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Performance evaluation for airlines including the consideration of financial ratios

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Abstract

Most previous studies concerning airline performance evaluation focus merely on operational performance. Financial performance, however, which might directly influence the survival of an airline is usually ignored. The absence of financial ratios will directly lead to biased assessment. This paper tries to construct a performance evaluation process for airlines with financial ratios taken into consideration. First, a conceptual framework is redeveloped, based on the one created by Fielding et al. to help form performance indicators involving both transportation and finance aspects. Second, to overcome the problems of small sample size and unknown distribution of samples, the grey relation analysis is used to select the representative indicators and the TOPSIS method is used for the outranking of airlines. Third, the organizational characteristics of an airline are used to divide the total performance into three major departments of an airline: production, marketing, and management. The division of total performance is helpful for operators to recognize the performance of a department of an airline and to identify the responsibility of a department. Finally, a case study is conducted using the example of Taiwan's five major airlines. The empirical result shows that performance evaluation for airlines can be more comprehensive, if financial ratios are considered.

Keywords: Airline; Performance evaluation; Financial ratio; Grey relation analysis; TOPSIS

1. Introduction

Since the deregulation of air transportation in Taiwan in 1987 and the Asian financial crisis in 1997, the air transportation market has become so competitive that just operating an airline is a challenge. For example, the total number of domestic airlines has grown from 4 in 1987 to 17 in 1997 and the average passenger load factor decreased from 0.82 to 0.67, during which time most airlines encountered financial hardship and some were forced to be reshuffled or merged as a result. With such fierce competition in the air transportation market, a comprehensive performance evaluation model is essential for operators to recognize and critically diagnose their operating problems.

Most previous studies concerning airline performance evaluation focus merely on operational performance, while financial performance, which directly influences the survival of an airline, is almost entirely ignored. For example, current ratio and debt ratio, used to measure a company's short-term liquidation and long-term solvency, and return on assets, used to evaluate the productivity of assets, are crucial and fundamental for general business assessment, but seldom appear in the airline assessment process. The absence of financial ratios will directly lead to bias assessment results.

Fielding et al. (1978) and Fielding and Anderson (1984) developed a conceptual framework that is commonly used by Becker et al. (1981), Talley and Anderson (1981), Simpson and Curtin (1981), Miller (1984), Tanaboriboon et al. (1993), Cheng and Shiau (1994) etc, to produce a set of performance indicators. In his model, three elements of transit operations, namely: resource input (labour; capital; fuel, etc.), service output (vehicle-hour; vehicle-km; capacity-km, etc.), and service consumption (passenger trip; passenger-km; operating revenue, etc.) constitute the three corners of a triangle. The three sides of this triangle represent resource–efficiency (measuring service output against resource input), resource–effectiveness (measuring service consumed against resource input), and service–effectiveness (measuring service consumed against service output), respectively. However, using this model makes it difficult to recognize the role of finance in an

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airline or to identify the relation between transportation and finance.

The purpose of this paper is to construct a conceptual framework, based on the one created by Fielding et al. (1978), Fielding and Anderson (1984), to help form performance indicators involving both transportation and aspects of finance. Besides, this framework also provides a powerful method to divide the airline's total performance into three parts — production, marketing, and execution. This division is helpful for operators to recognize the performance of a department of an airline and to identify the responsibility of that department. Finally, the case study shows that performance evaluations of airlines can be more comprehensive if financial ratios are considered.

2. A conceptual framework

The objective of most private-owned enterprises is to maximize profits. Whether the activities of an enterprise are efficient or not has direct influence on profitability, thereby potentially threatening the survival of the enterprise. As shown in Fig. 1, the operation activities of an airline include three parts — factor input, product output, and consumer consumption. These also constitute the three stages of the operation cycle — production, marketing, and execution.

In a competitive market situation, the activities of an airline can be viewed as a consecutive and cyclic process, and the operators decide on the most suitable factor input (e.g. labor, fleet, assets, capital, etc.) for the current period, based on customer consumption during the previous period. At the same time, they pursue more product output (e.g. seat-km, total debts, interest expense, etc.) in the production stage under a given factor input. Likewise, they seek more consumer consumption (e.g. passenger-km, operation revenue, net income, etc.) in the marketing stage given the product price and factor cost. The final result of sales during this period can be used to calculate the remuneration of factor input for this period in the execution stage and to decide the amount of factor input for the next period.

According to this functional departmentation structure, the three stages of airline operation as shown

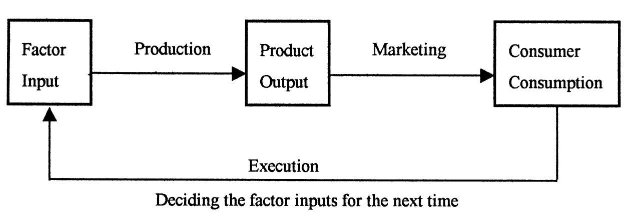

Fig. 1. Cycle of operation activities of an airline.

in Fig. 1 represent the three types of performance categories: production efficiency, marketing efficiency, and execution efficiency, respectively, corresponding to the departments of production, marketing, and management.

