Research on the evaluation of the communication power of sci-tech periodicals based on the hesitant fuzzy model

Bing Liu[a, *], Zhijun Lv[b], Dongyu Chang[c], Nan Zhu[d] and Fan Qu[e]

School of economics and management, Dalian University of Technology, Dalian 116024, China

[a]liubingbs@163.com, [b]lv98@dl.cn, [c]changdongyu@163.com, [d]nanzhu1228@mail.dlut.edu.cn, [e]18340879355@163.com

*Corresponding author

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Abstract: In order to realize the quantitative evaluation under the qualitative index of the communication power of sci-tech periodicals, this article takes sci-tech periodicals as the research object to transform the evaluation of communication power into a multi-strategy decision-making problem, and proposes a research method of sci-tech periodicals communication power based on hesitant fuzzy language correlation. Firstly, the four qualitative indicators of the strategic planning of the journal, the recognition of knowledge popularization, the consistency of the journal with its own positioning image, and the impact of the journal on target readers are used as indicators to be evaluated to construct a fuzzy hesitation language set. Then, a hesitant fuzzy language number correlation based on each evaluation criterion is established. Finally, the dominant matrix of the correlation is derived to obtain the evaluation judgment value. Theoretical analysis and example verification show that the proposed algorithm can quantitatively judge the communication power of different sci-tech periodicals, and provide a strong support for managers to make accurate decisions.

1. Introduction

Sci-tech periodicals are the important supporting force of the national innovation system, the important embodiment of the national scientific and technological strength and cultural soft power, as well as an important platform for competing for international intellectual property rights [1]. The related research on the communication power of sci-tech periodicals has gradually become a research hotspot in the publishing industry. Through the research on the communication power evaluation of the sci-tech periodicals, we can get the strategies and suggestions for the promotion of the communication ability, provide reference for the management decision-making, and provide guidance for the development of the industry.

The communication power of sci-tech periodicals is the ability and effectiveness of media or organizations to use their own or other communication channels to achieve their communication effects. As for the research on the qualitative index of the communication power of sci-tech periodicals, Li [2] analyzed the elements of the communication resources of sci-tech periodicals based on the system theory, and preliminarily analyzed the structure of the communication resources of sci-tech periodicals. Wang [3] focused on the status of communication effect in the communication power of sci-tech periodicals, and put forward that the communication power of sci-tech periodicals is an intuitive embodiment of the communication power of sci-tech periodicals, which can play a representative role in the communication power of sci-tech periodicals. Hou and Li [4] believed that the communication power of sci-tech periodicals refers to the means and the ability to use resources used by Sci-tech Periodicals in the effective dissemination of knowledge. Zhao [5] put forward that the communication power of sci-tech periodicals comes from the value of the communication resources they own, that is, content, information, channels, teams and so on. These existing studies use descriptive analysis, qualitative research, and other methods to explain the communication power of sci-tech periodicals. Few studies have been conducted on the evaluation of communication power under qualitative indicators. The quantitative evaluation of the communication power of sci-tech periodicals under qualitative indicators can be converted into multi-criteria decision-making problems under the uncertain conditions. In recent years, Xu and his team [6-7] has proposed a series of multi-criteria decision-making methods based on hesitant fuzzy models. This method can transform the determination of qualitative indicators into the determination of quantitative indicators. Applying the hesitant fuzzy model to the evaluation of the communication power of sci-tech periodicals under the qualitative indicators can better transform the evaluation of the qualitative indicators into the judgment of the quantitative indicators.

Based on the above problems, this paper proposes a method for evaluating the communication power of sci-tech periodicals based on hesitant fuzzy language correlations. The proposed method fully considers the subjective preferences of decision makers, and adds an incomplete compensatory assumption based on the traditional hesitant fuzzy language model. The decision-making value is derived by constructing the correlation of hesitant fuzzy language based on each criterion. The method makes the decision-making result more authentic and reliable to a certain extent.

2. Hesitation fuzzy language set

Assume that $S=\{s_i \mid i=0,1,2,\cdots,t\}$ is a set of language terms, satisfying: ①orderliness: $s_i > s_j, i > j$, ②reversibility: $s_i = neg(s_j), i+j=t$. Assuming $X=\{x_1,x_2,\cdots,x_n\}$ is the set of objects to be decided, the mathematical expression of the hesitant fuzzy set on X can be written as:

$$H=\{\langle x, h(x)\rangle \mid x\in X\} \tag{1}$$

Where, $h(x)\in[0,1]$ denotes the hesitant fuzzy element, which represents the membership of $x\in X$, it is a series of possible values in the language term set S.

