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Enhanced EXPROM Methodology Using SuperHyperSoft Sets for Evaluating the Quality of Cultural Industry Development in the Digital Economy with Single-Valued Neutrosophic Sets

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Abstract: With the advent of the digital economy era, the high-quality development of cultural industry has received people's attention. How to take advantage of the favorable opportunities of rapid development of the digital economy to further promote the innovative development of cultural industry is an important problem that needs to be solved in development process of Chinese cultural industries. The quality evaluation of cultural industry development in the context of the digital economy is MAGDM. The single-valued neutrosophic sets (SVNSs) is a useful tool to cope with uncertain information during the quality evaluation of cultural industry development in the context of the digital economy. In this paper, the single-valued neutrosophic number EXPROM (SVNN-EXPROM) model is formed to cope with the MAGDM. The SuperHyperSoft set (SHSS), which is an extension of HyperSoft set (HSS) is applied in this study to treat various criteria and sub criteria values. The average model is utilized to obtain weight numbers in light under SVNSs. Finally, numerical examples and comparative analysis for quality evaluation of cultural industry development in the context of the digital economy is utilized to validate SHSS-SVNN-EXPROM model. The main contributions of this study are formed: (1) the average model is formed to obtain the weight numbers; (2) the SHSS-SVNN-EXPROM model is formed under SVNNs with SHSS to deal with various criteria values; (3) Finally, numerical example and comparative analysis for quality evaluation of cultural industry development in the context of the digital economy is utilized to validate SHSS-SVNN-EXPROM model.

Keywords: MAGDM; SVNSs; EXPROM model; quality evaluation; SuperHyperSoft Set.

1. Introduction

The concept of "digital economy" was born in an atmosphere where the new economy is widely accepted and recognized. During the Clinton administration in the 1990s, driven directly by knowledge and technological innovation, the US economy continued to grow for nearly a decade, and people referred to it as the "new economy" [1]. Among them, the application of modern technology represented by electronic computers, the Internet and e-commerce has played a key role. The connotation of the digital economy has undergone a continuous expansion process [2]. The market-oriented application of information and communication technology, such as the birth of telecommunications, software and Internet industries, marks the arrival of the initial stage of the digital economy-the digital industrialization stage. Subsequently, information technology and traditional industries are increasingly merging, leading to a series of new economic styles [3]. These new economic styles are different from the new forms of digital industrialization, and their prominent features are reflected in the disruptive impact of digital technology on economic efficiency and industrial chain after deep application in traditional industries[4, 5]. This not only greatly improves production efficiency and quality, but also reconstructs traditional industries, enabling them to leap from industrialization to informatization. The so-called "Industry 4.0", intelligent logistics, modern agriculture, "technology finance", etc. all belong to this scope, which is the stage of industrial digitization. As two major development patterns of digital economy, digital industrialization and industrial digitization constitute the basic content of digital economy practice. Whether it is the G20 Hangzhou Summit's signing of the G20 Digital Economy Development and Cooperation Initiative, the 14th Five-Year Plan for Digital Economy Development issued through Chinese government or Statistical Classification of Digital Economy and Its Core Industries. The natural closeness between cultural industry and the digital economy enables the two to integrate quickly and deeply, resulting in a new form of industry-the digital cultural industry [6]. According to industry classification standards of China's national economy, the digital cultural industry is divided into four categories: digital cultural technology equipment manufacturing industry, digital creative content industry, digital cultural entertainment industry, and digital cultural service industry [7]. In China's economic practice, the digital cultural industry covers two major areas: the digital industrialization of digital cultural technology equipment manufacturing and the digitalization of digital cultural service supply. The scope of digital cultural industry is not limited to peripheral industries of digital economy, but also involves the core industries of digital economy. The digital cultural industry is no longer an optional form of industry, but an inevitable direction for development of cultural industries in digital economy era. In the era of digital economy, promoting the digital transformation of the cultural industry has become a necessary way to improve the cultural industry development quality [8]. Efficiency improvement brought by digitalization to the allocation of production resources and the creation of new cultural demands requires the emphasis on digital construction and continuous improvement of development quality in the development of the cultural industry. Against the backdrop of high-quality development becoming a development goal in various fields in China, promoting high-quality development of the digital cultural industry has become a necessary choice for the development of the cultural industry. So, what is high-quality development of digital cultural industry and what are its standards? According to current scholars, only the development of a good industrial ecosystem can achieve high-quality development. Specifically, in the digital cultural industry, it is necessary to build the high-level cultural industry digital ecosystem, achieve the integration of culture and technology, and match cultural supply with cultural demand in terms of technological innovation, demand feedback, and consumption upgrading. Whether it is the construction of a digital ecosystem or promoting the matching of cultural supply and demand, digitization is the core element. Only by grasping the core of digital construction can we truly achieve high-quality development of digital cultural industry. The foundation for empowering spiritual life and common prosperity through the digital cultural industry is digital technology facilities. We need to comprehensively and systematically promote the construction of digital infrastructure, narrow the spiritual gap brought about by the digital divide, and achieve a balance between the supply and demand of spiritual products. On the one hand, we need to comprehensively layout the construction of digital infrastructure from bottom to top. Building digital infrastructure such as data centers and cloud platforms, improving the cloud, network, and end infrastructure of the cultural industry, connecting the digital collection networked transmission intelligent computing digital chain, and providing technical support for promoting the free circulation of spiritual product resources across regions, levels, and populations [9]; Develop guidelines and regulations for digital governance, and strengthen the protection of intellectual property rights for intelligent spiritual products. On the other hand, we need to comprehensively promote construction of digital technology support systems and strengthen the integrated application and innovation of 5G, big data, cloud computing, Internet of Things, blockchain and other technologies in the cultural industry, ensure the effective supply of digital spiritual products, and meet the spiritual and cultural needs of people [10].

