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GREY RELATIONAL ANALYSIS OF NETWORK MODEL FOR LIVE BROADCAST PLATFORM IN E-SPORTS MARKET

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Abstract

The e-sports industry has developed vigorously in recent years. E-sports have become an event that global players pay attention to and participate in. With the development of Internet technology and the emergence of webcasting, the combination of e-sports events and webcasting has brought the e-sports market to another realm. Taiwan's overall gaming market revenue in 2019 has exceeded NT$55.9 billion, and is expected to reach NT$61.8 billion in 2020. Among the sources of e-sports revenue, media royalties from broadcast events have grown the most.

The live broadcast platform has changed the behavior mode of people watching the game, and the competition has become fierce. Therefore, it is of positive significance to understand the competition situation of e-sports events among different live broadcast platforms. This research hopes to understand the competitive advantage by analyzing network procedures and grey relational analysis. Provide an understanding of different platform strategies to enhance industry competitiveness.

The research found that the ranking of Taiwan's competitiveness in the e-sports market of the live broadcast platform is ranked first by Facebook Gaming, followed by the Bahamut Gaming Information Station Live Hall, Steam Live, Twitch, and YouTube. The most important aspect of the facet is "network externality", followed by "social demand", and the top three influential factors are "views", "number of users", and "emotional needs". Accumulating "number of users" and focusing on "community management" will help expand the e-sports market.

Key words: Analytic network process; Grey relational analysis; Live broadcast platform; E-sports; Competitive advantage.

Introduction

The increase in 5G frequency bands will drive the development of cross-information communications and various industries, and online live broadcast will also flourish. Various live broadcast content and marketing will be used to analyze the network traffic to grasp the preferences of customer groups and create The economic value of the live broadcast platform, and at the same time, due to the popularization of mobile networks and the development of online media, virtual live broadcasts (VTuber) and mobile live broadcasts have become popular, creating a business model that virtually drives the real economy and deriving a unique live broadcast ecology to stimulate the economic development of the live broadcast market.

Today's e-sports events are combined with online live broadcasts, and the number of audiences and players that are involved continues to grow. Compared with traditional sports events, their licensing costs are expensive. E-sports events, regardless of scale, can be broadcast online. Simultaneously broadcasting to the audience, and game live broadcasts generally do not need to worry about copyright issues. In fact, the more game content that appears on the live broadcast platform, it is also helping game companies to market. It can be seen that e-sports events have inherent advantages over traditional sports events.

Method

Evaluate competitive factors

The characteristics of the online audio-visual live broadcast platform can be divided into "interactive", "immediate" and "topical". Interactivity means that the audience can interact with the broadcaster and others through the online chat room, so the broadcaster can respond instantly to the content of the conversation and increase the audience's

participation. According to research data, the user's perceptual interaction situation and positive use attitude are positively correlated, showing consistency in performance behavior; instantaneous, because users no longer need to download audiovisual files as they did in the past and consume too much time for waiting , you can now watch live webcasts in real time; topical, various current affairs programs such as e-sports, sports events, political issues, etc., the live broadcast method can increase the degree of audience discussion, and can control the content propagation more effectively, through family and friends or discussions on the Internet, to shape the image and reputation of the live broadcast platform; through continuous participation to generate community identity, this behavior can satisfy the personal sense of belonging and attachment, which is self-expectation. , Maintain a good self-positioning with others and groups, and gain community identity, influence and self-worth through community communication and recognition. In summary, this research further summarizes five dimensions of Self-concept, Social needs, Psychological well-being, Internet externalities, and Internet platform characteristics and 15 possible competitive factors through the literature, as shown in Table 1.

