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Combining grey relation analysis with FMCGDM to evaluate financial performance of Taiwan container lines

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Abstract

In this paper, we combine grey relation analysis with fuzzy multi-criteria group decision-making (FMCGDM) to evaluate financial performance of Taiwan container lines. In the evaluating process, we apply grey relation analysis to partition financial ratios into several clusters, and find representative indices from the clusters. These representative indices are considered as evaluation criteria on financial performance assessments. Then an FMCGDM method is utilized to evaluate the financial performance of Taiwan container lines. By the evaluation, one container line can realize the finance competitive strength on container shipping market.

Keywords: Container lines; Financial performance; FMCGDM; Grey relation analysis; Representative indices

1. Introduction

The evaluation of financial performance is essential for container lines because they commonly need large capitals. In Taiwan, the domestic container lines includes Evergreen, Yang-Ming, Wan-Hai, etc. These container lines have lots of container ships and related equipments for cargo transportation. The machines and tools usually take them lots of capitals. Based on the concept, a container line has to evaluate the financial performance which directly influences the company's survival. To evaluate financial performance of container lines, evaluation criteria are firstly grasped from their financial ratios (Walter & Robert, 1988). Financial ratios are commonly from balance sheet, income statement, cash flow, etc. However, some financial ratios are similar on identified patterns. To avoid repeated evaluation on similar financial ratios, financial ratios will be partitioned into several clusters, and then one representative index is found from a cluster to be an evaluation criterion (Deogun, Kratsch, & Steiner, 1997; Dubes, 1988; Duda & Hart, 1973; Eom, 1999; Feng & Wang, 2000; Hirano, Sun, & Tsumoto, 2004; Kaufman & Rousseeuw, 1990; Krishnapuram & Keller, 1993; Lee, 1999; Miyamoto, 2003; Pedrycz & Vukovich, 2002). Finally, an evaluation method is utilized to evaluate the financial performance of container lines.

Further, the number of major container lines is merely three in Taiwan. The number is very small and the distribution is unknown, so the classic clustering methods (Johnson & Wichern, 1992) are not suitable for these situations. To solve the situations of scarce data and unknown distribution, we utilize grey relation analysis (Deng, 1989) to cluster financial ratios and then find representative indices to be evaluation criteria. Since there will be several criteria on the evaluation problem, financial performance evaluation is one of multi-criteria decision-making (MCDM) problems (Hwang & Yoon, 1981; Keeney & Raiffa, 1976). On the other hand, we evaluate the financial performance of container lines in five periods. These performance values expressed in the five periods are aggregated into fuzzy numbers, so the evaluation problem belongs to fuzzy multi-criteria decision-making (FMCDM) problems (Boender, de Graan, & Lootsma, 1989; Chang & Yeh, 2002; Chen, 2000; Chen & Hwang, 1992; Hsu & Chen, 1997; Jain, 1978; Lee, 2005; Liang, 1999; Ostrowski, O'Brien, & Gordon, 1993; Parasurman, Zeithaml, & Berry,

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1985; Truitt & Haynes, 1994; Tsaur, Chang, & Yen, 2002; Wang & Lee, 2007; Wang, Lee, & Lin, 2003). In this paper, we apply a FMCDM method combining experts' opinions to evaluate the financial performance of Taiwan container lines, so the evaluating method is a fuzzy multi-criteria group decision-making (FMCGDM) method (Wang & Lee, 2007). With the FMCGDM method, the evaluation problem of financial performance can be easily solved.

For the sake of clarity, representative indices found by grey relation analysis are expressed in Section 2. The notions of fuzzy sets and fuzzy numbers are introduced in Section 3. The FMCGDM method is presented in Section 4. Finally, an empirical study of three container lines in Taiwan is illustrated in Section 5.

2. Finding the representative indices of financial ratios by grey relation analysis

In accounting aspect, financial ratios are commonly classified into several categories (Feng & Wang, 2000; Walter & Robert, 1988), because experts suppose that financial ratios are partially similar in the same one category. Thus the financial ratios of container lines are originally divided into four categories shown in Table 1.