As Fig. 2 illustrates, the production efficiency of factor input and product output measures the resources expended to produce output (e.g. labor productivity, short-term liquidation, and long-term solvency). It can be represented as the efficiency of production-related departments, such as the manufacturing department. The marketing efficiency of product output and consumer consumption measures the extent to which output is used (e.g. flights marketing capability, seat marketing capability, and debts turnover). It can be represented as the efficiency of departments related to sales activities, such as the departments of sales and marketing. The execution efficiency of consumer consumption and factor input measures the output used against the resources expended (e.g. fleet execution capability, return of investment, and assets and stockholder's turnover). It can be represented as the efficiency of management-related departments, such as the departments of finance and management.

Financial statements, which constitute reports on managerial performance, attesting to managerial success or failure and flashing warning signals of impending difficulties, are the instrument panels of a business enterprise (Walter and Robert, 1988). But, in previous studies, there have been few discussions on the role of finance in the operation efficiency of an airline. In this paper, a set of performance indicators including financial ratios will be considered. Ratio analysis is an analytical technique of financial analysis. Financial analysis focuses on four main types of financial statements: the balance sheet, the income sheet, the statement of cash flows, and the statement of change in stockholders' equity. Generally, a financial ratio simply constitutes one item divided by another in the financial statement. This paper first makes a classification based on five accounting elements: assets, debts, owner's equity, revenue, and expense. Assets and the capital of the owner's equity are categorized as the input of financial factors, debts and expense as the output of the financial factors, and income/loss as the outcome of financial factors.

The factor input of an airline is characterized by sunk cost; while its output by intangible products, and its consumption by not-stored services. In view of the characteristics of sunk cost, flight equipment and interest expense are included in the financial factors to evaluate performance, in addition to the fundamental items of the classified financial statements. Besides, inventory is not included among the financial factors because of its intangible products and not-stored service characteristics. The evaluation items are as shown in the Appendix.

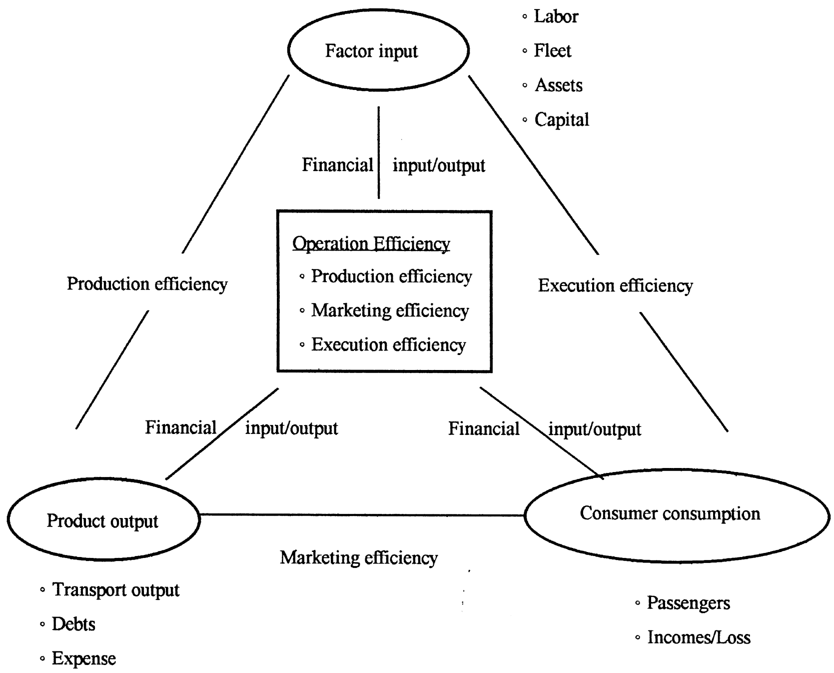

Fig. 2. A conceptual framework of the operation performance evaluation for the air industry.

3. Performance indicators set

Before producing the performance indicators set, two criteria were used for choosing the indicators. First, an evaluation indicator should have a preliminary explanatory meaning. For example, the ratio of debts per employee, the ratio of interest expense per passenger, and the ratio of passenger kilometers per current assets are not included in the set because they bear no relevant meaning. Second, if a priori knowledge can be employed to judge the high correlation among evaluation indicators, one of the indicators is chosen as the performance indicator. For example, for marketing efficiency, operation income/loss is closer to the operation of an airline than operation income/loss before tax and net income/loss, according to the accounting definition. Therefore, the ratios of operation income/loss in relation to flights, operation kilometers, number of seats, and seat kilometers were chosen as the performance indicators.

Based on the above two selection criteria and the ratios of both evaluation items in the Appendix, the set of indicators contains 63 evaluation indicators, which are classified into three main categories: production, marketing, and execution. Among them, 22 evaluation indicators in the production category, are re-categorized into six groups, including labor productivity, fleet productivity, flight equipment productivity, assets productivity, short-term liquidation, and long-term solvency, as shown in Table 1. Twenty-one indicators in the marketing category, are re-categorized into five groups, including flights marketing capability, operation kilometers marketing capability, seat marketing capability, profitability, and debts turnover, while 20 evaluation indicators in the execution category are re-categorized into four groups, including labour execution capability, fleet execution capability, return of investment, and assets and stockholder's turnover, as shown in Tables 2 and 3, respectively.

