An Integrated DEA-based Model to Measuring Financial Performance of Construction Companies

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Abstract: - This paper proposes an evaluation model which effectively assesses the financial performance of construction companies. This model successfully combines the methods of Strength Weakness Opportunity Threats (SWOT), Canonical Correlation Analysis (CCA) and Data Envelopment Analysis (DEA). The model first analyzes the operational characteristics of construction companies by using SWOT and, therefore, selects the representative indicators for evaluating financial performance. Next, it adopts CCA to solve the problems generated by the indicators' correlation and ensures the ability to distinguish performance evaluation. The model finally can utilize DEA to acquire reasonable efficiency values and priorities of financial performance. Through the case studies presented in the paper, it is evident that the proposed model is an effective tool that can rationally execute performance evaluation of construction companies and also suggests valuable improvements for company operations.

Key-Words: - financial performance, indicators' correlation, evaluation model, construction companies, data envelopment analysis

1. Introduction

The construction industry, one of the crucial industries, is usually regarded as an economic indicator for a country's development. In general, the operation of construction companies can be divided into the following phases: investment ideas, acquisition of land, planning and design, housing sales, construction, and completion of construction for transferring to customers. First of all, companies input capital to obtain the land for development, and then plan the architectural design according to market demand. Next, pre-sales will start, and then housing sales will follow after the completion of construction. Lastly, the capital will be received after the housing is sold.

Even though the operation of construction companies requires substantial input resources, it brings a variety of business outcomes. This characteristic is similar to that of other industries. But, in fact, the operation of construction companies is obviously different from that of other industries, and is significantly affected by societal and economic environments. Also, the products of construction companies have the properties of high price, immovability, high-capital demand and long-term operating cycles. Therefore, when assessing the performance of construction companies, we must pay particular attention to the impacts caused by their operational characteristics.

Furthermore, since the operational results of construction companies can be inferred from the financial statements, financial information is usually

adopted as the original indicator for performance evaluation, and financial performance is used for operational results. Hence, it is reasonable that financial performance represents the performance of construction companies in this paper.

However, if financial information is used as an evaluation indicator, the reliability of performance evaluation will be affected due to the indicator relevance generated by the financial information. Also, the criteria for indicator selection may be deviated from different people or situations. Thus, these indicators are incapable of reflecting the operational characteristics of construction companies reasonably.

As summarized above, it is certainly an important research topic to select the representative evaluation indicators and then to construct a performance evaluation model which can assess the financial performance of construction companies effectively.

2. Literature Review

This paper has reviewed some significant studies related to performance evaluation in order to understand the indicators and evaluation methods used for evaluating performance. They provide the foundation to construct a new model for assessing the financial performance of construction companies.

[8] used the Factor Analysis method to extract five factors from fourteen financial ratio variables. These factors were separately examined for their ability in prediction and random predictive samples by using the Chi-square test and F-Test. The research result pointed out that the correction percentage of the model achieved up to 74%, and it was capable of proving the effectiveness of the model.

[10] adopted the construction industry in Britain as a research subject. They used six financial ratios as evaluation indicators, including return of assets, return of working capital, working capital, financial leverage, days of accounts payable, and the trend of accounts receivable, to construct a model to predict the crisis of operation by using Discriminate Analysis. The result indicated that the return of assets and return of working capital made the highest contribution to the model.

[12] used financial ratios to evaluate the financial performance of construction companies in USA. The financial ratios were divided into three parts which involved six financial ratios, including current ratio, total liabilities to net worth, total assets to revenues, return on total assets, revenues to net working capital, and return on net worth. They constructed an evaluation model by means of Regression Analysis, and also used Probability Distribution to grade the companies into five groups according to their performances. However, case studies have not been actually carried out.

[9] used Ratio Analysis and Discriminate Analysis to explore whether construction companies in the UK were heading for insolvency. Six ratios were used in the ratio analysis to predict the financial crisis of business, including liquid assets ratio, acid test ratio, net worth fixed assets, working capital to total assets, net profit to net worth, and net worth to total liabilities. The financial ratios proposed by Mason and Harris in 1979 were applied in the Discriminate Analysis. The result indicated that the financial ratios could be useful in raising some pertinent questions about the performance of a company.