In Table 1, fixed assets to stockholder's equity ratio, debt to total assets ratio and accounts payable turnover belong to cost items, whereas the other ratios belong to benefit items.

According to the Table 1, grey relation analysis is applied to partition the financial ratios into several clusters and then find representative indices as evaluation criteria form clusters. Grey relation analysis is one technique of grey theory. Grey theory was first introduced by Deng (1989). The fundamental definition of greyness is the information being incomplete or unknown, so an element of the incomplete message is a grey element. Grey relation analysis is the method to measure the relations between the grey elements. Further, the definition and application of grey relation analysis in mathematics are stated as follows.

Assume that there are m container liners (companies) evaluated on s financial ratios. Let $x_i = \{x_i(k)|k = 1,2,\ldots,m\} \in X$ denote the sequence of financial ratio i on m companies, where $i = 1,2,\ldots,s$. Thus X is the set consisting of all financial ratio sequences. Then the elements will be normalized according to two following situations.

As $x_i(k)$ is a benefit item

$$y_i(k) = \frac{x_i(k)}{\sqrt{\sum_{t=1}^{m}[x_i(t)]^2}}.$$

Otherwise, $x_i(k)$ is a cost item, then

$$y_i(k) = \frac{1/x_i(k)}{\sqrt{\sum_{t=1}^{m}[1/x_i(t)]^2}}.$$

Table 1
The financial ratios on four categories

Category	Code	Formula	Ratio
Financial structure	F1	Fixed assets/total stockholder's equity	Fixed assets to stockholder's equity ratio
	F2	Fixed assets/long-term liabilities	Fixed assets to long-term liabilities ratio
	F3	Fixed assets/long term capital	Fixed assets to long term capital ratio
	F4	Total liabilities/total assets	Debt to total assets ratio
	F5	Total stockholder's equity/total liabilities	Stockholder's equity to total liabilities ratio
	F6	Working capital/total assets	Working capital to total assets ratio
Solvency	S1	Current assets/current liabilities	Current ratio
	S2	Quick assets/current liabilities	Quick ratio
	S3	Cash and cash equivalent/current assets	Cash ratio
	S4	Net cash provided by operating activities/current liabilities	Cash flow ratio
	S5	Working capital/current assets	Working Capital to current assets ratio
Turnover	T1	Operation cost/accounts payable	Accounts payable turnover
	T2	Operation cost/accounts receivable	Accounts receivable turnover
	T3	Operation revenue/fixed assets	Fixed assets turnover
	T4	Operation revenue/total assets	Total assets turnover
	T5	Net income (loss)/operation revenue	Net income (loss) turnover
Profitability	P1	(Operation revenue–operation cost)/operation revenue	Gross profit ratio
	P2	Operation income (loss)/operation revenue	Operation profit ratio
	P3	Income (loss) before tax/operation revenue	Income before tax ratio
	P4	Net income (loss)/operation revenue	Net income ratio
	P5	Net income (loss)/total assets	Return on total assets

In these above situations, $y_i(k)$ is the normalized value of the financial ratio i on the company k, $i = 1,2,\ldots,s$; $k = 1,2,\ldots,m$.

Let $y_i = \{y_i(k)|k = 1,2,\ldots,m\} \in Y$ indicate the sequences of normalized financial ratio i on m companies, where $i = 1,2,\ldots,s$. Y is a set composed of all the normalized financial ratios. Assume Y to be a factor set of grey relation. Let $y_0 \in Y$ represent the referential sequence, and $y_i \in Y$ represent the comparative sequence. $y_0(k)$ and $y_i(k)$ denote the financial ratio values of y_0 and y_i on company k, respectively. As average relation value $r(y_0, y_i)$ of $\{r(y_0(k), y_i(k))|k = 1,2,\ldots,m\}$ is a real number, the value can be defined by grey relation.