The quality evaluation of cultural industry development in the context of the digital economy is the real-life MAGDM [11]. The SVNSs [12] is useful technique to cope with uncertain information during the quality evaluation of cultural industry development in the context of the digital economy. Unfortunately, few valuable existing works were managed the EXPROM [13, 14,15] under SVNSs [12].

The main objective of this study is to cope with MAGDM through employing the SHSS-SVNN-EXPROM model to rank the alternatives. Finally, numerical examples and comparative analysis for quality evaluation of cultural industry development in the context of the digital economy is utilized to validate SHSS-SVNN-EXPROM model.

The main contributions of this study are formed: (1) the average model is formed to obtain the weight numbers; (2) the SHSS-SVNN-EXPROM model is formed under SVNNs; (3) the SHSS is employed to treat various sub criteria values in the decision making process (4) Finally, numerical example and comparative analysis for quality evaluation of cultural industry development in the context of the digital economy is utilized to validate the SHSS-SVNN-EXPROM model.

The remaining sections are organized as follows: Section 2 introduces the SVNSs. Section 3 develops the SHSS-SVNN-EXPROM model tailored for multi-attribute group decision-making (MAGDM). Section 4 applies the model to evaluate the quality of cultural industry development within the context of the digital economy, supplemented by comparative analyses to validate the effectiveness of the SHSS-SVNN-EXPROM model. Finally, Section 5 presents the conclusion.

2. Preliminaries

This section presents some definitions of the SHSS and SVNSs.

SuperHyperSoft Set (SHSS)

SHSS is an extension of the HyperSoft set and has various HyperSoft Sets. SHSS is used in this work for representing the computed criteria and sub criteria for selecting the best alternatives under SVNNs depending on the selected criteria and sub criteria [17,18,19].

