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A hybrid ANP model in fuzzy environments for strategic alliance partner selection in the airline industry

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ABSTRACT

Strategic airline alliances are an increasingly common strategy for enhancing airline competitiveness and satisfying customer needs, especially in an era characterized by blurring industry boundaries, fast-changing technologies, and global integration. Airlines have been very active in utilizing this form of strategic development. However, the selection of a suitable partner for a strategic alliance is not an easy decision, involving a host of complex considerations by different departments. Furthermore the decision-makers may hold diverse opinions and preferences arising due to incomplete information and knowledge or inherent conflict between various departments. In this study fuzzy preference programming and the analytic network process (ANP) are combined to form a model for the selection of partners for strategic alliances. The effects of uncertainty and disagreement between decision-makers as well as the interdependency and feedback that arise from the use of different criteria and alternatives are also addressed. This generic model can be easily extended to fulfill the specific needs of a variety of companies.

1. Introduction

Strategic alliances between airlines are now common in the aviation industry. They are frequently made in response to changing economic and regulatory conditions [1]. Three major alliances established within the last 10 years—Star Alliance, One-world and Sky Team—now account for nearly 70% of passengers and turnover in the global market [2]. Strategic alliance strategies allow airlines to expand networks, attract more passengers, and take advantage of product complementarities, as well as providing cost-reduction opportunities in passenger service related areas (such as code-sharing, joint baggage handling, joint use of lounges, gates and check-in counters, and exchange of flight attendants) [3]. A good strategic partner can further enhance the quality of their connecting services by adjusting arrival and departure flights so as to minimize waiting time between flights while providing sufficient time to make connections. On the other hand, ineffective strategic alliances can lead to the loss of core competencies and capabilities, exposure to unexpected risk and even business failure. Take for example—the fall of Swissair. Financial statements show that its airline alliance policy and investment strategy were responsible for the majority of its losses from 1997 to 2001 [4].

Prior research suggests that the choice of alliance partner is an important variable with significant influence on the performance of the strategic alliance partners [5,6]. An appropriate partner is one that can contribute resources and capabilities that the focal firm lacks. This ultimately determines the viability of the strategic alliance. Partner-related selection criteria require consideration to determine whether the corporate cultures of the partners are compatible, and whether trust exists between the partners' management teams. This ensures that the selected partner and focal firm achieve organizational interdependence. Although the importance of selecting the right partner for forming strategic alliances has been recognized in literature, there have been few empirical studies on how to choose that partner which stress the interrelationship between the partners and the focal firm at the same time. The analytic network process (ANP) was proposed by Saaty [7] to overcome the problem of interrelation among criteria or alternatives. The ANP is a general form of the analytic hierarchy process (AHP), which releases the restrictions of the hierarchical structure. It has been successfully applied in many multi-criteria decision making (MCDM) problems [8–11]. However, due to problems such as incomplete information and subjective uncertainty, even experts find it difficult to quantify the precise ratio of weights for the different criteria. The concept of fuzzy sets has been incorporated into

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AHP to deal with the problem of uncertainty, although ANP has not often been used to address this type of problem in fuzzy environments. A way to cope with uncertain judgments and to incorporate the vagueness that typifies human thinking is to express the preferences as fuzzy sets or fuzzy numbers [12]. Therefore, the objective of this study is to combine fuzzy preference programming and ANP to make a model capable of helping airlines select the best partner for strategic alliances.

The rest of this paper is structured as follows: In Section 2, we summarize some of the important previous studies regarding the strategic alliance strategy, and the problem characteristics are described. In Section 3, the basic concepts of fuzzy preference programming and ANP are reviewed. In Section 4, a strategic alliance model is developed. The implementation using the proposed fuzzy ANP is presented in Section 5. Section 6 includes discussions and some conclusions.

2. The strategic alliance

While merger activities have slowed significantly since 2000, strategic alliances are increasingly and widely used by airlines. International alliances give airlines access to parts of the world than would otherwise be economical, or where there may lack the authority to operate their own flights [3]. Through alliances, partners are able to compete more successfully. Yoshino and Rangan [13] and Gomes-Cassers [14] define the alliance as a cooperative venture between firms situated on the continuum between markets and hierarchies. The alliance is distinguished by several characteristics: independent firms; horizontal or vertical relationships; relationships which are not solely transactional; partners share resources, risks and benefits but have limited control and incomplete contracts. The types of airline alliance may include reciprocal frequent-flyer program recognition, shared lounges and check-in facilities, code-sharing agreements, marketing arrangements, procurement policies, system commonality, and even the interchangers of flight-crew personnel and aircraft [2].

