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Considering the financial ratios on the performance evaluation of highway bus industry

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This paper tries to construct a performance evaluation procedure for highway buses with the financial ratio taken into consideration. First, a conceptual framework is redeveloped, based on the one created by Fielding *et al.*, to help form evaluation items and performance indicators involving both transport and finance aspects. Second, the total performance is divided into three major kinds of efficiency—production, marketing, execution—according to the cycle of operation activities. Third, 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 highway bus. In addition, a case study is conducted using four highway bus companies as example. The empirical result shows that the performance evaluation for highway buses could become more comprehensive if financial ratios are considered.

1. Introduction

In the general affairs of business management, financial ratios are one of the tools commonly used to evaluate a company's performance. Generally speaking, financial information relating to the status of a company's business operations will be reported in the yearly financial statements, and it is the ratio of any two accounting items in the financial statement that composes a financial ratio. The observation and analysis of appropriate financial ratios can serve as a preliminary reference for the diagnosis of the results of business operation. However, when looking over related documents, one will discover that most transport researchers in the process of evaluating the results of the transport industry place the focus on the effective use of resources between transport input (employees, vehicles, fuel) and transport output (passengers, passenger-km, vehicle-km). The relationship between operative results and a company's operative performance represented by financial ratios is less discussed in the studies of performance evaluations, especially in academic journals.

The operative results of a company can be seen in financial ratios via currency flow. A portion of the operation performance represented by financial ratios is what the traditional method of using the effective use of resources and output between transport input and transport output to evaluate performance cannot measure. For example, short-term liquidity measured by the current ratio, long-term solvency represented by the debt ratio, and company profitability shown by the gross profit ratio. These ratios directly or indirectly demonstrate certain aspects of a company's operating situation. For example, are funds being used properly? Is the financial

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leverage appropriate? And are profit earnings at an average level? All influence the existence and continued development of the company. Therefore, if the only basis for performance evaluation is the ratio between transport input and output, it is probable that the overlooking of certain results reflected by financial ratios will make the evaluation model incomplete. This research is based on the conceptual framework raised by Fielding and Anderson (1984), a set of evaluation models for operation performance that take financial ratios in to consideration. This set makes the evaluation process of highway bus effectiveness much more comprehensive and thorough.

This research is composed of five parts. Section 2 discusses the development of the conceptual framework. Section 3 focuses on the production of a set of performance evaluation indicators. Section 4 uses information from 1997 of four highway bus companies operating in the Taipei region as a practical object of research. Section 5 discusses the relationship between transport indicators and financial ratios. Section 6 concludes the study.

2. Conceptual framework

2.1. *Literature review*

There is an abundance of studies of highway bus performance evaluations and they can be roughly divided in to two main types. One constructs a hierarchy programme of related factors that influence performance from different perspectives (consumer, operator, supervisor), thus forming a basis of selection indicators. Alter (1976) used the perspective of the consumer to select six items for evaluation of mass transport service quality. Talley and Anderson (1981) selected 12 items from the perspective of the operator and evaluated bus system service standards. Fielding *et al.* (1985) also took the view of the operator, selecting seven items of evaluation of bus system operation and service performance. Allen and Dicease (1976) on the other hand, considered both the operator and the consumer, dividing the evaluation items into three: quantity of service, quality of service and ratio of benefit–cost, and selecting a total of 30 indicators to evaluate the performance of operation and service of a transport system. In this kind of research, the weighing of various perspectives will enlarge the gaps in evaluation indicators, thereby limiting the scope of research.

The others are based on the conceptual framework provided by Fielding and Anderson (1984). Fielding *et al.* (1978) and Fielding and Anderson (1984) developed a conceptual framework commonly used by UMTA (1981a, 1981b), TRB (1984), Tanaboriboon *et al.* (1993), 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-h, vehicle-km, capacity-km, etc.), and service consumption (passenger trip, passenger-km, operating revenue, etc.) constitutes three corners of a triangle. The three sides 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 a highway bus and to identify the relation between transport and finance.

The aim of this paper is to construct a conceptual framework based on the one created by Fielding *et al.* (1978) and Fielding and Anderson (1984) to help form performance indicators involving both transport and aspects of finance. Furthermore, this framework also provides a powerful method to divide the total performance of a highway bus into three parts: production, marketing and execution. This division is helpful for operators to recognize the performance of a department of a bus company and to identify the responsibility of that department. Finally, the case study shows that performance evaluations of highway buses could become more comprehensive if financial ratios were considered.

2.2. *Cycle of operation activities*

The objective of an enterprise is to maximize profits, so whether the activities of an enterprise are efficient has direct influence on profitability, thereby potentially threatening the survival of the enterprise. As shown in figure 1, the operation activities of a highway bus include three parts: factor input, product output and consumer consumption. These also constitute three stages of the operation cycle: production, marketing and execution.

