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Key Selection Factors Influencing Animation Films from the Perspective of the Audience

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Abstract: The animation industry is an important part of China's cultural and creative industries. In fact, it is the leading cultural and creative industry in China. However, there is insufficient research on the audience's views in China's animation industry, which has become an important research gap. Thus, an integrated approach of FAHP and GRA is proposed in this study, to analyse and evaluate the key selection factors for the Chinese animation industry from the perspective of a Chinese audience. In this research, in both FAHP and GRA models, factors such as visual appealing character, interesting performance of character animation, and easy-to-understand storyline are prioritised conditions for the selection of Chinese animation from the perspective of Chinese audiences. The main contribution of this research is to underscore the value of the hybrid MCDM model to aid Chinese animation companies in aligning their productions with audience expectations and making informed decisions. Finally, this study offers a systematic and objective model for Chinese animation selection, providing practical insights that can be applied in the industry and can serve as a valuable reference for future research in similar domains.

Keywords: multi-criteria decision-making (MCDM); Chinese animation; perspective of Chinese audience; choice factors; fuzzy analytic hierarchy process (FAHP); grey rational analysis (GRA)

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1. Introduction

The animation industry is a capital-intensive, technology-intensive, and knowledge-intensive cultural industry, with all the characteristics of being a knowledge economy and having an attractive market perspective, which is why it is called an emerging sunrise industry [1]. With the development of digital technology and policy support, the cultural and creative industries have been undergoing rapid development and growth in recent decades, especially the animation industry, which is now one of the core industries in many developing countries [2]. Nurjati [3] argued that Indonesia has the potential to develop the animation industry. However, in areas including animation professionals, infrastructure, and art education, further efforts and improvements are still needed. Niracharapa [4] presented the results of a study on the competitiveness of Thailand's animation industry. The study found that a high-quality workforce and creativity are the basis for the rapid development of Thailand's animation industry. In the meantime, factors such as government policy support, infrastructure construction, marketing methods, and funds also have a significant impact on the development of Thailand's animation industry.

Meanwhile, Liu [5] presented a comparative study of the Chinese and British governments' policy support for the animation industry. Also, Cao [6] discussed the strategies and methods in which policy tools can be used to optimise the management of China's animation industry. From a talent development perspective, Collier [7] discussed the characteristics that cultural and creative graduates should possess in order to adapt to the animation industry's high-pressure work environment. Moreover, Tang et al. [8] discussed the inheritance relationship between animated films and traditional Chinese myths, from the perspective of content production. Yan et al. [9] conducted research on the cross-media operation mode of the animation industry, focusing on the relationship between the animation industry's intellectual property (IP) and various industries, for providing relevant suggestions. Shaw [10] reported that the output value of China's animation industry were about RMB 250 billion in 2020. However, the output value of China's animation industry was only about RMB 76 billion in 2002. This demonstrates that the scale and the output value of China's animation industry have been gradually increasing over the past 20 years.

Furthermore, Fan et al. [11] suggested that China's animation industry, having matured over recent decades, warrants strategic attention for sustainable growth. They applied Porter's Diamond Model to offer multifaceted strategies across production, demand, supply chain, corporate strategy, culture, and governance to ensure enduring development.

The above research has studied and discussed the Chinese animation industry from various aspects. Interestingly, many scholars [12–17] mentioned that the future transformation trend of China's animation industry will be toward market-oriented operation and development, that is, market-oriented operations will be the key to the future development of China's animation industry. Among them, Su [16] and Zhang [17] argued that the audience's psychology and participation are necessary and key factors in the process of Chinese animation moving towards marketisation. However, there is insufficient research on the audience's views of China's animation industry, which has become an important research gap. Most practitioners of the Chinese animation industry do not realise that their works can satisfy audiences. Accordingly, this research will explore the important factors that Chinese audiences consider and pay attention to when choosing animation works, from their perspectives, for filling the research gap.

When faced with the need to weigh various factors to choose between multiple options, it is termed multi-criteria decision-making (MCDM) [18]. MCDM techniques offer the notable benefit of allowing decision-makers to assign significant importance to factors such as risk and return, while allocating less importance to other criteria [19].

Two MCDM techniques, fuzzy analytic hierarchy process (FAHP) and grey rational analysis (GRA), were implemented in this study.

The analytic hierarchy process (AHP) was proposed by Saaty in 1980 [20]. It stands out among techniques for addressing multi-criteria decision-making (MCDM) across various domains, a notion supported by numerous studies [21–23]. Yet, AHP falls short in elucidating or resolving issues stemming from uncertain phenomena. Hence, in 1996, Chang [24] pioneered an integrated approach merging fuzzy theory with AHP, termed fuzzy AHP (FAHP). This method adeptly tackles decision-making challenges induced by imprecise phenomena. Over recent decades, FAHP has garnered widespread adoption and emerged as a dependable and validated research tool for MCDM problems [25–30].

Grey rational analysis (GRA) was proposed by Deng in 1982 [31]. It mainly targets uncertainty or incomplete information system models. This method can effectively deal with "uncertainty", "multivariate input information", or "discrete" data, through system correlation analysis, model building, prediction and decision-making, and other analysis methods [32].

In light of this, this study will construct the measurement structure for the selection factors of Chinese animation works from expert questionnaires. Afterwards, fuzzy analytic hierarchy process (FAHP) and grey rational analysis (GRA) will simultaneously be implemented and applied to evaluate and rank the selection factors of Chinese animation works from the perspective of a Chinese audience, to achieve the following research purposes:

1. To construct the measurement structure of selection factors' evaluation for Chinese animation works.
2. To calculate and rank the weight of dimensions and indicators for the selection factors of Chinese animation works using FAHP.
3. To evaluate and rank dimensions and indicators of Chinese animation works' selection factors by applying GRA.

4. To explore and discuss the differences between the results of the FAHP and the GRA assessments.
5. To provide relevant decision-making suggestions for the practitioners of the Chinese animation industry.

2. Literature Review

2.1. The Development of the Chinese Animation Industry

In the 1920s, the Wan brothers, with the inspiration of Disney animations, created the first Chinese animation short that opened up the history of Chinese animation and made the Wan brothers the forerunners of Chinese animation. [33]. In 1941, the Wan brothers produced a feature-length animated film called *The Iron Fan Princess*. It was considered to be Asia's first feature-length animated film [34]. In the two decades from the 1920s to the 1940s, a great deal of American technical and aesthetic influence can be seen in Chinese animation [35]. Afterwards, Shanghai Animation Film Studio was founded, in the late 1950s. From the 1950s to the 1980s, it produced a large number of high-quality and reputable animation works, which are regarded as the golden age of the Chinese animation industry [36].

Following the economic reforms that began in the late 1980s, the pace of China's economic development increased significantly over the next two decades. During this period, many foreign animation products were allowed to enter the Chinese market, which had an impact on China's animation industry. As a result, the development speed of China's animation industry began to slow down [37]. Since the beginning of the 21st century, the Chinese government has adopted various policies to support the development of animation [20–22]. Under the environment of strong support from policy instruments, China's animation industry has been riding a wave of development. There has been a steady improvement in the quantity and quality of animation works. In the meantime, the number of animation production companies is on the rise. To date, many high-quality and internationally renowned works have been produced, such as *Magic Lotus Lantern*, *Monkey King: Hero is Back*, *Ne Zha*, etc. [23].