There have been a number of empirical studies on the effectiveness of alliances, including those by Gellman Research Associates [15], Park and Cho [16], Oum et al. [17], Park et al. [18], and Zhang et al. [3]. Results show that alliances improve a carrier's performance on a number of economic measures, including productivity, pricing, profitability, and share price. Other studies, such as Dev et al. [19] discussed strategic alliances from a number of theoretical perspectives, including transaction cost economics, network relationships, game theory, developmental processes, ethics and firm internationalization. Brueckner [20] analyzed the effects of international airline code-sharing on traffic levels and welfare using specific demand and cost functions. He showed that the beneficial effects of code-sharing outweigh its harmful effects for most parameter values in his theoretical model. Fan et al. [21] examined the forces influencing the consolidation and structure of the airline alliance. They highlighted the following five forces: (i) increased globalization in trade and air transportation; (ii) increased intra-regional interaction, (iii) economic incentives for airline consolidation; (iv) pace of liberalization of international air transport industry, and (v) anti-trust concerns. Holtbrugge et al. [2] investigated human resource management (HRM) after strategic alliance. The main focus in all of these alliance studies has been the importance of the strategic alliance or the performance measures after the alliance. Discussion of the issue of strategic partner selection has been relatively rare. The selection of a suitable partner for a strategic alliance is not an easy decision, involving many complex considerations. It is essentially a group-decision involving many dimensions and inherent risks, such as inter-partner conflicts, and potential structural and cultural incompatibilities. The proposed hybrid fuzzy preference programming and ANP model is able to consider decision-makers' uncertainty and provides insights into the interrelationship between alliance motivations and partner selection criteria in the airline industry, which to the best of our knowledge, has largely been neglected.

3. Proposed hybrid fuzzy preference programming and ANP model

In this section, the concepts of fuzzy preference programming for coping with the uncertain judgments in a group-decision process are first introduced. The ANP method for determining the best partner for the strategic alliance is then discussed, including consideration of the dependence and feedback effects. The combined model can help companies to evaluate a suitable partner and fulfill their specified needs.

3.1. Fuzzy preference programming

Fuzzy preference programming was first proposed by Mikhailov and Singh [22]. It is mainly used to derive priority vectors from a set of comparison judgments or interval comparisons. Let $A = \{l_{ij}, u_{ij}\}$ represent an interval comparison matrix with n components, where l_{ij} and u_{ij} are the lower and upper bounds of the corresponding uncertain judgments. Interval judgments are considered consistent if there exists a priority vector $\boldsymbol{w}$ that satisfies the following inequalities:

$$l_{ij} \le \frac{w_i}{w_j} \le u_{ij}. \tag{1}$$

Inconsistency in the judgments indicates that no priority vector satisfies all the interval judgments simultaneously. Thus, a sufficient solution vector has to satisfy all the interval judgments as much as possible, that is

$$l_{ij} \tilde{\le} \frac{w_i}{w_j} \tilde{\le} u_{ij}, \quad i = 1, 2, \ldots, n-1; \quad j = 2, 3, \ldots, n; \quad j > i, \tag{2}$$

where $\tilde{\le}$ denotes the statement "fuzzy less or equal to".

In order to handle the above inequalities we can represent them as a set of single-sided fuzzy constraints:

$$\begin{aligned} w_i - w_j u_{ij} &\tilde{\le} 0, \\ -w_i + w_j l_{ij} &\tilde{\le} 0. \end{aligned} \tag{3}$$

The above m fuzzy constrains can be represented in the following matrix form:

$$\boldsymbol{R}\boldsymbol{w} \tilde{\le} 0, \tag{4}$$

where the matrix $\boldsymbol{R} \in \Re^{m \times n}$; $m = n(n-1)$.

The kth row of Eq. (4) is a fuzzy linear constraint, which can be defined as a linear membership function of the type:

$$\mu_{\tilde{A}_k}(\boldsymbol{R}_k\boldsymbol{w}) = \begin{cases} 1 - \dfrac{\boldsymbol{R}_k\boldsymbol{w}}{d_k}, & 0 < \boldsymbol{R}_k\boldsymbol{w} \le d_k, \\ 0, & \boldsymbol{R}_k\boldsymbol{w} \ge d_k, \\ 1, & \boldsymbol{R}_k\boldsymbol{w} \le 0 \end{cases} \tag{5}$$

where d_k is tolerance parameter for the kth row, representing the admissible interval of approximate satisfaction of crisp inequality $\boldsymbol{R}_k\boldsymbol{w} \le 0$. The membership function of $\boldsymbol{R}_k\boldsymbol{w}$ can be represented as in Fig. 1.

The membership function (5) is equal to zero when the corresponding crisp constraint $\boldsymbol{R}_k\boldsymbol{w} \le 0$ is strongly violated; it is between zero and one when the crisp constraint is approximately satisfied; and it is equal to one when the constraint is fully satisfied.

To solve the fuzzy preference programming, two assumptions are needed. First let $\mu_{\tilde{A}_k}(\boldsymbol{R}_k\boldsymbol{w})$, $k = 1, 2, \ldots, m$ be the membership functions of the fuzzy constraints $\boldsymbol{R}\boldsymbol{w} \tilde{\le} 0$ on the $n-1$ dimensional