Suppose the universe set $U = \{C_1, \ldots, C_n\}$, $P(U)$ is a power set of U. As well, C_1, C_2, C_3 are the criteria and the alternatives are assessed under these criteria

$P(C_1) \times P(C_2) \times P(C_3) \rightarrow P(U)$

$$P(C_1) \times P(C_2) \times P(C_3) =$$

$$\left\{\begin{matrix} \{\{C_{11}\},\{C_{12}\},\{C_{11},C_{12}\}\} \times \\ \{\{C_{21}\},\{C_{22}\},\{C_{21},C_{22}\}\} \times \\ \{\{C_{31}\},\{C_{32}\},\{C_{33}\},\{C_{31},C_{32}\},\{C_{31},C_{33}\},\{C_{33},C_{33}\},\{C_{31},C_{32}\}\} \end{matrix}\right\}$$

Definition 1 [12]. The SVNSs is outlined:

$$SA = \left\{\left(\vartheta, ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta)\right) \middle| \vartheta \in \Theta\right\} \tag{1}$$

where $ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta)$ depicts truth membership, indeterminacy membership and falsity membership, $ST_A(\vartheta), SI_A(\vartheta), SF_A(\vartheta) \in [0,1]$, $0 \le ST_A(\vartheta) + SI_A(\vartheta) + SF_A(\vartheta) \le 3$.

Definition 2 [16]. The score value function (SVF) of $SA = (ST_A, SI_A, SF_A)$ is outlined:

$$SVF(SA) = \frac{(2 + ST_A - SI_A - SF_A)}{3}, SVF(SA) \in [0,1]. \tag{2}$$

Definition 3 [16]. The accuracy value function (AVF) of $SA = (ST_A, SI_A, SF_A)$ is outlined:

$$AVF(SA) = ST_A - SF_A,\ AVF(SA) \in [-1,1]\ . \tag{3}$$

Peng et al. [16] outlined the order framework between two SVNNs.

Definition 4[16]. Let $SA = (ST_A, SI_A, SF_A)$ and $SB = (ST_B, SI_B, SF_B)$, let $SVF(SA) = \frac{(2 + ST_A - SI_A - SF_A)}{3}$ and $SVF(SB) = \frac{(2 + ST_B - SI_B - SF_B)}{3}$, and let $AVF(SA) = ST_A - SF_A$ and $AVF(SB) = ST_B - SF_B$, if $SVF(SA) < SVF(SB)$, then: $QA < QB$; if $SVF(SA) = SVF(SB)$, then: (1)if $AVF(SA) = AVF(SB)$, then $SA = SB$; (2) if $AVF(SA) > AVF(SB)$, then: $SA < SB$.

Definition 6. Let $SA = (ST_A, SI_A, SF_A)$ and $SB = (ST_B, SI_B, SF_B)$, then SVNN cosine similarity measure (SVNNCSM) based on the $SA = (ST_A, SI_A, SF_A)$ and $SB = (ST_B, SI_B, SF_B)$ is outlined:

$$SVNNCSM(SA, SB) = \frac{ST_A \times ST_B + SI_A \times SI_B + (1 - SF_A) \times (1 - SF_B)}{\left(\begin{matrix}\sqrt{(ST_A)^2 + (SI_A)^2 + (1 - SF_A)^2} \\ \cdot \sqrt{(ST_B)^2 + (SI_B)^2 + (1 - SF_B)^2}\end{matrix}\right)},$$

$$SVNNCSM(SA, SB) \in [0,1], \tag{4}$$

Definition 6. Let $SA=\left(ST_A,SI_A,SF_A\right)$ and $SB=\left(ST_B,SI_B,SF_B\right)$, then SVNN cosine function similarity measure (SVNNCFSM) based on the $SA=\left(ST_A,SI_A,SF_A\right)$ and $SB=\left(ST_B,SI_B,SF_B\right)$ is outlined:

$$SVNNCFSM\left(SA,SB\right)=\frac{1}{2}\left(\cos\left[\begin{array}{l}\frac{\pi}{12}\left(\left|ST_A-ST_B\right|+\left|SI_A-SI_B\right|+\left|SF_A-SF_B\right|\right)\\+\frac{\pi}{4}\max\left(\left(\left|ST_A-ST_B\right|,\left|SI_A-SI_B\right|,\left|SF_A-SF_B\right|\right)\right)\end{array}\right]\right)$$

$$SVNNCFSM\left(SA,SB\right)\in\left[0,1\right], \quad (5)$$

Definition 7 [12]. Let $SA=\left(ST_A,SI_A,SF_A\right)$ and $SB=\left(ST_B,SI_B,SF_B\right)$, the operations laws are outlined:

(1) $SA\oplus SB=\left(ST_A+ST_B-ST_A\cdot ST_B,SI_A\cdot SI_B,SF_A\cdot SF_B\right)$;

(2) $SA\otimes SB=\left(ST_A\cdot ST_B,SI_A+SI_B-SI_A\cdot SI_B,SF_A+SF_B-SF_A\cdot SF_B\right)$;

(3) $\gamma SA=\left(1-\left(1-ST_A\right)^{\gamma},\left(SI_A\right)^{\gamma},\left(SF_A\right)^{\gamma}\right),\gamma>0$;

(4) $\left(SA\right)^{\gamma}=\left(\left(ST_A\right)^{\gamma},\left(SI_A\right)^{\gamma},1-\left(1-SF_A\right)^{\gamma}\right),\gamma>0.$

The SVNNWA and SVNNWG approach are outlined.

Definition 8 [16]. If $SA_j = (ST_j, SI_j, SF_j)$, the SVNNWA operator is outlined:

$$\begin{aligned} \mathrm{SVNNWA}_{sw}(SA_1, SA_2, \cdots, SA_n) &= \bigoplus_{j=1}^{n}(sw_j SA_j) \\ &= \left(1-\prod_{j=1}^{n}(1-ST_j)^{sw_j}, \prod_{j=1}^{n}(SI_j)^{sw_j}, \prod_{j=1}^{n}(SF_j)^{sw_j}\right) \end{aligned} \tag{6}$$

with weight $sw = (sw_1, sw_2, ..., sw_n)^T$, $\sum_{j=1}^{n} sw_j = 1$.

Definition 9 [16]. If $SA_j = (ST_j, SI_j, SF_j)$, the SVNNWG approach is outlined:

$$\begin{aligned} \mathrm{SVNNWG}_{sw}(SA_1, SA_2, \cdots, SA_n) &= \bigotimes_{j=1}^{n}(SA_j)^{sw_j} \\ &= \left(\prod_{j=1}^{n}(ST_j)^{sw_j}, 1-\prod_{j=1}^{n}(1-SI_j)^{sw_j}, 1-\prod_{j=1}^{n}(1-SF_j)^{sw_j}\right) \end{aligned} \tag{7}$$

with weight $sw = (sw_1, sw_2, ..., sw_n)^T$, $\sum_{j=1}^{n} sw_j = 1$.

3. Methodology

This part shows the steps of the proposed methodology as shown in Figure 1.

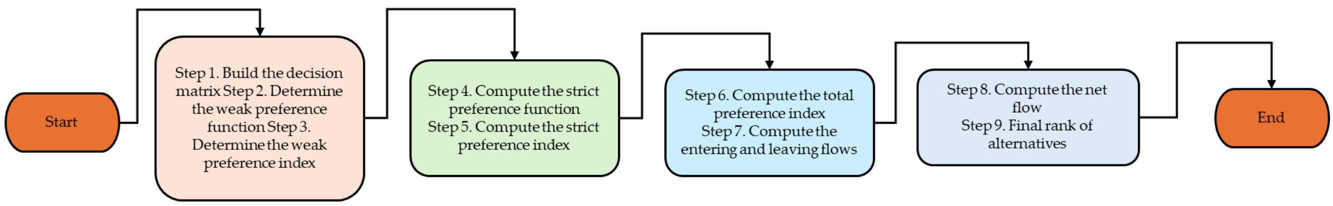

Figure 1. The steps of the proposed methodology.

Step 1. Build the decision matrix

$$Q = \begin{bmatrix} q_1(A_1) & \cdots & q_n(A_1) \\ \vdots & \ddots & \vdots \\ q_1(A_m) & \cdots & q_n(A_m) \end{bmatrix}; i = 1, \ldots, m; j = 1, \ldots, n \tag{8}$$

