World Academy of Science, Engineering and Technology
International Journal of Sport and Health Sciences
Vol:6, No:2, 2012

Evaluation of the Contribution of Starting Pitchers in a Professional Baseball Team by Grey Relational Analysis

Chih-Cheng Chen, Yung-Tan Lee, Shih-Yang Lee, Shih-Kuei Huang, Tien-Tze Chen and Qiu-Jun Chen

***Abstract*—**The evaluation of the contribution of professional baseball starting pitchers is a complex decision-making problem that includes several quantitative attributes. It is considered a type of multi-attribute or multi-criteria decision making (MADM/MCDM) problem. This study proposes a model using the Grey Relational Analysis (GRA) to evaluate the starting pitcher contribution for teams of the Chinese Professional Baseball League. The GRA calculates the individual grey relational degree of each alternative to the positive ideal alternative. An empirical analysis was conducted to show the use of the model for the starting pitcher contribution problem. The results demonstrate the effectiveness and feasibility of the proposed model.

***Keywords*—**Starting pitchers, Grey Relational Analysis, Chinese Professional Baseball

I. INTRODUCTION

EACH year, as the season ends, baseball fans and sportswriters exhibit considerable interest in discussing the contribution of professional baseball players for the favorite team in Taiwan. At the same time, all professional baseball team managers or coaches evaluates the contribution of players to their teams. The purpose of the evaluation is to provide information to the owner, who is a decision maker, to decide whether to increase or reduce the salaries of players in the next season. According to the history of baseball, starting pitchers were considered more crucial than players in other positions [1-3]. Starting pitchers pitch more innings over the course of a season and, for a century, all of the best pitchers in teams were starting pitchers [1-5]. In a professional baseball team, the manager and coaches are always concerned about the starting pitcher first.

Chen C. C. is with the Department of Sport Management, Aletheia University, No. 32, Chen-Li St., Danshui Dist., New Taipei City, 25103 Taiwan (phone: +886-2-26212121 ext. 7109; fax: +886-2-26213200; e-mail: ccchen@mail.au.edu.tw) and with the Graduate Institute of Management Science, Tamkang University, No. 151, Yingzhuan Rd., Danshui Dist., New Taipei City 25137, Taiwan.

Lee Y. T. is with the Department of Tourism, Aletheia University, No. 32, Chen-Li St., Danshui Dist., New Taipei City, 25103 Taiwan (e-mail: au4300@email.au.edu.tw).

Lee S. Y. and Huang S. K. are with the Department of Physical Education, Chinese Culture University, No. 55, Hwa-Kang St., Yang-Ming-Shan, Taipei, 111 Taiwan (email: isaac4883@yahoo.com.tw)

Chen T. T. is with the Department of Sport Management, Aletheia University, No. 32, Chen-Li St., Danshui Dist., New Taipei City, 25103 Taiwan (e-amil:au1169@mail.au.edu.tw).

Chen M. Y. is with Asia University, No. 500, Lioufeng, Rd., Wufeng, Taichung City, 41354, Taiwan.

Manager or coaches determine the contribution of starting pitchers by the number of innings pitched, strikeouts, and games won or lost. Therefore, the evaluation of the contribution of professional baseball starting pitchers is a complicated decision-making problem that includes several quantitative attributes. It is regarded as a type of multi-attribute or multi-criteria decision making (MADM/MCDM) problem [5]. The purpose of this study was to develop a method that can help the manager or coaches to assess the contribution of starting pitchers for the team in the domestic professional baseball sector in Taiwan. Several common methodologies were proposed for MADM, such as simple additive weighting (SAW), the technique for order preference by similarity to ideal solution (TOPSIS), analytical hierarchy process (AHP), data envelopment analysis (DEA), and Grey relational analysis (GRA) [6]. The grey system theory proposed by Deng [7] has been widely applied to various fields [6]. It is useful for managing inferior, incomplete, and uncertain information. Grey relational analysis (GRA) is part of grey system theory, which is suitable for solving problems with complicated interrelationships between multiple factors and variables[6]. The GRA was successfully applied to solve a variety of MADM problems, such as hiring decisions [8], the restoration planning for power distribution systems [9], and the modeling of quality function deployment [10]. The GRA solves MADM problems by combining the entire range of performance attribute values considered for every alternative into a single value. This reduces the original problem to a single attribute decision making problem. The GRA approach is applied to assess the contribution of starting pitchers in professional baseball teams in Taiwan. This is done according to the degree of similarity or difference of development trends between an alternative and the ideal alternative. We assume that this analysis provides useful information for professional baseball team managers or pitching coaches to help them to evaluate the contribution of their starting pitchers. The remainder of the paper is organized as follows: the methodology for evaluation is discussed in Section 2; Section 3 presents the empirical analysis to determine the contribution of professional team starting pitchers in Taiwan; and lastly, Section 4 offers conclusions and remarks for future studies.