Intriguingly, the scale and level of the animation industry in China has grown significantly with the help of policy tools. However, many scholars [38–40] have reported that the Chinese animation industry should still strive to create copyright value; for example, cultural brand building, sustainable development planning, balance between art and commercial value, etc. Meanwhile, Wei [41] and Sha [42] suggested that the Chinese animation industry must create a business model and build a complete industrial chain, in order to meet the future needs of market-oriented development.

2.2. The Integrated Approach of FAHP and GRA

Perman et al. [43] and Koosha et al. [44] reported that FAHP has two main advantages, as follows: (1) it outlines the hierarchy of the problem for analysing sensitivity and (2) verification of consistency contributes to resolving MCDM issues effectively.

In the meantime, Lin et al. [45] highlighted five key advantages of the GRA method, as follows: it is suitable as a model for non-functional sequences, its computational method is straightforward, it does not require a significant amount of data, it does not require the data to follow a normal distribution, and it provides results that are consistent with quantitative analysis, without any discrepancies.

Accordingly, Gumus et al. [46] suggested a hybrid methodology that melds AHP with GRA, employing fuzzy logic to address issues within the energy conservation sector. Zhang et al. [47] put forward an algorithm designed to assess the equilibrium of the network load in hybrid wireless settings, by integrating FAHP with GRA. Furthermore, some scholars [48,49] have utilised this combined FAHP and GRA approach for the assessment of mutual fund performance and the selection of wastewater treatment technologies.

The above research results prove the feasibility of applying the hybrid approach of FAHP and GRA in various fields, thus providing a great deal of inspiration for the research process and the methodology of this study.

3. Materials and Methods

In this research, a hybrid approach of FAHP and GRA was proposed for the evaluation of selection factors for Chinese animation. The research process is shown in Figure 1.

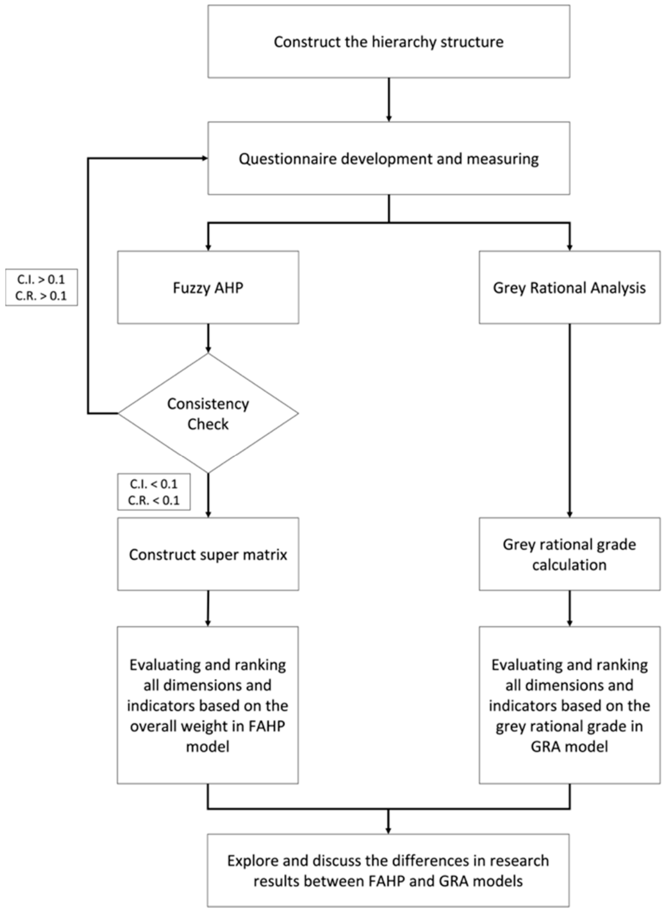

Figure 1. Research process of this study.

3.1. The Construction of the Hierarchy Structure

In this research, the issue has been methodically broken down into evaluative indicators based on the AHP method. Subsequently, a hierarchical framework is constituted by categorising these indices. In addition, Tsai et al. [50] suggested that the indices should be refined and revised via expert questionnaires. As such, the current study engages with expertly designed questionnaires to collate professional insights, thereby refining the indices, in line with the informed recommendations. This serves to ensure the indices' articulation is tailored to the distinctive selection parameters pertinent to productions of Chinese animation. In culmination, a hierarchically structured set of evaluative indices is constructed, reflective of the outcomes gleaned from the expert questionnaires.

3.2. Questionnaire Development and Measuring

This study employs the expert questionnaire method to collect research data for determining the weight and grey rational grade of each dimension and indicator within the hierarchy structure, following FAHP and GRA methodologies. Consequently, ensuring the validity of the questionnaire is crucial, prior to its development. To achieve this, the questionnaire statement is revised based on expert guidance, retaining the original representation of dimensions and indicators to uphold high content validity [51]. Subsequently, a pre-test is conducted, and statements are revised based on pre-test results to ensure clarity in questionnaire comprehension.

Regarding the quantity of specialists, F.J. Parenté and J.K. Anderson-Parenté [52] suggested a minimum of ten or more experts. Meanwhile, numerous academics [53–55] have noted that adopting the viewpoint of expert audiences may simplify the identification and understanding of true research issues. Also, Darko et al. [56] observed that an extensive sample size might prove counterproductive, as engaging "cold-called" experts could significantly influence the outcome of consistency reviews. In the meantime, various studies [57–63] have discovered that a considerable amount of research employed a modest cohort of four to nine experts, to secure a sound and dependable basis for decision-making.

Accordingly, a total of 20 experts are selected in this study to avoid the influence of opinions from "cold-called" experts on the consistency evaluation results, thus achieving our main research objectives.

3.3. Fuzzy Analytic Hierarchy Process

3.3.1. Fuzzy Sets and Linguistic Variables

Herreva et al. [64] believed that linguistic variables such as "very important", "somewhat important", and "unimportant" are often considered to represent the degree to which human psychology perceives a given problem. However, Zimmermann [65] found that the linguistic variables used to express the priority of human psychological perception are usually ambiguous, thus it is necessary to introduce fuzzy theory to clarify the degree of human psychological perception.

Fuzzy theory was proposed by Dr. Lotfi Zadeh in 1965 [66]. It is an algorithm that works with fuzzy numbers, which introduces a concept such as reasoning to discover the result that is closest to the variable of the human psychological perception.

Therefore, this research studied fuzzy numbers and found that fuzzy numbers are often expressed in a mathematical way [67–74]. For example, the triangular fuzzy number A (L_{ij}, M_{ij}, U_{ij}), given by the following equation, is shown in Figure 2.