The scoring function for the hesitant fuzzy element $h(x)$ can be expressed as:

$$r(h(x))=\frac{1}{l_{h(x)}}\sum_{\gamma\in h(x)}\gamma \tag{2}$$

Where, $l_{h(x)}$ is the number of elements in $h(x)$. For any two hesitant fuzzy elements $h_1(x), h_2(x)$ satisfies: ①if $r(h_1(x)) > r(h_2(x))$, then $h_1(x) > h_2(x)$; ②if $r(h_1(x)) < r(h_2(x))$, then $h_1(x) < h_2(x)$; ③if $r(h_1(x)) = r(h_2(x))$, then $h_1(x) = h_2(x)$.

The fuzzy hesitation language set A of the object set a to be decided can be defined as:

$$A=\{\langle x, s_{\theta(x)}, h(x) \mid x\in X\rangle\} \tag{3}$$

Where, $s_{\theta(x)}\in S$ denotes the language evaluation value of x; $\theta(x)$ denotes the subscript corresponding to the language evaluation value. When there is only one element in the object set X to be decided, the fuzzy hesitant language set A can be expressed as $\alpha=\langle s_{\theta(\partial)}, h(\partial)\rangle$, which is called the hesitant fuzzy language number. When there is only one element in the object set s to be decided, the fuzzy hesitation language set D can be expressed as F and G as the number of hesitation fuzzy language.

3. The decision of hesitation and fuzzy language correlation

Before studying the correlation of the hesitant fuzzy languages, four kinds of correlation relations of any two hesitant fuzzy language numbers $a=\langle s_a, h_a\rangle$ and $b=\langle s_b, h_b\rangle$ are defined as:

Strongly dominance relationship: $if\ s_a < s_b\ and\ \delta < r(h_a) - r(h_b) \to b \succ_s a$, then it is called b strong dominant a;

Weak dominance relationship: if $s_a < s_b$ and $0 < r(h_a) - r(h_b) \le \delta$ and $r(h_a) < r(h_b) \rightarrow b \succ_w a$, then it is called b weak dominant a;

No difference relationship: *if* $s_a = s_b$ *and* $r(h_a) = r(h_b) \rightarrow b \sim a$, then it is called b is not different from a;

Incomparable relationship: *if* $s_a < s_b$ *and* $\delta < r(h_a) - r(h_b) \rightarrow b \approx a$, then it is called a and b are not comparable.

Assume that the solution set of the problem to be decided is $A = \{a_1, a_2, \cdots, a_n\}$, the corresponding criterion set $Z = \{z_1, z_2, \cdots, z_n\}$, the weight vector $W = \{w_1, w_2, \cdots, w_n\}$, and the set of all the criteria's subscripts Z is $J = \{j \mid j = 1, 2, \cdots, n\}$, a_{ij} denotes the evaluation value of a_i under the criterion z_j, and it can be also expressed in the form of hesitant fuzzy language as $a_{ij} = \langle s_{\theta_{ij}}, h_{a_{ij}} \rangle$.

Assume that the consistency correlation between scheme a_i and scheme a_k can be defined as:

$$F_{ik} = \omega_{Cs} \sum_{j \in Cs(a_i, k_i)} w_j + \omega_{Cw} \sum_{j \in Cw(a_i, k_i)} w_j \tag{4}$$

Similarly, the non-consistent correlation between scheme a_i and scheme a_k can be defined as:

$$G_{ik} = \frac{\max_{j \in D_s(a_i, a_k) \cup D_w(a_i, a_k)} \omega_D^* D(a_i, a_k)}{\max j \in D(a_i, a_k)} \tag{5}$$

Where, ω_{Cs} denotes the weight of the strong dominance relationship, ω_{Cw} denotes the weight of the weak dominance relationship; w_j denotes the weight of the criterion, and ω_D^* denotes ω_{Ds} or ω_{Dw}.
According to (5), the consistency correlation matrix $\boldsymbol{F}$ can be expressed as:

$$\boldsymbol{F} = \begin{bmatrix} - & f_{12} & f_{13} & \cdots & f_{1(\mathrm{m}-1)} & f_{1m} \\ f_{21} & - & f_{23} & \cdots & f_{2(\mathrm{m}-1)} & f_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ f_{(\mathrm{m}-1)1} & f_{(\mathrm{m}-1)2} & f_{(\mathrm{m}-1)3} & \cdots & - & f_{(\mathrm{m}-1)\mathrm{m}} \\ f_{m1} & f_{m2} & f_{m3} & \cdots & f_{m(\mathrm{m}-1)} & - \end{bmatrix} \tag{6}$$

Similarly, according (6), the non-consistent correlation matrix $\boldsymbol{G}$ can be expressed as:

$$\boldsymbol{G} = \begin{bmatrix} - & g_{12} & g_{13} & \cdots & g_{1(m-1)} & g_{1m} \\ g_{21} & - & g_{23} & \cdots & g_{2(m-1)} & g_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ g_{(m-1)1} & g_{(m-1)2} & g_{(m-1)3} & \cdots & - & g_{(m-1)m} \\ g_{m1} & g_{m2} & g_{m3} & \cdots & g_{m(m-1)} & - \end{bmatrix} \tag{7}$$

The greater the g_{ik} is, the greater degree of scheme a_i is inferior to scheme a_k. Assume that the maximum value of g_{ik} is $g\nabla$.