[7] studied the influence of national culture on capital structure, and furthermore explored the relationship between capital structure and firm performance. They used return on assets and pretax profit margin as indicators to assess financial performance, and adopted sales per employee and growth in sales as indicators to analyze operational performance. By means of Regression Analysis, this study found that capital structures varied according to the cultural classification of retailers. The results suggested that agency conflicts could have been primarily responsible for the overleveraging of retailers, resulting in a negative relationship between capital structure and performance.

[2] presented an empirical study of factors contributing to the success and failure of 24 large international construction companies originating in the United States, Europe and Japan. They focused on the aspects of operation, financial, technical and personnel relationships, and used a Fundamental Analysis to perform strategic performance, which adopted financial ratios as evaluation indicators including return of assets and return of stockholders' equity. The study suggested that an open perspective of strategy was necessary in construction organization that provided the foundation for

establishing a new strategic model for the construction industry.

[1] adopted Data Envelopment Analysis (DEA) to establish an enhanced contractor prequalification model, which used relative efficiency scores as prequalification criteria for selecting contractors. The model was developed together with a methodology for determining a "practical frontier" of the best contractors. The established practical frontier could be used as a regional performance standard for the owner and also as an improvement guideline for contractors.

[3] examined the strategic performance of large international engineering and construction companies from the regions of North America, Europe and East Asia. They focused on affecting aspects of profitability through the methods of Fundamental Analysis and Analytical Review. The findings of research suggested that there was no significant correlation between firm size and profitability, but firm size had some influence on generic strategies. Furthermore, the critical factors were identified in affecting the corporate strategy for long-term planning. A diversification strategy needed to be adopted to strengthen the competition when small-sized firms searched for a trend in growth.

[13] used financial ratios as evaluation indicators to evaluate the financial state of construction companies which were solvent and had financial risk caused by their commercial activities. They applied a Multi-criteria evaluation method to perform the evaluation analysis, in which the indicators included current ratio, ratio of current assets minus stocks to current liabilities, ratio of equity to liabilities, ratio of assets to liabilities and ratio of current assets to equity. The results indicated that the efficiency of financial management of construction companies could be described by the ratios of current assets to current liabilities, current assets minus stocks to current liabilities, equity to liabilities, current assets to equity and assets to liabilities.

[5] thought that there were over 50 financial ratios that could be used during evaluation analysis and some were more important than others for different industries. There were about 25 ratios that were important for the construction industry. They collected financial data from Turkish construction companies and then used Factor Analysis to determine five financial indicators that could be used to analyze the trend of the construction industry. The result of this study provided valuable information for the government to realize industrial changes.

From this comprehensive survey of the studies relevant to performance evaluation, it can be seen that the previous studies usually utilized financial ratios as evaluation indicators when assessing performance of construction companies. However, the indicators selected were not consistent throughout each study. To select indicators, most of the authors used expert opinions or questionnaires. Some authors adopted the indicators from other studies often without index selecting criteria. It would be easy to construct arguments regarding selected indicators because of the lack of a systematic selection approach.

Furthermore, it can be found that the previous studies usually adopted the methods of Factors Analysis, Discriminate Analysis, Multi-criteria evaluation, and Regression Analysis to assess performance, and in the last few years DEA has been also applied in performance evaluation.

DEA is a powerful analysis tool that uses multiple inputs and outputs data to measure performance [11], and has been applied in many areas of research such as finance and management [15]. Hence, this paper recognizes that DEA is capable of assessing the performance of construction companies and benchmarking the effectiveness of the industry. However, even though DEA is a useful tool for evaluating performance, when using financial ratios as evaluation indicators for DEA they may reduce the ability to distinguish performance evaluation because of financial indicators possessing highly-related problems.

To overcome the shortcomings mentioned above, this paper proposes a new model of performance evaluation. This model analyzes the operational characteristics of construction companies by using the method of Strength Weakness Opportunity Threats (SWOT), so as to select the representative indicators for evaluating performance. Then, it combines the methods of Canonical Correlation Analysis (CCA) and DEA in order to improve the situation caused by the indicators' correlation and ensure the ability to distinguish performance evaluation. Therefore, this model can utilize DEA to acquire reasonable efficiency values and priorities

of financial performance for construction companies.