The activities of a highway bus can be viewed as a consecutive and cyclic process, and the operators decide on the most suitable factor input (e.g. labour, vehicle, assets, capital, etc.) for the current period based on customer consumption during the previous period. At the same time they pursue the maximum product output (e.g. vehicle-km, total debts, interest expense, etc.) in the production stage under a given factor input. Likewise, they seek maximum consumer consumption (e.g. passenger-km, operation revenue, net income, etc.) in the marketing stage given the existing output level. 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 then to decide the amount of factor input for the next period.

2.3. *Organization characteristics of a highway bus*

Organizations such as a highway bus that have special safety needs with routine and highly standardized activities are likely to be a machine bureaucracy (Robbins 1990). The key concept that underlies all machine bureaucracies is standardization. One characteristic of this structure is the reliance on functional departmentation, with similar and related specialties grouped together. According to this functional departmentation structure, the three stages of highway bus operation (figure 1) represent three types of performance categories: production efficiency, marketing efficiency and execution efficiency respectively, corresponding to the departments of production, marketing and management.

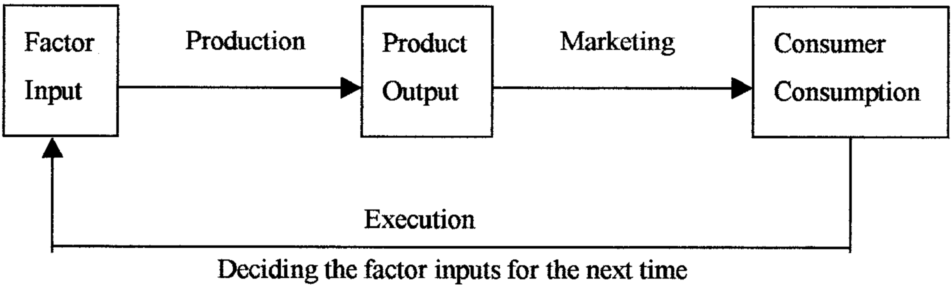

Figure 1. Cycle of operation activities of a highway bus.

As figure 2 illustrates, the production efficiency of factor input and product output measures a bus company's degree of resource usage. Given the same factor input, the efficiency increases as the output level increases. The marketing efficiency of product output and consumer consumption measures a bus company's marketing planning capability. Given the same output level, the marketing efficiency increases if consumers are willing and able to buy more products. The execution efficiency of consumer consumption and factor input measures planning and execution capability during its preliminary and interim period. Given the same consumption level, the execution efficiency increases as factor input decreases, which means that the operator can plan objectives in the preliminary period better and execute them in the interim period.

In this paper, the total performance of a highway bus is divided, based on the characteristics of operation activities and organization structure, into production efficiency, marketing efficiency and execution efficiency.

2.4. *Evaluation items of operational performance*

Taking finance into consideration, the 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. Furthermore, the study incorporates the special

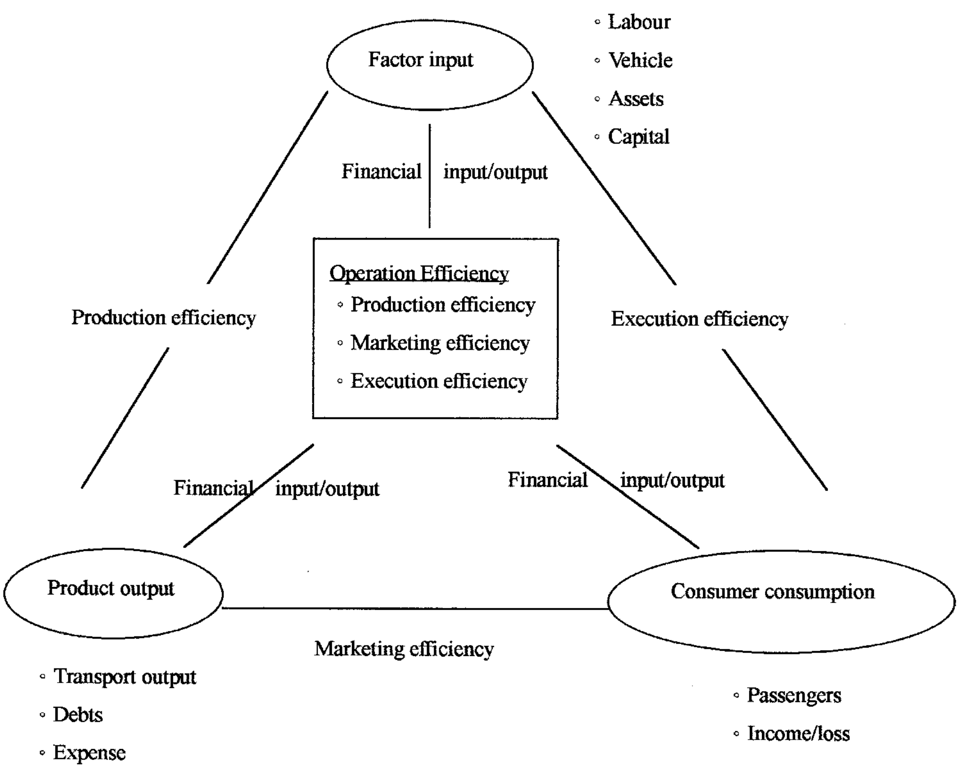

Figure 2. Conceptual framework of the operation performance evaluation for the highway bus.

characteristics of the highway bus industry to assist in the selection of items for evaluation. Highway bus is a capital- and labour-intensive business. Its factor input is characterized by a sunk cost, while its output by intangible products and its consumption by not-stored services. In view of the characteristics of sunk cost, interest expense is 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 shown in table 1.

