

OPERATION COST CONTROL STRATEGIES FOR AIRLINES

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ABSTRACT

The purpose of this study is to explore the ranking of international airlines operation cost control strategies based on empirical studies of an international full-service airlines operation in Taiwan. Cost control has become more and more important for airlines in recent years, especially after experiencing a severe increase in crude oil prices and the 2008 serious financial crisis. In this study, the criteria and strategies were extracted from questionnaires answered by airline industry experts and evaluated using fuzzy Delphi method. Then the cost control strategies were ranked using the analytic hierarchy process (AHP). The findings of this study can provide international full-service airlines with five key criteria for the operational cost control including fuel cost reduction policy, employee' productivity improvement, flight operations, aircraft maintenance cost reduction, and operation procedure simplification. By ranking these potential cost reduction strategies, we identified the top ten significant strategies out of twenty-one that branched out of their upper five criteria. They include: (1) optimizing aircraft fleet dispatch, (2) conducting fuel hedging strategies, (3) improving aircraft fuel saving performance, (4) reducing the dead weight of an aircraft, (5) optimizing flight speeds using the efficient cost index, (6) scheduling reasonable flight hours for flight crew, (7) correcting en route flight plans and alternate airports, (8) increasing direct ticket sales, (9) encouraging employees to provide cost-control strategies, and (10) replacing old aircraft. Therefore, this study uncovered airlines operation cost-control strategies and ranked them in order to establish guidelines for international airlines on the distribution of operational resources. We expect that the total operating costs of airlines can be reduced significantly through the use of these cost control strategies.

Keywords: Airline; Operation cost control; Fuzzy Delphi; Analytical hierarchy process

1. INTRODUCTION

The airline industry is a service industry with a low level of profitability because it is labor, capital, and technology intensive. It is also affected by external environmental changes as well as internal operations. Among other things, jet fuel is a major component of commercial airlines' operational costs (Rao, 1999; Adams, 1997; Berrittella, La Franca, & Zito, 2009). Therefore, airline companies must always exercise cost control, especially after having experienced the extreme crude oil price increases and deadly financial crisis in 2008. According to International Air Transport Association (IATA) statistics, in 2008 the global airline industry's fuel bill in 2008 grew somewhere between \$31 and 165 billion USD, and lost about \$16.8 billion USD, which accounted for 31% of operating expenses at \$99USD/barrel Brent of oil. Thus, improving fuel-efficiency continues to top the agenda of the airline industry (IATA, 2008). Under this challenging economic environment, operation cost control is of the utmost importance to the airline industry.

Previous research has mainly focused on airline cost components from the perspective of top-down procedures and providing airline decision makers with resource allotment references (David et al., 1990; Berrittella, et al., 2009). In this study we look at empirical operational strategies from the viewpoints of both top-down and bottom-up procedures to fully understand airline operation cost control strategies practiced by an international full service airlines in Taiwan. Then, a further ranking on these strategies obtained from Taiwan airlines to not only provide procedure of empirical operation control but also provide references of pragmatic ways to operating cost control for airline industry.

For the purpose of controlling airline operating costs, this study first established policies for airline operation cost control. Then, criteria for meeting policy goals were identified, and strategies were developed under each criterion using the expert questionnaires that were used to construct the criteria and strategies. The Fuzzy Delphi method was utilized to confirm the appropriateness of the selected criteria and strategies and to further obtain the experts' cognizable consensus. Afterwards, the analytic hierarchy process (AHP) was used to produce the consistency ratio and the weights of each criteria and strategy, and then acquired the priority rankings of the airline operating cost control strategies.

2. AIRLINES OPERATING COST COMPONENT

This study utilized past research on airline cost accounting categories to construct cost control criteria and strategies. According to airlines operating cost categories and a Taiwan airlines' distribution of operating cost, this study identified five criteria for airlines operating cost control including fuel cost reduction policy, employee' productivity improvement, flight operations, aircraft maintenance cost reduction and operation procedure simplification. Each of the criteria was illustrated separately.

Holloway (2003) illustrated that the fuel cost was belonged to among variable direct operating costs (DOC) and he also pointed out that one of the fuel cost drivers was the age and the fuel efficiency of a particular carrier's fleet. Doganis (1991) addressed that the fuel consumption varied depending on the route to route course in relation to the sector length, aircraft weight, wind condition, cruise altitude. Berrittella et al. (2009) argued that the fuel cost relied on the weight and distance flown. According to above literature, this study

established two criteria named as the fuel cost reduction policy (C_1) and the flight operations (C_3).

O'Connor (2001) categorized the labor and fuel as the two biggest costs on operating an airline, Doganis (1991) classified the labor and fuel costs as direct operation costs where the labor is the first major cost and the fuel is the second major one. O'Connor (2001) pointed out that airlines' labor unions dominated the labor cost where the three major unions, pilots, flight attendants and mechanics can greatly influence the aircraft costs. In this study, the salaries of the flight crew, cabin crew and maintenance employees were considered as the three major operating labor costs. In order to reduce over working hours of the flight crew, cabin crew and maintenance employees, this study developed the criterion of employee' productivity improvement (C_2).

O'Connor (2001) classified the maintenance burden (also called the indirect maintenance costs) into upkeep and repairing of flight equipment, administration of stockrooms and maintenance records keeping. The objective of maintenance management was to make aircrafts in an appropriate condition about when and where was required to support the scheduled performance and to implement cost efficiency (Holloway, 2003). Berritella et al. (2009) illustrated that the maintenance costs consisted of the machine equipment purchase costs, quality checking costs and hangar costs. Based on the components of maintenance costs, this study built the criterion of aircraft maintenance cost reduction (C_4).

O'Connor (2001) factored the passenger service cost into the cost of foods and cabin crew supply. He also argued that the commissions paid to travel agents were the reservations and sales costs. This study utilized a Taiwan international airline empirical practice and IATA cost control recommendations to establish the criterion of operation procedure simplification (C_5).