According to (7), the dominant matrix $\boldsymbol{Y}$ of consistency correlation can be defined as:

$$\boldsymbol{Y} = \begin{bmatrix} - & y_{12} & y_{13} & \cdots & y_{1(m-1)} & y_{1m} \\ y_{21} & - & y_{23} & \cdots & y_{2(m-1)} & y_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ y_{(m-1)1} & y_{(m-1)2} & y_{(m-1)3} & \cdots & - & y_{(m-1)m} \\ y_{m1} & y_{m2} & y_{m3} & \cdots & y_{m(m-1)} & - \end{bmatrix} \tag{8}$$

Where, $y_{ik} = f\nabla - f_{ik}$, and the greater f_{ik} is, the less degree of scheme a_i is superior to scheme a_k.
Similarly, according to (8), the dominant matrix $\boldsymbol{L}$ of the non-consistent correlation can be defined as:

$$
\boldsymbol{L}=\begin{bmatrix} - & l_{12} & l_{13} & \cdots & l_{1(m-1)} & l_{1m} \\ l_{21} & - & l_{23} & \cdots & l_{2(m-1)} & l_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ l_{(m-1)1} & l_{(m-1)2} & l_{(m-1)3} & \cdots & - & l_{(m-1)m} \\ l_{m1} & l_{m2} & l_{m3} & \cdots & l_{m(m-1)} & - \end{bmatrix} \tag{9}
$$

Where, $l_{ik}=g\nabla-g_{ik}$, the larger l_{ik} is, the better scheme a_i is than scheme a_k.

Therefore, according to (9) and (10), the dominant matrix $\boldsymbol{K}$ of the correlation can be defined as:

$$
\boldsymbol{K}=\begin{bmatrix} - & k_{12} & k_{13} & \cdots & k_{1(m-1)} & k_{1m} \\ k_{21} & - & k_{23} & \cdots & k_{2(m-1)} & k_{2m} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ k_{(m-1)1} & k_{(m-1)2} & k_{(m-1)3} & \cdots & - & k_{(m-1)m} \\ k_{m1} & k_{m2} & k_{m3} & \cdots & k_{m(m-1)} & - \end{bmatrix} \tag{10}
$$

Therefore, according to $\boldsymbol{K}$, the decision-making value $\aleph$ based on the correlation of hesitant fuzzy language can be expressed as:

$$
\aleph_i=\frac{1}{m-1}\sum_{k=1}^{m}k_{ik} \quad (i=1,2,\cdots,m) \tag{11}
$$

According to (12), the decision criteria are: if $\aleph_i>\aleph_k$, then scheme a_i is better than scheme a_k; if $\aleph_i<\aleph_k$, then scheme a_i is worse than scheme a_k.

4. Evaluation and verification of communication power of sci-tech periodicals

In order to verify the effectiveness of the proposed algorithm, three different sci-tech journals (a_1,a_2,a_3) are assumed to be evaluated, and the four evaluation criteria are: strategic planning of the journal (z_1), the recognition of knowledge popularization (z_2), the consistency of the journal with its own positioning image (z_3), and the impact of the journal on target readers (z_4), the weight vector of the four criteria for the evaluation of communication power is $W=\{0.3,0.2,0.4,0.1\}$.

According to the experimental conditions, the language term set is defined as:

$$
S=\{s_0,s_1,s_2,s_3,s_4,s_5,s_6\}=\{\text{terrible, worse, poor, average, good, better, excellent}\} \tag{12}
$$

Five experts from the publishing industry were invited to grade the membership of the four evaluation criteria of the three different sci-tech journals. The number of hesitant fuzzy languages of different journals under different criteria is shown in Table 1.

Table 1. The number of hesitant fuzzy languages of different journals under different criteria

criteria / journals	z_1	z_2	z_3	z_4
a_1	$\langle s_4,\{0.6,0.7,0.8\}\rangle$	$\langle s_5,\{0.5,0.6\}\rangle$	$\langle s_2,\{0.4,0.6,0.7\}\rangle$	$\langle s_3,\{0.4,0.5\}\rangle$
a_2	$\langle s_2,\{0.6,0.8\}\rangle$	$\langle s_3,\{0.2,0.3,0.5\}\rangle$	$\langle s_3,\{0.4,0.6\}\rangle$	$\langle s_4,\{0.5,0.7\}\rangle$
a_3	$\langle s_6,\{0.4,0.5,0.7\}\rangle$	$\langle s_3,\{0.5,0.8\}\rangle$	$\langle s_5,\{0.6,0.7,0.9\}\rangle$	$\langle s_2,\{0.5,0.6\}\rangle$

