is the great importance of high-quality publications for the student influx and state subsidies to the TKUT.

For the department head stakeholder: This was the least motivated with the lowest evaluations in all four conditions. Further, its motivation varied considerably in value and direction (row 4). The regulations of the Bulgarian public universities are a possible reason for this weak motivation, as they do not require attestation of the university management.

For the researcher stakeholder: For the researchers in natural and technical sciences: Their motivation increased under the studied conditions (rows 1 and 3). It increased from lack of motivation (N1, T1) to strong (N3, N4, T3, T4), going through weak (N2, T2). Technical researchers were generally more motivated for high-quality publications, perhaps because they had fewer high-quality articles than natural science researchers.

For the researchers in social sciences: In the first three conditions (row 2), they were more motivated than the other researchers. In condition 4, their motivation dropped sharply. There are two main possible reasons for these results: First, they were ambitious to publish more high-quality articles because they had the least. Second, they considered condition 4 unattainable.

6. DISCUSSION

The model proposed in this paper suggests a The model proposed in this paper suggests a solution to the issue of evaluating the for high-quality publications. The review of the WoS and Scopus literature (section 2) has shown that there is currently a gap in the scientific literature, both conceptually and instrumentally. Therefore, it can be concluded that the proposed model contributes to the advancement of management science, particularly research management and organizational behavior. The products of the model (motivation evaluations and the university motivation map) are indicators of the stakeholders' striving to improve the quality of university publication activity. They provide a reasonable basis for well-grounded decision-making by the university management toward this goal. Expected practical implications of the model are improved university research management and, as a result, higher scientific ratings of researchers and the university.

Conceptually, this model confirms the validity of Vroom's expectancy theory in research management. This is a *theoretical contribution* of the model. This confirmation of Vroom's theory refers to its classical goal of measuring motivation. It is not a supportive conceptual framework for generating models of motivational factors typical of other applications of Vroom's theory to research management (e.g., Erez & Shneorson, 1980; Lambovska & Todorova, 2021; Lee et al., 2016). *Another theoretical contribution* of the model is combining Vroom's theory with the stakeholder approach in the research management context. It refines the model, reflecting the specifics of the university and stakeholders. In practical terms, this combination contributes to a more targeted managerial influence on the

stakeholders' motivation for high-quality publications, thus increasing the practical effectiveness of the model application.

Instrumentally, this model complements the tools of research management and organizational behavior by applying, for the first time, fuzzy logic to Vroom's expectancy theory as a tool for evaluating the level of motivation. Unlike previous research (see section 2), this model addresses the essence of Vroom's theory and is not a "… complementary tool to EIV model and motivational analysis…" (Yeheyis et al., 2016, p. 870). That is the *main contribution* of this model.

The proposed model has several *strengths*. *First*, thanks to its tools, this model overcomes the inability to use/generate objective (statistical) evaluations due to the subjectivity of motivation and the lack of sufficient retrospective data. *Second*, despite the non-use of statistics, the model is precise. The toolkit of expert evaluations and fuzzy sets allows for considering both the subjective nature of motivation and the uncertainty of the environment. It is not the case with models using discrete rational numbers or confidence intervals. The first type does not reflect uncertainty, including subjective. The second type reckons the deviations of expert evaluations caused by uncertainty but not the degree of experts' hesitation. *Third*, this model is flexible. It simultaneously processes/generates qualitative and (fuzzy and crisp) quantitative evaluations, ensuring an immediate transition between them. The use of fuzzy sets/numbers brings about this effect. In addition, thanks to the fuzzy logic, the model allows rapid and easy adaptation to changes in the environment, the university applying it, stakeholders, expert groups, etc. This adaptation is achieved based on changes in the scales of variables and fuzzy rules. *Fourth*, using fuzzy logic, this model follows the process approach as a prerequisite for generating well-founded motivational evaluations. *Fifth*, the model is simple and easy to use. Describing input variables with fuzzy triangular/trapezoidal numbers requires each expert to generate no more than three/four (characteristic) evaluations per indicator (see Bojadziev & Bojadziev, 2007, p. 22-26). They are sufficient to shape the membership functions of the fuzzy variables. In addition, the model can be implemented using spreadsheets (e.g. in MS Excel) without specialized software.

