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Enhancing decision-making model based on the analytic hierarchy process to evaluate negotiation offers for the music tour

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Abstract. A tour determined by the decision-making model is a way that performers use to gain popularity, incomes by performing shows around different places. Recently Taylor Swift will be planning to wrap up her record-breaking Eras Tour in December. In this work, we build a decision-making model by analyzing the musical performer's past tour in order to help plan their next tour. First, we investigate and evaluate factors to perform a successful music show. We then start to create our model to help plan a tour for the musical performer. In this part, we built the Analytic Hierarchy Process (AHP) in order to evaluate the weights of each variable for each individual. By analyzing the data earlier, we evaluated variables that we needed to consider such as the number of concerts, venues, ticket prices, and some more. After clarifying these variables, we considered some variables that help makes the "best" plan for performers, including the maximum number of fan attendance, maximum profits, and some more. Incorporating elements derived from a detailed analysis of Ed Sheeran's past tour, our model aligns with the AHP framework, ensuring it is adeptly tailored to meet the diverse needs of various performers. Finally, we first apply our model on the past tours using the historical data that we investigated, and identify the total score of past tour in 2025 is 0.621 which is slightly successful. In addition, the results of total scores of seven alternative plans we proposed in 2027 are ranked as P4 (0.887) > P7 (0.813) > P3 (0.767) > P5 (0.632) > P1 (0.621) > P6 (0.581) > P2 (0.556). Consequently, the alternative plan (P4) with the highest total score is recommended to Ed Sheeran.

Keywords: analytic hierarchy process, comprehensive evaluation model, music performer, tour show, decision making model

1. Introduction

Multi-criteria decision making serves as a core analytical paradigm in modern systems engineering, management science, and social economic research, which aims to resolve complex practical decision problems involving multiple conflicting evaluation criteria, heterogeneous indicator dimensions, and

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ambiguous attribute priorities that cannot be effectively addressed by traditional single-index quantitative analysis methods [1-8]. In complex real-world scenarios including industrial performance evaluation, resource allocation optimization, urban infrastructure planning, ecological environmental assessment, and public policy formulation, scientific and standardized decision making models can transform vague qualitative decision logic into systematic quantitative calculation processes, effectively reduce subjective judgment deviations caused by empirical experience, improve the rationality and credibility of decision results, and provide stable and actionable theoretical and technical support for complex system optimization and scheme selection [9-16]. The continuous innovation and optimized application of decision-making model methodologies have become indispensable driving forces for promoting standardized, intelligent and scientific modern decision management, helping decision makers sort out complex factor relationships, balance the advantages and disadvantages of different alternative schemes, and avoid one-sided or arbitrary decision behaviors in multi-dimensional benefit trade-off scenarios [17-24].

The Analytic Hierarchy Process (AHP) method, as one of the most classic and widely applied subjective weighting and decision analysis methods, constructs a hierarchical structural framework by decomposing complex decision objectives into target layers, criterion layers and index layers, and realizes the quantification of qualitative judgment through pairwise comparison of the relative importance of different indicators at each layer, which perfectly adapts to complex decision problems with hierarchical logic and ambiguous index importance [25-27]. This method effectively integrates human subjective experience and professional judgment with mathematical quantitative analysis, making the decision process hierarchical and systematic, and it has outstanding applicability in scenarios where indicator priority cannot be directly determined and empirical expertise plays a key guiding role. Despite its wide practical application value, the analytic hierarchy process still faces prominent research and application challenges in academic and engineering fields. The subjective comparison matrix constructed based on expert experience is easily affected by individual cognitive differences, professional background limitations and subjective preference biases, which may lead to inconsistent judgment logic and reduce the objectivity of weighting results. The traditional consistency check mechanism of the analytic hierarchy process has certain tolerance for unreasonable judgment data, and it cannot effectively eliminate subtle subjective deviations in the comparison matrix, resulting in unstable weight distribution results in complex multi-layer index systems. In addition, the classic analytic hierarchy process is difficult to adapt to fuzzy, uncertain and dynamic decision environments, and it lacks effective correction mechanisms for extreme judgment values and missing index data, which limits its application accuracy in high-dimensional and complex decision scenarios.

Recent the music industry sees numerous artists embarking on concert tours, which are pivotal for fan engagement and revenue generation. A notable example is Taylor Swift's Eras Tour, which is set to conclude in December and has been a benchmark for success. Spanning 152 shows, each lasting about 3.5 hours, the tour has been attended by approximately 72,000 fans per concert, garnering $13 million per show. This has led to the Eras Tour being the first to surpass $1 billion in earnings. Despite the high demand and steep ticket prices, which can run into the thousands and sell out instantly, the tour's success underscores the intricacies of planning such ventures. Taylor Swift's generosity towards her team, including band members and technicians, further highlights the scale of these operations. The task is to make a strategy for a chosen musical performer's upcoming tour by analyzing past tours and developing a planning model. This model should account for various factors to ensure the tour's success, whether it be maximizing fan attendance, expanding to new venues, or increasing profits. The challenge is to create a tailored approach that aligns with the performer's objectives and leverages historical data to forecast and optimize the tour's outcomes. In this work, our main job in this work is to analyze the performer's past tour and design a model to help plan their next tour. To

develop further, we need to consider the reason going for the tour, the length of a single show and also the numbers of shows needed. When we considered these basic questions, we can further develop our model by analyzing past tours of the musical performer in order to develop a model using past experiences, and this includes considering factors that's needed to run a single show, factors that's needed for running multiple shows for a tour, and also what results in a successful show. After this, we then need to use our model to help plan a future tour for the musical performer. By doing this, we need to analyze if our model works for every performer or how it might help for planning another tour for another performer. In conclusion, we build a Comprehensive Evaluation Model based on the Analytic Hierarchy Process (AHP) method and evaluate the past tours of Ed Sheeran and other performers. After that, we need to consider some details, such as the number of concerts, venues, ticket prices, etc. Also, to meet the expectation of the performer, we should take the maximize fan attendance, venues, profits into account in order to create the "best" plan for the musical performer. Finally, to ensure the appliance of our model, we need to analyze past tours and future plans by using our models created, and using it to help plan a future tour for the musical performer.