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & , \quad x < L_{ij} \\ \frac{x-L_{ij}}{M_{ij}-L_{ij}} & , \quad L_{ij} \le x \le M_{ij} \\ \frac{U_{ij}-x}{U_{ij}-M_{ij}} & , \quad M_{ij} \le x \le U_{ij} \\ 0 & , \quad x > U_{ij} \end{cases}, \tag{1}$$

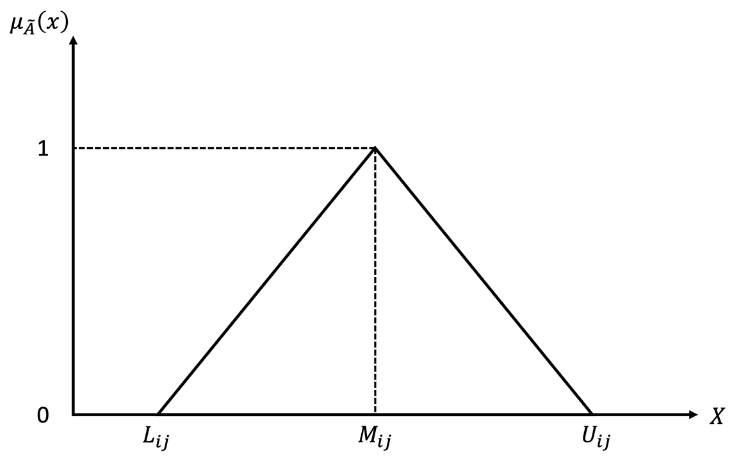

Figure 2. Fuzzy triangular numbers.

Meanwhile, many scholars [67–74] have reported that the most likely evaluation value of triangular fuzzy numbers is the crisp value. The crisp value of triangular fuzzy numbers is given by the following equation [75].

$$A_a = \left[L_{ij}{}^a, M_{ij}{}^a\right] = \left[\left(M_{ij} - L_{ij}\right)a - \left(U_{ij} - M_{ij}\right)a + U_{ij}\right] \tag{2}$$

Also, Buckley [76] and Pedrycz [77] reported that triangular fuzzy numbers can accurately convert fuzzy numbers into clear and practical numbers, in order to accurately perceive the variables in the human psychology in the fuzzy states. Moreover, triangular fuzzy numbers have also been proven by Pedrycz [77] to be very suitable for expressing the relative psychological perception and judgment degree of each dimension and indicator in the hierarchical structure. In light of this, this research utilises triangular fuzzy numbers to represent linguistic variable scales.

Furthermore, AHP used a nine-point evaluation scale to indicate the importance of each evaluation criterion. Therefore, we integrate the triangular fuzzy number and AHP evaluation scale for assessing and measuring human psychological true preferences for specific options. The corresponding fuzzy numbers are provided in Table 1.

Table 1. Fuzzy numbers and scales [78].

Linguistic Variables	Fuzzy Numbers	Triangular Fuzzy Scale			Reversed Triangular Fuzzy Scale		
Equally Preferred	$\tilde{1}$	1	1	1	1	1	1
Intermediate	$\tilde{2}$	1	2	3	1/3	1/2	1
Moderately Preferred	$\tilde{3}$	2	3	4	1/4	1/3	1/2
Intermediate	$\tilde{4}$	3	4	5	1/5	1/4	1/3
Strongly Preferred	$\tilde{5}$	4	5	6	1/6	1/5	1/4
Intermediate	$\tilde{6}$	5	6	7	1/7	1/6	1/5
Very Strongly Preferred	$\tilde{7}$	6	7	8	1/8	1/7	1/6
Intermediate	$\tilde{8}$	7	8	9	1/9	1/8	1/7
Extremely Preferred	$\tilde{9}$	9	9	9	1/9	1/9	1/9

3.3.2. Synthesise Opinions of All Experts

In this paper, the geometric mean method is employed to synthesise the outcomes of expert questionnaires, principally because Saaty [79] considered the geometric mean approach to be relatively unaffected by extreme values. The aggregated result of all expert opinions is determined using the subsequent equation:

$$\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}, \tag{3}$$

where

n is the number of experts.

3.3.3. Set up the Fuzzy Pairwise Comparison Matrix

In this step, a fuzzy pairwise comparison matrix is performed and presented as follows:

$$\tilde{A}^k = \begin{bmatrix} \tilde{a}_{11}^k & \tilde{a}_{12}^k & \cdots & \tilde{a}_{1n}^k \\ \tilde{a}_{21}^k & \tilde{a}_{22}^k & \cdots & \tilde{a}_{2n}^k \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1}^k & \tilde{a}_{n2}^k & \cdots & \tilde{a}_{nn}^k \end{bmatrix}, \tag{4}$$

where

$\widetilde{A}^k$ represents the fuzzy pairwise comparison matrix.

$\widetilde{a}^k_{nn}$ is the triangular fuzzy mean value for comparing priority pairs among elements.

3.3.4. The Calculation of Fuzzy Geometric Mean ($\widetilde{r}_i$) and Fuzzy Weight ($\widetilde{w}_i$)

The calculation of fuzzy geometric mean and fuzzy weight is as follows:

$$\widetilde{r}_i = \left[\left(L_{ij1} \bigotimes L_{ij2} \bigotimes, \cdots, \bigotimes L_{ijk}\right)^{\frac{1}{i}}, \left(M_{ij1} \bigotimes M_{ij2} \bigotimes, \cdots, \bigotimes M_{ijk}\right)^{\frac{1}{i}}, \left(U_{ij1} \bigotimes U_{ij2} \bigotimes, \cdots, \bigotimes U_{ijk}\right)^{\frac{1}{i}}\right] \quad (5)$$

$$\widetilde{w}_i = \widetilde{r}_i \bigotimes \left(\widetilde{r}_1 \bigoplus \widetilde{r}_2 \bigoplus \cdots \bigoplus \widetilde{r}_n\right)^{-1} = (lw_i,\ mw_i,\ uw_i) \quad (6)$$

3.3.5. Defuzzification

In terms of fuzzy decomposition, the optimism index (α, β) is utilised to combine the smallest and largest values of triangular fuzzy numbers (L_{ij}, U_{ij}) for defuzzification [80–82]. Thus, the process of fuzzy decomposition is as follows:

$$t_{\alpha,\beta}(\overline{a}_{ij}) = \left[\beta f_a(L_{ij}) + (1-\beta) f_a(U_{ij})\right], \alpha \in [0,1],\ \beta \in [0,1], \quad (7)$$

where

$$f_a(L_{ij}) = \left(M_{ij} - L_{ij}\right)\alpha + L_{ij}, \quad (8)$$

$$f_a(U_{ij}) = U_{ij} - \left(M_{ij} - L_{ij}\right)\alpha, \quad (9)$$

When the diagonal matrix is matching, we have

$$t_{\alpha,\beta}(\overline{a}_{ij}) = \frac{1}{t_{\alpha,\beta}(\overline{a}_{ij})}, \alpha \in [0,1],\ \beta \in [0,1], i > j \quad (10)$$

3.3.6. Normalisation

Afterwards, the defuzzified weights (w_i) were normalised using the following equation to obtain a weighted total of 1.

$$\omega_i = \frac{w_i}{\sum w_i} \quad (11)$$

3.3.7. Consistency Check

Saaty [83] proposed adopting the consistency index (*C.I.*) and consistency ratio (*C.R.*) to verify the consistency of the comparison matrix. The *C.I.* and *C.R.* are defined as follows:

$$C.I. = \frac{\lambda max - n}{n-1}, \quad (12)$$

where

n is the number of criteria.

$$C.R. = \frac{C.I.}{R.I.}, \quad (13)$$

The random index (*R.I.*) is a consistency index that is produced using positive reciprocal matrices of different orders. Table 2 shows the values of the random index.