As the evaluation items are shown in table 1, there are three evaluation items representing the labour category: number of employees, number of maintenance employees and number of drivers. The vehicle category has two: number of vehicles and amount of fuel. Assets are represented by three items: current assets, fixed assets and total assets. Capital has two: stock capital and stockholders' equity. Transportation output is divided into frequency and vehicle-km. The liability category has three: current, long-term and total liabilities. In the cost category, there are two: operation cost and interests expense. The passenger category includes number of passengers and passenger-km; and as for income/loss, the total number of items is five: operation revenue, operation gross income (loss), interest expense, operation income (loss) and net income (loss).

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-km 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 a highway bus 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 frequencies, operation-km, number of seats and seat-km were chosen as the performance indicators.

Based on the above two selection criteria and the ratios of both evaluation items in table 1, the set contains 56 evaluation indicators, which are classified into three main classifications: production, marketing and execution. Among them, 17 in the production category are recategorized into five groups, including labour productivity, vehicle productivity, assets productivity, short-term liquidity and long-term solvency (table 2). Sixteen indicators in the marketing category are recategorized into four groups, including frequencies, marketing capability, seat marketing capability, profitability and liabilities turnover, while 23 evaluation indicators in the execution category are recategorized into four groups, including labour execution capability, vehicle execution capability, return of investment, and assets and stockholder's turnover (tables 3 and 4).

4. Applications

This study is based on the operation data from 1997 of each highway bus company. In dividing the 32 operators in the region according to the area covered by

Table 1. Items for performance evaluation.

Classifications	Evaluation category	Evaluation items
Factor input	labour	number of employees
		number of maintenance employees
		number of drivers
	vehicle	number of vehicles
		fuel
	assets	current assets*
		fixed assets*
		total assets*
	capital	stock capital*
		stockholders' equity*
Product output	transport output	frequencies
		vehicle-km
	debts	current liabilities*
		long-term liabilities*
		total liabilities*
	expense	operation cost*
		interest expense*
Consumer consumption	passengers	number of passengers
		passenger-km
	income/loss	operation revenue*
		gross profit(loss)*
		interest expense*
		operation income (loss)*
		net income (loss)*

*Accounting items in financial statements.

their bus routes, there are 12 companies within the northern region, and seven of those, namely San-Chung, Capital, Taipei, Tam-Sui, Fu-Ho, Hsin-Tien and Chih-Nan, together cover Taipei in their operating range. This study selected these seven companies as its object of research. However, obtaining the complete financial statements of each of the companies proved extremely difficult. It was only possible to calculate necessary financial information based on data already in possession, so three companies whose data were insufficient had to be eliminated, leaving the four companies of San-Chung, Capital, Tam-Sui and Chih-Nan as the objects of this performance evaluation study. The four operators are engaged mainly in both urban and long-distance work. The details of each bus company's characteristics are summarized in table 5.

4.1. *Value for evaluation items of each highway bus*

Based on table 1, the evaluation items listed are classified into three categories: balance sheet, income statement and non-financial statement. The value of each bus company is stated in table 6.

4.2. *Grouped indicator and representative indicators*

During the accumulation of performance evaluation indicators, it was discovered that the number of indicators was extremely high, and the relationship between each of them was unclear. If it were possible to separate the indicators

Table 2. Performance indicators set in production.

Classification	Code	Indicator	Evaluation formula
Labour productivity	F_1	ratio of frequencies to number of employees	frequencies/number of employees
	F_2	ratio of vehicle-km to number of employees	vehicle-km/number of employees
	F_3	ratio of frequencies to number of maintenance employees	frequencies/number of maintenance employees
	F_4	ratio of vehicle-km to number of maintenance employees	vehicle-km/number of maintenance employees
	F_5	ratio of frequencies to number of drivers	frequencies/number of drivers
	F_6	ratio of vehicle-km to number of drivers	vehicle-km/number of drivers
Fleet productivity	F_7	ratio of frequencies to number of vehicle	frequencies/number of vehicle
	F_8	ratio of vehicle-km to vehicle	vehicle-km/number of vehicle
	F_9	ratio of vehicle-km to fuel	vehicle-km/fuel
Assets productivity	F_{10}	ratio of frequencies to total assets	frequencies/total assets
	F_{11}	ratio of vehicle-km to total assets	vehicle-km/total assets
Short-term liquidity	F_{12}	current ratio	current assets/current liabilities
	F_{13}	equity/fixed ratio	stockholders' equity/fixed assets
	F_{14}	equity ratio	stockholders' equity/total assets
Long-term solvency	F_{15}	fixed/long-term ratio	fixed assets/long-term liabilities
	F_{16}	debt ratio	total assets/total liabilities
	F_{17}	equity/debt ratio	stockholders' equity/total liabilities