Table 1. List of competitive factors affecting the e-sports market on live broadcast platforms

Criteria	Factor	Criteria	Factor
Internet platform characteristics	Stability Difference Content quality	Self-concept	Life goal Experience Personal qualities
Social demand	Building confidence needs emotional needs Interpersonal needs	Psychological well-being	Self-actualization Life satisfaction Eliminate negative emotions
Internet externalities	word-of-mouth views number of users		

Analytic Network Process

Analytical Network Procedure (ANP) is an advanced decision-making model derived from Analytical Hierarchical Procedure (AHP). ANP has the characteristics of dependence and feedback, that is, it incorporates the interaction between clusters, so that various elements can be linked to other cluster elements according to the needs of users. The characteristics of the AHP and ANP evaluation methods are to establish models for fuzzy and complex problems and decision-making problems according to graphics and evaluation matrices. The difference between the two is that

the former has a linear structure and the latter has a nonlinear network structure.

ANP evaluates the goals, groups, criteria, and alternatives through pairwise comparisons to form a super matrix, then generates a weighted super matrix, and finally calculates the limit matrix to obtain the final solution. The main process includes the following steps:

1. Model construction and problem establishment.
2. Establish a paired comparison matrix and eigenvector.

$$\mathbf{A} \cdot \mathbf{w} = \lambda_{max} \cdot \mathbf{w}, \quad (1)$$

Where $\mathbf{A}$ is the pairwise comparison matrix, $\mathbf{w}$ is the eigenvector, and λ_{max} is the maximum eigenvalue of the $\mathbf{A}$ matrix. The consistency index and the consistency ratio can be used to judge whether the pairwise comparison is consistent.

3. Form an unweighted super matrix.
4. Transform into a weighted super matrix.
5. Calculate the ultimate super matrix.
6. Choose the best solution.

Grey Relational Analysis

Grey System Theory was proposed by Professor Ju-long Deng of China at an international conference in 1982. It is mainly to conduct correlation analysis and model construction of the system for the ambiguity of the system model and the incompleteness of the information. It can effectively deal with the "uncertainty", "multivariate input", "discrete data", and "incomplete data" of things. Grey relational analysis measures the degree of relevance among subjects according to the degree of similarity or dissimilarity between subjects within the system, and replaces them with a finite sequence of numbers. Through this analysis method, the importance of affecting the goals of the system is determined. The larger the overall gray incidence matrix value, the closer the relationship between the reference sequence and the comparison sequence; the larger the gray incidence value, the greater the benefit of the scheme; therefore, the larger the overall gray incidence matrix value, the closer the relationship the better.

Methods of Evaluating Competitiveness

The gray correlation used in this study is mainly based on ANP, and competitive factors are used to construct a network structure relationship diagram using ANP, as shown in Figure 1. In the process, Super Decisions software (version 3.2.0) was used to calculate the relative weight of the structure to the goal and the relative weight of the factors. Finally, the gray correlation coefficient is used for comparison to obtain the competitiveness ranking. The gray correlation steps are as follows:

1. Dividing the questions into groups according to evaluation criteria and alternatives, and construct their relationships with a network model.
2. Set the proportions of elements at each level, compare the elements at the same level in pairs, and construct a judgment matrix.
3. When calculating the proportions between the elements of each level, the proportions of the entire