After determining the operating cost categories, we interviewed a Taiwan international airline company to recognize the actual distribution of operating cost in 2008, which included the fuel costs, depreciation, rentals, labor costs, airport charge and handling, sales and general administration, maintenance costs, passenger services, and insurance expenses as basis to establish the operating cost control criteria and strategies. In the distribution of the total cost, the fuel cost occupied more than 50% of the total operating cost, and so this study focused on line-operating field. The other financial items such as depreciation, rentals and insurance expenses were not considered in this paper. In addition, the external charges on a Taiwan airlines company such as airport charge, landing fees, air traffic control charges and airport security charges administrated by the government were also eliminated in this study.

Under each of the five criteria, there were several airlines operating cost control strategies developed via literature review, airlines empirical operations and the IATA cost control recommendations. These criteria and strategies are explained in details in the next section.

3. AIRLINES OPERATING COST CONTROL PRACTICE AND CONSTRUCTION

In this section five independent criteria and twenty-one strategies are developed via literature review, airlines empirical operations interviews, and IATA cost control recommendations. These five criteria are : (1) fuel cost reduction policy (C_1), (2) employee' productivity improvement (C_2), (3) flight operations (C_3), (4) aircraft maintenance cost reduction (C_4), and (5) operation procedure simplification (C_5). Furthermore, the twenty-one strategies developed under the appropriate criteria are elaborated in the following sub-sections. The construction of criteria and strategies is presented in Table 1.

3.1 Fuel Cost Reduction Policy (C_1)

Fuel cost reduction is a major operation in the airline industry. There are many different strategies to choose from. With regard to this policy, the following items were selected. Four strategies constitute this policy including: optimizing fleet dispatch (C_{11}), reducing the dead weight of aircraft (C_{12}), improving aircraft fuel saving performance (C_{13}), and conducting fuel hedging strategies (C_{14}). In order to optimize the fleet dispatch (C_{11}), airline companies monitor aircraft performance methods (APM) (Haacker, 2006) and dispatch different types of aircrafts to execute long haul and short haul flights (Martin & Roman, 2008). Because of high fuel prices airlines focus on reducing the dead weight of aircraft (C_{12}) and reducing fuel costs (Pegrum & Kennell, 2002). Methods include: controlling aircraft dead weight via relevant improvement of fueling quantity accuracy, adjusting water supply to flight time, reducing the number of newspapers and magazines on flights, using lighter material for utensils and catering carts, removing front seats footrests, etc. Airlines also try to improve aircraft fuel saving performance (C_{13}) so as to reduce fuel costs using methods such as cleaning engines and the fuselage on a regular basis. This strategy can not only can reduce fuel consumption, but also improve aircraft performance by reducing flight drag. One other cost reduction policy is financial operation, which are conducting fuel hedging strategies (C_{14}) due to uncertainty caused by extreme oil price volatility, airlines usually "lock-in" the fuel cost in order to lower future fuel cost losses (Rao, 1999; Morrell & Swan, 2006).

3.2 Employee' Productivity Improvement (C_2)

Reducing airline labor costs and increasing employee productivity are like two sides of the same coin (Martin & Roman, 2008). The four constructed strategies include: scheduling reasonable flight hours for flight crew (C_{21}), reducing cabin crew over-time (C_{22}), dispatching maintenance staff efficiently during direct working hours (C_{23}), and encouraging employees to provide cost-control strategies (C_{24}).

Reducing airlines labor costs and increasing employees' productivity are like two sides of the same coin (Martin & Roman, 2008). In airlines industry, the flight crew costs were always

higher than those of other employee, so airlines try to monitor working hours and to schedule reasonable flight hours for flight crew (C_{21}) in order to avoid over-time flight hour payments (Alamdari & Morrell, 1997; Tekiner, Birbil, & Bulbul, 2009). Airlines also try to reduce cabin crew over-time working hours (C_{22}) by keeping cabin crew's total flight hours reasonable (Alamdari & Morrell, 1997), and by dispatching cabin crew efficiently and effectively assigning pursers to a fixed duty. In order to reduce maintenance labor costs airlines dispatched maintenance staff efficiently during direct working hours (C_{23}), monitor over-time working hours, and allocate manpower in accordance with the maintenance schedule to enable tasks to be accomplished within a reasonable time frame by avoiding excessive overtime pay (Candell, Karim, & Soderholm, 2009). In order to maneuver practical online-operations, airlines encourage employees to provide cost-control strategies (C_{24}) via a suggestion system (Rapp & Eklund, 2007).

3.3 Flight Operations (C_3)

Airlines always utilize flight operations techniques to reduce the fuel consumption and costs, several pertinent strategies are discussed below. Five strategies were extracted from this criterion. Airlines correct en route flight plans and alternate airports (C_{31}) via reviewing and modifying flight plan routes and alternate airports (Abdelghany, Abdelghany & Raina, 2005; Haacker, 2006) as well as departure/arrival routes and procedures to adjust for different contingencies and taxi fuel to minimize fuel consumption. Flight crew try to optimize flight speeds and to use the efficient cost index (C_{32}) by calculating time-related parameters and fuel costs accurately to establish optimal speeds for each flight segment (Abdelghany, et al., 2005; Haacker, 2006). Flight crew also try to optimize the aircraft landing procedures (C_{33}) by using minimum flap and idle reverse thrust landing procedures to reduce fuel consumption during the landing stage (Haacker, 2006). During ramp operations flight crew utilize ground power units (GPU) instead of auxiliary power units (APU) (Haacker, 2006) to reduce the fuel consumption in ground operations (C_{34}). Airlines not only pay attention to fuel saving operations but also to safety operations, thus, they announce fuel saving policies and procedures to carry out safety audits (C_{35}) by applying aviation safety management techniques and facilities such as flight operational quality assurance (FOQA) to improve flight safety and to reduce insurance costs (Lin & Chang, 2008) .