into groups, with loose intergroup relations and close intragroup relations, then to select a representative indicator from each group, it would assist in the clarification of the complex relations between indicators as well as making it easier to explain the evaluation results. When the amount of sample data is large enough and conforms to normal distribution, then most researchers use the mathematical statistic method (factor analysis, cluster analysis, discriminate analysis, regression analysis) to conduct the selection of representative indicators. However, in the analysis of the highway bus industry, data are often incomplete or unclear, and this paper, therefore, is bound by realistic limits, confining itself to a situation where the amount of data is small and its significance indefinite. This paper follows the work of Professor Deng Ju-Long, who in 1982 proposed the selection of representative indicators based on the grey relation analysis. The basic concept and mathematical model of grey relation analysis are shown in appendix A. Moreover, this study calculates the performance score and ranking status of each case (highway bus operators) utilizing TOPSIS multiple criteria decision-making.

4.2.1. *Distribution of 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

Table 3. Perfomance indicators set in marketing.

Classification	Code	Indicator	Evaluation formula
Frequencies marketing capability	M_1	ratio of passenger to frequencies	number of passengers/frequencies
	M_2	ratio of passenger-km to frequencies	passenger-km/frequencies
	M_3	ratio of operation revenue to frequencies	operation revenue/frequencies
	M_4	ratio of income (loss) before tax to frequencies	income (loss) before tax/ frequencies
Vehicle-km marketing capability	M_5	ratio of passengers to vehicle-km	number of passengers/vehicle-km
	M_6	ratio of passenger-km to vehicle-km	passenger-km/vehicle-km
	M_7	ratio of operation revenue to vehicle-km	operation revenue/vehicle-km
	M_8	ratio of operation income (loss) to vehicle-km	operation income (loss)/ vehicle-km
Profitability	M_9	operation ratio	operation revenue/operation cost
	M_{10}	gross profit ratio	(operation revenue − operation cost)/operation revenue
	M_{11}	operation profit ratio	operation income (loss)/ operation revenue
	M_{12}	income before tax ratio	income (loss) before tax/ operation revenue
Debts turnover	M_{13}	current liabilities turnover	operation revenue/current liabilities
	M_{14}	long-term liabilities turnover	operation revenue/long-term liabilities
	M_{15}	total liabilities turnover	operation revenue/total liabilities
	M_{16}	interest expense ratio	operation revenue/interest expense

results of this program, indicators are grouped into three classifications: production, marketing and execution, in accordance with the coefficient of each indicator (table 7).

There are three types of indicators, divided up according to their composition: transport indicators, financial ratios and mixed indicators. A transport indicator consists of two items of transport data divided by each other; while a financial ratio is one item divided 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, 16 representative indicators are selected for evaluating highway bus performance.

Among them, six representative indicators are in the category of production, F_{14} represents the financial ratio, F_{10} represents the mixed indicator, while F_1, F_3, F_8 and F_9 represent transport indicators, which implies that transport indicators are more suitable for measuring the production efficiency of a highway bus than either the financial ratios or mixed indicators. The representative indicators M_3, M_5, M_{11} and M_{15} represent marketing efficiency, in which M_{11} and M_{15} are financial ratios, while M_5 is the transport indicator, and M_3 is the mixed indicator. The result shows that

Table 4. Performance indicators set in execution.

Classification	Code	Indicator	Evaluation formula
Labour execution capability	C_1	ratio of passengers to number of employees	number of passengers/number of employees
	C_2	ratio of passenger-km to number of employees	passenger-km /number of employees
	C_3	ratio of operation revenue to number of employees	operation revenue/number of employees
	C_4	ratio of income (loss) before tax to number of employees	income (loss) before tax/number of employees
	C_5	ratio of operation revenue to number of maintenance employees	operation revenue/number of maintenance employees
	C_6	ratio of operation revenue to number of drivers	operation revenue/number of drivers
Fleet execution capability	C_7	ratio of passengers to vehicle	number of passengers/vehicle
	C_8	ratio of passenger-km to vehicle	passenger-km/vehicle
	C_9	ratio of operation revenue to vehicle	passenger-km/vehicle
	C_{10}	ratio of income (loss) before tax to vehicle	income (loss) before tax/vehicle
	C_{11}	ratio of passengers to fuel	number of passengers/fuel
	C_{12}	ratio of passenger-km to fuel	passenger-km/fuel
	C_{13}	ratio of operation revenue to fuel	operation revenue/fuel
	C_{14}	ratio of income (loss) before tax to fuel	income (loss) before tax/fuel
Return of investment	C_{15}	return on current assets	income (loss) before tax/current assets
	C_{16}	return on fixed assets	income (loss) before tax/fixed assets
	C_{17}	return on total assets	income (loss) before tax/total assets
	C_{18}	return on stockholders' equity	income (loss) before tax/ stockholders' equity
	C_{19}	return on operation profit to capital	operation income (loss)/stock capital
Assets and stockholders' turnover	C_{20}	current assets turnover	operation revenue/current assets
	C_{21}	fixed assets turnover	operation revenue/fixed assets
	C_{22}	total assets turnover	operation revenue/total assets
	C_{23}	stockholders' equity turnover	operation revenue/stockholders' equity

Table 5. Details of the operators' characteristics.