Table 2. Random indexes (*R.I.s*).

The Order of Matrix	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I.	-	-	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.53	1.56	1.57	1.59

When $C.I. \leq 0.1$, it refers to the best acceptable error. When $C.R. \leq 0.1$, it means that the consistency of the matrix is satisfactory.

3.3.8. The Construction of Super Matrix

After completing the above steps, the super matrix is formed as follows:

$$W_N = \begin{bmatrix} 0 & 0 & 0 \\ w_1 & W_3 & 0 \\ 0 & W_2 & W_4 \end{bmatrix}, \tag{14}$$

where

W_N represents the weight of indicators in the super matrix.
w_1 is the vector of the feature.
W_2 means the vector of the criterion.
W_3 represents the dependency of dimensions.
W_4 is the dependency of criteria.
Finally, the weight of indicators in the super matrix (W_N) is calculated as follows:

$$\left.\begin{array}{l} W_3 \times w_1 = W_c \\ W_4 \times W_2 = W_e \end{array}\right\rangle \Rightarrow W_e \times W_c = W_N, \tag{15}$$

where

W_c is the weight matrix of the main criteria, considering the interdependence degree.
W_e is the evaluation weight matrix of the sub-criteria, considering the interdependence degree.

3.4. Grey Rational Analysis

3.4.1. The Definition of Evaluation Indicators and Data Treatment

This study utilises a direct rating scale from 1 to 9, with higher scores reflecting greater aptitude, to assess dimensions and indicators. Experts assign scores reflecting each aspect's importance, enabling the evaluation of their significance within the hierarchy.

3.4.2. The Calculation of Referential Series and Compared Series

The referential series (x_0) with the number of indicators (n) is defined as follows:

$$x_0 = (x_0(1), x_0(2), \ldots, x_0(n)) \tag{16}$$

The compared series (x_i) is defined as follows:

$$x_i = (x_i(1), x_i(2), \ldots, x_i(n)),\ i = 1, 2, \ldots, m \tag{17}$$

3.4.3. Normalisation

Data from reference and comparison series are normalised to ensure comparability. In this study, larger scores signify a better performance, with the normalisation method for both series detailed below [84]:

$$x_i^*(k) = \frac{x_i(k) - \min\limits_k x_i(k)}{\max\limits_k x_i(k) - \min\limits_k x_i(k)}, \tag{18}$$

where

$\max\limits_k x_i(k)$ is the maximum value of the k indicator.
$\min\limits_k x_i(k)$ represents the minimum value of the k indicator.

3.4.4. Calculate the Difference between Referential Series and Compared Series

The series difference is calculated as follows:

$$\Delta_{0i}(k) = |x_0(k) - x_i(k)|,\ k = 1, 2, \ldots, 18, \tag{19}$$

where

$x_0(k)$ is the referential series of 18 evaluation indicators.

$x_i(k)$ represents the compared series of 18 evaluation indicators.

3.4.5. Calculate the Gray Rational Coefficient

The grey relational coefficient between the compared series (x_i) and the referential series (x_0) at the j^{th} indicator is defined as follows:

$$\gamma_{0i}(k) = \frac{\Delta\min + \zeta\Delta\max}{\Delta_{0i}(k) + \zeta\Delta\max} \tag{20}$$

3.4.6. The Calculation of the Gray Rational Grade

The grey rational grade (GRG) of a series (x_i) is calculated as follows:

$$\Gamma_{0i} = \sum_{k=1}^{n} \omega_k \gamma_{0i}(k) \tag{21}$$

Finally, the alternatives are prioritised based on the magnitude of GRG values (Γ_{0i}). The alternative with the largest GRG value represents the best alternative and so on.

4. Results

4.1. The Construction of the Hierarchy Structure

In this research, a total of ten experts in the Chinese animation industry, including two senior managers, three senior practitioners, three senior film critics, and two senior instructors, were invited for the reviewing and revision of dimensions and indicators in the hierarchy structure. Then, 10 expert questionnaires with revised indicators were sent to the above mentioned experts and 10 valid questionnaires were collected. Afterwards, a survey questionnaire on the audience selection factors of the Chinese animation industry was formulated, according to the experts' suggestions.

After the development of the questionnaire, a pre-test was conducted in this study for the evaluation of semantic clarity. Then, in accordance with the results of the pre-test, another 10 experts modified the expression and added auxiliary descriptions to construct the evaluation structure of audience selection factors for the Chinese animation, including 4 dimensions and 14 indicators, as shown in Figure 3.

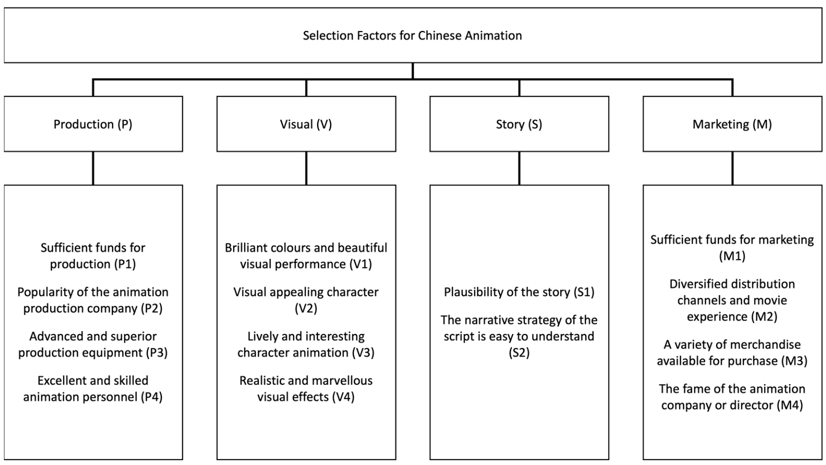

Figure 3. The hierarchy structure of this research.

4.2. Questionnaire Development and Measurement

After the hierarchical structure was constructed, the pairwise comparison questionnaires of the nine-point scale and the direct scoring questionnaires were created by entering all the evaluation criteria in the hierarchical structure into Super Decisions 3.2 and Microsoft Excel 16.84 software.

Then, a total of 70 expert questionnaires, including 35 pairwise comparison questionnaires and 35 direct rating questionnaires, were sent to the experts in the Chinese animation industry from 18 July 2022 to 21 November 2022. Subsequently, a total of 20 valid questionnaires were recovered, including 10 valid pairwise comparison questionnaires and 10 valid direct rating scale questionnaires.

Afterwards, the results of the pairwise comparison and direct rating questionnaires were analysed and calculated using the FAHP and GRA methods.

4.3. Numerical Analysis

4.3.1. Fuzzy Analytic Hierarchy Process

After collecting valid pairwise comparison questionnaires, the opinions of experts were integrated through the use of Equation (3). Afterwards, the fuzzy pairwise comparison matrix for all criteria from the FAHP model was established using Equation (4).

Table 3 demonstrates the fuzzy comparison matrix for four main dimensions.