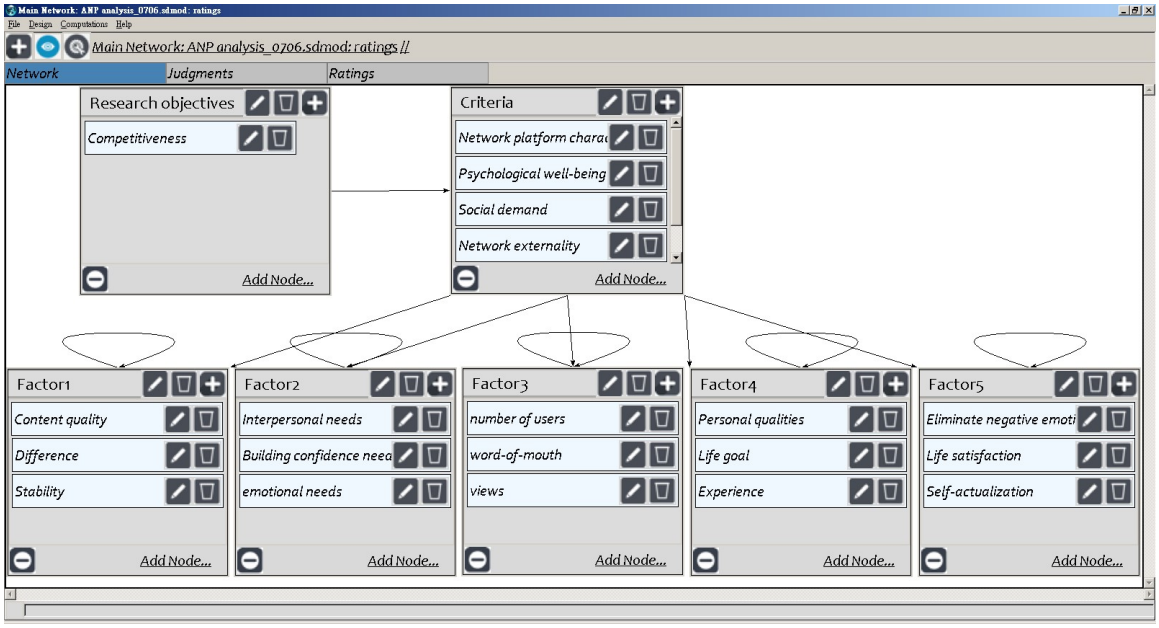

Figure 1. Network model diagram

hierarchy are set to determine the priority of each alternative to the target. When calculating gray correlation, the original data execution range should be between 0 and 1. In the hierarchical system, there are m alternatives; each of them considers n evaluation factors. The vector of the alternatives layer can be expressed as an equation 2.

$$\mathbb{S} = \{S_1, S_2, \ldots S_i, \ldots, S_m\}, \quad (2)$$

The alternative can be expressed as equation 3.

$$S_i = (s_i(1), s_i(2), s_i(3), \ldots, s_i(j), \ldots s_i(n)), \quad (3)$$

Among them, $\mathbb{S}_i$ is the feature vector, which represents a given alternative i. Taking $\mathbb{S}_i(j)$ as an example, it refers to the j-th factor of $\mathbb{S}_i$, which is an element contained in its factor sequence; it is generated by gray correlation to form a measurement space, and normalization can make the sequence have better performance; therefore, ideal The measurement space can be expressed as equation 4.

$$S_o = (S_{o1}, S_{o2}, S_{o3}, \ldots, S_{on}) = (1, 1, \ldots, 1), \quad (4)$$

$S_{01}, S_{02}, S_{03}, \ldots, S_{0n}$ represent the representation of each evaluation factor of the factor layer.

The gray correlation coefficient $\xi_{0i}(j)$ of the j-th factor of the reference sequence S_0 and the comparison sequence S_i can be calculated by the following formula, such as equation 5.

$$\xi_{0i}(j) = \frac{\min_i\left\{\min_j|x_{0j}-x_{ij}|\right\}+\rho\max_i\left\{\max_j|x_{0j}-x_{ij}|\right\}}{|x_{0j}-x_{ij}|+\rho\max_i\left\{\max_j|x_{0j}-x_{ij}|\right\}}, \quad (5)$$

i=1, 2… m; j=1, 2…, n.