4. Grey relation analysis and TOPSIS method

If all performance indicators in the set are placed into the evaluation process, data collection would be more difficult and resources would be wasted. The purpose of this section is to reduce the number of indicators by selecting representative indicators from among them. In general, the representative indicators can be selected by grouping, which minimizes the differences within a certain group, and maximizes the differences between those groups. If the samples are large enough and normally distributed, some statistical or econometrical methods such as factor analysis, cluster analysis, and discriminate analysis can be used to decide the representative indicators. However, if the sample size is small and distribution of samples is unknown, the grey relation analysis should be used to select the representative indicators. Moreover, the TOPSIS method will be used in conjunction to calculate performance scores and outranking.

Table 1
Performance indicators set in production

Classification	Code	Indicator	Evaluation formula
Labor productivity	F_1	Ratio of flights to number of employees	Flights/number of employees
	F_2	Ratio of operation kilometers to number of employees	Operations kilometers/number of employees
	F_3	Ratio of number of seats to number of employees	Number of seats/number of employees
	F_4	Ratio of seat kilometers to number of employees	Seat kilometers/number of employees
Fleet productivity	F_5	Ratio of number of flights to number of fleets	Number of flights/number of fleets
	F_6	Ratio of operation kilometers to number of fleets	Number of operation kilometers/number of fleets
	F_7	Ratio of number of seats to number of fleets	Number of seats/number of fleets
	F_8	Ratio of seat kilometers to number of fleets	Seat kilometers/number of fleets
Flight equipment productivity	F_9	Ratio of number of flights to flight equipment	Number of flights/flight equipment
	F_{10}	Ratio of operation kilometers to flight equipment	Operations kilometers/flight equipment
	F_{11}	Ratio of number of seats to flight equipment	Number of seats/flight equipment
	F_{12}	Ratio of seat kilometers to flight equipment	Seat kilometers/flight equipment
Assets productivity	F_{13}	Ratio of number of flights to total assets	Number of flights/total assets
	F_{14}	Ratio of operation kilometers to total assets	Operation kilometers/total assets
	F_{15}	Ratio of number of seats to total assets	Number of salable seats/total assets
	F_{16}	Ratio of seat kilometers to total assets	Seat kilometers/total assets
Short-term liquidation	F_{17}	Current ratio	Current assets/current liabilities
	F_{18}	Equity/fixed ratio	Stockholders' equity/fixed assets
	F_{19}	Equity ratio	Stockholders' equity/total assets
Long-term Solvency	F_{20}	Fixed/long-term ratio	Fixed assets/long-term liabilities
	F_{21}	Debt ratio	Total assets/total liabilities
	F_{22}	Equity/debt ratio	Stockholders' equity/total liabilities

4.1. Grey relation analysis

Grey system theory was originated by Deng (1982). The fundamental definition of "greyness" is information being incomplete or unknown, thus an element from an incomplete message is considered to be of grey element. "Grey relation" means the measurements of changing relations between two systems or between two elements that occur in a system over time. The analysis method, which measures the relation among elements based on the degree of similarity or difference of development trends among these elements, is called "grey relation analysis". More precisely, during the process of system development, should the trend of change between two elements be consistent, it then enjoys a higher grade of synchronized change and can be considered as having a greater grade of relation, otherwise, the grade of relation would be smaller. Grey relation analysis will be applied in the selection of representative indicators. Its definition and model in mathematics are as follows:

Let $\mathbf{X}$ be a factor set of grey relation, $\mathbf{x}_0 \in \mathbf{X}$ represents the referential sequence, $\mathbf{x}_i \in \mathbf{X}$ represents the comparative sequence. $\mathbf{x}_0(k)$ and $\mathbf{x}_i(k)$ represent the respective numerals at point k for $\mathbf{x}_0$ and $\mathbf{x}_i$. If the average relation value $\gamma\,(\mathbf{x}_0(k),\mathbf{x}_i(k))$ is a real number, then it can be defined as (Deng, 1989)

$$\gamma(\mathbf{X}_0, \mathbf{X}_i) = \frac{1}{n}\sum_{k=1}^{n} \gamma(\mathbf{X}_0(k), \mathbf{X}_i(k)) \tag{1}$$

$\gamma(\mathbf{x}_0, \mathbf{x}_i)$ is designated as the grade of grey relation in $\mathbf{x}_i$ correspondence to $\mathbf{x}_0.\gamma(\mathbf{x}_0(k), \mathbf{x}_i(k))$ is said to be the grey relational coefficient of the same at point k. Professor Deng has proposed a mathematical equation that will satisfy these four axioms of grey relation, which is as follows:

$$\gamma(\mathbf{X}_0(k), \mathbf{X}_i(k)) = \frac{\min_{i\in I} \min_k |\mathbf{X}_0(k) - \mathbf{X}_i(k)| + \zeta \max_{i\in I} \max_k |\mathbf{X}_0(k) - \mathbf{X}_i(k)|}{|\mathbf{X}_0(k) - \mathbf{X}_i(k)| + \zeta \max_{i\in I} \max_k |\mathbf{X}_0(k) - \mathbf{X}_i(k)|}, \tag{2}$$

where ζ is the distinguished coefficient ($\zeta \in [0,1]$), the function of which is to reduce its numerical value by $\max_{i\in I} \max_k |\mathbf{x}_0(k) - \mathbf{x}_i(k)|$ getting large, so as to effect its loss-authenticity and to heighten the remarkable difference among relation coefficients.