3.4 Aircraft Maintenance Cost Reduction (C_4)

The integration of maintenance management systems can provide advantages in establishing maintenance cost control strategies. Airlines replace old aircrafts (C_{41}) for the purpose of reducing maintenance costs and preserving fleets' high performance, reducing fuel consumption and improving the company's public image (Abdelghany, et al., 2005). In order to optimize the maintenance scheduling (C_{42}), airlines monitor the life cycle of parts to prevent unexpected malfunctions and breakdowns (Candell, et al., 2009). Airlines also

establish maintenance resources sharing networks (C_{43}) between airlines such as hangars, maintenance materials sharing (Candell, et al., 2009), and also conduct allied material purchases for the same-type of aircrafts, thus lowering inventory and maintenance costs. Airlines establish effective parts supply chain (C_{44}) via e-Maintenance to utilize manufacturer supply chains and networks as purchase channels, which enable airlines to track orders efficiently and to reduce spare parts inventory costs (Candell, et al., 2009).

3.5 Operation Procedure Simplification (C_5)

In order to reduce airline service costs, airlines usually refer to the IATA Simplifying the Business program (StB) and the practice simplifying service procedures. Airlines attempt to sell the e-tickets directly (C_{51}) via airlines web-sites to avoid agent or delegate commission expenditures (Shon, Chen, & Chang, 2003) in order to increase direct sales of airlines tickets. Airlines promote bar code boarding passes and/or adapt the heat induction paper for bar code boarding passes (C_{52}) which have lower cost than magnetic bar stripe boarding passes (IATA, 2008). In order to reduce system-related reservations costs (C_{53}), airlines try to reduce induced expenditures of multiple, invented and waiting reservations by improving reservation procedure (Law and Leung, 2000; Yoon, Yoon, & Yang, 2006). In cabin service procedure, airlines want to shorten the taxi-out times (C_{54}) and to simplify before take-off cabin procedure, for instance, to simplify passenger address (PA) announcement by limiting the number of different broadcasting languages or dialects.

The complete structure of criteria and strategies specified is summarized in Table 1.

Table1– The Evaluation Criteria and Strategies for Airlines Cost Control Analysis

Criteria	Strategies
C_1 : Fuel cost reduction policy	C_{11} : Optimizing aircraft fleet dispatch
	C_{12} : Reducing dead weight of an aircraft
	C_{13} : Improving aircraft fuel saving performances
	C_{14} : Conducting fuel hedging strategies
C_2 : Employee' productivity improvement	C_{21} : Scheduling reasonable flight hours for flight crew
	C_{22} : Reducing cabin crew over-time working hours
	C_{23} : Dispatching maintenance staff efficiently during direct working hours
	C_{24} : Encouraging employees to provide cost-control strategies

Criteria	Strategies
C_3 : Flight operations	C_{31} : Correcting en route flight plans and alternate airports
	C_{32} : Optimizing flight speeds using the efficient cost index
	C_{33} : Optimizing aircraft landing procedures
	C_{34} : Reducing fuel consumption in ground operations
	C_{35} : Announcing fuel saving policies and procedures, and carrying out safety audits
C_4 : Aircraft maintenance cost reduction	C_{41} : Replacing old aircraft
	C_{42} : Optimizing maintenance scheduling
	C_{43} : Establishing maintenance resources sharing networks
	C_{44} : Establishing effective parts supply chain
C_5 : Operation procedure simplification	C_{51} : Increasing direct ticket sales
	C_{52} : Promoting bar code boarding passes
	C_{53} : Reducing system-related reservations costs
	C_{54} : Shortening taxi-out times

In addition, the Taiwan airlines allocated the operation costs depending on the frequency distribution of the past operating costs. In other words, they established the operation cost control policies via the past operating experiences (these being from top-down) and line-operating cost control practices fed back from employees (these being from bottom-up). After interviewing airlines experts, this study collected the experiences of Taiwan international airlines operation cost control practice which was implemented by both top-down and bottom-up activities as shown in Figure.1. The pattern in Figure.1 is established by two groups: the top-down group consists of chief executive officers (CEO) and general managers, and the bottom-up group contains line-operating employee such as flight crew. By this manner, on one hand, we had developed five top-down policies as independent criteria as described in Section 3. On the other hand, the bottom-up strategies were developed according to feedback from line-operation employees such as: encouraging employees to provide cost-control strategies (C_{24}), correcting en route flight plans and alternate airports (C_{31}), optimizing flight speeds using efficient cost index (C_{32}), optimizing the aircraft landing procedures (C_{33}), reducing the fuel consumptions in ground operations (C_{34}) and shortening the taxi-out times (C_{54}). Among these bottom-up operating cost control strategies, the strategy (C_{24}) was fed back by all employees, and all other strategies were implemented by flight crew.