When the reference sequence and the comparison sequence are equal, $\min_i \min_j |x_{0j} - x_{ij}| = 0$, the identification coefficient $\rho = 0.5$, and the gray correlation coefficient can be simplified to equation 6.

$$\xi_{0i}(j) = \frac{0.5 \max_i \left\{\max_j |x_{0j} - x_{ij}|\right\}}{|x_{0j} - x_{ij}| + 0.5 \max_i \left\{\max_j |x_{0j} - x_{ij}|\right\}}, \quad (6)$$

Therefore, the gray correlation coefficient matrix of all alternatives can be expressed as equation 7.

$$G = \begin{vmatrix} g_{c_1} \\ g_{c_2} \\ \vdots \\ g_{c_x} \end{vmatrix} = \begin{vmatrix} \xi_{01}(1) & \xi_{02}(1) & \cdots & \xi_{0m}(1) \\ \xi_{01}(2) & \xi_{02}(2) & \cdots & \xi_{0m}(2) \\ \vdots & \vdots & \vdots & \vdots \\ \xi_{01}(n) & \xi_{02}(n) & \cdots & \xi_{0m}(n) \end{vmatrix}, \quad (7)$$

Taking the evaluation layer C_k of the facet layer as an example, the gray correlation coefficient matrix can be expressed as g_{c_k}, and its corresponding value is the gray correlation coefficient of the evaluation factor in the factor layer, so g_{c_k} can be expressed as equation 8.

$$g_{c_k} = \begin{vmatrix} \xi_{01}(p) & \xi_{02}(p) & \cdots & \xi_{0m}(p) \\ \xi_{01}(p+1) & \xi_{02}(p+1) & \cdots & \xi_{0m}(p+1) \\ \vdots & \vdots & \vdots & \vdots \\ \xi_{01}(q) & \xi_{02}(q) & \cdots & \xi_{0m}(q) \end{vmatrix}, \quad (8)$$

g_{c_k} represents the symbol of the gray incidence matrix of the k-th evaluation criterion, in which there are 1~m alternatives. In each row, $\xi_{0i}(p)$, $\xi_{0i}(p+1)$, ..., $\xi_{0i}(q)$ represent The gray correlation coefficient of the reference sequence s_0 and the comparison sequence s_i, and the values of p, p+1,...,q are between $1 \le p \le q \le n$.

Calculating the weighted original gray correlation coefficient matrix. Taking C_k as an example, the weighted original gray correlation coefficient matrix calculation is shown in equation 9.

$$\delta_{c_k} = W_{c_k} g_{c_k} = \left(w_{I_p}, w_{I_{p+1}}, \ldots, w_{I_q}\right) \times g_{c_k}, \quad (9)$$

Where W_{c_k} is the priority weight obtained by ANP, $I_p, I_{p+1}, \ldots, I_q$ is The expression of each factor in the evaluation factor, $w_{I_p}, w_{I_{p+1}}, \ldots, w_{I_q}$ is the ANP weight value obtained from the evaluation factor in the factor layer; the weighted original gray correlation coefficient matrix obtained from all schemes can be expressed as $G_{weighted}$.

After obtaining the weighted original gray correlation coefficient matrix, in order to improve the comparability of the data, $G_{weighted}$ is re-normalized, and the initial value processing, maximum value processing, minimum value processing, and specific value processing are brought into the gray correlation generation. The weighted original gray correlation coefficient matrix after normalization is expressed as $G'_{weighted}$.

Recalculating the gray correlation coefficient between the reference sequence and the comparison sequence by $G'_{weighted}$ to obtain the second gray correlation matrix. The second gray correlation matrix is expressed as G_c, and the overall gray correlation matrix can be expressed as equation 10.

$$\varepsilon = W_c G_c = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_m), \quad (10)$$

$W_c = (w_{c_1}, w_{c_2}, \ldots, w_{c_k}, \ldots, w_{c_g})$ is the priority weight obtained by using the analysis network procedure method, where $w_{c_1}, w_{c_2}, \ldots, w_{c_k}, \ldots, w_{c_g}$ are the ANP weight values obtained from each evaluation criterion of the facet layer, and $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_m$ are the overall gray correlation vectors obtained from each alternative.

The larger the overall gray incidence matrix value, the closer the relationship between the reference sequence and the comparison sequence; the larger the gray correlation value, the greater the benefit of the scheme; therefore, the larger the overall gray incidence matrix value, the closer the relationship the better.