Table 3. The fuzzy comparison matrix for four main dimensions.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)
Production (P)	(1, 1, 1)	(6, 7, 8)	(2, 3, 4)	(1/3, 1/2, 1)
Visual (V)	(1/8, 1/7, 1/6)	(1, 1, 1)	(1/6, 1/5, 1/4)	(1/8, 1/7, 1/6)
Story (S)	(1/4, 1/3, 1/2)	(4, 5, 6)	(1, 1, 1)	(1/5, 1/4, 1/3)
Marketing (M)	(1, 2, 3)	(6, 7, 8)	(3, 4, 5)	(1, 1, 1)

The computation of fuzzy geometric mean values ($\widetilde{r}_i$) for all dimensions is shown in Table 4.

Table 4. The calculation of fuzzy geometric mean values.

Dimensions	Computation Process	Results		
Production (P)	$\left[(1\times6\times2\times1/3)^{\frac{1}{4}}, (1\times7\times3\times1/2)^{\frac{1}{4}}, (1\times8\times4\times1)^{\frac{1}{4}}\right]$	1.41	1.8	2.38
Visual (V)	$\left[(1/8\times1\times1/6\times1/8)^{\frac{1}{4}}, (1/7\times1\times1/5\times1/7)^{\frac{1}{4}}, (1/6\times1\times1/4\times1/6)^{\frac{1}{4}}\right]$	0.23	0.25	0.29
Story (S)	$\left[(1/4\times4\times1\times1/5)^{\frac{1}{4}}, (1/3\times5\times1\times1/5)^{\frac{1}{4}}, (1/2\times6\times1\times1/3)^{\frac{1}{4}}\right]$	0.67	0.8	1
Marketing (M)	$\left[(1\times6\times3\times1)^{\frac{1}{4}}, (2\times7\times3\times1)^{\frac{1}{4}}, (3\times8\times5\times1)^{\frac{1}{4}}\right]$	2.06	2.74	3.31
	Total	4.37	5.59	6.98

The calculation process of fuzzy weights ($\widetilde{w}_i$) for all dimensions is shown in Table 5.

Table 5. The calculation of fuzzy weights for all dimensions.

Dimensions	Computation Process	Results		
Production (P)	$(1.41,\ 1.8,\ 2.38)\otimes\left(\frac{1}{6.98}, \frac{1}{5.59}, \frac{1}{4.37}\right)$	0.2	0.32	0.54
Visual (V)	$(0.23,\ 0.25,\ 0.29)\otimes\left(\frac{1}{6.98}, \frac{1}{5.59}, \frac{1}{4.37}\right)$	0.03	0.05	0.07
Story (S)	$(0.67,\ 0.8,\ 1)\otimes\left(\frac{1}{6.98}, \frac{1}{5.59}, \frac{1}{4.37}\right)$	0.1	0.14	0.23
Marketing (M)	$(2.06,\ 2.74,\ 3.31)\otimes\left(\frac{1}{6.98}, \frac{1}{5.59}, \frac{1}{4.37}\right)$	0.3	0.49	0.76

Table 6 reveals the fuzzy geometric mean values and fuzzy weights of all dimensions in the fuzzy pairwise comparison matrix.

Table 6. Fuzzy geometric mean values and fuzzy weights of all dimensions.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)	$\tilde{r}_i$	$\tilde{w}_i$
Production (P)	(1, 1, 1)	(6, 7, 8)	(2, 3, 4)	(1/3, 1/2, 1)	(1.41, 1.8, 2.38)	(0.2, 0.32, 0.54)
Visual (V)	(1/8, 1/7, 1/6)	(1, 1, 1)	(1/6, 1/5, 1/4)	(1/8, 1/7, 1/6)	(0.23, 0.25, 0.29)	(0.03, 0.05, 0.07)
Story (S)	(1/4, 1/3, 1/2)	(4, 5, 6)	(1, 1, 1)	(1/5, 1/4, 1/3)	(0.67, 0.8, 1)	(0.1, 0.14, 0.23)
Marketing (M)	(1, 2, 3)	(6, 7, 8)	(3, 4, 5)	(1, 1, 1)	(2.06, 2.74, 3.31)	(0.3, 0.49, 0.76)

As for fuzzy decomposition, $\alpha = 0.5$ and $\beta = 0.5$ are used during defuzzification. The calculation processes of fuzzy decomposition and defuzzified weight for dimensions between production (P) and visual (V) are as follows:

$$t_{0.5,0.5}(\overline{a_{P,V}}) = [0.5 \times 7.5 + (1 - 0.5) \times 6.5] = 7$$

$$f_a(L_{P,V}) = (7 - 6) \times 0.5 + 6 = 6.5$$

$$f_a(U_{P,V}) = 8 - (7 - 6) \times 0.5 = 7.5$$

$$t_{0.5,0.5}(\overline{a_{V,P}}) = \frac{1}{7}$$

$$t_{0.5,0.5}(\overline{w_{P,V}}) = [0.5 \times 0.485 + (1 - 0.5) \times 0.262] = 0.374$$

$$W_{\text{a}}(L_{ij}) = (0.32 - 0.2) \times 0.5 + 0.2 = 0.262$$

$$W_{\text{a}}(U_{ij}) = 0.54 - (0.32 - 0.2) \times 0.5 = 0.485$$

The processes of fuzzy decomposition and defuzzified weight for the remaining main dimensions are similar to the above calculation. Afterwards, the defuzzified pairwise comparison matrix for the four main dimensions from the FAHP model are shown in Table 7.

Table 7. Defuzzified pairwise comparison matrix for the four main dimensions.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)	Defuzzified Weight
Production (P)	1	7	3	1/2	0.374
Visual (V)	1/7	1	1/5	1/7	0.049
Story (S)	1/3	5	1	1/4	0.162
Marketing (M)	2	7	4	1	0.526
			Total		1.112

The normalised weight (ω_i) of all dimensions is calculated using Equation (11), as shown in Table 8.

Table 8. Normalised weights of all dimensions.

Dimensions	Computation Process	Results
Production (P)	$\frac{0.374}{1.112}$	0.336
Visual (V)	$\frac{0.049}{1.112}$	0.044
Story (S)	$\frac{0.162}{1.112}$	0.146
Marketing (M)	$\frac{0.526}{1.112}$	0.474

Table 9 demonstrates the normalised weight (ω_i) of all dimensions in the defuzzified pairwise comparison matrix.

Table 9. Normalised weight of all dimensions.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)	ω_i
Production (P)	1	7	3	1/2	0.336
Visual (V)	1/7	1	1/5	1/7	0.044
Story (S)	1/3	5	1	1/4	0.146
Marketing (M)	2	7	4	1	0.474
			Total		1

The calculation processes of normalised matrix and maximum eigenvector (W_1) are shown in Tables 10 and 11.

Table 10. Normalised matrix.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)
Production (P)	1×0.336	7×0.044	3×0.146	$1/2 \times 0.474$
Visual (V)	$1/7 \times 0.336$	1×0.044	$1/5 \times 0.146$	$1/7 \times 0.474$
Story (S)	$1/3 \times 0.336$	5×0.044	1×0.146	$1/4 \times 0.474$
Marketing (M)	2×0.336	7×0.044	4×0.146	1×0.474

Table 11. Maximum eigenvector for each dimension.