In this work, we have undertaken a comprehensive approach to model and plan an optimal tour for a musical performer. Our methodology is centered around a thorough analysis of the performer's past tours, identification of key factors influencing tour success, and the development of a strategic plan for a future tour. One of the innovative aspects of our solution is the application of the Analytic Hierarchy Process (AHP) model. The AHP model, developed by Thomas L. Saaty, is a structured technique for organizing and analyzing complex decisions [25-27]. We build AHP model which has been widely used in various fields for decision-making, including project management, resource allocation, and policy planning. In the context, AHP allowed us to systematically evaluate and compare different criteria that contribute to a successful tour, such as fan attendance, venue selection, ticket pricing, and overall profitability. By leveraging the AHP model, we were able to provide a structured and rational approach to decision-making in the complex domain of concert tour planning. This not only added a layer of sophistication to our model but also ensured that our recommendations were grounded in a robust and transparent methodology. The insights gained from the AHP have been integral in formulating our proposed tour plan, which we believe will best meet the goals of the performer. The inherent flexibility of the AHP methodology is harnessed to enable customization, allowing it to be effectively adapted for different scenarios. This strategic approach ensures that our model can be finely tuned to accommodate the unique artistic styles, audience preferences, and logistical considerations of each performer, thereby enhancing its overall utility and effectiveness in the meticulous planning and execution of tours across the spectrum.

2. Notation

The symbol and description of the notation mentioned in the paper are summarized and listed in the Table 1, such as the ratio of consistency, consistency index, judgement matrix, the total score of one tour, audience attendance index, venues and concerts index, profits index, marketing and promotion index, logistics and operations index, time and number of shows index.

Table 1. The symbol and description of the notation mentioned in the paper

Symbol	Description
CR	Ratio of consistency
RI	Average random consistency index
CI	Consistency index

Table 1. Continued

$\lambda_{\max}$	Largest eigenvalue of Judgement Matrix
C_i	The criteria in the AHP model
P_i	Alternative plans
w_i	The weight of each factor
A	Judgement Matrix
S	The total score of one tour
U	The factors we considered
AAI	Audience attendance Index
VCI	Venues and Concerts Index
PI	Profits Index
MPI	Marketing and Promotion Index
LOI	Logistics and Operations Index
TSI	Time and Number of Shows Index

3. Model assumption

In order to build a comprehensive model, we make the following basic assumptions, each of which is properly justified. We assumed that a music tour is usually when an album of a singer was released, the singers travel to different places to present them. Music tours cost a lot, but earn more for the singers. We use the chart below for any information about our singer that was not available. We assume that the singer we pick is 100% sure about their music tour. The singer we choose will not quit after the decision of having a music tour is made. Otherwise, there is no need to create a model nor the best plan. No accident happens during or before the tour. These accidents might include the singer getting sick, unsuitable weathers or technical accidents. These problems only occur accidentally, and a professional singer should consider well and protect themselves well form these issues. We pick the singer with abundant information online. First, this means that this singer was famous, therefore the best plan for his/her will be important. Additionally, it will help us create a more precise model with all the data. We assume that all information about our singer online is accurate. Since we are not first-hand, it makes it very hard to check the accuracy of the article.

4. Collection and analyses of data

4.1. Selection of a musical performer

We select Ed Sheeran which is a popular musical performer since his music style combines various elements such as pop, folk, rock, hip-hop, etc., creating his own unique style. According to our survey and research on Ed Sheeran, the possible reasons why Ed Sheeran goes on tour can be summarized as following main points as shown in Figure 1.

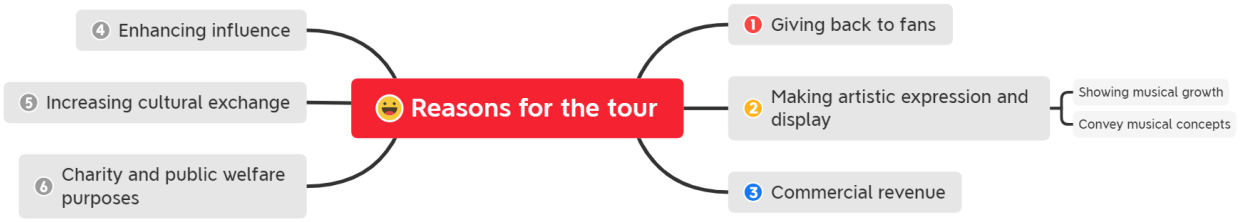

Figure 1. The possible reasons why Ed Sheeran goes on tour

Fans are an important support for artists, and touring is a way of interacting with them closely and in personal. Through live performances, fans can feel the charm of his music and satisfy their desire to see their idol perform in person. Making artistic expression and display evolves two different ways Showing musical growth and convey musical concepts. Every tour is an opportunity to show the development of his music. Ed Sheeran can present new musical works, new singing styles and stage performances in different tours, showing the audience that he is constantly exploring and progressing in his music. His songs often carry certain themes and emotions, and the touring stage can better convey these concepts to the audience, allowing them to understand the connotation of his music in a deeper way. For the commercial revenue, touring is an important commercial activity that can bring great economic income. Including ticket sales, sales of peripherals, etc. These can support the development of his music career as well as maintain the operation of the team. As for the Enhancing influence, touring around the world can expand his popularity and influence, attracting more people to his music. Each successful tour attracts new fans and strengthens his position in the music industry. For the increasing cultural exchange, touring to different countries and regions can promote the exchange between different cultures. Sheeran's music is a blend of many elements, through the tour can spread his music and culture to all over the world, and at the same time it can also absorb the cultural characteristics of different regions, for his music creation to bring new inspiration. For the Charity and public welfare purposes, sometimes Sheeran will combine his tour with charity activities, such as donating a certain amount of money to charity for every ticket sold, or calling attention to certain social issues and contribute to public welfare. We collected the data about the date of each show held by Ed Sheeran in 2027. As shown in Table 2, Ed Sheeran's tour starts from 10 January 2027 and ends on Friday 13 September 2027. Therefore, Ed Sheeran's tour lasts about nine months in one year.