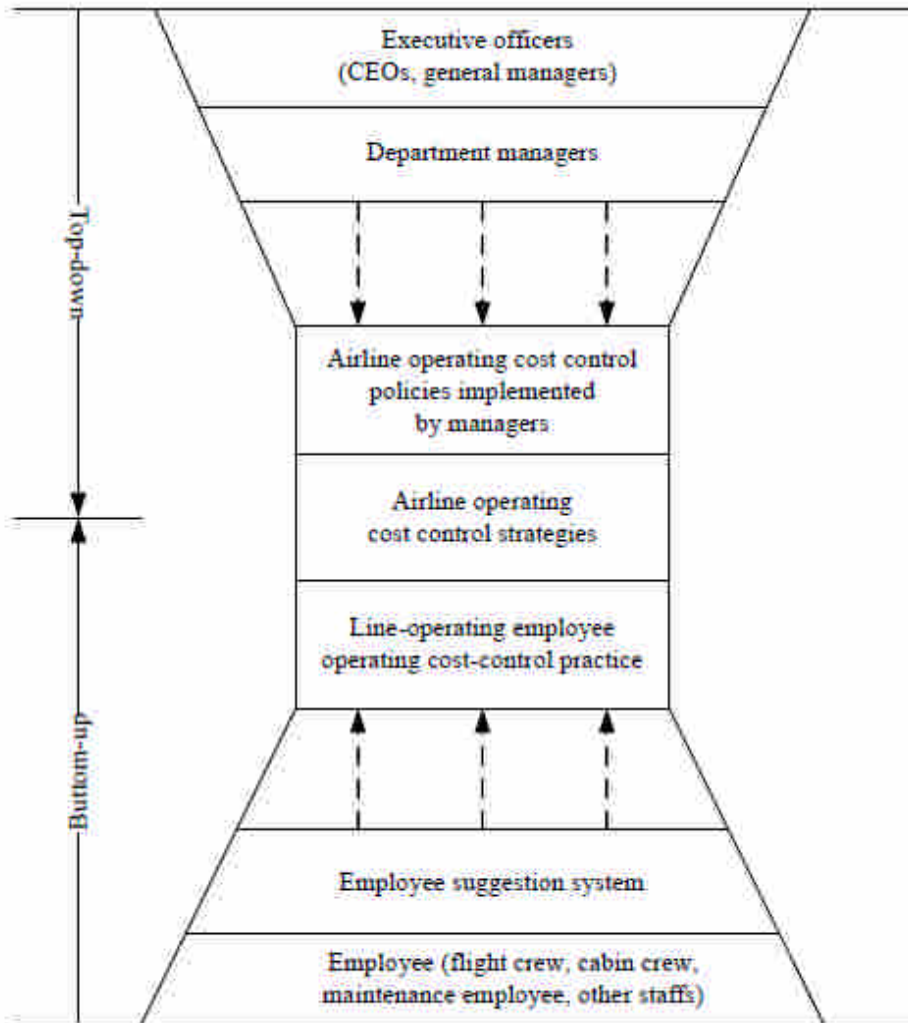


Figure 1–The development of Taiwan international airline operating cost control strategies

4. METHODOLOGY

This study first utilized the fuzzy Delphi method to evaluate the airlines operations cost control criteria and strategies, then used the Analytical Hierarchy Process (AHP) to rank the priority of the cost control criteria and strategies. The evaluation procedures and the methods used consisted of several steps as described in following process. First of all, the criteria and strategies of airlines operation cost control were extracted from the literature review, International Air Transportation Association (IATA) Simplifying the Business (StB) program and airlines' empirical options for operation cost control aspects. Secondly, airline industry experts were invited to evaluate the importance of all criteria and strategies using the fuzzy Delphi method. After the criteria and strategies were established, the airline cost control hierarchy was constructed. Thirdly, the Analytic Hierarchy Process (AHP) was employed to estimate the weights of all criteria and strategies. Finally, all criteria and strategies for airline

cost control were ranked by using the responses obtained from the expert questionnaires. Detailed descriptions of each step are illustrated in the following sub-sections.

4.1 Selecting Experts and Determining Criteria and Strategies

For the purpose of identifying airlines cost control elements, the first step was choosing the executive managers of airlines, principal inspectors from the Civil Aviation Administration (CAA), and scholars in Taiwan to determine the criteria and strategies. All of the experts had at least ten years of working experience in the aviation industry and held high-level management positions at airlines. According to previous research, a sample of size ten to fifteen participants would provide a homogeneous group (Hwang & Lin, 1987). Thus, in this study ten questionnaires were sent out to the experts in Taiwan, and ten questionnaires were returned with sufficient responses. The procedure used to determine the criteria and strategies was described as follows:

Airline cost control criteria and strategies were selected from the literature review. The literature review included research papers, IATA simplifying business programs, and airlines critical operations. With the defined goal of airlines operational cost control, five independent criteria and twenty-one strategies under appropriate criteria were selected as the evaluation elements. They are summarized in Table 1. Questionnaire were designed based on a 10-point fuzzy linguistic scale ranging from “very unimportant” (with a score of 1) to “unimportant” (with a score of 3) to “no comment” (with a score of 5) to “somewhat important” (with a score of 7) to “important” (with a score of 9) to “very important” (with a score of 10), and even scores 2,4,6,8 as intermediate values between adjacent scale values. For each element (a criterion or strategy) an expert was asked to rank its importance using the interval scale from 1 to 10 to express their most conservative, most likely and most optimistic judgment on the element, respectively. These importance scores provided by experts were analyzed using the fuzzy Delphi method.

4.2 Application of Fuzzy Delphi Method

The Delphi Method was proposed by Dalkey (1963) and Helmer (1966) to express experts' opinions systematically and to acquire the common consensus from experts and looking for a consistent judgment. Hence, the Delphi method determines the criteria by measuring the mean by the experts' judging responses. Since expert judgments may probably be affected by extreme values, Ishikawa et al. (1993) utilized the concepts of cumulative frequency distribution and fuzzy integral to integrate the expert opinions and their outcomes to produce sets of fuzzy numbers. This is now called the fuzzy Delphi Method and it has been applied in the prediction of time series. Hsu and Yang (2000) applied the geometric mean to determine the criteria for expert judgment. In order to avoid the extreme values affecting the results of expert opinions, they used the minimum and maximum value of experts' scores as triangular end values and used the geometric mean as the center of the triangular membership function, and made use of the experts' opinions appropriately. Chang, J. H. et al. (2001) employed the gray interval to examine the convergent cognition of all experts, and utilized the possible

range of the minimum and maximum values to make the results reasonable. The fuzzy Delphi method is described below.

Step1. Developing all possible elements (criteria or strategies) denoted by E_i 's. Collect all possible elements that may be related to operation cost control in airline industry and let it be denoted by $E=\{E_i, i=1,2, \dots, n\}$ After the targeted criteria and strategies have been collected using the by Ishikawa et al.'s (1993) process, we establish a fuzzy triangular function for an individual element (criterion or strategy).

Step 2. Collecting the observable score of each element (E_i) from each expert. Let $A_i = \{(C_{ik}, S_{ik}, O_{ik})\}$ be the set of scores obtained from k experts regarding element i , where C_{ik} is the lowest score of the k th expert who evaluated the i th element referred to as "the most conservative cognition value", S_{ik} is the moderate value referred to as "the most likely cognition value", and O_{ik} is the highest score referred to as "the most optimistic cognition value"; C_{ik} , S_{ik} and O_{ik} have scores within the linguistic interval-scaled value of (1, 2, ..., 10) that the experts had assigned to element i (strategy i or criterion i) about its importance. Thus, the most conservative score is the smallest cognition value of the quantitative score, the most likely score is the subjective cognition value of the quantitative score and the most optimistic score is the most optimistic cognition value of the quantitative score about its importance for element i .