4.2. The selection of representative indicators

The performance indicators can be divided into several groups according to the calculation of all indicators by

Table 2
Performance indicators set in marketing

Classification	Code	Indicator	Evaluation formula
Flights marketing capability	M_1	Ratio of passenger kilometers to number of flights	Passenger kilometers/flights
	M_2	Ratio of operation revenue to number of flights	Operation revenue/number of flights
	M_3	Ratio of operation income (loss) to number of flights	Operation income (loss)/number of flights
Operation kilometers marketing capability	M_4	Ratio of operation revenue to operation kilometers	Operation revenue/operation kilometers
	M_5	Ratio of operation revenue to operation kilometers	Operation revenue/operation kilometers
Seat marketing capability	M_6	Passenger ratio	Number of passengers/number of seats
	M_7	Ratio of passenger kilometers to number of seats	Passenger kilometers/number of seats
	M_8	Ratio of operation revenue to number of seats	Operation revenue/number of seats
	M_9	Ratio of operation income (loss) to number of seats	Operation income (loss)/number of seats
	M_{10}	Ratio of seat kilometers to number of passengers	Seat kilometers/number of passengers
	M_{11}	Ratio of operation revenue to seat kilometers	Operation revenue/seat kilometers
	M_{12}	Ratio of operation income (loss) to seat kilometers	Operation income (loss)/seat kilometers
Profitability	M_{13}	Operation cost ratio	Operation cost/operation revenue
	M_{14}	Gross profit ratio	(Operation revenue-operation cost)/operation revenue
	M_{15}	Operation profit ratio	Operation income (loss)/operation revenue
	M_{16}	Income before tax ratio	Income (loss) before tax/operation revenue
	M_{17}	Net income ratio	Net income (loss)/operation revenue
Debts turnover	M_{18}	Current liabilities turnover	Operation revenue/current liabilities
	M_{19}	Long-term liabilities turnover	Operation revenue/long-term liabilities
	M_{20}	Total liabilities turnover	Operation revenue/total liabilities
	M_{21}	Interest expense ratio	Operation revenue/interest expense

Table 3
Performance indicators set in execution

Classification	Code	Indicator	Evaluation formula
Labor execution capability	C_1	Ratio of number of passengers to number of employees	Number of passengers/number of employees
	C_2	Ratio of passenger kilometers to number of employees	Passenger kilometers/number of employees
	C_3	Ratio of operation revenue to number of employees	Operation revenue/number of employees
	C_4	Ratio of net income (loss) to number of employees	Net income (loss) /number of employees
Fleet execution capability	C_5	Ratio of number of passengers to number of fleets	Number of passengers/number of fleets
	C_6	Ratio of passenger kilometers to number of fleets	Passenger kilometers/number of fleets
	C_7	Ratio of operation revenue to number of fleets	Operation revenue/number of fleets
	C_8	Ratio of net income (loss) to number of fleets	Net income (loss)/number of fleets
Return of Investment	C_9	Return on current assets	Net income (loss)/current assets
	C_{10}	Return on flight equipment	Net income (loss)/flight equipment
	C_{11}	Return on fixed assets	Net income (loss)/fixed assets
	C_{12}	Return on total assets	Net income (loss)/total assets
	C_{13}	Return on stockholders' equity	Net income (loss)/average stockholders' equity
	C_{14}	Return on operation profit to capital	Operation income (loss)/average capital
	C_{15}	Return on income before tax to capital	Income before tax/average capital
Assets and stockholder's turnover	C_{16}	Current assets turnover	Operation revenue/current assets
	C_{17}	Flight equipment turnover	Operation revenue/flight equipment
	C_{18}	Fixed assets turnover	Operation revenue/fixed assets
	C_{19}	Total assets turnover	Operation revenue/total assets
	C_{20}	Stockholders' equity turnover	Operation revenue/average stockholders' equity

the grey relation coefficient. A representative indicator has to be selected from each group and the principal of selection depends on the degree of the relationship between an indicator and the other indicators in the same group. An example is cited as follows: as Table 4 shows, the sequence of indicators in a group is based on the magnitude of the grey relation coefficient. The ranking of first, second, third, and fourth are scored with points 4,3,2,1 respectively. As $\mathbf{x}_1$ illustrates, once in second place (as column 2 shows), three times in third place (as column 3 shows), and its total score is $1 \times 3 + 3 \times 2 = 9$. So, $\mathbf{x}_4$, whose total score is the highest, is selected as the representative indicator of the group. If the total score is the same, it depends on how many times it leads the sequence. If the times that it leads the sequence are the same, the times that it ranks second in a sequence becomes the factor to decide the result. The rest may be deduced by analogy.