Table 2. The planned date of each show held by Ed Sheeran in 2027

Show	Date	Show	Date
1	10 January 2027	23	15-23 June 2027
2	15 January 2027	24	
3	19 January 2027	25	26 June 2027
4	20 January 2027	26	29 June 2027
5	27 January 2027	27	3-6 July 2027
6	28 January 2027	28	6 July 2027
7	31 January 2027	29	12 July 2027
8	3 February 2027	30	13 July 2027
9	10 February 2027	31	14 July 2027
10	11 February 2027	32	20 July 2027
11	16 February 2027	33	27 July 2027

Table 2. Continued

12	17 February 2027	34	28 July 2027
13	24 February 2027	35	3 August 2027
14	2 March 2027	36	4 August 2027
15	9 March 2027	37	14 August 2027
16	16 March 2027	38	17 August 2027
17	3 May 2027	39	24 August 2027
18	22 May 2027	40	31 August 2027
19	24-26 May 2027	41	7 September 2027
20	8 June 2027	42	8 September 2027
21	9 June 2027	43	13-22 September 2027
22	12 June 2027		

From the data of each show in the tour we collected, there are 43 shows in total held by Ed Sheeran in 2027. The detailed date of each show is listed in Table 3. Based on the data we collected, Ed Sheeran went to the 30 countries including Thailand, Bahrain, United Arab Emirates, Japan, China, Singapore, Malaysia, Indonesia, Philippines, India, the United States, Italy, Germany, Portugal, Netherlands, Malta, Spain, Norway, Spain, Poland, Croatia, Hungary, Czech Republic, Lithuania, Austria, Serbia, Romania, Bulgaria, Cyprus and Brazil.

Table 3. The planned location of each show held by Ed Sheeran in 2027

Show	Location	Show	Location
1	Bangkok, Thailand	23	Lisbon, Portugal
2	Manama, Bahrain	24	Landgraaf, Netherlands
3	Dubai, United Arab Emirates	25	Ħ'Attard, Malta
4		26	Tenerife, Spain
5	Osaka, Japan	27	Stavern, Norway
6		28	Santiago de Compostela, Spain
7	Tokyo, Japan	29	Gdansk, Poland
8	Kaohsiung, China	30	
9	Bangkok, Thailand	31	Zagreb, Croatia
10		32	Budapest, Hungary
11	Singapore	33	Hradec Králové, Czech Republic
12		34	
13	Kuala Lumpur, Malaysia	35	Kaunas, Lithuania
14	Jakarta, Indonesia	36	
15	Manila, Philippines	37	St Pölten, Austria
16	Mumbai, India	38	Belgrade, Serbia
17	Hollywood, FL, US	39	Bucharest, Romania
18	Brooklyn, NY, US	40	Sofia, Bulgaria

Table 3. Continued

19	Boston, MA, US	41	Larnaca, Cyprus
20	Viale Carducci, Lucca, Italy	42	
21		43	Rio de Janeiro, Brazil
22	Munich, Germany		

4.2. Selection of factors

As for the single show, we consider four factors such as the venue selection and setup, promotion and marketing, performance preparation and experience of fans.

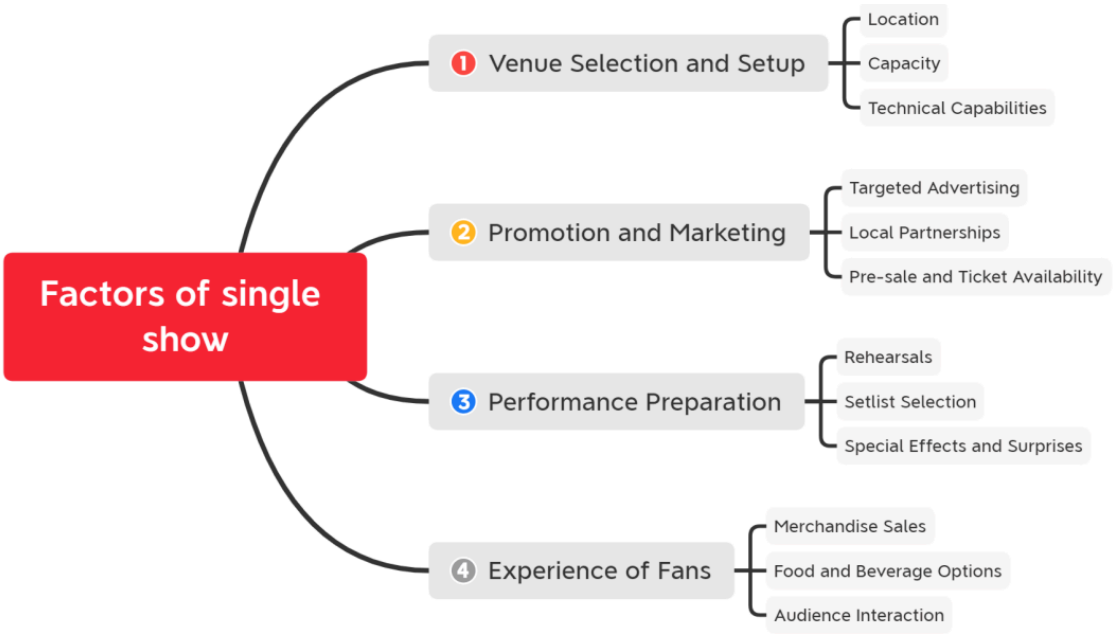

Figure 2. The main and sub-factors of single show in the tour

As illustrated in Figure 2, the first factor we considered is the venue selection and setup which includes the selections of location, capacity and technical capabilities. For Ed Sheeran's shows, the venue selection is pivotal. His global appeal means that venues near major transportation hubs, with ample parking and public transit options, are ideal. A central location in a city or close to major highways can significantly boost attendance. In addition, Sheeran's popularity necessitates venues that can accommodate large crowds, especially for his high-demand shows. However, for a more intimate connection with fans, smaller venues can also be considered for specific performances. Given Sheeran's dynamic performances, venues must have state-of-the-art sound and lighting systems, ample staging areas, and robust backstage facilities to ensure a high-quality show and the safety of all involved.

The second factor we built is the promotion and marketing which contains the targeted advertising, local partnerships and sale and ticket availability. Utilizing social media, email newsletters, radio, and print ads, Sheeran's team targets his diverse fan base. Messaging is tailored to highlight the unique aspects of each show, building excitement among fans. Collaborating with local businesses, radio stations, and community organizations increases the show's visibility and attracts a broader audience. Sale opportunities for fans who

engage with Sheeran on social media or sign up for newsletters are offered. Tickets are made available through multiple channels at various price points to cater to different budgets.