Operators	Total route length (km)	No. of vehicles	Total vehicle-km (thousand/year)	Total passenger-km (thousand/year)
San-Chung	1027.9	505	35 876	338 493
Capital	414.5	210	13 457	12 393
Tam-Sui	700.1	50	3 132	32 442
Chih-Nan	801.3	260	16 836	169 244

Table 6. Value for evaluation items of four highway bus companies.

Classification	Item	San-Chung	Capital	Tam-Sui	Chih-Nan
Balance sheet	current assets	145 543	205 621	62 073	360 023
	fixed assets	883 830	395 859	251 137	910 358
	total assets	1 032 064	606 158	465 453	1 372 633
	current liabilities	323 734	192 039	48 843	446 233
	long-term liabilities	527 500	343 134	339 027	791 254
	total liabilities	856 399	540 366	391 238	1 314 402
	stockholders' equity	175 665	65 791	74 215	58 232
	capital amount	190 000	148 000	70 000	120 000
Income statement	operation revenue	1 251 268	462 544	70 750	487 903
	operation cost	833 566	331 929	45 614	409 689
	operation gross income (loss)	417 702	130 615	25 136	78 214
	interest expense	60 822	33 885	30 828	67 780
	operation income (loss)	49 436	(15 551)	7 365	(54 707)
	income (loss) before tax	13 557	(15 775)	14 098	(23 536)
Non-financial statement	number of employees	1 051	377	71	434
	number of maintenance employees	120	39	7	62
	number of drivers	705	245	48	307
	number of vehicle	505	215	50	260
	frequencies (thousand/year)	2 898	1 239	148	1 075
	fuel (thousand litres/year)	16 901	6 333	1 028	7 581
	number of passengers (thousand/year)	83 902	39 528	3 581	31 433
	passenger-km (thousand/year)	338 493	17 393	32 442	169 244
	vehicle-km (thousand/year)	35 836	13 457	3 132	16 836

Values are NT$1000. (), Negative value. *Source*: each highway bus (1997).

the three types of indicators should measure the marketing efficiency all together. Six representative indicators exist in the category of execution: C_2, C_4, C_6, C_{16}, C_{19} and C_{22}. The first one is the transport indicator, while the following two are the mixed indicators, and the last three are all financial ratios. This result shows that the financial ratios are more suitable for measuring the execution efficiency than the other two types.

4.2.2. *Implications of the representative indicators*

Four of the six representative transport indicators belong to the production category of evaluation indicators, whereas the other two belong to the marketing and execution categories respectively. This demonstrates that transport indicators are more suited to measuring the production efficiency between the input and output of transport. The evaluation indicators are

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_5	F_1* (ratio of frequencies to number of employees)
	F-II	F_2, F_4, F_6, F_9, F_{12}	F_9* (ratio of vehicle-km to fuel) < 33,0.906> ****
	F-III	F_3	F_3* (ratio of frequencies to number of maintenance employees)
	F-IV	F_7, F_8, F_{15}, F_{16}	F_8* (ratio of vehicle-km to number of vehicle) < 27,1.000>
	F-V	F_{10}, F_{11}	F_{10}*** (ratio of frequencies to total assets)
	F-VI	F_{13}, F_{14}, F_{17}	F_{14}** (equity ratio) < 6,1.000>
Indicators in marketing	M-I	M_1, M_3, M_6, M_7, M_9, M_{10}	M_3*** (ratio of operation revenue to frequencies) < 31,0.867>
	M-II	M_2, M_4, M_8, M_{11}	M_{11}** (operation profit ratio) < 10,0.778>
	M-III	M_5	M_5* (ratio of passengers to vehicle-km)
	M-IV	M_{12}, M_{13}, M_{14}, M_{15}, M_{16}	M_{15}** (total liabilities turnover)
Indicators in execution	C-I	C_1, C_3, C_5, C_6, C_7, C_9, C_{11}, C_{13}, C_{23}	C_6*** (ratio of operation revenue to number of drivers) < 73,0.813>
	C-II	C_2, C_8, C_{12}	C_2* (ratio of passenger-km to number of employees) < 4,1.000>
	C-III	C_4, C_{10}, C_{14}, C_{15}	C_4*** (ratio of income (loss) before tax to number of employees) < 14,0.917>
	C-IV	C_{16}, C_{17}, C_{18}	C_{16}** (return on fixed assets) < 4,1.000>
	C-V	C_{19}	C_{19}** (return on operation profit to capital)
	C-VI	C_{20}, C_{21}, C_{22}	C_{22}** (total assets turnover) < 6,1.000>