Step 3. Eliminating the extreme values of C_{ik} , S_{ik} and O_{ik} for each element. For each element, calculate all "the most conservative cognition values, C_{ik} ", "the most likely cognition values, S_{ik} ", and "the most optimistic cognition values, O_{ik} " for all elements, and then eliminate those values beyond two standard deviations from the mean of the scores given by experts with respect to each element.

Step 4. Establishing the triangular fuzzy functions. After eliminating the extreme values, let $C^i = (C_L^i, C_M^i, C_U^i)$ represent the most conservative vector, where C_L^i, C_M^i, C_U^i stand for the smallest, the geometric mean, and the largest value, respectively, of the most conservative scores for element i among k experts, and similarly, let $B^i = (B_L^i, B_M^i, B_U^i)$ stand for the smallest, the geometric mean and the largest value, respectively, of the most optimistic scores with respect to the same strategy (see Figure. 2). In order to cognize the consensus of all experts assume that there are two triangular fuzzy functions over (C_L^i, C_M^i, C_U^i) and (B_L^i, B_M^i, B_U^i) , respectively, for strategy i . The overlapping area of the two triangular fuzzy functions is called the gray area (Figure 2).

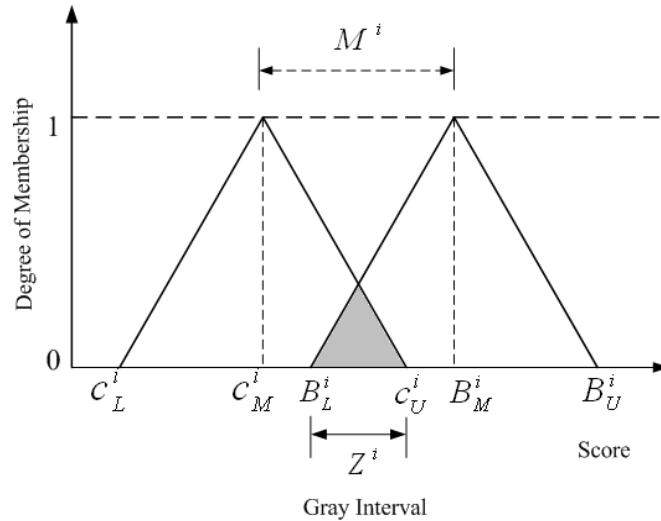


Figure 2 – Triangular fuzzy numbers and gray triangular area

Step 5. Denote the length of the line interval (B_L^i, C_U^i) on the horizontal axis by Z^i , as shown at the bottom of Fig. 2, and the length of the line segment (C_M^i, B_M^i) by M^i as shown at the top.

(1) If there is no overlap between two triangular fuzzy functions, i.e., $C_U^i \leq B_L^i$, then no gray area of vague relationship exists, this indicates that the experts' cognitions are consensus for the element i , and hence the consensus among experts for element i has been reached. The value of the consensus is calculated as $G^i = (C_M^i + B_M^i) / 2$.

(2) If there is overlap between the two triangular fuzzy functions, i.e., $C_U^i > B_L^i$ and the gray area exists. Then:

(a) If $Z^i < M^i$, then G^i is calculated using the following equations

$$F^i(x_j) = \int_x \{\min[C^i(x_j), B^i(x_j)]\} dx, \quad i \in E,$$

$$G^i = \{x_j \mid \max \mu_{F^i}(x_j)\}, \quad i \in E,$$

(b) If $Z^i > M^i$, then there are differences between the experts' opinions.

This means that there are serious discrepancies among experts' cognitions about strategy i , so, we have to send out a second round of questionnaires to the same experts for additional advices and suggestions, and then repeat Steps 2 to 5. Relevant works about the gray area test procedure can be found in Ishikawa, et al. (1993) and Hsiao (2006).

The G^i -value for element i is generally compared with a threshold value S for an element importance. The threshold value S is a subjective choice by decision makers, but it is usually chosen to be 80% of the average of all geometric means S_M^i of "the most likely scores over all elements" as suggested by the Pareto Principle rule (Kuo & Chen, 2008).

According to certain research objectives, the decision makers can make an appropriate decision depending on the following decision rule:

- a. if $G^i > S$, then a consensus about importance of element i has been reached, and
- b. if $G^i < S$, then a consensus about importance of element i has been not reached.

We can compare the G^i -value with the threshold value S to determine the number of elements of importance under consideration. If there are too many elements, one may raise the threshold value; otherwise, one may decrease the threshold value.

Based on the opinions of ten experts who filled in the questionnaires, all grey area tests based on the difference $M^i - Z^i$ were greater than zero, thus one concluded that experts' cognitions were converged for all criteria and strategies. On the other hand, according to the Pareto Principle, the 80 percent rule generates a threshold value of $S = 5.48344$ that was surpassed by all G^i values which indicated that the experts had reached a consensus of importance over all criteria and strategies. Therefore, by gray area tests and the threshold value, all five criteria and twenty-one strategies were identified as reasonably and appropriately important elements.

4.3 Application of Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) (Saaty, 1980) is a theory of measurement for decision making and complex decision problem solving. It is also a ratio scale to deal with the inconsistency in judgment and in setting priority by group decision makers (Saaty, 1990). AHP procedure can assist one to decompose a complex problem with a multi-level hierarchy structure consisting of objective, criteria, sub-criteria and alternatives (Saaty, 1990). This study applied the Analytic Hierarchy Process (AHP) to evaluate the consistency of criteria and strategies made by experts, to estimate the weights and to find the rankings for these criteria and strategies in airlines operations cost control.