The third factor we considered is the Performance Preparation which includes the Rehearsals, Set-list Selection, Special Effects and Surprises. Thorough rehearsals are conducted with Sheeran's band, dancers, and any special guests to ensure a polished and well-coordinated performance. Emphasis is placed on stage presence, audience interaction, and technical aspects. The set-list is curated to feature Sheeran's best work, including popular hits, fan favorites, and new material, ensuring each show is fresh and engaging. Sheeran's shows often incorporate special effects like pyrotechnics, confetti cannons, or video projections to enhance the visual experience. Surprise elements, such as guest appearances, are planned to create memorable moments.

We also considered the factor of experience of fans, such as the merchandise sales, food and beverage options and audience interaction. A variety of tour merchandise, including T-shirts, posters, and albums, are offered at the venue, providing fans with a tangible memory of the show and generating additional revenue. To enhance the fan experience, a range of food and beverage concessions are provided, catering to various dietary needs and preferences. Sheeran encourages audience interaction during his shows, often inviting fans to sing along, dance, or participate in contests, creating a more engaging and memorable experience.

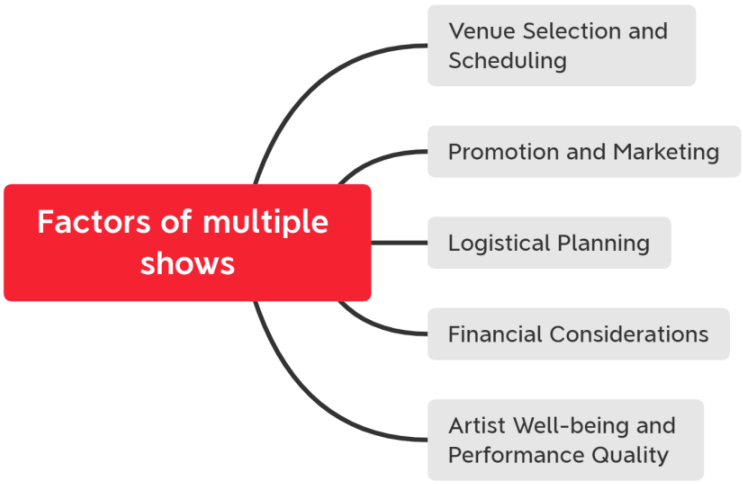

Figure 3. The main factors of multiple shows in the tour

As for the main factors of multiple shows in the tour illustrated in Figure 3, we considered the venue selection and scheduling, promotion and marketing, logistical planning, financial considerations, artist well-being and performance quality. Ed Sheeran's tour venues are strategically chosen to cater to his diverse fan base. He often includes a mix of major cities with high demand for live music and smaller markets to reach a wider audience. Ensuring that the venues are suitable in terms of capacity and acoustics is essential. Sheeran's tour schedule is carefully planned to minimize travel time and ensure adequate rest between shows, which is crucial for maintaining the energy and quality of his performances. Sheeran's team develops targeted marketing campaigns for each location, leveraging local media and social media influences to engage potential attendees. They implement various ticketing strategies, including sales and VIP packages, to cater to different fan segments and ensure fair access to tickets. Engaging with fans through social media and offering exclusive content helps build excitement and encourages attendance. Efficient transportation for Sheeran and his crew, as well as equipment, is arranged to facilitate smooth transitions between venues. Proper accommodation near the venues is booked to minimize travel time and ensure the team's comfort. Equipment management and crew management are also meticulously planned to ensure that all technical aspects run seamlessly. A

comprehensive budget is developed to cover all tour expenses, from venue rentals to crew salaries. Sheeran's team focuses on maximizing revenue through various channels, including ticket sales, merchandise, and sponsorship. They also explore alternative revenue streams, such as live streaming, to enhance profitability. Sheeran's well-being is a priority, with sufficient rest days scheduled and access to proper nutrition and medical support. Continuous rehearsals and performance refinements are conducted to maintain a high standard of show quality. Emotional support and a positive work environment are provided to ensure the best possible performance for his fans at every show. These factors, when effectively managed, contribute to the success of Ed Sheeran's multiple shows, ensuring that each concert is a memorable experience for his fans around the world.

A successful music tour is influenced by multiple factors, such as the artist's popularity and appeal, quality of performances, venue selection, promotion and marketing and Tour management and organization as shown in Figure 4.

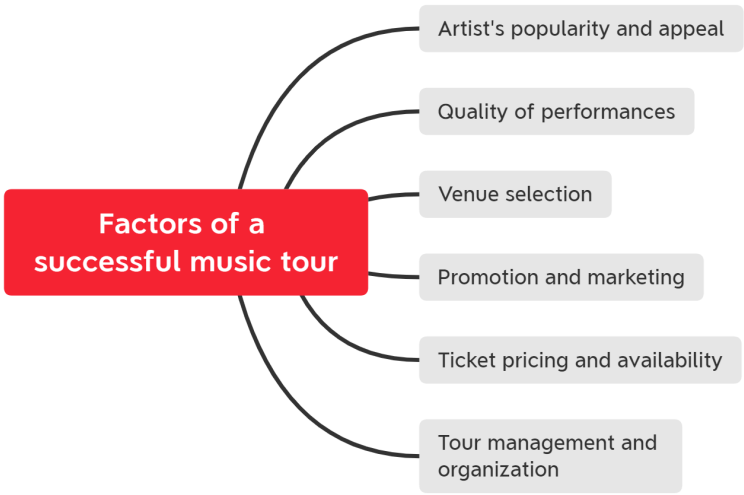

Figure 4. The main factors of a successful music tour

We considered the six main factors of a successful music tour as illustrated in Figure 4, including the artist's popularity and appeal, quality of performances, venue selection, promotion and marketing, ticket pricing and availability, tour management and organization. Well-known artists draw larger crowds due to their established fan bases. For example, Taylor Swift's tours are highly anticipated, with tickets selling out rapidly because of her global popularity. Unique styles or exceptional talents can also attract more audiences, like Beyoncé's powerful vocals and elaborate stage performances. High musical standards ensure that the live music is excellent, including precise instrument playing and accurate singing. Engaging stage presence is essential. Artists like Mick Jagger of The Rolling Stones have captivating stage charisma that energizes the audience. Spectacular visual effects enhance the overall experience. For instance, Coldplay's use of colorful lights and innovative stage designs creates an immersive atmosphere. Appropriate venue size is crucial. A large stadium may be suitable for a famous artist with a huge following, while an intimate club might be better for a niche or emerging act. Good acoustics and comfortable facilities at the venue contribute to the audience's enjoyment, as seen in renowned concert halls like Carnegie Hall. Effective advertising through various channels, such as social media, TV commercials, and billboards, helps increase awareness. Word-of-mouth also plays a significant role. Positive reviews and recommendations from fans can attract more people to the tour. Reasonable ticket prices make the tour more accessible to a wider range of fans. Sufficient ticket availability ensures that interested fans can purchase tickets without facing excessive difficulties, although