*Transport indicators, of which the number totals 6.
**Financial ratios, of which the number totals 6.
***Mixed indicators, of which the number totals 4.
****< a,b> is the < total score, the distance from the worst solution> .

centred around the frequencies ratio (F_1, F_3) produced by the separation of number of employees from number of maintenance employees, and the vehicle-km ratio (F_9, F_8), produced by the separation of fuel amount from number of vehicles. Among the six financial ratios there are three belonging to the execution category, two belonging to the marketing category and only one from the production category. This shows that using financial ratios to evaluate highway bus performance favours the executive effectiveness of input and consumption. The evaluation indicators are also founded on the income (loss) before tax created by fixed assets (C_{16}), the operation income (loss) created by stock capital (C_{19}) and the operation revenue created by total assets (C_{22}). As for the four representative mixed indicators, they are arranged into three categories, acting as support for the transport and financial indicators. F_{10} represents the degree of utilization of assets (production category), M3 represents marketing results of marketing (marketing category), and C_6 and C_4 represent the profit-making ability of labour power (execution category).

4.3. *Evaluation result of highway bus*

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

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. The ideal solution is the one that enjoys the largest benefit indicator and the smallest cost indicator among each of the substitutive bus companies. The worst solution is the one that enjoys the smallest benefit indicator and the largest cost indicator among each of the substitute bus companies.

4.3.1. *Outranking of highway bus companies*

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

the outranking of bus companies in total performance:
San-Chung (0.663) > Tam-Sui (0.649) > Capital (0.376) > Chih-Nan (0.182);
the outranking of bus companies in production efficiency:
San-Chung (0.767) > Capital (0.639) > Tam-Sui (0.394) > Chih-Nan (0.151);
the outranking of bus companies in marketing efficiency:
San-Chung (0.743) > Tam-Sui (0.614) > Capital (0.445) > Chih-Nan (0.128);
the outranking of bus companies in execution efficiency:
Tam-Sui (0.731) > San-Chung (0.623) > Capital (0.297) > Chih-Nan (0.203).

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

4.3.2. *Implications of the evaluation result*

Taking San-Chung as an example, although in the total performance evaluation it holds first among the four companies, after making more detailed analysis of its efficiency, one discovers that in execution efficiency it does not compare to Tan-Sui. It is necessary to examine the company's financial situation to correct its execution efficiency, and to ask such questions about whether the financial leverage is being utilized improperly, or whether it is too far in debt, thus creating a heavy interest burden, etc. Although Tan-Sui occupies the second spot in overall ratings, its performance in production efficiency is lacking. This shows that its production department is not making full use of its current capacity. For instance, perhaps

Table 8. Vector normalization value of representative indicators.

Companies	F_1	F_3	F_8	F_9	F_{10}	F_{14}	M_3	M_5	M_{11}	M_{15}	C_2	C_4	C_6	C_{16}	C_{19}	C_{22}
San-Chung	0.513	0.499	0.561	0.440	0.785	0.653	0.495	0.535	0.248	0.838	0.471	0.061	0.525	0.200	0.477	0.817
Capital	0.611	0.657	0.494	0.441	0.572	0.419	0.428	0.680	−0.210	0.491	0.068	−0.199	0.559	−0.533	−0.192	0.514
Tam-Sui	0.388	0.437	0.495	0.632	0.089	0.611	0.548	0.262	0.644	0.104	0.669	0.944	0.436	0.746	0.192	0.102
Chih-Nan	0.461	0.358	0.443	0.461	0.219	0.161	0.521	0.427	−0.693	0.213	0.571	−0.258	0.470	−0.346	−0.836	0.239

there are too many unnecessary employees, vehicles are not being fully utilized or assets are being improperly employed, etc. The Capital Company should be placed under the double heading of the marketing and execution categories. In the former case, due to the intended marketing mix strategy (4P), designed to increase growth of product sales. The latter refers to critical reviews of the company's financial strategy. As for Chih-Nan, it ranked lower than the other companies in all categories, falling far below the ideal. Chih-Nan needs to make a complete overhaul.

5. Relationship between financial ratios and transport indicators

Among the 16 representative evaluation indicators selected by case study, six belong to transport indicators, six belong to financial ratios and the remaining four belong to mixed indicators. This result demonstrates that if one only considers financial ratios or transport indicators, it is impossible to express the overall performance of highway bus industries. After closer analysis of the characteristics of the indicators within each of the groups, it was discovered that there are parts between transport indicators and financial ratios that are independent of each other and parts that can be mutually substituted. This is explained below.