Step 2. Determine the weak preference function

To compute the weak preference function, we compute the pair difference between alternatives in the decision matrix as:

$$d_j(A_i, A_{i'}) = q_j(A_i) - q_j(A_{i'}) \tag{9}$$

Then we compute the value of preference function as:

$$P_j(A_i, A_{i'}) = q_j[d_j(A_i, A_{i'})] \tag{10}$$

$$0 \le P_j(A_i, A_{i'}) \le 1 \tag{11}$$

Step 3. Determine the weak preference index

The weak preference index can be computed as:

$$WP\left(P_j(A_i, A_{i'})\right) = \sum_{j=1}^{n} P_j(A_i, A_{i'}).\, w_j \,/\, \sum_{j=1}^{n} w_j \quad (12)$$

Step 4. Compute the strict preference function

The strict preference function can be computed by the positive and negative criteria as:

$$q_j(x) = \max\{q_j(x_1), q_j(x_2), \dots, q_j(x_n)\} \quad (13)$$

$$q_j(x) = \min\{q_j(x_1), q_j(x_2), \dots, q_j(x_n)\} \quad (14)$$

Step 5. Compute the strict preference index

$$SP(A_i, A_{i'}) = \sum_{j=1}^{n} P_j'(A_i, A_{i'}).\, w_j \,/\, \sum_{j=1}^{n} w_j \quad (15)$$

Step 6. Compute the total preference index

$$TP(A_i, A_{i'}) = \min\{1,\}WP\left(P_j(A_i, A_{i'})\right) + SP\left(P_j(A_i, A_{i'})\right) \quad (16)$$

Step 7. Compute the entering and leaving flows

$$E^{+}(A_i) = \frac{1}{m-1}\sum_{A_i \in A} TP(A_i, A_{i'}) \quad (17)$$

$$E^{-}(A_i) = \frac{1}{m-1}\sum_{A_i \in A} TP(A_{i'}, A_i) \quad (18)$$

Step 8. Compute the net flow

$$E(A_i) = E^{+}(A_i) + E^{-}(A_{i'}) \quad (19)$$

Step 9. Final rank of alternatives

The alternative A_i can be better than $A_{i'}$ if

$$if\ E(A_i) > E(A_{i'}) \quad (20)$$

4. Illustrative Example

In this study, the SVNN-EXPROM technique is employed to evaluate the quality of cultural industry development in the context of the digital economy. Five high-tech development zones are assessed based on eight attributes. Three experts and decision-makers participate in the evaluation process, using SVNNs to assess the criteria and alternatives. The evaluations are then converted into crisp values and aggregated into a single decision matrix.

The criteria weights calculated using the average method, are as follows: W1 is 0.1264, W2 is 0.1426, W3 is 0.1530, W4 is 0.1124, W5 is 0.1332, W6 is 0.1046, W7 is 0.1072, and W8 is 0.1207.

The criteria used in this study are:

1. Digital Infrastructure and Technology Integration

Assesses the availability and quality of digital infrastructure (e.g., internet access, data storage, and cloud computing) and the integration of advanced technologies (e.g., AI, AR/VR, blockchain) into cultural industry operations. Internet Penetration and Speed, Adoption of Emerging Technologies, Digitalization of Cultural Content,

2. Innovation and Creative Output

Evaluates the ability of the cultural industry to generate new and innovative cultural products, content, and services that appeal to diverse audiences in the digital economy. Cultural Product Diversity, Originality of Content, Involvement in Global Cultural Trends.

3. Market Competitiveness

Measures the cultural industry's ability to compete in domestic and international markets, including its branding, export potential, and market share in the digital economy. Global Market Presence, Branding and Marketing Efficiency, Revenue Growth in Digital Channels.

4. Talent and Skills Development

Focus on the availability of skilled personnel in the cultural industry, including technical, creative, and managerial talent, and the efforts to develop these skills through training and education. Availability of Skilled Workforce, Investment in Skill Development Programs, Collaboration with Educational Institutions.

5. Cultural Heritage Preservation and Digital Adaptation

Evaluates efforts to preserve cultural heritage while adapting it for digital platforms to ensure relevance in the digital economy. Digital Archiving of Heritage, Use of Technology in Cultural Conservation, Engagement with Younger Audiences

6. Policy Support and Regulation

Assesses the role of government policies and regulations in supporting the cultural industry, such as tax incentives, copyright protection, and funding for digital initiatives. Government Funding and Subsidies, Intellectual Property Rights Protection, Policy Alignment with Digital Economy Goals.