Dimensions	P	V	S	M	Total	ω_i	W_1
P	0.336	0.310	0.438	0.237	1.321	0.336	$1.321/0.336 = 3.983$
V	0.048	0.044	0.029	0.068	0.189	0.044	$0.189/0.044 = 4.244$
S	0.112	0.221	0.146	0.118	0.598	0.146	$0.598/0.146 = 4.114$
M	0.672	0.310	0.584	0.474	2.040	0.474	$2.040/0.474 = 4.264$

Afterwards, the numbers of the main dimensions are 4, thus we obtain $n = 4$. Therefore, λ_{max} and $C.I.$ are calculated as follows:

$$\lambda_{max} = \frac{(3.983 + 4.244 + 4.114 + 4.264)}{4} = 4.1514$$

$$C.I. = \frac{\lambda_{max} - n}{n - 1} = \frac{4.1514 - 4}{4 - 1} = 0.0505$$

For $C.R.$, with $n = 4$, we have $R.I. = 0.90$.

$$C.R. = \frac{C.I.}{R.I.} = \frac{0.0505}{0.90} = 0.0561$$

The calculation result of maximum eigenvalue (λ_{max}), consistency index ($C.I.$), and consistency ratio ($C.R.$) between the four main criteria is shown in Table 12.

Table 12. The pairwise comparison matrix for four main dimensions from the FAHP model.

Dimensions	Production (P)	Visual (V)	Story (S)	Marketing (M)	ω_i
Production (P)	1	7	3	1/2	0.336
Visual (V)	1/7	1	1/5	1/7	0.044
Story (S)	1/3	5	1	1/4	0.146
Marketing (M)	2	7	4	1	0.474
			Total		1
		$\lambda_{max} = 4.1514,\ C.I. = 0.0505,\ C.R. = 0.0561$			

In addition, the calculation processes of defuzzification, maximum eigenvalue (λ_{max}), consistency index ($C.I.$), and consistency ratio ($C.R.$) for all indicators are similar to the above calculation. Afterwards, the defuzzified pairwise comparison matrix for all sub-criteria is shown in Tables 13–16.

Table 13. The pairwise comparison matrix for production criteria.

Indicators	P1	P2	P3	P4	ω_i
P1	1	1/2	1	3	0.252
P2	2	1	3	2	0.41
P3	1	1/3	1	2	0.197
P4	1/3	1/2	1/2	1	0.141
		Total			1
$\lambda_{max} = 4.1742,\ C.I. = 0.0581,\ C.R. = 0.0645$					

Table 14. The pairwise comparison matrix for visual criteria.

Indicators	V1	V2	V3	V4	ω_i
V1	1	4	3	1	0.376
V2	1/4	1	1/3	1/4	0.083
V3	1/3	3	1	1/3	0.166
V4	1	4	3	1	0.376
		Total			1
$\lambda_{max} = 4.0829,\ C.I. = 0.0276,\ C.R. = 0.0307$					

Table 15. The pairwise comparison matrix for story criteria.

Indicators	S1	S3	ω_i
S1	1	4	0.795
S2	1/4	1	0.205
	Total		1
$\lambda_{max} = 2.0,\ C.I. = 0.0,\ C.R. = 0.0$			

Table 16. The pairwise comparison matrix for marketing criteria.

Indicators	M1	M2	M3	M4	ω_i
M1	1	1	2	3	0.326
M2	1	1	2	4	0.349
M3	1/2	1/2	1	3	0.231
M4	1/3	1/4	1/3	1	0.093
		Total			1
$\lambda_{max} = 4.0457,\ C.I. = 0.0152,\ C.R. = 0.0169$					

As shown in Tables 12–16, the values of consistency index ($C.I.$) and consistency ratio ($C.R.$) for all criteria are less than 0.1. This means that the result of the consistency tests is acceptable.

4.3.2. Grey Rational Analysis

This study considers higher expert scores on all dimensions and indicators as being more favourable. The maximal score for each criterion forms the reference series (x_0), while the remaining scores represent the comparison series (x_i), detailed in Tables 17 and 18.

Table 17. Referential series and compared series of each dimension.

Expert No.	Referential Series (x_0)	Production	Visual	Story	Marketing
1	9	6	7	9	4
2	9	5	7	9	6
3	7	5	7	7	2
4	8	6	7	8	5
5	9	7	9	9	6
6	9	8	8	9	6
7	9	5	7	9	6
8	7	5	6	7	5
9	7	4	7	6	1
10	9	5	9	9	6

Table 18. Referential series and compared series of each indicator.

Expert No.	Referential Series (x_0)	P1	P2	P3	P4	V1	V2	V3	V4	S1	S2	M1	M2	M3	M4
1	9	9	1	2	3	5	3	7	6	4	9	8	1	2	1
2	9	9	1	2	1	6	3	8	5	4	8	8	1	2	6
3	7	7	2	4	2	5	4	9	6	4	9	8	3	2	4
4	8	8	1	2	3	5	3	7	6	4	8	8	3	6	5
5	9	9	3	4	3	5	3	7	7	3	6	7	4	4	3
6	9	9	1	2	4	5	2	7	6	4	9	8	1	2	1
7	9	9	1	3	3	5	3	7	4	4	9	8	1	2	1
8	7	7	1	2	2	5	3	7	6	5	9	8	1	2	1
9	7	7	1	1	3	5	4	7	8	4	9	8	1	2	1
10	9	9	1	2	5	5	2	7	6	6	9	8	1	2	1

Then, the normalised data of dimensions and indicators are calculated using Equation (17). Afterwards, Equations (18) and (19) are utilised to calculate the deviation sequences and grey rational coefficient of all dimensions and indicators. Finally, the calculation results of normalised data, deviation sequences, and grey rational coefficient of all dimensions and indicators are shown in Tables 19–24.

Table 19. Normalised data of each dimension.

Expert No.	Production	Visual	Story	Marketing
1	0.400	0.600	1.000	0.000
2	0.000	0.500	1.000	0.250
3	0.600	1.000	1.000	0.000
4	0.333	0.667	1.000	0.000
5	0.333	1.000	1.000	0.000
6	0.667	0.667	1.000	0.000
7	0.000	0.500	1.000	0.250
8	0.000	0.500	1.000	0.000
9	0.500	1.000	0.833	0.000
10	0.000	1.000	1.000	0.250

Table 20. Normalised data of each indicator.