Also, a threshold value is computed to judge whether the representative indicator is suitable or not. The concept of threshold value based on the chosen indicator should have higher representation if the indicator is close to the maximum value and far from the minimum value. The maximum value as shown in Table 4 implies that one indicator is always in first place, and the maximum value is $4 \times 4 = 16$. The minimum value implies that one indicator is always in last place, and the minimum value is $1 \times 4 = 4$. According to Table 5, the value is 0.917. In this paper, a representative indicator is chosen when the threshold value is more than 0.75.

Table 4
Selection of representative indicators illustration

Reference indicators sequence	Order of indicators in comparison sequence				Total scores (Maximum value: 16 ; minimum value: 4)
$\mathbf{X}_1$	$\mathbf{X}_4$	$\mathbf{X}_3$	$\mathbf{X}_2$	$\mathbf{X}_5$	$1 \times 3 + 3 \times 2 = 9$
$\mathbf{X}_2$	$\mathbf{X}_5$	$\mathbf{X}_4$	$\mathbf{X}_1$	$\mathbf{X}_3$	$1 \times 4 + 2 \times 2 + 1 \times 1 = 9$
$\mathbf{X}_3$	$\mathbf{X}_4$	$\mathbf{X}_1$	$\mathbf{X}_2$	$\mathbf{X}_5$	$3 \times 3 + 1 \times 1 = 10$
$\mathbf{X}_4$	$\mathbf{X}_2$	$\mathbf{X}_3$	$\mathbf{X}_1$	$\mathbf{X}_5$	$3 \times 4 + 1 \times 3 = 15$
$\mathbf{X}_5$	$\mathbf{X}_4$	$\mathbf{X}_3$	$\mathbf{X}_1$	$\mathbf{X}_2$	$1 \times 4 + 3 \times 1 = 7$
Score	4	3	2	1	Threshold value of $\mathbf{X}_4$: $(15 - 4)/(16 - 4) = 0.917$

4.3. TOPSIS method

After the selection of representative indicators, the next stage is to calculate the performance score of an airline and to rank it. There are many different ways to calculate the performance score and ranking. TOPSIS, developed by Hwang and Yoon in 1981, will be used as the ranking method in this paper. The advantage of this method is simple and yields an indisputable preference order. But it assumes that each indicator takes monotonic (increasing or decreasing) utility.

TOPSIS is based on the concept that the chosen indicator should have the shortest distance from the ideal solution and the farthest from the worst solution. The ideal solution is the one that enjoys the largest benefit indicator value and the smallest cost indicator value among each of the substitutive airlines. The worst solution is the one that enjoys the smallest benefit indicator value and the largest cost indicator value among each of the substitute airlines. The steps are as follows:

Step 1: *Normalization of indicator values*: Normalization aims at obtaining comparable scales (Hwang and Yoon, 1981). There are different ways of normalizing the indicator values. This paper will use vector normalization, which utilizes the ratio of the original value ($\mathbf{x}_{ij}$) and the square root of the sum of the original indicator values. The advantage of this method is that all indicators are measured in dimensionless units, thus facilitating inter-indicator comparisons. This procedure is usually utilized in TOPSIS. The formula is as follows:

$$\mathbf{r}_{ij} = \frac{\mathbf{X}_{ij}}{\sqrt{\sum_{i=1}^{m} \mathbf{X}_{ij}^2}} \tag{3}$$

where i is the ith airline, j the jth evaluation indicator, $\mathbf{r}_{ij}$ the indicator value after vector normalization for the ith airline company and jth evaluation indicator, $\mathbf{x}_{ij}$ the original value of indicators for the ith airline company and jth evaluation indicator and m the number of airline companies.

Step 2: *To determine ideal* ($\mathbf{A}^+$) *and worst* ($\mathbf{A}^-$) *solution*

$$\begin{aligned}\mathbf{A}^+ &= \{(\max_i \mathbf{r}_{ij} | j \in J), (\min_i \mathbf{r}_{ij} | j \in \mathbf{J}') | i = 1,2,\ldots,m\} \\ &= \{\mathbf{A}_1^+, \mathbf{A}_2^+, \ldots, \mathbf{A}_j^+, \ldots, \mathbf{A}_k^+\},\end{aligned} \tag{4}$$

Table 5
Domestic air transport market share of Taiwan's five main airlines (unit: percentage)[a]

Items	FAT	TNA	UIA	GCA	FMA	Total share ratio of the whole market
Number of passengers carried	29.04	21.64	11.48	10.89	11.51	84.56
Number of seats provided	27.46	24.51	11.21	11.81	10.71	85.70
Number of flights supplied	16.92	21.37	7.97	17.21	21.06	84.53

[a]Source: annual report of Taiwan's Civil Aeronautics Administration (1997).

$$\mathbf{A}^- = \{(\min_i \mathbf{r}_{ij} | j \in J), (\max_i \mathbf{r}_{ij} | j \in \mathbf{J}') | i = 1,2,\ldots,m\}$$
$$= \{\mathbf{A}_1^-, \mathbf{A}_2^-, \ldots, \mathbf{A}_j^-, \ldots, \mathbf{A}_k^-\}. \quad (5)$$

$J = \{ j = 1,2,\ldots,k | k$ belongs to benefit criteria$\}$, benefit criteria implies a larger indicator value and a higher performance score; $\mathbf{J}' = \{ j = 1,2,\ldots k | k$ belongs to cost criteria$\}$, cost criteria implies a smaller indicator value and a higher performance score.