Results

The questionnaire is designed according to the ratings of 1 to 10 given by each live broadcast platform, and the original questionnaire data is summarized as shown in Table 2.

Table 2. Original questionnaire information

	YouTube	Facebook	Bahamut	Twitch	Steam
Stability	4	6	5	4	5
Difference	5	7	6	4	5
Content quality	4	7	6	4	5
Building confidence needs	5	7	5	4	5
emotional needs	5	6	5	5	5
Interpersonal needs	4	6	5	4	5
word-of-mouth	2	6	5	4	5
views	2	6	5	3	5
number of users	2	6	5	3	4
Life goal	4	6	6	5	5
Experience	4	6	5	4	5
Personal qualities	4	6	5	4	5
Self-actualization	4	6	6	4	5
Life satisfaction	5	6	6	5	5
Eliminate negative emotions	4	6	6	5	5

When the reference sequence and the comparison sequence are equal, $\min_i \min_j |x_{0j} - x_{ij}| = 0$, where the identification coefficient $\rho = 0.5$, among all the difference sequence values, the maximum value is 0.667, so $0.5 \max_i \left\{ \max_j |x_{0j} - x_{ij}| \right\} = 0.667$, then the gray correlation coefficient can be calculated as follows:

$$\xi_{0i}(j) = \frac{0.5 \times 0.667}{|x_{0j} - x_{ij}| + 0.5 \times 0.667}, \quad (11)$$

The gray correlation coefficient table of each questionnaire is shown in Table 3.

Table 3. Grey correlation coefficient

	YouTube	Facebook	Bahamut	Twitch	Steam
Stability	0.5	1	0.667	0.5	0.667
Difference	0.539	1	0.7	0.438	0.539
Content quality	0.438	1	0.7	0.438	0.539
Building confidence needs	0.539	1	0.539	0.438	0.539
emotional needs	0.667	1	0.667	0.667	0.667
Interpersonal needs	0.5	1	0.667	0.5	0.667
word-of-mouth	0.334	1	0.667	0.5	0.667
views	0.334	1	0.667	0.4	0.667
number of users	0.334	1	0.667	0.4	0.500
Life goal	0.5	1	1	0.667	0.667
Experience	0.5	1	0.667	0.5	0.667
Personal qualities	0.5	1	0.667	0.5	0.667
Self-actualization	0.5	1	1	0.5	0.667
Life satisfaction	0.667	1	1	0.667	0.667
Eliminate negative emotions	0.5	1	1	0.667	0.667

The above table is composed of network platform characteristics (g_{c1}), social needs (g_{c2}), network externalities (g_{c3}), self-concept (g_{c4}), and psychological well-being (g_{c5}). The weighted gray correlation coefficient matrix $G_{weighted}$ can be expressed as follows:

$$G_{weighted} = \begin{vmatrix} W_{c1} \cdot g_{c1} \\ W_{c2} \cdot g_{c2} \\ W_{c3} \cdot g_{c3} \\ W_{c4} \cdot g_{c4} \\ W_{c5} \cdot g_{c5} \end{vmatrix}, \quad (12)$$

Where W_{c1}、W_{c2}、W_{c3}、W_{c4}、W_{c5} are the ANP weights generated by Limit Matrix, W_{c1}= (0.008 0.047 0.013), W_{c2}= (0.028 0.123 0.078), W_{c3}= (0.042 0.217 0.200), W_{c4}= (0.038 0.040 0.040), W_{c5}= (0.067 0.024 0.036), the weighted gray correlation coefficient matrix is obtained after multiplication.

Repeating the above steps for the second gray correlation generation and calculation, and obtain the second gray correlation coefficient table, as shown in Table 4.