At the beginning, this study built the hierarchy structure according to relevant literature, theories, experience and group brainstorming. The goal of study had been identified, and then selected appropriate criteria and strategies under the goal. Secondly, we employed the steps of constructing a pair-wise comparison matrix as described by Yoo and Choi (2006) to evaluate the relative importance for each element (strategy or criterion), where the Saaty's pair-wise comparison rating scale (Satty, 1977) 1–9 ratio scale was used to compare two elements for expressing the strength of their relative importance, e.g., 1 = equally important, 3 = moderately more important, 5 = strongly more important, 7 = very strongly more important, and 9 = extremely more important. After the matrix of pair-wise comparisons among elements was constructed for each level, the largest eigenvalue of the matrix was calculated.

Secondly, this study continued to measure the inconsistency of the matrix and to calculate the weights of elements. A measure of inconsistency using the largest eigenvalue to create the consistency ratio (CR) suggested by Satty (1980) was calculated. A CR value of less than 0.10 can lead to an acceptable consistency of relative importance among elements judged by decision makers. Finally, the ranking of the criteria and strategies according to their weights produced by relative importance of pair-wire comparison matrix (Saaty, 1993) were calculated and the results were given in Tables 2 and 3.

5. RESULTS

An empirical study of a Taiwan full service international airline is presented and all criteria and strategies formulated passed the standard of the fuzzy Delphi procedure and AHP method. Using the software of Expert Choice 2000 Enterprise 10.1, the weights of the relative importance for criteria and strategies were calculated and were ranked accordingly as shown in Table 2. The rank of the proportional weights among the five criteria were as follows: first was the “Fuel cost reduction policy C_1 ”, second was “Flight operations C_2 ”, third was “Employee’ productivity improvement C_3 ”, and fourth was both “Aircraft maintenance cost reduction C_4 ” and “Operation procedure simplification C_5 ” (C_4 and C_5 have the same rank). The proportional weights of strategies for each criterion are also shown as Table. 3. The top one ranked strategy under the criterion of “fuel cost reduction policy C_1 ” was “Optimizing aircraft fleet dispatch C_{11} ”; the first ranked strategy under the criterion “Employee’ productivity improvement C_2 ” was “Scheduling reasonable flight hours for flight crew C_{21} ”; the primary ranked strategy under the criterion “Flight operations C_3 ” was “Optimizing flight speeds using the efficient cost index C_{32} ”; the number one ranked strategy under the criterion “Aircraft maintenance cost reduction C_4 ” was “ replacing old aircraft C_{41} ”; and the most important strategy under the criterion “Operation procedure simplification C_5 ” was “ Increasing direct ticket sales C_{51} ”.

At the end of AHP procedure, the final weights of the strategies were calculated by the products of each criterion and its lower level strategy. The strategies ranked by weight of relative importance are shown as Table 3. The top ten strategies among all criteria, as shown in Table 3, they are: (1) optimizing aircraft fleet dispatch, (2) conducting fuel hedging strategies, (3) improving aircraft fuel saving performances, (4) reducing dead weight of aircraft, (5) optimizing flight speeds using an efficient cost index, (6) scheduling reasonable flight hours for flight crew,(7) correcting en route flight plans and alternate airports, (8) increasing direct ticket sales, (9) encouraging employees to provide cost-control strategies, and (10) replacing old aircraft. The most important criterion in Table 2 is “Fuel cost reduction policy”. The top four strategies in Table 3 are all under the criterion of the “fuel cost reduction policy”.

Operation Cost Control Strategies for Airlines
Yu-Hern Chang and Pei-Chi Shao

Table 2 –Weights of Relative Importance for Criteria and Strategies

Criteria	Weights of criteria (Rank)	Strategies	Weights of each strategies*	Rank
C_1 : Fuel cost reduction policy	0.418 (1)	C_{11} : Optimizing aircraft fleet dispatch	0.337	1
		C_{14} : Conducting fuel hedging strategies	0.264	2
		C_{13} : Improving aircraft fuel saving performances	0.233	3
		C_{12} : Reducing dead weight of an aircraft	0.116	4
C_2 : Employee' productivity improvement	0.147 (3)	C_{21} : Scheduling reasonable flight hours for flight crew	0.367	1
		C_{24} : Encouraging employees to provide cost-control strategies	0.269	2
		C_{22} : Reducing cabin crew over-time working hours	0.191	3
		C_{23} : Dispatching maintenance staff efficiently during direct working hours	0.174	4
C_3 :Flight operations	0.197 (2)	C_{32} : Optimizing flight speeds using the efficient cost index	0.275	1
		C_{31} : Correcting en route flight plans and alternate airports	0.271	2
		C_{34} : Reducing fuel consumption in ground operations	0.157	3
		C_{33} : Optimizing aircraft landing procedures	0.149	4
		C_{35} : Announcing fuel saving policies and procedures, and carrying out safety audits	0.147	5
C_4 :Aircraft maintenance cost reduction	0.119 (4)	C_{41} : Replacing old aircraft	0.321	1
		C_{42} : Optimizing maintenance scheduling	0.249	2
		C_{43} : Establishing maintenance resources sharing network	0.219	3
		C_{44} : Establishing effective parts supply chain	0.212	4

Criteria	Weights of criteria (Rank)	Strategies	Weights of each strategies*	Rank
C_5 : Operation procedure simplification	0.119 (4)	C_{51} : Increasing direct ticket sales	0.355	1
		C_{53} : Reducing system-related reservations costs	0.262	2
		C_{54} : Shortening taxi-out times	0.245	3
		C_{52} : Promoting bar code boarding passes	0.138	4

*Numbers show proportional weights of criteria and strategies. Total of each category on each level = 1.

6. DISCUSSION AND IMPLICATIONS

According to the results, the most important operating control criterion is the “fuel cost reduction policy”, followed by the “flight operations”. The number one strategies, optimizing aircraft fleet dispatch, and the number ten strategy, replacing old aircraft, reflect the Taiwan airline’s fleet development planning program. The Taiwan airline utilize fourteen new A350 aircrafts for middle-long haul flights and are going to eliminate six A340-300 aircrafts and six A330-300 aircrafts after 2015. After a severe crude oil price increase and the deadly financial crisis of 2008, The Taiwan airline stored idle cargo planes and these planes will be put back into service once the economy recovers. Therefore, for the short run, airlines tried to maintain high performance on aircraft by monitoring fuel consumption during each flight, and for the long run, programs of replacing old aircraft require a long term strategic plan.