Step 3: *To calculate the separation measure*: The separation of each airline from the ideal one ($\mathbf{S}_i^+$) and the worst one ($\mathbf{S}_i^-$) is then respectively given by

$$\mathbf{S}_i^+ = \sqrt{\textstyle\sum_{j=1}^{k} (\mathbf{r}_{ij} - \mathbf{A}_j^+)^2},$$
$$\mathbf{S}_i^- = \sqrt{\textstyle\sum_{j=1}^{k} (\mathbf{r}_{ij} - \mathbf{A}_j^-)^2} \quad i = 1,2,\ldots m. \quad (6)$$

Step 4: *To calculate the relative closeness to the ideal solution* ($\mathbf{C}_i^*$): It is defined as

$$\mathbf{C}_i^* = \frac{\mathbf{S}_i^-}{\mathbf{S}_i^+ + \mathbf{S}_i^-} \; 0 < \mathbf{C}_i^* < 1 \quad (7)$$

Step 5: *To rank the preference order according to the descending order of* $\mathbf{C}_i^*$:

5. Application

This paper applies this developed process to five Taiwanese domestic airlines: Far Eastern Air Transport (FAT), TransAsia Airways (TNA), UNI Air (UIA), Great China (GCA), and Formosa Airlines (FMA) for evaluation. Information sources are based mostly on the annual report published by Taiwan's Civil Aeronautics Administration and the financial statements published by each airline in 1997. These five airlines which carried 84.56% of the total number of passengers in the whole market, provided 85.70% of the total number of available seats, and 84.53% of the number of flights, can represent the whole Taiwanese domestic air transport market, as shown in Table 5.

Table 6
Value for evaluation items of Taiwan's five main airlines (unit: one thousand NT dollars)[a]

Classification	Item	FAT	TNA	UIA	GCA	FMA
Balance sheet	Capital amount (1996)	2,997,750	2,500,000	1,900,000	1,500,000	1,300,000
	Capital amount (1997)	4,196,850	4,000,000	2,000,000	1,575,000	1,495,000
	Average capital amount	3,597,300	3,250,000	1,950,000	1,537,000	1,397,500
	Current assets	2,958,119	1,502,450	2,845,176	488,169	427,090
	Flight equipment	7,880,331	7,732,166	5,174,225	4,025,610	5,654,269
	Fixed assets	7,261,365	12,402,391	5,537,285	3,477,921	4,702,466
	Total assets (1996)	10,147,164	15,300,119	6,287,033	3,592,673	5,354,377
	Total assets (1997)	12,789,859	16,220,994	9,578,121	4,604,168	5,405,679
	Average total assets	11,468,512	15,760,557	7,932,577	4,098,421	5,380,028
	Current liabilities	2,062,481	3,556,778	3,326,513	902,913	1,222,088
	Long-term liabilities	2,529,332	6,822,315	4,301,664	1,971,046	2,810,136
	Total liabilities	5,038,914	10,464,639	7,686,314	2,920,814	4,085,286
	Stockholders' equity (1996)	5,959,003	4,744,808	1,183,922	1,878,519	1,231,203
	Stockholders' equity (1997)	7,750,945	5,756,355	1,891,807	1,683,354	1,320,383
	Average stockholders' equity	6,854,974	5,250,582	1,537,865	1,780,937	1,275,793
Income statement	Operation revenue	5,917,857	6,524,474	3,339,992	2,060,663	2,390,328
	Operation cost	4,954,607	6,679,043	2,773,583	1,830,171	1,821,089
	Operation gross profit (loss)	963,250	(154,569)	566,409	230,492	569,239
	Operation income (loss)	221,152	(788,650)	224,220	90,297	283,373
	Interest expense	240,141	574,607	453,568	144,249	259,232
	Income (loss) before tax	613,721	(1,397,055)	57,380	(130,003)	(183,932)
	Net income (loss)	551,721	(1,397,055)	57,630	(115,803)	(144,820)
Non-financial statement	Number of employees	1,837	1,720	1,109	783	679
	Number of fleets	14	23	11	14	21
	Flights	48,428	61,145	22,799	49,258	60,263
	Operation kilometers	15,272,133	17,189,876	6,899,390	10,810,968	11,878,459
	Number of seats	7,683,806	6,857,195	3,136,002	3,304,797	2,995,536
	Seat kilometers (thousand)	2,441,714	2,041,733	964,824	769,861	699,784
	Number of passengers	5,402,912	4,025,634	2,136,184	2,025,900	2,141,248
	Passenger kilometers (thousand)	1,713,952	1,186,036	659,462	467,251	492,947

[a](refers to negative value) Sources: 1. the annual report is from Taiwan's Civil Aeronautics Administration (1997). 2. the balance sheet and the income statement are from the company statistics of each airline (1997).

5.1. The value for evaluation items of each airline

The evaluation items listed are classified into three categories: balance sheet, income statement, and non-financial statement. The value of each airline is stated in Table 6.