7. CONCLUSION

A fuzzy logic model for evaluating the level of stakeholder motivation for high-quality publications is proposed in this paper. For evaluation purposes, the model applies tools of fuzzy logic, expert evaluations, focus groups, and the stakeholder approach to Vroom's expectancy theory of motivation. The model is suitable for any university. Further, it reflects university specificity, using specific motivational factors in one of the evaluation procedures.

The model was applied at the Todor Kableshkov University of Transport in Sofia and performed well. In evidence, the established trends in the motivation of internal university stakeholders under the studied conditions are logical. First, differences in motivation evaluations of researchers in natural/technical and social sciences correspond to their previous publication activities in WoS/Scopus journals. Second, the variegated motivation evaluations of the university management are an expected and inevitable consequence of the current Bulgarian regulations in higher education.

To the best of our knowledge, this is the first model for evaluating the motivation for high-quality publications. The model enriches research management and organizational behavior theoretically. Above all, it contributes instrumentally to these management sciences, complementing their tools. The fuzzy tools make the model precise, flexible, simple, and easy to use. It easily generates motivation evaluations based on vague, subjective human perceptions.

Further, the model simultaneously produces/processes qualitative and quantitative (fuzzy and discrete) evaluations with immediate transitions between them. In practical terms, its implementation will contribute to well-grounded management decisions on incentives for scientific achievement, attestation, promotion, and remuneration of researchers and managers. They are the basis for better research, people and performance management, and higher scientific results of researchers/universities.

In future research, it will be helpful to incorporate more stakeholder specifics in the model. This means changing the scales and/or logical rules or removing the first two limitations. The result will be a refinement of the university motivation map. It is also worth linking this model to a model for evaluating the potential of stakeholders to influence researchers' motivation for high-quality publications. This link will shed light on possible approaches to increase the number of high-quality publications through motivation and thus contribute to better research management.

REFERENCES

1. Aggarwal, M. (2021). Redefining fuzzy entropy with a general framework. *Expert Systems with Applications*, *164*. Article 113671
2. Atieno, A., Onyancha, O., & Kwanya, T. (2021). Trends, patterns and determinants of research productivity at the Technical University of Kenya. *Information Development*. Article 0266666920983400.
3. Bak, H., & Kim, D. (2019). The unintended consequences of performance-based incentives on inequality in scientists' research performance. *Science and Public Policy*, *46*(2), 219-231.
4. Belcher, B., Davel, R., & Claus, R. (2020). A refined method for theory-based evaluation of the societal impacts of research. *MethodsX*, *7*, Article 100788.
5. Belcher, B., Rasmussen, K., Kemshaw, M., & Zornes, D. (2016). Defining and assessing research quality in a transdisciplinary context. *Research Evaluation*, *25*(1), 1-17.
6. Bojadziev, G., & Bojadziev, M. (2007). *Fuzzy logic for business, finance, and management*. World Scientific.
7. Chan, I., Leung, M., & Liang, Q. (2018). The roles of motivation and coping behaviours in managing stress: Qualitative interview study of Hong Kong expatriate construction professionals in Mainland China. *International Journal of Environmental Research and Public Health*, *15*(3), Article 561.
8. Chopra, K. (2019). Vroom's expectancy theory to motivate academic library users in India using grounded theory

approach. *Global Knowledge, Memory and Communication*, *68*(4/5), 300–322.