II. Methodology

The evaluation procedure consists of several steps. Detailed descriptions of each step are provided in the following subsections.

A. Grey Relational Analysis method

The grey relational analysis is based on the degree of similarity or difference of development trends between an alternative and the ideal alternative. A stronger relationship exists if the trend of change between the alternative and the ideal alternative is consistent. Otherwise, the relational grade is smaller[10-11]. The procedure of GRA is to first translate the performance of all alternatives into a comparability sequence. This step is called grey relational generating. A reference sequence (ideal target sequence) is defined according to these sequences. Subsequently, the grey relational coefficient between all comparability sequences and the reference sequence is calculated. Finally, based on these grey relational coefficients, the grey relational grade between the reference sequence and every comparability sequence is calculated. If a comparability sequence translated from an alternative has the highest grey relational grade between the reference sequence and itself, that alternative is the optimal choice[12]. The procedures of grey relational analysis are shown in Fig. 1.

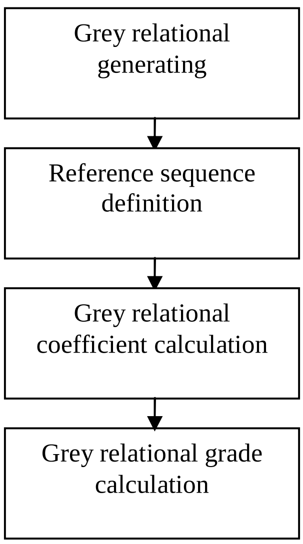

Fig 1 Procedure of grey relational analysis

Step1: Grey relational generating

When the units in which performance is measured differ for various attributes, the influence of a number of attributes may be neglected. This may also occur if a number of performance attributes have a large range. In addition, if the goals and directions of these attributes differ, it would cause incorrect results in the analysis [12-13]. For a MADM problem, if m alternatives and n attributes exist, the i^{th} alternative can be expressed as $Y_i = (y_{i1}, y_{i2}, ..., y_{ij})$, where y_{ij} is the performance value of attribute j of alternative i . The term Y_i can be translated into the comparability sequence $X_{ij} = (x_{i1}, x_{i2}, ..., x_{ij})$ by using either (1) or (2).

$$x_{ij} = \frac{y_{ij} - \min(y_{ij}, i = 1,2,...,m)}{\max(y_{ij}, i = 1,2,...,m) - \min(y_{ij}, i = 1,2,...m)} \quad \text{for} \quad i = 1,2,...,m;\ j = 1,2,...,n \tag{1}$$

$$x_{ij} = \frac{\max(y_{ij}, i = 1,2,...,m) - y_{ij}}{\max(y_{ij}, i = 1,2,...,m) - \min(y_{ij}, i = 1,2,...m)} \quad \text{for} \quad i = 1,2,...,m;\ j = 1,2,...,n \tag{2}$$

Equation (1) is used for benefit attributes and (2) is used for cost attributes.

Step2: Reference sequence definition

All performance values are scaled into [0, 1] after the grey relational generating procedure using (1) or (2). For an attribute j of alternative i , if the value x_{ij} , which was processed by grey relational generating procedure, is equal to 1, or nearer to 1 than the value for any other alternative, the performance of alternative i is optimal for the attribute j . Therefore, an alternative is the optimal choice if all of its performance values are closest to or equal to 1. However, this type of alternative does not usually exist[12]. Our study defined the reference sequence X_0 as $(x_{01}, x_{02}, ..., x_{0j})$, and subsequently aimed to find the alternative in which the comparability sequence is the closest to the reference sequence.

Step3: Grey relational coefficient calculation

Grey relational coefficient is used for determining how close x_{ij} is to x_{0j} . The best grey relational coefficient is a sequence that closer to X_0 . The grey relational coefficient can be calculated by Eq. (3).

$$r(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \xi \Delta_{\max}}{\Delta_{ij} + \xi \Delta_{\max}} \quad \text{for} \quad i = 1,2,...,m;\ j = 1,2,...,n \tag{3}$$

In (3), $r(x_{oj}, x_{ij})$ is the grey relational coefficient between x_{0j} and x_{ij} , and

$\Delta_{ij} = \left| x_{0j} - x_{ij} \right|,$

$\Delta_{\min} = \min(\Delta_{ij}, i = 1,2,...,m;\ j = 1,2,...,n),$

$\Delta_{\max} = \max(\Delta_{ij}, i = 1,2,...,m;\ j = 1,2,...,n),$

ξ is the distinguishing coefficient, $\xi \in [0,1]$

The purpose of the distinguishing coefficient is to expand or compress the range of the grey relational coefficient. In most studies [10-15], the distinguishing coefficient ξ was set as 0.5, which is the same value used in our study.