5.2. The grouped indicator and representative indicators

For the convenience of calculating the grey relation coefficient of the indicators, this study produced a computer program with Turbo PASCAL 7.0. Based on the results of this program, indicators are grouped into three categories, i.e. production, marketing, and execution, in accordance with the coefficient of each indicator, as showed in Table 7. Both Eqs. (2) and (3) are used to group the indicators from the performance indicators set and the selection of representative indicators is based on Section 4.2

5.2.1. The distribution of representative indicators

There are three types of indicators, divided up according to their composition: transportation indicators, financial ratios, and mixed indicators. A transportation indicator consists of two items of transport data divided by each other; while a financial ratio is one item divided

Table 7
Classification of indicators groups of production, marketing, and execution

Categories	Groups	Indicators within each group	Representative indicator of each group
Indicators in production	F–I	F_1, F_2, F_9, F_{13}, F_{14}	F_2[a](ratio of operation kilometers to number of employees) ⟨43,0.886⟩[b]
	F–II	F_3, F_4, F_6, F_{11}, F_{12}	F_4[a](ratio of seat kilometers to number of employees) ⟨54,0.962⟩
	F–III	F_5, F_{10}, F_{16}	F_5[a](ratio of number of flights to number of fleets) ⟨17,0.938⟩
	F–IV	F_7, F_8, F_{17}	F_7[a](ratio of number of seats to number of fleets) ⟨18,1.000⟩
	F–V	F_{15}, F_{18}, F_{19}, F_{20}, F_{21}, F_{22}	F_{19}[c](equity ratio) ⟨74,0.863⟩
Indicators in marketing	M–I	M_1, M_2, M_3, M_4, M_5, M_{12}	M_3[d](ratio of operation income (loss) to number of flights) ⟨52,0.783⟩
	M–II	M_6, M_7, M_8, M_{10}, M_{11}, M_{13}, M_{14}	M_6[a](passenger ratio) ⟨57,0.944⟩
	M–III	M_9, M_{15}	M_9[d](ratio of operation income (loss) to number of seats)
	M–IV	M_{16}, M_{17}	M_{17}[c](net income ratio)
	M–V	M_{18}, M_{19}, M_{20}, M_{21}	M_{21}[c](interest expense ratio) ⟨21,1.000⟩
Indicators in execution	C–I	C_1, C_2, C_3, C_{17}, C_{18}, C_{19}	C_3[d](ratio of operation revenue to number of employees) ⟨29,0.800⟩
	C–II	C_5, C_6, C_7	C_5[a](ratio of number of passengers to number of fleets) ⟨4,1.000⟩
	C–III	C_8, C_{11}	C_{11}[c](return on fixed assets)
	C–IV	C_{14}, C_{16}, C_{20}	C_{14}[c](return on operation profit to capital) ⟨6,0.750⟩
	C–V	C_4, C_9, C_{10}, C_{12}, C_{13}, C_{15}	C_{15}[c](return on income before tax to capital) ⟨29,0.800⟩

[a] refers to the transportation indicators, of which the number totals 6.
[b] ⟨a, b⟩ = ⟨total score, threshold value⟩.
[c] refers to the financial ratios, of which the number totals 6.
[d] refers to the mixed indicators, of which the number totals 3.

Table 8
Vector normalization value of representative indicators

Airlines	F_2	F_4	F_5	F_7	F_{19}	M_3	M_6	M_{15}	M_{17}	M_{21}	C_3	C_5	C_{11}	C_{14}	C_{15}
FAT	0.313	0.544	0.522	0.742	0.718	0.260	0.475	0.196	0.375	0.750	0.480	0.774	0.529	0.177	0.349
TNA	0.377	0.486	0.401	0.403	0.412	− 0.733	0.397	− 0.633	− 0.862	0.346	0.566	0.035	− 0.784	− 0.699	− 0.879
UIA	0.234	0.356	0.313	0.385	0.235	0.559	0.460	0.351	0.070	0.224	0.449	0.389	0.072	0.331	0.060
GCA	0.520	0.403	0.531	0.319	0.435	0.104	0.414	0.229	− 0.226	0.435	0.392	0.290	− 0.232	0.169	− 0.173
FMA	0.659	0.422	0.433	0.193	0.282	0.267	0.483	0.620	− 0.244	0.281	0.525	0.205	− 0.214	0.584	− 0.269

by another in the financial statement. A mixed indicator is one item of transport data and another in a financial statement divided by each other. As Table 7 shows, 15 representative indicators are selected for evaluating airline performance.

Among them, five representative indicators are in the category of production. F_{19} represents the financial ratio, while F_2, F_4, F_5, and F_7 represent transportation indicators, which implies that transportation indicators are more suitable to be used to measure the production efficiency of an airline than either the financial ratios or mixed indicators. The representative indicators, M_3, M_9, M_6, M_{17}, and M_{21}, represent marketing efficiency in which M_3 and M_9 are mixed indicators, while M_6 is the transportation indicator, and M_{17}, M_{21} are financial ratios. The result shows that the three types of indicators should measure the marketing efficiency all together. Five representative indicators exist in the category of execution: C_3, C_5, C_{11}, C_{14}, and C_{15}. The first one is the mixed indicator, while the second is the transportation indicator, and the last three are all financial ratios. This result shows that financial ratios are more suitable to be used to measure the execution efficiency than the other two types.