scarcity can sometimes create a sense of exclusivity. Smooth logistics ensure that equipment, crew, and artists can move between venues efficiently. Professional staff handling various aspects, such as sound engineering, lighting, and security, contribute to the seamless running of the tour.

5. Comprehensive evaluation model

5.1. Selecting indicators

For Ed Sheeran's tour, the primary goals include promoting his latest album, expanding his global fan base, and achieving a significant revenue target. These objectives will guide all aspects of the tour planning, from venue selection to marketing strategies. By adhering to these indicators, Ed Sheeran's tour is poised for success, providing an unforgettable live music experience for fans while achieving the set goals and objectives as demonstrated in Figure 5.

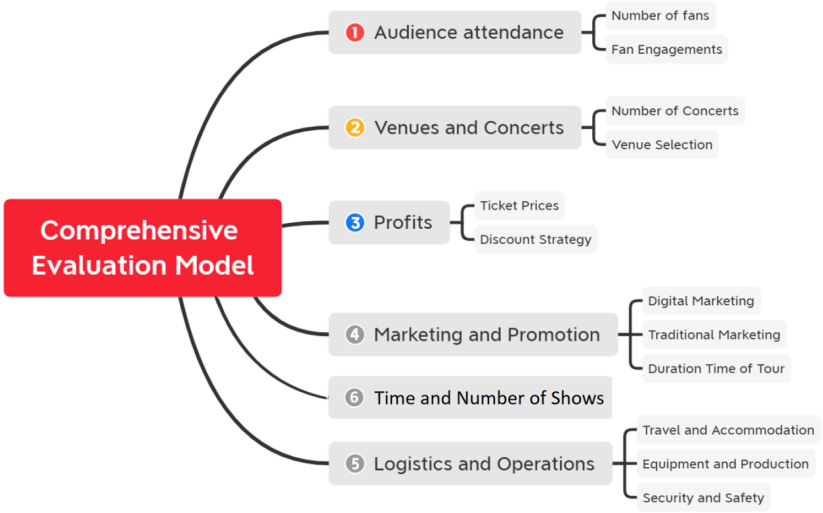

Figure 5. The main and sub-indicators we considered in the comprehensive evaluation model

For the first indicator of audience attendance, we selected the number of fans, and fan engagements. Sheeran's audience is diverse, spanning various age groups and musical preferences. Geographically widespread, his fans are found across continents, with a strong presence in urban areas. Understanding their spending power is crucial for ticket pricing and merchandise sales. This research will inform the tour's marketing and venue choices. Fan engagement is fostered through meet-and-greets and social media interactions, using a specific hashtag to increase visibility and promote word-of-mouth. For the second indicator of venues and concerts, we choose the Number of Concerts and Venue Selection. Sheeran's tour will feature a mix of large stadium shows and smaller, more intimate gigs to cater to different audience segments. The number of concerts is determined by his popularity, availability, and the financial goals set forth. Venues are chosen based on capacity, acoustics, and location, with a preference for those with a reputation for hosting live music events and offering excellent facilities.

For the third indicator of Profits, we considered the ticket prices and discount strategy. Ticket prices are compared against similar artists and events, considering venue size, location, and demand. Feedback from potential ticket buyers is gathered to set reasonable price expectations. A tiered pricing structure is implemented to accommodate various budgets, including VIP packages and premium seating. Early bird discounts and bundle deals with merchandise are considered to boost sales. For the fourth indicator of

marketing and promotion, we selected the Digital Marketing and Traditional Marketing. Sheeran's team leverages social media, email newsletters, and online advertising to reach a broad audience. Engaging content such as teaser videos and exclusive offers are created to build excitement. Traditional channels like local newspapers, radio, and billboards are used in conjunction with digital marketing to maximize reach.

For the fifth indicator of logistics and operations, we considered the travel and accommodation, equipment and production, security and safety. Travel arrangements are made with cost, convenience, and safety in mind, ensuring performers and crew are well-rested and ready for each performance. All necessary equipment is transported and set up by a professional team, ensuring high-quality production values for each show. Professional security is hired, and a comprehensive security plan is developed to address crowd control and emergencies, ensuring the safety of all involved. Last, for the sixth indicator of time and number of shows, we selected the duration time of shows and tour, number of single and multiple shows. The tour dates are strategically planned to avoid conflicts with local events and to capitalize on seasonal factors and holidays, which can influence attendance. The total number of single and multiple shows can be determined by the musical performer and organizers to achieve their goals.

5.2. Analytic Hierarchy Process (AHP)

We use the Analytic Hierarchy Process (AHP) to make the best plan a tour for the musical performer. The AHP is a simple method to make decisions to some complicated and vague problems [25-27]. It is especially suitable for those problems which can't be completely quantitative analyzed. We build the hierarchical structure of our AHP model with three layers including the goal layer, criteria layer and plan layer as illustrated in Figure 6.