7. Audience Engagement and Satisfaction

Measures the level of audience interaction and satisfaction with cultural products and services, focusing on user experience in digital platforms and consumer feedback mechanisms. User Experience and Accessibility, Customer Feedback and Reviews, Audience Retention Rates

8. Sustainability and Social Responsibility

Examine the cultural industry's commitment to environmental sustainability and social responsibility, including green practices and community-oriented projects. Adoption of Green Technologies, Community Engagement Initiatives, Sustainability Reporting and Compliance

The criteria and their values for SHSS

A. Digital Infrastructure and Technology Integration {sufficient, insufficient}
B. Innovation and Creative Output {sufficient, insufficient}
C. Market Competitiveness {low, medium, high}
D. Talent and Skills Development {penetrable, impenetrable}
E. Cultural Heritage Preservation and Digital Adaptation {adjustable, non-adjustable}
F. Policy Support and Regulation {appropriate, inappropriate}
G. Audience Engagement and Satisfaction {sufficient, insufficient}
H. Sustainability and Social Responsibility {bad, good}

Based on the SHSS can be suggest a set of groups for sub criteria to rank the alternatives as:

{sufficient, insufficient}, {sufficient, insufficient}, {low, medium, high}, {penetrable, impenetrable}, {adjustable, non-adjustable}, {appropriate, inappropriate}, {sufficient, insufficient}, {bad, good}

We choose the values as:

{sufficient}, {sufficient}, {medium}, {penetrable}, {non-adjustable}, {appropriate}, {sufficient, insufficient}, {bad, good}

There are four groups for SHSS or four HyperSoft sets as:

Group 1: {sufficient}, {sufficient}, {medium}, {penetrable}, {non-adjustable}, {appropriate}, {sufficient}, {bad}

Group 2: {sufficient}, {sufficient}, {medium}, {penetrable}, {non-adjustable}, {appropriate}, {sufficient}, {good}

Group 3: {sufficient}, {sufficient}, {medium}, {penetrable}, {non-adjustable}, {appropriate}, {insufficient}, {bad}

Group 4: {sufficient}, {sufficient}, {medium}, {penetrable}, {non-adjustable}, {appropriate}, {insufficient}, { good}

We can implement the proposed method under four groups as:

Based on the Group 1 Eq. (8) is used to build the decision matrix.

The opinions of the first expert as:

(0.2,0.7,0.8)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
(0.3,0.6,0.7)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.9,0.1,0.2)
(0.5,0.5,0.5)	(0.5,0.5,0.5)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.3,0.6,0.7)	(0.8,0.2,0.3)
(0.6,0.4,0.5)	(0.6,0.4,0.5)	(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.7,0.3,0.4)
(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.2,0.7,0.8)	(0.3,0.6,0.7)	(0.5,0.5,0.5)	(0.6,0.4,0.5)

The opinions of the second expert as:

(0.6,0.4,0.5)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.5,0.5,0.5)	(0.6,0.4,0.5)	(0.6,0.4,0.5)	(0.1,0.8,0.9)
(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.7,0.3,0.4)	(0.9,0.1,0.2)	(0.9,0.1,0.2)	(0.6,0.4,0.5)
(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.9,0.1,0.2)	(0.6,0.4,0.5)	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.9,0.1,0.2)
(0.6,0.4,0.5)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)
(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.1,0.8,0.9)	(0.3,0.6,0.7)	(0.1,0.8,0.9)	(0.6,0.4,0.5)

The opinions of the third expert as:

(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.7,0.3,0.4)	(0.6,0.4,0.5)	(0.1,0.8,0.9)	(0.3,0.6,0.7)	(0.2,0.7,0.8)	(0.1,0.8,0.9)
(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.5,0.5,0.5)	(0.1,0.8,0.9)
(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.1,0.8,0.9)	(0.9,0.1,0.2)
(0.6,0.4,0.5)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)	(0.9,0.1,0.2)	(0.8,0.2,0.3)
(0.7,0.3,0.4)	(0.8,0.2,0.3)	(0.8,0.2,0.3)	(0.1,0.8,0.9)	(0.8,0.2,0.3)	(0.3,0.6,0.7)	(0.8,0.2,0.3)	(0.6,0.4,0.5)