9. Cournot, A. A. (1847). *De l'origine et des limites de la correspondance entre l'algèbre et la géométrie*. L. Hachette, Paris.
10. Cruz-Castro, L., & Sanz-Menendez, L. (2021). What should be rewarded? Gender and evaluation criteria for tenure and promotion. *Journal of Informetrics*, *15*(3).
11. Dörnyei, Z., & Ushioda, E. (2021). *Teaching and researching motivation: New directions for language learning*. Taylor and Francis.
12. Drucker, P.F. (1954), The Practice of Management, *Harper*, New York.
13. Ebadi, A., & Schiffauerova, A. (2016). How to boost scientific production? A statistical analysis of research funding and other influencing factors. *Scientometrics*, *106*(3), 1093-1116.
14. Eccles, J., & Wigfield, A. (2020). From expectancy-value theory to situated expectancy-value theory: A developmental, social cognitive, and sociocultural perspective on motivation. *Contemporary Educational Psychology*, *61*, Article 101859.
15. Erez, M., & Shneorson, Z. (1980). Personality types and motivational characteristics of academics versus professionals in industry in the same occupational discipline. *Journal of Vocational Behavior*, *17*(1), 95-105.
16. Freeman, R.E. (2015). *Strategic management: A stakeholder approach*, Cambridge University Press.
17. Hilletofth, P., Sequeira, M., & Adlemo, A. (2019). Three novel fuzzy logic concepts applied to reshoring decision-making. *Expert Systems with Applications*, *126*, 133-143.
18. Jaskiene, J., & Buciuniene, I. (2021). Human resource management-research performance linkage in higher education institutions. *Management-Journal of Contemporary Management Issues*, *26*(1), 149-168.
19. Kang, D., Kang, I., Kim, Y., Nguyen, C., & Choung, J. (2021). Academic entrepreneurship and attentional discrepancy among key stakeholders: Evidence from research universities in Korea. *Science and Public Policy*, *48*(1), 1-15.
20. Gil-Aluja, J. (2014). *Fuzzy Sets in the Management of Uncertainty*. Springer.
21. Kirillova, O. V. (2021). On the prospects of increasing publication activity in the 'informatization of education' field. *2021 1st International Conference on Technology Enhanced Learning in Higher Education (TELE)*, 243–246.
22. Kirova, M., & Velikova, P. (2016). Risk management method for small photovoltaic plants. *Management & Marketing-Challenges for the Knowledge Society*, *11*(3), 498-512.
23. Lambovska, M., & Todorova, D. (2021). 'Publish and flourish' instead of 'publish or perish': A motivation model for top-quality publications. *Journal of Language and Education*, *7*(1), 141-155.
24. Lambovska, M., & Yordanov, K. (2020). Motivation of researchers to publish in high-quality journals: A theoretical framework. *TEM Journal-Technology Education Management Informatics*, *9*(1), 188-197.
25. Langrafe, T., Barakat, S., Stocker, F., & Boaventura, J. (2020). A stakeholder theory approach to creating value in higher education institutions. *Bottom Line*, *33*(4), 297-313.

26. Lee, M., Raschke, R., & St Louis, R. (2016). Exploiting organizational culture: Configurations for value through knowledge worker's motivation. *Journal of Business Research*, *69*(11), 5442-5447.
27. Lewin, K. (1938). *The conceptual representation and the measurement of psychological forces*. Duke University Press.
28. Liu, H., Jiang, L., & Martinez, L. (2018). A dynamic multi-criteria decision making model with bipolar linguistic term sets. *Expert Systems with Applications*, *95*, 104-112.
29. Locke, E., & Latham, G. (1990). Work motivation and satisfaction: Light at the end of the tunnel. *Psychological Science*, *1*(4), 240-246.
30. Mamdani, E., & Assilian, S. (1975). An experiment in linguistic synthesis with a fuzzy logic controller. *International Journal of Man-Machine Studies*, *7*(1), 1-13.
31. Marasini, D., Quatto, P., & Ripamonti, E. (2017). Inferential confidence intervals for fuzzy analysis of teaching satisfaction. *Quality and Quantity*, *51*(4), 1513–1529.
32. Matveeva, N., Sterligov, I., & Yudkevich, M. (2021). The effect of Russian University Excellence Initiative on publications and collaboration patterns. *Journal of Informetrics*, *15*(1), Article 101110.
33. McLean, R., & Sen, K. (2019). Making a difference in the real world? A meta-analysis of the quality of use-oriented research using the Research Quality Plus approach. *Research Evaluation*, *28*(2), 123-135.
34. Nedelko, Z., Potocan, V., & Alfirevic, N. (2017). Personal values as a building block for social responsibility of higher education institutions. In Z. Nedelko, & M. Brzozowski (Ed.), *Exploring the Influence of Personal Values and Cultures in the Workplace* (pp. 119-142). IGI Global.
35. Oberkampf, W. L., DeLand, S. M., Rutherford, B. M., Diegert, K. V., & Alvin, K. F. (2002). Error and uncertainty in modeling and simulation. *Reliability Engineering and System Safety*, *75*(3), 333–357.
36. Osafo, E., Paros, A., & Yawson, R. (2021). Valence–instrumentality–expectancy model of motivation as an alternative model for examining ethical leadership behaviors. *SAGE Open*, *11*(2).
37. Perig, A. V. (2018). Didactic student-friendly approaches to more effective teaching of the fundamentals of scientific research in a digital era of scientometrics. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(12), em1632.
38. Ramlall, S. (2004). A review of employee motivation theories and their implications for employee retention within organizations. *Journal of American Academy of Business*, *5*(1/2), 52-63.
39. Raitskaya, L., & Tikhonova, E. (2020). Overcoming cultural barriers to scholarly communication in international peer-reviewed journals. *Journal of Language and Education*, *6*(2), 4-8.
40. Simeonov, O. (1997). *Theoretical issues of control,* M-8-M, Sofia.
41. Stoyanov, I. (2014). Expectations, attitudes and behavior of the human factor in the organizational environment. *KSI Transactions on Knowledge Society*, *7*(1), 45-49.
42. Todorova, D. (2019). The sustainable relationship "education-science-business" - a key factor for the strategic development of Todor Kableshkov