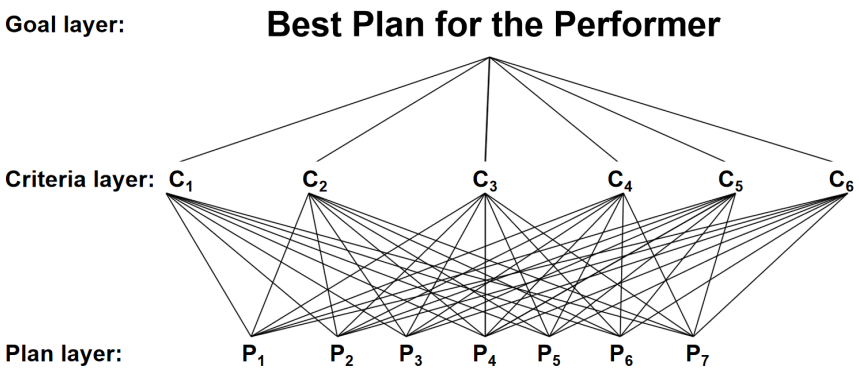

Figure 6. The hierarchical structure of our AHP model

The hierarchical structure reflects the relationship between the factors, but the criteria in the criteria layer do not necessarily occupy the same proportions in the goal measurement. In the minds of decision makers, they each occupy a certain proportion.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix} \tag{1}$$

The judgment matrix A corresponds to the feature vector W of the maximum eigenvalue λ_{max}. After normalization, it is the ranking weight of the relative importance of corresponding factors at the same level to

a factor at the previous level. This process is called hierarchical order.

When summing up all the comparison results, it is inevitable to include a certain degree of inconsistency. If the comparison result is completely consistent, the elements of matrix A should also satisfy:

$$a_{ij} \times a_{jk} = a_{ik},\ \forall i, j, k = 1, 2, \ldots, n \tag{2}$$

The steps to check the consistency of the judgment matrix are as follows:

(i) Calculate the consistency index CI:

$$CI = \frac{\lambda_{max} - n}{n-1} \tag{3}$$

(ii) Find the corresponding average random consistency index RI. For n = 1~9, Saaty gives the value of RI, as shown in Table 4.

Table 4. The values of RI

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

The value of RI is obtained by using a random method to construct 500 sample matrices: randomly select numbers from 1 to 9 and its reciprocal to construct a reciprocal matrix, and obtain the average value of the largest eigenvalue λ'_{max} and define:

$$RI = \frac{\lambda'_{max} - n}{n-1} \tag{4}$$

(iii) Calculate the ratio of consistency CR as follows.

$$CR = \frac{CI}{RI} \tag{5}$$

When CR < 0.10, the consistency of the judgment matrix is considered acceptable, otherwise the judgment matrix should be adjusted appropriately.

What we get above is the weight vector of a set of elements to an element in the upper layer. We finally need to get each element, especially the ranking weight of each program in the lowest layer for the target, so as to select the program. The total ranking weight is important to combine the weights under a single criterion from top to bottom.

Find the total ranking weight of each factor in layer B, $b_1, ..., b_n$, the calculation is carried out as:

$$b_i = \sum_{j=1}^{m} b_{ij} a_j, \quad i = 1 \sim n \tag{6}$$

Suppose that the pairwise comparison judgment matrix of factors related to A_j in layer B is tested for consistency in single ranking, and the single ranking consistency index is $CI(j)$, $(j = 1, ..., m)$, then the corresponding average random consistency index is $RI(j)(CI(j)$, $RI(j)$ have been obtained when doing the single level ranking), then the random consistency ratio of the total ranking of the B layer is:

$$CR = \frac{\sum_{j=1}^{m} CI(j) a_j}{\sum_{j=1}^{m} RI(j) a_j} \tag{7}$$

When CR < 0.10, we consider that the overall ranking result of the hierarchy has a satisfactory consistency and accept the analysis result. When the weight of each factor $w_i (i = 1, ..., 6)$ is calculated from the AHP model, the total score of one tour S can be obtained as follows.

$$S = w_1 C_1 + w_2 C_2 + w_3 C_3 + w_4 C_4 + w_5 C_5 + w_6 C_6 \tag{8}$$

Where $w_i(i=1,...,6)$ is the weight of each factor, $C_i(i=1,...,6)$ is the value of each factor, and S is the total score of one tour. The formula can be simplified in a more condensed way as:

$$S = \sum_{i=1}^{6} w_i C_i \tag{9}$$

6. Model application

6.1. Evaluation of the past tour

To evaluate the past tour, we first build the comparison matrix as follows.

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} & a_{26} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} & a_{46} \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & a_{66} \end{bmatrix} = \begin{bmatrix} 1 & 2 & \frac{1}{2} & \frac{1}{3} & 2 & 3 \\ \frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{2} & \frac{1}{3} & \frac{1}{2} \\ 2 & 2 & 1 & \frac{1}{3} & \frac{1}{2} & 1 \\ 3 & 2 & 3 & 1 & 2 & 3 \\ \frac{1}{2} & 3 & 2 & \frac{1}{2} & 1 & 2 \\ \frac{1}{3} & 2 & 1 & \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix} \tag{10}$$

Then according to the AHP model we build in the former chapter, the weight of each factor $w_i(i=1,...,6)$ with $\sum_i^6 w_i = 1$ is calculated and summarized in the Table 5 as follows.

Table 5. The weight of each factor calculated from the AHP model

weight	w_1	w_2	w_3	w_4	w_5	w_6
value	0.18	0.08	0.14	0.32	0.18	0.10

The largest eigenvalue λ_{max} was calculated as 6.54, consistency index CI was calculated as 0.11 and average random consistency index RI was 1.24, respectively. The normalized eigenvector was obtained as [0.18, 0.08, 0.14, 0.32, 0.18, 0.10]. In addition, the ratio of consistency CR is calculated as 0.09 which is less than 0.10. Therefore, it can be considered that the overall ranking result of the hierarchy has a satisfactory consistency and accept the analysis result. Hence, the total score of Ed Sheeran's tour S can be obtained as follows.

$$S = w_1C_1 + w_2C_2 + w_3C_3 + w_4C_4 + w_5C_5 + w_6C_6 \tag{11}$$

In summary, the total score of Ed Sheeran's tour S can be calculated as:

$$S = 0.18 \cdot C_1 + 0.08 \cdot C_2 + 0.14 \cdot C_3 + 0.32 \cdot C_4 + 0.18 \cdot C_5 + 0.10 \cdot C_6 \tag{12}$$

There are some strengths of Ed Sheeran's the past tour we selected in the former chapter. As a famous singer, Ed Sheeran's song is famous worldwide. There are many factors that contribute to his success in his past music tour. First, one of the most appealing points about his music tour is his famous songs and numerous hot fans. Therefore, he has money to run all forty-three of his music tours without worrying about the income. As a result, there is no doubt that he will have high income from his music tours. Second, the time arrangement was well planned for him.