Then we determine the weak preference function for the first alternative as:

0	0	0	0	0	0	0	0
-0.377777778	0.488888889	-0.2	0.077777778	-0.355555556	-0.111111111	-0.277777778	-0.388888889
-0.155555556	0.022222222	0.322222223	-0.088888889	-0.111111111	-0.211111111	0.144444445	-0.700000001
-0.255555556	0.277777778	-0.133333333	0.011111111	-0.488888889	0.066666667	-0.311111111	-0.388888889
-0.355555556	0	0.077777778	0.433333334	0	0.077777778	-0.122222222	-0.433333334

We determined the weak preference index using Eq. (12), followed by the computation of the strict preference function using Eq. (13). Next, we calculated the strict preference index using Eq. (15) and the total preference index using Eq. (16). Subsequently, we computed the entering and leaving flows and, finally, the net flow using Eq. (19). Based on these computations, the alternatives were ranked as follows: A1 > A5 > A3 > A4 > A2.

For Group 2, the same steps were applied as in Group 1, resulting in the final rank of alternatives:
A1 > A5 > A3 > A4 > A2.
For Group 3, the process was repeated using the same methodology, yielding the same final rank:
A1 > A5 > A3 > A4 > A2.
For Group 4, the steps were again applied as in Group 1, resulting in the identical rank:
A1 > A5 > A3 > A4 > A2.
The final consolidated rank across all four groups is:
A1 > A5 > A3 > A4 > A2.
This analysis indicates that Alternative 1 (A1) is the best option, while Alternative 2 (A2) is the least favorable across all four groups.

4.1 Results and Discussion

The world is currently undergoing a profound technological revolution, with new-generation information intelligent technologies such as 5G, Internet of Things, blockchain, cloud computing, artificial intelligence, etc., bringing opportunities for economic digitization. The digital industry is emerging like mushrooms after rain, and the digital economy era has arrived. As the core driving force of economic growth in the new era, the digital economy has penetrated various fields of human production and become the commanding heights of a new round of competition in various industries. The growth of digital economy in major countries around the world is significantly higher than the growth of their domestic gross domestic product, and governments are continuing to promote development of key areas of digital economy.

The digital economy can integrate well with traditional industries and play an important role in connecting, driving and balancing the development of three major industries of the national economy. From the natural evolution of technology, digital technology will first spread from the digital industry to the industry with the highest correlation with it. The symbolic characteristics of the cultural industry have a natural commonality with digital technology.

Compared to other industries, the cultural industry can more conveniently obtain digital empowerment and integrate with it. From the development process of China's digital economy, the cultural industry not only bears the brunt, but also achieves a dual increase in economic structure and scale through digital transformation and the emergence of new formats. The natural affinity between cultural industry and the digital economy makes it the main area for countries to develop their digital economy.

The digital transformation of the cultural industry has taken solid steps in practice, but the weak theoretical research cannot be ignored, and there are obvious deficiencies in some basic cognition and internal law exploration. The quality evaluation of cultural industry development in the context of the digital economy is MAGDM.

We obtained the criteria weights using the average method. We show criterion 3 has the highest importance and criterion 6 has the lowest importance. Then we applied the SHSS with the proposed method to deal with the various values of sub criteria. Then we ranked the alternatives. We show the alternative 1 is the best and alternative 2 is the worst in four groups.

4.2. Comparative Analysis

The outlined SHSS-SVNN-EXPROM approach is always compared with SVNN-VIKOR technique, SVNN-COPRAS technique, SVNN-WASPAS approach, SVNN-TODIM technique , SVNN-TOPSIS technique and SVNN-CODAS technique. The sufficient comparative results are verified in Table 1.