Expert No.	P1	P2	P3	P4	V1	V2	V3	V4	S1	S2	M1	M2	M3	M4
1	0.000	0.125	0.250	0.500	0.250	0.750	0.625	0.375	1.000	0.875	0.000	0.125	0.000	0.500
2	0.000	0.143	0.000	0.714	0.286	1.000	0.571	0.429	1.000	1.000	0.000	0.143	0.714	1.000
3	0.000	0.286	0.000	0.429	0.286	1.000	0.571	0.286	1.000	0.857	0.143	0.000	0.286	0.429
4	0.000	0.143	0.286	0.571	0.286	0.857	0.714	0.429	1.000	1.000	0.286	0.714	0.571	0.286

Table 20. *Cont.*

Expert No.	P1	P2	P3	P4	V1	V2	V3	V4	S1	S2	M1	M2	M3	M4
5	0.000	0.250	0.000	0.500	0.000	1.000	1.000	0.000	0.750	1.000	0.250	0.250	0.000	0.500
6	0.000	0.125	0.375	0.500	0.125	0.750	0.625	0.375	1.000	0.875	0.000	0.125	0.000	0.500
7	0.000	0.250	0.250	0.500	0.250	0.750	0.375	0.375	1.000	0.875	0.000	0.125	0.000	0.500
8	0.000	0.125	0.125	0.500	0.250	0.750	0.625	0.500	1.000	0.875	0.000	0.125	0.000	0.500
9	0.000	0.000	0.250	0.500	0.375	0.750	0.875	0.375	1.000	0.875	0.000	0.125	0.000	0.500
10	0.000	0.125	0.500	0.500	0.125	0.750	0.625	0.625	1.000	0.875	0.000	0.125	0.000	0.500

Table 21. Deviation sequences of all dimensions.

Expert No.	Production	Visual	Story	Marketing
1	0.600	0.400	0.000	1.000
2	1.000	0.500	0.000	0.750
3	0.400	0.000	0.000	1.000
4	0.667	0.333	0.000	1.000
5	0.667	0.000	0.000	1.000
6	0.333	0.333	0.000	1.000
7	1.000	0.500	0.000	0.750
8	1.000	0.500	0.000	1.000
9	0.500	0.000	0.167	1.000
10	1.000	0.000	0.000	0.750

Table 22. Deviation sequences of all indicators.

Expert No.	P1	P2	P3	P4	V1	V2	V3	V4	S1	S2	M1	M2	M3	M4
1	1.000	0.875	0.750	0.500	0.750	0.250	0.375	0.625	0.000	0.125	1.000	0.875	1.000	0.500
2	1.000	0.857	1.000	0.286	0.714	0.000	0.429	0.571	0.000	0.000	1.000	0.857	0.286	0.000
3	1.000	0.714	1.000	0.571	0.714	0.000	0.429	0.714	0.000	0.143	0.857	1.000	0.714	0.571
4	1.000	0.857	0.714	0.429	0.714	0.143	0.286	0.571	0.000	0.000	0.714	0.286	0.429	0.714
5	1.000	0.750	1.000	0.500	1.000	0.000	0.000	1.000	0.250	0.000	0.750	0.750	1.000	0.500
6	1.000	0.875	0.625	0.500	0.875	0.250	0.375	0.625	0.000	0.125	1.000	0.875	1.000	0.500
7	1.000	0.750	0.750	0.500	0.750	0.250	0.625	0.625	0.000	0.125	1.000	0.875	1.000	0.500
8	1.000	0.875	0.875	0.500	0.750	0.250	0.375	0.500	0.000	0.125	1.000	0.875	1.000	0.500
9	1.000	1.000	0.750	0.500	0.625	0.250	0.125	0.625	0.000	0.125	1.000	0.875	1.000	0.500
10	1.000	0.875	0.500	0.500	0.875	0.250	0.375	0.375	0.000	0.125	1.000	0.875	1.000	0.500

Table 23. Grey rational coefficient of all dimensions.

Expert No.	Production	Visual	Story	Marketing
1	0.455	0.556	1.000	0.333
2	0.333	0.500	1.000	0.400
3	0.556	1.000	1.000	0.333
4	0.429	0.600	1.000	0.333
5	0.429	1.000	1.000	0.333
6	0.600	0.600	1.000	0.333
7	0.333	0.500	1.000	0.400
8	0.333	0.500	1.000	0.333
9	0.500	1.000	0.750	0.333
10	0.333	1.000	1.000	0.400

Table 24. Grey rational coefficient of all indicators.

Expert No.	P1	P2	P3	P4	V1	V2	V3	V4	S1	S2	M1	M2	M3	M4
1	0.333	0.364	0.400	0.500	0.400	0.667	0.571	0.444	1.000	0.800	0.333	0.364	0.333	0.500
2	0.333	0.368	0.333	0.636	0.412	1.000	0.538	0.467	1.000	1.000	0.333	0.368	0.636	1.000
3	0.333	0.412	0.333	0.467	0.412	1.000	0.538	0.412	1.000	0.778	0.368	0.333	0.412	0.467
4	0.333	0.368	0.412	0.538	0.412	0.778	0.636	0.467	1.000	1.000	0.412	0.636	0.538	0.412
5	0.333	0.400	0.333	0.500	0.333	1.000	1.000	0.333	0.667	1.000	0.400	0.400	0.333	0.500
6	0.333	0.364	0.444	0.500	0.364	0.667	0.571	0.444	1.000	0.800	0.333	0.364	0.333	0.500
7	0.333	0.400	0.400	0.500	0.400	0.667	0.444	0.444	1.000	0.800	0.333	0.364	0.333	0.500
8	0.333	0.364	0.364	0.500	0.400	0.667	0.571	0.500	1.000	0.800	0.333	0.364	0.333	0.500
9	0.333	0.333	0.400	0.500	0.444	0.667	0.800	0.444	1.000	0.800	0.333	0.364	0.333	0.500
10	0.333	0.364	0.500	0.500	0.364	0.667	0.571	0.571	1.000	0.800	0.333	0.364	0.333	0.500

4.4. Research Results

In the FAHP and GRA models, all dimensions and indicators are ranked based on overall weights and grey rational grades (Γ_{0i}), respectively. As for the calculation of the overall weights, all data in the defuzzified pairwise comparison matrix were input into Super Decisions software. In terms of grey rational grades calculation, Equation (20) was utilised to calculate the grey rational grades of all dimensions and indicators. The ranking results of all dimensions and indicators based on overall weights and grey rational grades in the FAHP and GRA models are shown in Figures 4 and 5.

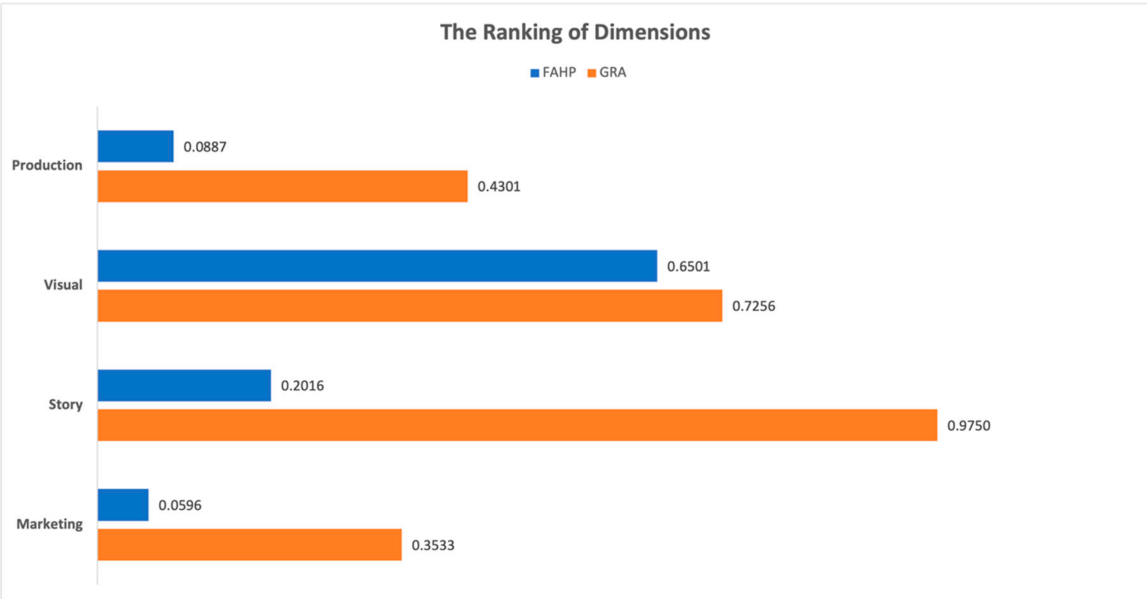

Figure 4. The ranking of dimensions in FAHP and GRA models.