In some shows, he held music tours of 2-4 days at the same place, especially in places where his fans are more. This will help his fans by giving more chance for them to watch his music tours is tickets of some days were sold out. It also secures the income he is receiving. If he chooses to perform his tour 4 day in a place where not much people is familiar with his songs like India, then he might lose money because of the lack of people attending the show.

Therefore, his time arrangements are very wise. Moreover, he has tours that are indoor (in a stadium) and outdoor. This further enhances the interest of his fans, making his tour worth attending. Additionally, he was special clothes for each tour. For example, he has colorful letters of the place he has his tours, including Osaka, Tokyo, Bahrain. There are also peripherals for his tours and album. An example of this is "+ - ÷ x" designed on hoodies, bags, jackets, T-shirts for his fans. This creates additional income for him of $110-$10 per one product. However, there are still some weaknesses of Ed Sheeran's the past tour. For example, to maximize his profit, there are still many things he can consider doing. First, increasing the ticket price for his tours. His price ticket currently is about $121 per person, which was quite cheap. He may consider increasing it to about $130 or above for his ticket. As our group have observed, his tickets for the tour usually sold out quickly. Therefore, there is not a burden of losing audience. This strategy is especially useful in famous and wealthy countries like US, China or UK. Secondly, he should consider creating more meaningful and useful peripherals. Adding his own signature to the bag will no doubt increase its popularity and price, creating more income for Ed Sheeran.

Currently, his best-selling products are all his albums. Many other products are mostly clothes that is not so unique compared with other singers. A solution for this is to increase the variety of his product, making them more useful. Such as pens with his album name. He could even try to co-brand to famous Zebra, a famous stationary company, to increase his sales. Third, he could add an additional section to his tours, that is a short time where fans can pay certain amount of money and have signatures and short talk with him, creating a better engagement between the two. Lastly, he and his team might want to take more official photos of each tour. Currently, in Ed Sheeran's official website, there are not much picture in the photo album. Increasing pictures can add to his publicity, making future tours more successful. According to our AHP model, the total score of Ed Sheeran's the past tour in 2025 is calculated as 0.621, indicating the past tour of Ed Sheeran is slightly successful. In addition, the score of six indicators including the Audience Attendance Index (AAI), Venues and Concerts Index (VCI), Profits Index (PI), Marketing and Promotion Index (MPI), Logistics and Operations Index (LOI), Time and Number of Shows Index (TSI) of Ed Sheeran's past tour with the alternative plan (P1) can also be calculated as demonstrated in Table 6. Herein, the values of the six indicators in each alternative plan were determined by the comparative judgement matrix objectively.

Table 6. The score of six indicators in the alternative plan (P1) for Ed Sheeran's past tour

NO.	Indicator	Score
1	Audience Attendance Index (AAI)	0.821
2	Venues and Concerts Index (VCI)	0.732
3	Profits Index (PI)	0.891
4	Marketing and Promotion Index (MPI)	0.689
5	Logistics and Operations Index (LOI)	0.132
6	Time and Number of Shows Index (TSI)	0.457

We have researched Ed Sheeran's past music tour that had just ended in 2025, and determined whether it is a good music tour based on our indexes. Overall, we believed that Ed Sheeran held a relatively outstanding music tour, fitting our indexes. He was a fairly well-known singer worldwide, with his famous guitar playing fitted our first two indicators. Moreover, he selected venues that has good traffic and abundant fans. He also created promotion and advertisements on different commercial medias. The price of his ticket is broken down by different area, and offer discounts if bought for multiple audience. All of his tour went smoothly, meaning that he has a good organization. Therefore, he met all our criteria for a good music tour. As for the seven

alternative plans with different values of total scores, we rank the seven alternative plans according to the total score of each alternative plan. The results of score of six indicators and ranking total score are listed in Table 7 with the ranked total score as P4 (0.887) > P7 (0.813) > P3 (0.767) > P5 (0.632) > P1 (0.621) > P6 (0.581) > P2 (0.556). Consequently, the alternative plan (P4) with the highest total score is recommended to Ed Sheeran.

Table 7. The score of six indicators and total score for the seven alternative plans

Rank	alternatives	AAI	VCI	PI	MPI	LOI	TSI	Total Score
1	P4	0.687	0.948	0.842	0.973	0.889	0.985	0.887
2	P7	0.824	0.746	0.792	0.764	0.854	0.962	0.813
3	P3	0.814	0.913	0.791	0.673	0.967	0.469	0.767
4	P5	0.549	0.571	0.763	0.942	0.236	0.364	0.632
5	P1	0.821	0.732	0.891	0.689	0.132	0.457	0.621
6	P6	0.731	0.682	0.648	0.645	0.268	0.497	0.581
7	P2	0.762	0.814	0.746	0.542	0.214	0.374	0.556

6.2. Aspects of a future based on our model

Upon the foundation of our sophisticated tour planning model, which integrates the Analytic Hierarchy Process (AHP), we foresee several critical aspects that will substantially enhance the future touring endeavors of Ed Sheeran. This model employs a data concentric strategy to tour planning, ensuring that every strategic decision is meticulously aligned with Sheeran's artistic objectives and the fervent expectations of his fan base. In the strategic venue selection and scheduling, our model will serve as a pivotal tool in identifying venues that are both financially rewarding and logistically viable on a global scale. By factoring in the density of Sheeran's fan base and the specific demands of local markets, we can optimize the fan experience and financial outcomes of the tour. This approach ensures that each performance is not only well-attended but also a pinnacle of revenue generation. For the enhanced fan engagement, through the analysis of historical data and the application of predictive analytic, our model will empower Sheeran's team to devise targeted marketing campaigns that profoundly resonate with the fan community. This encompasses personalized promotions, strategic social media engagement, and the creation of exclusive content, all of which will amplify anticipation and stimulate ticket sales. For the optimized ticket pricing and availability, drawing on the insights gleaned from our model, Sheeran can adopt a dynamic pricing strategy that adeptly balances the principles of accessibility and profitability. This strategy will facilitate a tiered ticketing system, providing premium experiences for his most dedicated fans while ensuring that his music remains accessible to a diverse audience. In the logistical efficiency, our model will streamline the logistical planning processes, encompassing transportation, accommodation, equipment setup, and crew management. This will not only reduce operational costs but also ensure the seamless execution of the tour, minimizing disruptions to Sheeran's performance schedule and enhancing the overall tour dynamics. For the sustainability and community impact, our model takes into account the environmental footprint of the tour, advocating for sustainable practices that are in harmony with Sheeran's global reputation. This includes the adoption of eco-friendly transportation and the implementation of community-oriented initiatives, which will further solidify his standing as a conscientious global ambassador. In conclusion, our model presents a comprehensive approach to tour planning that not only elevates financial performance but also enriches the overall experience for Ed Sheeran and his fans. The application of this model will position Sheeran's future tours for unparalleled success, sustainability, and memorability, setting new benchmarks in the music touring industry.