5.2.2. Observation of the three types of indicators

As Table 7 shows, any one of the three types is mutually interchangeable with the others or can stand independent of the others. In the category of production, transportation indicators replace some mixed indicators. Within F–I group, F_9, F_{13}, and F_{14} are replaced by F_2; within F–II group, F_{11} and F_{12} are replaced by F_4; within F–III group, F_{10} and F_{16} are replaced by F_5. But within F–IV group, transportation indicator, F_7, replaces one financial ratio, F_{17}.

In the category of marketing, mixed indicators M_3 and M_9 can, respectively replace the transportation indicator, M_1, in the M–I group and the financial ratio, M_{15}, in the M–III group. In addition, the indicators in the two groups M–IV (M_{16}, M_{17}) and M–V ($M_{18}, M_{19}, M_{20}, M_{21}$) are all financial ratios, which implies that these two groups are independent of the other two types of indicators. A special indicator to measure marketing efficiency is the passenger ratio (number of passengers per seat), M_6. This one can replace all three types of indicators: transportation indicators (M_7, M_{10}), financial ratios (M_{13}, M_{14}), and mixed indicators (M_8, M_{11}).

In the category of execution, the financial ratios C_{11} and C_{15} can, respectively, replace the mixed indicator, C_8, in C–III group and C_4, in C–V group. Within C–I group, the transportation indicator, C_5, replaces the mixed indicator, C_7. In addition, the indicators in C–IV (C_{14}, C_{16}, C_{20}) are all financial ratios, which implies that these groups are independent of the other two types of indicators. The ratio of operation revenue per employee (C_3) is a special indicator to measure execution efficiency. This one could replace two transportation indicators (C_1, C_2) and three financial ratios (C_{17}, C_{18}, C_{19}).

5.3. The evaluation result of airlines

The TOPSIS method was used to calculate the total performance score of each airline. This performance can be divided into three categories: production, marketing, and execution, according to the normalized value of each representative indicator in Table 8, followed by the preference order.

The outranking of airlines in total performance:

$$\text{FAT}(0.757) > \text{UIA}(0.627) > \text{FMA}(0.601) > \text{GCA}(0.585) > \text{TNA}(0.109)$$

the outranking of airlines in production efficiency:

$$\text{FAT}(0.687) > \text{GCA}(0.601) > \text{TNA}(0.414) > \text{FMA}(0.343) > \text{UIA}(0.208)$$

the outranking of airlines in marketing efficiency:

$$\text{FAT}(0.705) > \text{FMA}(0.678) > \text{UIA}(0.642) > \text{GCA}(0.535) > \text{TNA}(0.052)$$

the outranking of airlines in execution efficiency:

$$\text{FAT}(0.836) > \text{UIA}(0.699) > \text{FMA}(0.579) > \text{GCA}(0.529) > \text{TNA}(0.070)$$

The figures inside the parentheses refer to the relative closeness to the ideal solution. The higher the figure is, the closer the distance is.

6. Conclusion

This paper develops a performance evaluation model for airlines that includes the consideration of financial ratios. This model is then applied to a case study for the performance evaluation of five domestic airlines in Taiwan. The conceptual framework in this paper is more complete than a framework in which only the transportation indicators are considered. Likewise, in order to overcome the limitation of sample size and distribution type, grey relation analysis has been utilized for selecting the representative indicators. It provides a solution for grouping the indicators when the sample size is small and the distribution type is unknown.

Total performance of an airline is divided into three categories (production, marketing, and execution), based on the cycle of operation and the characteristics of organization. The division of the total performance can successfully be used as a diagnostic tool to provide a preliminary insight into an airline for operators. Finally, from the case study done in this paper, we see that any one of the three types of indicators can be replaced by another or can stand independent of another. This result reveals that transportation indicators or financial ratios cannot alone measure all performance aspects of an airline. Advanced analysis of Table 7 reveals that transportation indicators are more suitable to measure the production efficiency than financial ratios and mixed indicators, and the execution efficiency is best measured by financial ratios.

Appendix A. Items for performance evaluation

Classifications	Evaluation category	Evaluation items
Factor input	Labor	Number of employees
	Fleet	Number of fleets
	Assets	Current assets[a]
		Flight equipment[a]
		Fixed assets[a]
		Total assets[a]
	Capital	Stock capital[a]
		Stockholders' equity[a]
Product output	Transport output	Flights
		Operation kilometers
		Number of salable seats
		Seat kilometers
	Debts	Current liabilities[a]
		Long-term liabilities[a]
		Total liabilities[a]
	Expense	Operation cost[a]
		Interest expense[a]
Consumer consumption	Passengers	Number of passengers
		Passenger kilometers
	Income (loss)	Operation revenue[a]
		Gross profit (loss)[a]
		Operation income (loss)[a]
		Income (loss) before tax[a]
		Net income (loss)[a]

[a]Refers to the accounting items in financial statements.

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