The overall gray correlation coefficient matrix ε is equal to $\varepsilon = W_c G_c$, where W_c= (0.068 0.127 0.228 0.459 0.118) is the ANP weight generated by the Cluster Matrix; the overall gray correlation coefficient matrix obtained by multiplying the two is as follows:

$$\varepsilon = |0.394 \quad 1.000 \quad 0.604 \quad 0.413 \quad 0.483|, \quad (13)$$

Table 4. The second gray correlation coefficient

	YouTube	Facebook	Bahamut	Twitch	Steam
Internet platform characteristics	0.407	1	0.523	0.376	0.428
Social demand	0.452	1	0.490	0.444	0.490
Internet externalities	0.333	1	0.500	0.361	0.451
Self-concept	0.400	1	0.597	0.428	0.501
Psychological well-being	0.415	1	1	0.441	0.499

The results of the study found that the competitiveness of the Taiwan's e-sports market for live streaming platforms is ranked according to the overall grey correlation coefficient, from largest to smallest as "Facebook", "Bahamut", "Steam", "Twitch", "YouTube ", the details are shown in Table 5.

Table 5. The overall grey correlation coefficient and competitiveness ranking

	YouTube	Facebook	Bahamut	Twitch	Steam
Overall grey correlation coefficient	0.394	1	0.604	0.413	0.483
Competitive ranking	5th	1st	2nd	4th	3rd

In terms of impact, "Internet platform characteristics" accounted for 6.8%, "Social demand" accounted for 12.7%, "Internet externalities" accounted for 22.8%, "Self-concept" accounted for 45.9%, and "Psychological well-being" accounted for 11.8%. Among them, "Internet externalities" is the most important, followed by "social demand", both of which account for 68.6% of the overall influence. And in-depth discussion of factors, using the "number of views" of the system platform (accounting for 21.7%), the "number of users" (accounting for 20%), and the "emotional needs" of users (accounting for 12.2%) to influence consumers the choice of platform is the largest; the list of influences of various aspects and factors is shown in Table 6.

Table 6. List of influence

Criteria	Influence	Factor	Influence
Internet external-ities	45.9 %	views	21.7 %
		number of users	20.0 %
		word-of-mouth	4.2 %
Social demand	22.8 %	emotional needs	12.2 %
		Interpersonal needs	7.8 %
		Building confidence needs	2.8 %
Psychological well-being	12.7 %	Self-actualization	6.7 %
		Eliminate negative emotions	3.6 %
		Life satisfaction	2.4 %
Self-concept	11.8 %	Personal qualities	4.0 %
		Experience	4.0 %
		Life goal	3.8 %
Internet platform characteristics	6.8 %	Difference	4.7 %
		Content quality	1.3 %
		Stability	0.8 %

Discussion

The results show that if live broadcast platform operators can attract more users, or increase exposure and increase click-through rate, they can get the most benefits. The live broadcast platform itself needs to meet the needs of users and improve through listening and investigation. Only platform functions or service items can truly retain the guest group.

- Number of users

The most important factor affecting the live broadcast platform in the e-sports market is to accumulate the number of its users and expand a wide range of age groups and ethnic groups. For example, Facebook is the most popular social media in Taiwan, with 19 million active users every month. The data in the "2019 Taiwan Internet Report" shows that the domestic use rate of Facebook is 98.9%. Even across many age groups, there are more than 95% of users aged 15-30 with a slightly lower usage rate, which clearly shows the influence of Facebook in the community.

- Community management

The most important thing for community management is to meet the needs of consumers. With all kinds of needs, infinite business opportunities can be created. In the marketing report of Facebook Gaming 2019, it also shows that in terms of game player loyalty, the community has a pivotal position. From the early arcades to the rise of e-sports, games have acted as a platform for players to connect and communicate with others. The game community is constantly evolving and developing, and its influence is growing and changing. For example, for mobile game players, the community provides information about their discovery of new games and influences their purchase intentions. At the same time, the epidemic (COVID-19) has also led to rapid growth in demand for online entertainment, and it will not disappear due to the slowdown of the epidemic. For today's gamers, social platforms are one of the indispensable "social needs".

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