According to Table 1, the hesitant fuzzy language decision matrix can be constructed as:

$$
\boldsymbol{A}=\begin{bmatrix} \langle s_4,\{0.6,0.7,0.8\}\rangle & \langle s_5,\{0.5,0.6\}\rangle & \langle s_2,\{0.4,0.6,0.7\}\rangle & \langle s_3,\{0.4,0.5\}\rangle \\ \langle s_2,\{0.6,0.8\}\rangle & \langle s_3,\{0.2,0.3,0.5\}\rangle & \langle s_3,\{0.4,0.6\}\rangle & \langle s_4,\{0.5,0.7\}\rangle \\ \langle s_6,\{0.4,0.5,0.7\}\rangle & \langle s_3,\{0.5,0.8\}\rangle & \langle s_5,\{0.6,0.7,0.9\}\rangle & \langle s_2,\{0.5,0.6\}\rangle \end{bmatrix}
$$

Under each evaluation criterion of communication power, the set of footnotes of the correlations of the three different journals can be written as:

$$C_s(a_1,a_2)=\{1,2\}\quad C_w(a_1,a_2)=\varnothing\quad D_s(a_1,a_2)=\{4\}\quad D_w(a_1,a_2)=\{3\}$$
$$C_s(a_2,a_3)=\{4\}\quad C_w(a_2,a_3)=\varnothing\quad D_s(a_2,a_3)=\{3\}\quad D_w(a_2,a_3)=\{1,2\}$$
$$C_s(a_1,a_3)=\varnothing\quad C_w(a_1,a_3)=\{4\}\quad D_s(a_1,a_3)=\{2,3\}\quad D_w(a_1,a_3)=\{1\}$$

Suppose $\omega_{Cs}=\omega_{Ds}=2/3$ and $\omega_{Cw}=\omega_{Dw}=1/3$, according to (9) and (10), the consistent correlation matrix and the non-consistent correlation matrix can be expressed respectively:

$$\boldsymbol{F}=\begin{bmatrix} - & 0.333 & 0.067 \\ 0.2 & - & 0.067 \\ 0.5 & 0.433 & - \end{bmatrix}\qquad \boldsymbol{G}=\begin{bmatrix} - & 0.456 & 0.667 \\ 0.667 & - & 0.667 \\ 0.032 & 0.395 & - \end{bmatrix}$$

Finally, the dominant matrix of the correlation can be calculated as:

$$\boldsymbol{K}=\begin{bmatrix} - & 0.558 & 0 \\ 0 & - & 0 \\ 1 & 0.803 & - \end{bmatrix}$$

Therefore, we can get three different decision-making values for the evaluation of the communication power of three different scientific journals:

$$\aleph_1=0.279,\aleph_2=0,\aleph_3=0.901$$

According to the decision-making value, we can see that the communication power of Sci-tech Journal 3 is the best, and the communication power of sci-tech journal 2 is the worst.

5. Conclusions

The research on the evaluation of periodical communication power is of great significance for managers to make proper decisions. This paper proposes a method for evaluating the communication power of sci-tech periodicals based on hesitant fuzzy language correlation. Considering the evaluation of communication power of scientific journals under the qualitative indicators as a multi-strategic decision-making problem, hesitant fuzzy language models are used to obtain quantitative decision judgment value expressions, and the qualitative evaluation of communication power is converted into a quantitative judgment problem. The judgment value directly reflects the quality of the communication power of different journals.

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References

[1] H. CHEN. Current situation of authors and the content of Non-academic sci-tech periodicals and their future development, J. Science & Technology Information, 32(3):125-128. (2013)

[2] R. X. LI. Dissemination system of sci-tech periodicals and it’s innovation, J. Acta Editologica, 12(04):187-189. (2001)

[3] Y. M. YING, J. H. YANG. Elements of the dissemination process of sci-tech periodicals, J. Editorial Friend, 15(06):41-44. (2009)

[4] Q. ZHAO. Identification of core competitiveness of sci-tech periodicals based on reader value, J. Chinese Journal of Scientific and Technical Periodicals, 15(22):410-413. (2011)

[5] G. JI, Y. J. ZHANG, Y. J. MA. Readers' psychological needs for sci-tech periodicals and their enlightenment, J. Chinese Journal of Scientific and Technical Periodicals, 26(01):23-26. (2015)

[6] M. M. XIA, Z. S. XU. Hesitant fuzzy information aggregation in decision making, J. International Journal of Approximate Reasoning, 52(3):395-407. (2011)

[7] Z. S. XU, M. M. XIA. On distance and correlation measures of hesitant fuzzy information, J. International Journal of Intelligent Systems, 26(5):410-425. (2013)