Table 1. Order for different approaches

METHOD	ORDER
SVNN-VIKOR TECHNIQUE	A1>A5>A4>A3>A2
SVNN-COPRAS TECHNIQUE	A1>A3>A5>A4>A2
SVNN-WASPAS TECHNIQUE	A1>A5>A3>A4>A2
SVNN-TODIM TECHNIQUE	A1>A5>A3>A4>A2
SVNN-TOPSIS TECHNIQUE	A1>A3>A5>A4>A2
SVNN-CODAS TECHNIQUE	A1>A5>A3>A4>A2

The similarity coefficients between SVNN-VIKOR technique , SVNN-COPRAS technique, SVNN-WASPAS approach, SVNN-TODIM approach, SVNN-TOPSIS approach, SVNN-CODAS approach and SHSS-SVNN-EXPROM approach was obtained in light with WS coefficients, the derived results are outlined in Table 2.

Table 2. The WS coefficient

	SHSS-SVNN-EXPROM	*SVNN-VIKOR technique*	*SVNN-COPRAS technique*	*SVNN-WASPAS technique*	*SVNN-TODIM technique*	*SVNN-TOPSIS technique*	*SVNN-CODAS technique*
A_1	5	5	5	5	5	5	5
A_1	1	1	1	1	1	1	1
A_1	3	2	4	3	3	4	3
A_1	2	3	2	2	2	2	2
A_1	4	4	3	4	4	3	4
	-	0.9	0.9	1	1	0.9	1

The WS coefficient information corroborates the order of SHSS-SVNN-EXPROM approach is same to the order of SVNN-WASPAS technique, SVNN-TODIM, and SVNN-CODAS. And it differs from the SVNN-VIKOR, SVNN-COPRAS, SVNN-TOPSIS.

Thus, the main advantages of SHSS-SVNN-EXPROM approach are outlined: (1) the outlined SHSS-SVNN-EXPROM not only corroborated the uncertainty for MAGDM, (2) the outlined SHSS-SVNN-EXPROM conducted different behavior approach as MAGDM when these approaches are combined. (3) it can deal with various values of sub criteria.

5. Conclusion

Contemporary industrial development has the attribute of globalization, thanks in large part to the universality and uniformity of industrial technical standards. The unification of technical standards is crucial to promoting the cultural industry to realize in-depth development and a wider range of product circulation. The unification of technical standards can not only effectively reduce transaction costs and generate more network externalities, but also help build a more open and unified cultural products trading market, so that all parties are involved in the main body to obtain greater benefits. In the era of digital economy, technology is updated and iterated more rapidly. Specifically in the field of cultural industry, there is an urgent need to build and update the production technology standards, product quality standards and safety standards of cultural products. The market scale of China's cultural industry is huge, and there is a huge demand for industrial standards. At the same time, the development of China's cultural industry is facing fierce competition with international industry giants. Only by creating various types of industrial standards suitable for the needs of industrial development and future trends, it is possible to maintain the safety of China's cultural industry and thus enhance China's cultural construction. New, effective and universal technical standards occupy the core position among all kinds of standards related to the industry, and they are also the industrial commanding heights for which all countries are competing. The quality evaluation of cultural industry development in the context of the digital economy is MAGDM. In this paper, the SHSS-SVNN-EXPROM model is formed to cope with the MAGDM. The average method is utilized to obtain the weight numbers under SVNSs. Finally, numerical examples for quality evaluation of cultural industry development in the context of the digital economy and comparative analysis is utilized to validate SHSS-SVNN-EXPROM model.

The main contributions of this study are formed: (1) the average model is formed to obtain the weight numbers; (2) the SHSS-SVNN-EXPROM model is formed SHSS to deal with various criteria under SVNNs; (3) Finally, numerical example and comparative analysis for quality evaluation of cultural industry development in the context of the digital economy is utilized to validate SHSS-SVNN-EXPROM model.

There may be some possible research limitations for quality evaluation of cultural industry development in the context of the digital economy, which could be further conducted in our future research directions: (1) It is the worthwhile research content to conduct prospect theory model for quality evaluation of cultural industry development in the context of the digital economy under SVNSs; (2) It is also worthwhile research content to conduct regret theory for quality evaluation of cultural industry development in the context of the digital economy under SVNSs environment; (3) In subsequent research contents, the application of SVNSs needs to be formed with consensus issues for quality evaluation of cultural industry development in the context of the digital economy.

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