Step4: Grey relational grade calculation

After calculating the entire grey relational coefficient $r(x_{0j}, x_{ij})$, the grey relational grade is subsequently calculated by (4).

$$\Gamma(X_0, X_i) = \sum_{j=1}^{n} w_j r(x_{0j}, x_{ij}) \quad \text{for} \quad i = 1,2,...,m \tag{4}$$

In (4), $\Gamma(X_0, X_i)$ is the grey relational grade between X_0 and X_i . It represents the level of correlation between the reference sequence and the comparability sequence. w_j is the weight of attribute j and usually depends on the judgments of the decision makers or the structure of the proposed problem. In addition, $\sum_{j=1}^{n} w_j = 1$. The grey relational grade indicates the degree of similarity between the comparability sequence and the reference sequence [10-12]. As discussed, for each attribute, the reference sequence represents the optimal performance that can be achieved by any of the comparability sequences. Therefore, if a comparability sequence for an alternative obtains the highest grey relational grade with the reference sequence, the comparability sequence is most similar to the reference sequence, and that alternative would be the optimal choice[12].

B. Data

The data used in this study were obtained from the official CPBL website (http://www.cpbl.com.tw), which collected and posted records of every CPBL baseball game in 2011. We selected alternatives for one team from the official CPBL website in 2011. Every alternative chosen has played in one of the top five games for his team. The commonly cited statistics for starting pitchers in the empirical analysis were innings pitched (IP)[1, 5], win games (Wins) [1, 16], lost games (Lost), and the number of opponent batters out (outs) [17], all of which are included in this study. The calculation was performed using GRA, in which parameters used as criteria are familiar to all fans.

III. Empirical Analysis for Contribution of Starting Pitchers

A. Alternative pitchers' information of pitch

A brief description of five pitchers for a team is provided. The names of pitchers for a team in the CPBL are listed in Table 1. As shown in Table 1, all starting pitchers started more than 12 games in 2011 season. A1 was the best performance player, and started 26 games, won 16 games, pitched 203 innings, and struck 412 opponent batters out. However, others were not discriminated clearly.

TABLE I
Alternative pitchers' pitching information

Player	Game Started	Wins	Lost	Innings Pitched	Outs
A1	26(1)	16(1)	6(2)	203(1)	412(1)
A2	21(2)	10(2)	11(4)	143(2)	304(2)
A3	18(3)	3(5)	7(3)	100(4)	232(4)
A4	14(4)	5(4)	11(4)	110(3)	243(3)
A5	12(5)	9(3)	3(1)	89(5)	207(5)

B. GRA for alternative pitchers

Based on the data of Table I, the GRA procedure is as follows:

1. Grey relational generating

The main purpose of grey relational generating is to transfer the original data into comparability sequences. Lost is considered a cost attribute, and wins, innings pitched, and outs are benefit attributes. The grey relational generating process used (1) for the data of performance values of wins, innings pitched, and distance of outs; (2) was used for the data of performance values of lost.

For example, in the case of the wins attribute, the maximal value was 16 and the minimal value was 3. By using (1), the results of grey relational generating of A2 is equal to (10-3)/(16-3) = 0.5385. All results of grey relational generating are shown in Table II.

TABLE II
Results of grey relational generating

Player	Wins	Lost	Innings Pitched	Outs
X_0	1.0000	1.0000	1.0000	1.0000
A1	1.0000	0.6250	1.0000	1.0000
A2	0.5385	0.0000	0.4729	0.4732
A3	0.0000	0.5000	0.0972	0.1220
A4	0.1538	0.0000	0.1839	0.1756
A5	0.4615	1.0000	0.0000	0.0000

2. Grey relational coefficient calculation

In Table II, X_0 is reference sequence. After calculating Δ_{ij}, $\Delta_{\max}$ and $\Delta_{\min}$, all grey relational coefficients can be calculated by (3). For example, $\Delta_{21} = |1-.625| = 0.3750$, $\Delta_{\max} = 1$, and $\Delta_{\min} = 0$ if $\xi = 0.5$; subsequently, $r(x_0, x_{21}) = (0+.5\times1)/(0.375+.5\times1) = 0.5714$. All results for the grey relational coefficient are shown in Table 3.

TABLE III
Results of grey relational coefficient

Player	Wins	Lost	Innings Pitched	Outs
A1	1.0000	0.5714	1.0000	1.0000
A2	0.5200	0.3333	0.4868	0.4869
A3	0.3333	0.5000	0.3564	0.3628
A4	0.3714	0.3333	0.3799	0.3775
A5	0.4815	1.0000	0.3333	0.3333

3. Grey relational grade calculation

In this case, the importance of all performance attributes was assumed as equal. Thus, the weights of the four performance attributes were all the same (1/4). By using (4), the grey relational grade can be calculated, as shown in column 2 of Table IV.