6.3. Suggestions to the performers

For an artist like Ed Sheeran, who is known for his intimate connection with his fans and his dynamic live performances, here are some suggestions to enhance his tour experience. For the engage with local cultures, Ed Sheeran could incorporate elements of local culture into his performances at different venues. This could involve collaborating with local artists or incorporating traditional instruments into his music, which would not only make each show unique but also resonate with the local audience. For the interactive fan experiences, Sheeran could consider more interactive segments during his shows, such as audience singalongs, Q&A sessions, or even impromptu acoustic performances in the crowd. These moments can create a deeper connection with fans and make the concert a more memorable experience. For the sustainability practices, as a performer with a global reach, Ed could lead by example in promoting sustainability. This could include reducing the environmental impact of his tours through eco-friendly transportation, minimizing single-use plastics backstage, and encouraging fans to participate in clean-up initiatives. For the health and wellness, Given the rigorous demands of touring, it's crucial for Ed Sheeran to prioritize his health. This could involve maintaining a balanced diet, regular exercise, and adequate rest. He could also share his wellness routines with fans to inspire them to lead healthier lifestyles. For the community Involvement, Ed Sheeran could use his platform to give back to the communities he visits. This could be through charity concerts, supporting local businesses, or engaging in community service projects. Such actions can leave a lasting positive impact and strengthen the bond between the artist and his fans. For the technological Integration, to enhance the concert experience, Ed could explore the use of augmented reality or virtual reality during his performances. These technologies could provide fans and make his shows even more immersive. For the post-show analysis, after each show, it would be beneficial for Ed to review fan feedback and his own performance. This analysis can provide insights into what worked well and what could be improved, ensuring that each subsequent show is better than the last. By implementing these suggestions, Ed Sheeran can further elevate his performances, creating a more engaging and meaningful experience for both himself and his fans.

7. Reflection of model to other musical performers

7.1. Plan a tour for another musical performer

We plan a tour for another musical performer Cold Play, and the results are shown in Table 8. Based on research for cold play's past events, we found that this team usually present several music tours in a single place rather than traveling to another country immediately after one or two shows. Therefore, we created a chart fitting their preferences.

Table 8. The plan for music tours of Cold Play in 2027

Show	Location	Date	Show	Location	Date
1	London, England	15, January	13	Hongkong, China	2, April
2	London, England	16, January	14	Hongkong, China	3, April
3	London, England	17, January	15	Hongkong, China	4, April
4	London, England	18, January	16	Tokyo, Japan	24, April
5	London, England	19, January	17	Tokyo, Japan	25, April
6	London, England	20, January	18	New York, USA	1, June
7	Paris, France	10, February	19	New York, USA	2, June
8	Paris, France	11, February	20	New York, USA	3, June

Table 8. Continued

9	Paris, France	12, February	21	New York, USA	6, June
10	Paris, France	13, February	22	New York, USA	6, June
11	Shanghai, China	25, March	23	Barcelona, Spain	12, August
12	Shanghai, China	26, March	24	Barcelona, Spain	13, August

7.2. Plan a tour for every musical performer

Since our AHP model is a universal and subjective comprehensive evaluation model, every musical performer could make the comparison matrix according to their preferences, such as maximizing fan attendance, maximize venues, maximizing profits, or something else. For example, if Justin Bieber prefers maximizing fan attendance, he can adjust the comparison matrix as follows.

$$A = \begin{bmatrix} 1 & 2 & \frac{1}{2} & \frac{1}{3} & 2 & 2 \\ \frac{1}{2} & 1 & \frac{1}{2} & \frac{1}{3} & \frac{1}{3} & \frac{1}{2} \\ 2 & 2 & 1 & \frac{1}{3} & \frac{1}{2} & 1 \\ 3 & 3 & 3 & 1 & 2 & 3 \\ \frac{1}{2} & 3 & 2 & \frac{1}{2} & 1 & 2 \\ \frac{1}{2} & 2 & 1 & \frac{1}{3} & \frac{1}{2} & 1 \end{bmatrix} \tag{13}$$

According to the AHP model we build in this work, the weight of each factor can be updated for every musical performer. The AHP model uses a fairly easy principle, so that it can form easily without much need in deep mathematical specialized field or great amount of data. Its calculation process and results are relatively intuitive, and can be presented in a clear hierarchical structure and clear weight values, which facilitates communication and exchange between decision makers and between decision makers and relevant personnel, and is conducive to improving decision-making efficiency and decision-making quality.

8. Conclusion

In conclusion, our comprehensive evaluation model for tour planning has demonstrated its efficacy in optimizing various aspects of Ed Sheeran's concert tours. Through the application of the Analytic Hierarchy Process (AHP), we have been able to systematically evaluate critical factors such as venue selection, fan engagement, ticket pricing, and logistical efficiency. This structured approach has not only enhanced the decision-making process but also provided a transparent methodology for maximizing fan attendance, expanding to new venues, and increasing profits. Our model's ability to adapt and make data-driven decisions positions it as a valuable tool for future tour planning, ensuring that each concert is a memorable experience for fans while achieving the performer's commercial and artistic goals. With the insights gained from our analysis, we are confident that our model can be instrumental in shaping the strategic direction of Ed Sheeran's upcoming tours, setting a new standard for success in the music touring industry.

Author contribution

S.S. Wang designed the project and finalized the manuscript. Q.Y. An and B.E. Tang performed the modelling, calculations and analyses. All the authors participated in the discussion and preparation of the manuscript.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article.

Declarations

Competing interests Authors are required to disclose financial or non-financial interests that are directly or indirectly related to the work submitted for publication.

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