In the FAHP model, the top three significant dimensions are "Visual" (0.6501), "Story" (0.2016), and "Production" (0.0887). In the GRA model, the most important dimension is "Story" (0.975), followed by "Visual" (0.7256) and "Production" (0.4301), while "Marketing" is the least important dimension in both the FAHP and GRA models.

As for the ranking of indicators in the FAHP model, the top indicator is "Visual appealing character" (V2, 0.343), followed by "Lively and interesting character animation" (V3, 0.17) and "The narrative strategy of the script is easy to understand" (S2, 0.161). Meanwhile, the fourth to sixth important indicators are "Brilliant colours and beautiful visual performance" (V1, 0.068), "Realistic and marvellous visual effects" (V4, 0.067), and "Plausibility of the story" (S1, 0.04), respectively.

In the GRA model, the top three indicators are "Plausibility of the story" (S1, 0.967), "The narrative strategy of the script is easy to understand" (S2, 0.86), and "Visual appealing character" (V2, 0.778). While the fourth to sixth important indicators are "Lively and interesting character animation" (V3, 0.628), "The fame of the animation company or director" (M4, 0.541), and "Excellent and skilled animation personnel" (P4, 0.517).

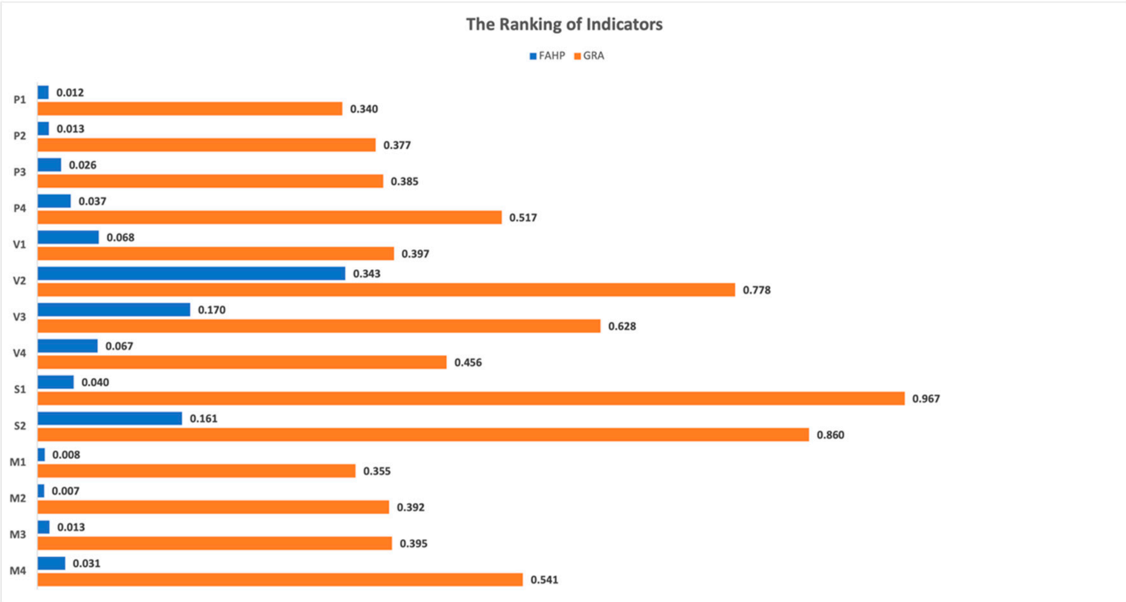

Figure 5. The ranking of indicators in FAHP and GRA models.

5. Conclusions

In this research, the overall weights of all criteria were obtained using the Super Decisions software within the FAHP model. Then, this study ranked all the criteria in order of importance, based on their overall weights within the FAHP model. Meanwhile, this study ranked all dimensions and indicators according to the grey rational grades within the GRA model.

Also, the views of two groups of expert audiences were collected and analysed using FAHP and GRA in this study. In the FAHP model, expert audiences believed that the two dimensions, "Visual" and "Story", are the main factors that influence audiences to choose Chinese animated movies. In the GRA model, the order of these two aspects is opposite. The "Story" aspect is the most important factor that affects audiences' choice of Chinese animated films, followed by the "Visual" dimension. This illustrates some slight differences in the perspectives of the two groups of expert viewers. However, in general, the two groups of expert viewers have had similar views on factors that influence viewer choice.

As for the ranking of indicators, the ranking results in the FAHP and GRA models both represent indicators in the two main dimensions of "Visual" and "Story", such as "Visual appealing character", "Lively and interesting character animation", "Plausibility of the story", and "The narrative strategy of the script is easy to understand", which are the four indicators with highest ranking. In light of this, the animation production team should give priority to these four elements during the animation production process, largely due to the fact that these four indicators will affect the audience's choice of Chinese animation. Moreover, the opinions of expert audiences show that brilliant visual performance, realistic visual special effects, and high-quality animation practitioners are also factors that audiences will consider when choosing animated movies.

Regarding the research limitations, this study employed a combination of FAHP and GRA methodologies. In the pairwise comparison of indicator importance, the values of C.I. and C.R. were utilised to assess their progression and consistency. In GRA models, experts evaluated both dimensions and indicators. Therefore, the research findings are contingent upon expert opinions, constituting a limitation of this study and the FAHP and

GRA methods employed. To mitigate this, the research involved the participation of highly experienced experts in completing the questionnaire.

Furthermore, more than half of the experts involved in completing the questionnaire were Chinese professionals within the animated film industry, aged between 28 and 52 years. Of these participants, 79.26% were male, with the remaining identifying as female. Consequently, the findings of this study hold relevance for China's animated film sector, offering valuable insights to enhance understanding and alignment with audience preferences. Thus, these insights serve as a crucial reference and guide for the industry to produce animated films that align closely with audience expectations.

This work contributes scientifically by demonstrating the efficacy of the hybrid MCDM approach proposed. It illustrates how the integration of methods like FAHP and GRA aid in understanding the preferences of the Chinese audience, regarding animated film selection. From a practical standpoint, this research indicates that Chinese animation companies can utilise the decision-making model proposed herein to produce works that better cater to audience needs, thereby reducing risks and making informed decisions.

Overall, the integrated operations conducted in this study exhibit logical coherence, practicality, and functionality. By establishing a systematic and objective selection model tailored to the study's context and reflecting the practical needs of the industry, it not only provides a valuable framework for decision-making, but also serves as a reference for future studies.

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