5.1. *Substitute relationship*

As shown in table 7, within the production evaluation indicator group, the F-II group includes F_2, F_4, F_6, F_9 and F_{12}. This group's representative indicator (F_9) is a transport indicator and can replace the financial ratio F_{12} (current ratio). Group F-IV includes F_7, F_8, F_{15} and F_{16}. This group's representative indicator (F_8) also belongs to the transport indicator category, and can replace financial ratio F_{15} (fixed/long-term ratio) and F_{16} (debt ratio). Within the marketing evaluation indicator group, group M-II includes M_2, M_4, M_8 and M_{11}. This group's representative indicator is a financial ratio, and can replace the transport indicator M_2 (ratio of passenger-km to frequencies). No mutual replacement possibility exists in the execution category between transport indicators and financial ratios.

In observing the mixed indicators, one can see that group M-I includes M_1, M_3, M_6, M_7, M_9 and M_{10}. Its representative indicator, M_3, is a mixed indicator and can replace two transport indicators (M_1 and M_6) and two financial ratios (M_9 and M_{10}). Group C-I includes C_1, C_3, C_5, C_6, C_7, C_9, C_{11}, C_{13} and C_{23}. Its representative indicator, C_6, is a mixed indicator and can replace three transport indicators (C_1, C_7, C_{11}) and one financial ratio (C_{23}). Group C-III includes C_4, C_{10}, C_{14} and C_{15}. Its representative indicator, C_4, is also a mixed indicator and can replace financial ratio C_{15}. The substitutive relationship among indicators is shown in table 9.

5.2. *Independent relationship*

As shown in table 7, the evaluation indicator groups in the production category, F-I (F_1, F_5), F-III (F_3) are transport indicators and F-VI (F_{13}, F_{14}, F_{17}) are composed of financial ratios. Other categories of indicators do not exist within these three groups. Also, these three groups are not replaceable by other types of indicators, and neither can they enclose other types within themselves. This study views this as an independent relation. This phenomenon of independent groups demonstrates that performance evaluation for highway bus companies that use only transport indicators or financial ratios will have non-comprehensive and incomplete results, due to its inability to enclose the independent relations of other categories of evaluation indicator groups. In the marketing group, M-III (M_5) is a transport indicator and M-IV (M_{12}, M_{13}, M_{14}, M_{15}, M_{16}) is a financial ratio. These two groups are also independent. In the execution group, C-II (C_2, C_8, C_{12}), C-V (C_{19}), and C-VI (C_{20}, C_{21}, C_{22}) are all financial ratios. These three groups are all independent. The independent relation among indicators is shown in table 10.

6. Conclusions

This paper developed a performance evaluation model for a highway bus including the consideration of financial ratios, and this model was then applied to the case study for the performance evaluation of four bus companies. The conclusions are as follows:

- The conceptual framework here is more complete than a framework in which only the transport indicators are considered.
- To overcome the limitation of sample size and distribution type, grey relation analysis should be 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 a highway bus is divided into three categories (production, marketing, execution), based on the cycle of operation and the

Table 9. Substitute relationship among indicators.

Groups	Representative indicators	The indicators are represented
F-II	F_9*	F_{12}**
F-IV	F_8*	F_{15}**, F_{16}**
M II	M_{11}**	M_2*
M-I	M_3***	M_1*, M_6*, M_9**, M_{10}**
C-I	C_6***	C_1*, C_7*, C_{11}*, C_{23}**
C-III	C_4***	C_{15}*.

*Transportation indicators, **financial ratios, ***mixed indicators.

Table 10. Independent relationship among indicators.

Type of indicators	Groups	Indicators within group
Transport indicators	F-I	F_1, F_5
	F-III	F_3
	M-III	M_5
	C-II	C_2, C_8, C_{12}
Financial ratios	F-VI	F_{13}, F_{14}, F_{17}
	M-IV	M_{12}, M_{13}, M_{14}, M_{15}, M_{16}
	C-IV	C_{10}, C_{17}, C_{18}
	C-V	C_{19}
	C-VI	C_{20}, C_{21}, C_{22}

characteristics of organization. The division of the total performance can successfully be used as a diagnostic tool to provide a preliminary insight into a highway bus for operators.

- From the case study done here, the total performance of a highway bus is not fully equal to its performance in production, marketing or execution. For example, although San-Chung and Tam-Sui rank first and second respectively in total performance, the execution efficiency of San-Chung and the production efficiency of Tam-Sui still need improvement. This reveals that it is more difficult to discover problems in operation if the focus is only on the evaluation of total performance.
- As shown in tables 9 and 10, it can be seen that any one of the three types of indicators can be replaced by another or can stand independent of another. This result reveals that transport indicators or financial ratios can not alone measure all performance aspects of a highway bus. Advanced analysis of table 7 reveals that the transport indicators are more suitable to measuring the production efficiency than financial ratios and mixed indicators, and the execution efficiency is best measured by financial ratios.
- The research here is based on cases of small sample size. If it is possible to secure more data in the future, it is suggested that the evaluation procedure presented here could be adopted to conduct the comparison between evaluation results of different sample sizes.