The most significant finding was the criterion of fuel cost reduction policy, in which conducting fuel hedging strategy is the second ranking strategy. This reveals that the Taiwan airlines have paid more attention to fuel hedging options since the severe crude oil price increase in 2008, and shows that Taiwan airlines are easily harmed by external factors. In other words, the airlines fuel hedging strategy is a variable which depends on the operating policies and external environment.

In the flight operational field, the Taiwan airlines focus on the fifth ranked strategy, optimizing flight speeds using the efficient cost index, and the seventh ranked strategy, correcting en route flight plans and alternate airports. This means that fuel consumption pressure makes airlines rearrange flight operations and route plans. By doing this, and using a flight cost index, the Taiwan airlines can save nine million USD per year.

In employee’ improvement field, the criteria of “employee’ productivity improvement”, which is the third ranking among five criteria, indicates Taiwan airline’s emphasis on the labor cost of the flight crews and it applies to the strategy “scheduling reasonable flight hours for flight crews” which is the sixth ranking among all strategies. The result also responds to the Taiwan airline practical implementation on aircraft A340 flight crew flight hours monitoring which has an annual financial benefit of twenty one thousand USD per year. The Taiwan airlines tried to reduce employee over-time working hours especially aiming at the high labor cost employees, such as flight crew, cabin crew and maintenance employees.

Operation Cost Control Strategies for Airlines
Yu-Hern Chang and Pei-Chi Shao

As mentioned earlier, this study attempts to utilize the viewpoint of both top-down and bottom-up procedures to recognize airlines' empirical operational strategies. Most of the top ten strategies are airline policies, which are strategies with top-down viewpoint, and three strategies for line operations processes, which are bottom-up procedures, which include the fifth ranked strategy, optimizing flight speeds using an efficient cost index, the seventh ranked element, correcting en route flight plans and alternate airports, and the ninth ranked element, encouraging employees to provide cost-control strategies. This shows that airlines need suggestions from line-operation staffs to pursue empirical operating cost control. Airlines can build their own database from employee suggestion system which can help employees discover their potential in line-operation problems.

Table 3 – Final Ranking of All Strategies under All Criteria

Rank	Airlines cost control strategies	Ranking weights
1	C_{11} : Optimizing aircraft fleet dispatch	0.140866
2	C_{14} : Conducting fuel hedging strategies	0.110352
3	C_{13} : Improving aircraft fuel saving performances	0.097394
4	C_{12} : Reducing dead weight of an aircraft	0.069388
5	C_{32} : Optimizing flight speeds using the efficient cost index	0.054175
6	C_{21} : Scheduling reasonable flight hours for flight crew	0.053949
7	C_{31} : Correcting en route flight plans and alternate airports	0.053387
8	C_{51} : Increasing direct ticket sales	0.042245
9	C_{24} : Encouraging employees to provide cost-control strategies	0.039543
10	C_{41} : Replacing old aircraft	0.038199
11	C_{53} : Reducing system-related reservations costs	0.031178
12	C_{34} : Reducing fuel consumption in ground operations	0.030929
13	C_{42} : Optimizing maintenance scheduling	0.029631
14	C_{33} : Optimizing aircraft landing procedures	0.029353
15	C_{54} : Shortening taxi-out times	0.029155
16	C_{35} : Announcing fuel saving policies and procedures, and carrying out safety audits	0.028959
17	C_{22} : Reducing cabin crew over-time working hours	0.028077
18	C_{43} : Establishing maintenance resources sharing network	0.026061
19	C_{23} : Dispatching maintenance staff efficiently during direct working hours	0.025578
20	C_{44} : Establishing effective parts supply chain	0.025228
21	C_{52} : Promoting bar code boarding passes	0.016422

On the other hand, in order to reduce service costs, airlines develop websites and direct channels to sell the tickets. This study found the eighth most important ranked strategy to be increasing direct sales of airlines tickets. The Taiwan airlines earned six million USD per year from direct ticket sales in 2007. The result reflects airline's endeavor to reduce commissions of travel agencies and also to change the reservation service procedures using internet reservation processes.

7. CONCLUSIONS

This study attempts to explore Taiwan international full service airlines' operation cost control strategies. First, based on the results of the questionnaires given to ten experts in the Taiwan airline industry, relatively important criteria and strategies were identified using the fuzzy Delphi method from which the experts' cognizable consensus was extracted using convergence. Next, the analytic hierarchy process was employed to confirm the consistency of the experts' opinions via pair-wise judgment of the criteria and strategies, respectively. Finally, the selected criteria and strategies were ranked according to their relative weights.

Previous research on airline operating cost categories and operating cost control was reviewed. It was found that there were few studies focusing on airlines' operating cost control strategies from the view of both top-down policies and bottom-up line-operations. After a severe crude oil price increase and deadly financial crisis in 2008, this study found a tendency for airlines to implement operating cost control strategies using both top-down and bottom-up procedures as discussed in Section 3. The results provide airlines with the most important strategies for reducing the operating costs in a harsh economic environment and may help airlines ensure the operational cost control strategies and empirical practices in the short term. In addition, this study also points out the fact that the line operation staffs do have the opportunity to provide appropriate suggestions and to participate in the process of airline operational cost control and they can react to the real environmental changes, not only from the inside, but also from the outside. Furthermore, airline operational cost control strategies derived in the study are both effective and useful. Therefore, the results are compatible with the relevant literature and empirical practice. Although the operational cost control strategies were developed by the Taiwan airlines, they are likely to be applicable and exportable to any other similar international airlines around the world.