University of Transport. *Mechanics Transport Communications*, *1*, Article 1774.

43. Vogel, R., & Hattke, F. (2018). How is the use of performance information related to performance of public sector professionals? Evidence from the field of academic research. *Public Performance & Management Review*, *41*(2), 390-414.
44. Vorontsova, A., Shvindina, H., Mayboroda, T., Mishenina, H., & Heiets, I. (2020). The impact of state regulation in a sphere of education on sustainable development of national economy. *Problems and Perspectives in Management*, *18*(4), 275–288.
45. Vroom, V.H. (1964). *Work and motivation*, John Wiley and Sons, NY.
46. Yeheyis, M., Reza, B., Hewage, K., Ruwanpura, J., & Sadiq, R. (2016). Evaluating motivation of construction workers: a comparison of fuzzy rule-based model with the traditional expectancy theory. *Journal of Civil Engineering and Management*, *22*(7), 862-873.
47. Zadeh, L. A. (1965). Fuzzy sets. *Information and Control*, *8*(3), 338-353.
48. Zadeh, L. A. (1975). Fuzzy logic and approximate reasoning - In memory of Grigore Moisil. *Synthese*, *30*(3-4), 407-428.
49. Zadeh, L. A. (2008). Is there a need for fuzzy logic? *Information Sciences*, *178*(13), 2751-2779.
50. Zhou, Q., Mo, H., & Deng, Y. (2020). A new divergence measure of Pythagorean fuzzy sets based on belief function and its application in medical diagnosis. *Mathematics*, *8*(1), Article 142.

MODEL NEIZRAZITE LOGIKE U EVALUACIJI MOTIVURANOSTI ZA PUBLIKACIJE VISOKE KVALITETE: DOKAZI S BUGARSKOG SVEUČILIŠTA

Sažetak

U ovom se radu predlaže model neizrazite logike za evaluaciju razine motivacije dionika za publikacije visoke kvalitete. U konceptualnom smislu, model je zasnovan na teoriji dionika i Vroomovoj teoriji motivacije, zasnovanoj na očekivanjima. U aplikativnom smislu, model se zasniva na neizrazitim skupovima, neizrazitoj logici i evaluaciji od strane eksperata. Smatra se da je model prikladan za bilo koje sveučilište. Nadalje, u njemu se uzimaju u obzir specifičnosti sveučilišta, s obzirom na korištenje specifičnih motivacijskih faktora u jednoj od evaluacijskih procedura. Uz njegovu se pomoć jednostavno evaluira razina motivacije, zasnovane na nejasnim i subjektivnim percepcijama. Model je primijenjen na jednom bugarskom sveučilištu, korištenjem opsežne ankete, u kojoj je sudjelovalo 106 ispitanika te se pokazao kao učinkovit. Na ovaj se način pruža doprinos kvantitativnom pristupu u menadžmentu kroz teorijski doprinos upravljanju istraživanjima i organizacijskom ponašanja, kao i nadopunjavanju njihovih alata. Očekivane praktične implikacije odnose se na unapređenje upravljanja sveučilištima i ostvarivanje boljih istraživačkih rezultata.

Ključne riječi: *upravljanje istraživanjima, motivacija, neizrazita logika, evaluacija, model, publikacije visoke kvalitete, sveučilište*