Appendix A. Basic concept and mathematical model of grey relation analysis

A.1. *Basic concept*

Grey system theory was originated by Deng in 1982. The fundamental definition of 'greyness' is information that is incomplete or unknown, thus an element from an incomplete message is considered to be a 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 is based on the degree of similarity or difference of development trends among elements to measure the relation among elements, is called 'grey relation analysis'. Namely, 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.

A.2. *Definition and model in mathematics*

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 γ $(\mathbf{x}_0(k),\mathbf{x}_i(k))$ is a real number, then it can be defined as:

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

The average value of γ $(\mathbf{x}_0(k),\mathbf{x}_i(k))$, must satisfy the following four axioms: normal interval, duality symmetric, wholeness and approachability.

Axiom 1. Norm interval

$$0<\gamma(\mathbf{X}_0(k),\mathbf{X}_i(k)) \leq 1, \forall(k)$$
$$\gamma(\mathbf{X}_0(k),\mathbf{X}_i(k)) = 1 \quad \text{iff} \quad \mathbf{X}_0(k) = \mathbf{X}_i(k)$$
$$\gamma(\mathbf{X}_0(k),\mathbf{X}_i(k)) = 0 \quad \text{iff} \quad \mathbf{X}_0(k), \mathbf{X}_i(k) \in \oslash$$

where $\oslash$ is an empty set.

Axiom 2. Duality symmetric

$$x, y \in \mathrm{X}$$
$$\gamma(x,y) = \gamma(y,x) \quad \text{iff} \quad \mathrm{X} = \{x,y\}$$

Axiom 3. Wholeness

$$\mathbf{X}_i, \mathbf{X}_j \in \mathrm{X} = \{\mathbf{X}_\sigma | \sigma = 0,\ 1,\ 2,\ \ldots,n\}, n>2$$
$$\gamma(\mathbf{X}_i,\mathbf{X}_j) \neq \gamma(\mathbf{X}_j,\mathbf{X}_i)$$

Axiom 4. Approachability

$\gamma(\mathbf{X}_0(k),\mathbf{X}_i(k))$ decrease along with $|\mathbf{X}_0(k) - \mathbf{X}_i(k)|$ increasing.

If the foregoing four axioms are satisfied, $\gamma(\mathbf{x}_{\gtrsim}, \mathbf{x_i})$ is then designated as the grade of grey relation in $\mathbf{x}_i$ correspondence to $\mathbf{x}_0.\gamma, (\mathbf{x}_0(\kappa), \mathbf{x}_\iota(\kappa))$ is said to be the grey relational coefficient of the same at point k. Deng has proposed a mathematical equation that will satisfy these four axioms of grey relation:

$$\gamma(\mathbf{X}_0(k),\mathbf{X}_i(k)) = \frac{\min\limits_{i\in \mathrm{I}} \min\limits_{k} |\mathbf{X}_0(k) - \mathbf{X}_i(k)| + \zeta \max\limits_{i\in \mathrm{I}} \max\limits_{k} |\mathbf{X}_0(k) - \mathbf{X}_i(k)|}{|\mathbf{X}_0(k) - \mathbf{X}_i(k)| + \zeta \max\limits_{i\in \mathrm{I}} \max\limits_{k} |\mathbf{X}_0(k) - \mathbf{X}_i(k)|},$$

where ζ is the distinguished coefficient ($\zeta \in [\gtrsim, \curvearrowright]$), the function of which is to reduce its numerical value by $\max\limits_{i\in \mathrm{I}} \max\limits_{k} |x_0(k) - x_i(k)|$ getting large, so as to effect its loss-authenticity and to heighten the remarkable difference among relation coefficients.

Appendix B. Calculation steps of TOPSIS

Step 1: Normalization of indicator values

Normalization aims at obtaining comparable scales. There are different ways of normalizing the indicator values. This paper uses vector normalization, which utilizes the ratio of the original value (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:

$$\mathbf{r}_{ij} = \frac{\mathbf{X}_{ij}}{\sqrt{\sum\limits_{i=1}^{m} \mathbf{X}_{ij}^2}},$$

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

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

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

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

Step 3: To calculate the separation measure

$$S_i^{+} = \sqrt{\sum_{j=1}^{k} (r_{ij} - \mathbf{A}_j^{+})^2}\ ;\ S_i^{-} = \sqrt{\sum_{j=1}^{k} (r_{ij} - \mathbf{A}_j^{-})^2},$$
$$i = 1, 2, \ldots, m$$

The separation of each highway bus from the ideal one ($\mathbf{S}_i^{+}$) and the worst one ($\mathbf{S}_i^{-}$) is then respectively given by:

$$c_i^{*} = \frac{S_i^{-}}{S_i^{+} + S_i^{-}} \quad 0 < c_i^{*} < 1$$

Step 4: To calculate the relative closeness to the ideal solution (C_i^{*})

Step 5: To rank the preference order according to the descending order of C_i^{*}

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