8. REFERENCES

- Abdelghany, K., Abdelghany, A., & Raina, S. (2005). A model for the airlines' fuel management strategies. *Journal of Air Transport Management*, 11(4), 199-206.
- Adams, J., (1997). Airlines struggle with fuel price turbulence. *Corporate Finance* 147, 25-26.
- Alamdari, F.E., & Morrell, P., (1997). Airline labor cost reduction: post-liberalisation experience in the USA and Europe. *Journal of Air Transport Management*, 3(2) 53-66.
- Berritella, M., La Franca, L., & Zito, P. (2009). An analytic hierarchy process for ranking operating costs of low cost and full service airlines. *Journal of Air Transport Management*, 15(5), 249-255.
- Bodin, L. & Gass, S.I., (2003). On teaching the analytic hierarchy process. *Computers and Operations Research*, 30, 1487-1497.
- Cheng, J. H., Chen, C.W., Lee, C.Y. (2006). Using fuzzy analytic hierarchy process for multi-criteria evaluation model of high-yield bonds investment. *IEEE International Conference on Fuzzy Systems*, Institute of Electrical and Electronics Engineers Vancouver, Inc., BC, Canada, 1045-1056.
- Candell, O., Karim, R., & Soderholm, P. (2009). eMaintenance-Information logistics for maintenance support. *Robotics and Computer-Integrated Manufacturing*, 25(6), 937-944.
- Dalkey, N. & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts, *Management Science*, 9(3) 458.
- David, W. G., Tae, H. O. & Michael W. T., (1990). Airline Cost Structure and Policy Implications: A Multi-Product Approach for Canadian Airlines. *Journal of Transport Economics and Policy*, 24(1), 9-34.
- Doganis, R., (1991). *Flying off Course*, second edition, New York, Routledge.
- Expert Choice 2000. Pittsburgh: Expert Choice, Inc., 2000.
- Haacker, J., (2006) IATA Fuel Efficiency Campaign. ICAO, Transportation Canada for fuel and emission reductions, Canada.
- Helmer, O. (1966). *The Delphi Method for Systematizing Judgments about the Future*, Institute of Government and Public Affairs, University of California.
- Holloway, S. (2003). *Straight and Level: Practical Airline Economics*. Ashgate, Aldershot.
- Hsiao, T.Y. (2006). Establish standards of standard costing with the application of convergent gray zone test. *European Journal of Operational Research*, 168, 593-611.
- Hsu, T. H., & Yang, T. H. (2000). Application of fuzzy analytic hierarchy process in the selection of advertising media. *Journal of Management and Systems*, 7(1) 19-39.
- Hwang, C.L. & Lin, M.J. (1987). *Group Decision Making under Multiple Criteria: Methods and Applications*. Springer-Verlag.
- International Air Transport Association (2008). *IATA 2008 Report on Alternative Fuel*. International Air Transport Association, Montreal.
- International Air Transport Association. (2008). *Simplifying the Business: Delivering Industry Change*. International Air Transport Association, Montreal.
- Ishikawa, A., 1993. The new fuzzy Delphi methods: economization of GDS (group decision support). In: *Proceedings of the 26th Annual Hawaii International Conference on System Sciences*, 255–264.

- Ishikawa, A., Amagasa, M., Shiga, T., Tomizawa, G., Tatsuta, R. & Mieno, H. (1993). The max–min Delphi method and fuzzy Delphi method via fuzzy integration. *Fuzzy Sets and Systems*, 55, 241-253.
- Law, R., Leung, R. (2000). A study of airlines' online reservation services on the Internet. *Journal of Travel Research* 39, 202-211.
- Lin, Y.H., & Chang, Y.H. (2008). Significant factors of aviation insurance and risk management strategy: An empirical study of Taiwanese airline carriers. *Risk Analysis*, 28(2), 453-461.
- Martin, J.C., & Roman, C. (2008). Airlines and their Focus on Cost Control and Productivity. *European Journal of Transport and Infrastructure Research*, 8(2), 117-136.
- Morrell, P., & Swan, W. (2006). Airline jet fuel hedging: Theory and practice. *Transport Reviews*, 26(6), 713-730.
- Kuo, Y.F., & Chen, P.C. (2008). Constructing performance appraisal indicators for mobility of the service industries using Fuzzy Delphi Method. *Expert Systems with Applications*, 35(4), 1930-1939.
- O'Connor, W.E. (2001). *An Introduction to Airline Economics*, 6th edition. New York, Praeger.
- Pegrum, M., & Kennell, C. (2002). Fuel efficiency comparison between high speed sealift ships and airlift aircraft. *Marine Technology and Sname News*, 39(2), 105-108.
- Rao, V.K. (1999). Fuel price risk management using futures. *Journal of Air Transport Management* 5, 39- 44.
- Rapp, C., & Eklund, J. (2007). Sustainable development of a suggestion system: Factors influencing improvement activities in a confectionary company. *Human Factors and Ergonomics in Manufacturing*, 17(1), 79-94.
- Saaty, T.L. (1977). A scaling method for priorities in hierarchical structures. *Journal of Mathematical Psychology*, 15, 234-281.
- Saaty, T.L. (1980). *The Analytic Hierarchy Process: Planning, Priority Setting and Resource Allocation*. McGraw-Hill, New York.
- Saaty, T.L. (1990). How to make a decision: the analytic hierarchy process. *European Journal of Operational Research*, 48, 9–26.
- Saaty, T.L. (1990). An exposition of the AHP in reply to thee paper: remarks on the analytic hierarchy process, *Management Science*, 36(3) 259-268.
- Shon, Z.Y., Chen, F.Y. & Chang, Y.H. (2003). Airline e-commerce: the revolution in ticketing channels. *Journal of Air Transport Management*, 9(5), 325-331.
- Tekiner, H., Birbil, S.I. & Bulbul, K. (2009). Robust crew pairing for managing extra flights. *Computers & Operations Research*, 36(6), 2031-2048.
- Yoo, K.E. & Choi, Y.C (2006). Analytic hierarchy process approach for identifying relative importance for factors to improve passenger security checks at airports. *Journal of Air Transport Management*, 12(3), 135-142.
- Yoon, M.G., Yoon, D.Y. & Yang, T.W. (2006). Impact of e-business on air travel markets: Distribution of airline tickets in Korea. *Journal of Air Transport Management*, 12(5), 253-260.