TABLE IV
The results of grey relational analysis

Player	Grey Relational Grade	Ranking
A1	0.8929	1
A5	0.5370	2
A2	0.4568	3
A3	0.3881	4
A4	0.3656	5

4. Evaluate contribution of starting pitchers

The GRA approach identified A1 player as the optimal contributing starting pitcher in one CPBL team because A1 player ranked first in three attributes. According to Table 1, the A2 player won 10 games, pitched 143 innings, struck 304 opponents outs, and was ranked second by intuition. However, as shown in Table IV, A2 ranked third by GRA because A2 lost 11 games in 2011 season. The A5 player ranked second unexpectedly. His performance of innings pitched and outs ranked fifth; however, he lost 3 games in 2011 season, which was the among all starting pitchers. Finally, the contribution of the A4 player ranked fifth, and his performance of innings pitched and outs were superior to that of A3 player. However, he lost 11 games; therefore, his performance of lost was inferior to that of the others.

IV. Conclusion

Evaluation of contribution of starting pitchers is a difficult problem that can be classified as a type of multi criteria decision making problem (MCDM) for managers or coaches of professional baseball teams. Therefore, our study applied grey relational analysis (GRA) to calculate the performance of starting pitchers with respect to each criterion. Finally, all starting pitchers were ranked by grey relational grade. This methodology can be used to provide team managers and coaches with a thorough understanding of the contribution of starting pitchers in their teams.

References

[1] C.C. Chen, M.L. Lin, Y.T. Lee, T.T. Chen, and C.Y. Tseng, "Best Starting Pitcher of the Chinese Professional Baseball League in 2009", World Academy of Science, Engineering and Technology, vol. 72, pp. 210-212, 2010.
[2] C.C. Chen, and T.T. Chen, "Starting Pitchers' Pitch Skills Positioning of CPBL in 2008-Multidimentional Scaling Analysis", Journal of Physical Education Fu Jen Catholic University, vol. 8, pp. 109-125, 2009.
[3] M. Lewis, Moneyball: The Art of Winning an Unfair Game. New York: Norton, 2003
[4] R.L. Sparks, and D.L. Abrahamson, "A Mathematical Model to Predict Award Winners", Math Horizons, vol. April, pp. 5-13, 2005.
[5] C.C. Chen, M.L. Lin, Y.T. Lee, and T.T. Chen, "Starting Pitcher Rotation in the Chinese Professional Baseball League based on AHP and TOPSIS", World Academy of Science, Engineering and Technology, vol. 58, pp. 74-79, 2011.
[6] Y. Kuo, T. Yang, and G.W. Huang, "The use of grey relational analysis in solving multiple attribute decision-making problems", Computers & Industrial Engineering, vol. 55, pp. 80-93, 2008.
[7] J. Deng, "Control problems of grey systems ", Systems and Control Letters, vol. 1 pp. 288-294, 1982
[8] D.L. Olson, and D. Wu, "Simulation of fuzzy multiattribute models for grey relationships", European Journal of Operational Research, vol. 175, pp. 111-120, 2006.
[9] W.H. Chen, "Distribution system restoration using the hybrid fuzzy-grey method", IEEE Transactions on Power Systems, vol. 20, pp. 199-205, 2005.
[10] H.H. Wu, "A comparative study of using grey relational analysis in multiple attribute decision making problems", Quality Engineering, vol. 15, pp. 209-217, 2002.
[11] H. Gu, and B. Song, "Study on effectiveness evaluation of weapon systems based on grey relational analysis and TOPSIS", Journal of Systems Engineering and Electronics, vol. 20, pp. 106-111, 2009.
[12] Y. Kuo, T. Yang, and G.W. Huang, "The use of grey relational analysis in solving multiple attribute decision-making problems", Computers & Industrial Engineering, vol. 55 pp. 80-93, 2008.
[13] J.T. Huang, and Y.S. Liao, "Optimization of machining parameters of Wire-EDM bases on grey relation and statistical analysis", International Journal of Production Research, vol. 41 pp. 1707-1720, 2003.
[14] G. Wei, "Grey relational analysis model for dynamic hybrid multiple attribute decision making", Knowledge-Based Systems, vol. 24, pp. 672-679, 2011.
[15] J. Zhang, D. Wu, and D.L. Olson, "The Method of Grey Related Analysis to Multiple Attribute Decision Making Problems with Interval Numbers", Mathematical and Computer Modelling, vol. 42, pp. 991-998, 2005.
[16] L. Bodin, and E. Epstein, "Who's on "rst}with probability 0.4", Computers & Operations Research, vol. 27, pp. 205-215, 2000.
[17] H.O. Stekler, D. Sendor, and R. Verlander, "Issues in sports forecasting", International Journal of Forecasting, vol. 26, pp. 606-621, 2010.