3. Basic Concept of modeling

As mentioned above, this paper establishes a performance evaluation model which successfully combines the methods of SWOT, DEA and CCA. It is an effective tool for assessing financial performance and the operational decisions of construction companies. This model involves three issues of assessment described as the following: the nature of performance, performance evaluation indicators, and performance evaluation method.

1. The nature of performance

Performance is basically divided into two parts, efficiency and effectiveness [14]. Effectiveness is the achievement status of an organizational target. For efficiency, also called productivity, it is the measurement of the ratio calculated by input resources and output results, in order to evaluate whether the usage of input resources is effectively employed for the outcome or not. Due to the characteristics of multiple input resources and output results for construction companies, the evaluation of the utilization of resources belongs to the efficiency part. Thus, this paper adopts efficiency as the measurement basis for performance evaluation of construction companies.

2. Performance evaluation indicators

Financial ratios, as original indicators, are often used to evaluate the performance of construction companies, but in fact, there is a variety of financial ratios. The selected ratios which are used for evaluation may be different because of different standards adopted by researchers. However, companies make decisions according to the financial goals and uses of financial ratios to assess the performance. Even though the financial ratios can be used to inspect the results of the business operation, different business actions caused by the characteristics will generate different results. Hence, the financial ratios used as evaluation indicators must reflect the operational characteristics in order to effectively assess the performance of the business actions executed.

Accordingly, this paper utilizes the theory of SWOT proposed by [6] to analyze the operation characteristics of construction companies. It considers the strength, weakness, opportunity and threat from internal and external environments of construction companies, and then defines the related input resources and their outcomes during the operational process. Therefore, the paper can find the financial ratios as evaluation indicators of input and output which can directly reflect the characteristics of construction companies for evaluating performance.

3. Performance evaluation method

According to the rule of Pareto Optimality, DEA can produce a group of optimal weights by using mathematical linear programming, and thus solve the problem regarding the weights' setting of evaluation indicators. DEA also objectively combines multiple input and output items to calculate the relative efficiency value for each Decision Management Unit (DMU), so as to execute performance sorting of DMUs. Thus, it can distinguish between the efficiency and inefficiency performance for DMUs, and also provide the benchmarking effect for construction companies.

DEA is capable of calculating efficiency values for DMUs. It is a good method for evaluating performance. However, the indicators' relevance caused by financial information will reduce the ability of performance discrimination when using DEA for performance evaluation. This paper adopts CCA to improve this deficiency. CCA can decline two group variables, input indicators and output indicators, into the pairs of canonical variables which are also called potential indicators. After this process, it can identify the largest correlation between original indicators and potential indicators. The potential indicators still remain informative which is provided by the original indicators. Consequently, these indicators exactly reflect the operational characteristics of construction companies. They can also emphasize the meaning of input indicators and output indicators. Thus, by means of CCA, they can improve the ability of performance discrimination in the usage of DEA and raise the quality of performance evaluation for construction companies.

To summarize the discussion mentioned above, a flowchart of the proposed model is shown in Figure 1. The model first analyzes the operation characteristics of construction companies by using

SWOT and hence selects the representative indicators for evaluating performance. Next, it adopts CCA to modify the indicators correlation in order to ensure the ability to distinguish evaluating performance in usage of DEA and acquire the evaluation results to provide the operation references for construction companies.

4. Selection of Evaluation indicators

As discussed above, performance evaluation has to reflect the industrial characteristics of construction companies exactly. By using the theory of SWOT, the paper can analyze the operation characteristics of construction companies and therefore select the representative evaluation indicators of input and output.

The analysis of SWOT involves the competitive strength of high barriers to entry, the weakness of expensive and immovable products, the opportunity of obtaining long-term assets and the threat of a long cycle in operation. The strengths and weaknesses of construction companies derive from the internal conditions of firms. On the other hand, the opportunities and threats to construction companies caused by external environments are the elements that the enterprises have to face. Influences generated by these elements for construction companies are separately described below.

1. The strength of operation

The operation of construction companies requires a large amount of capital due to its high unit price and complicated process of production. The source of financing that can be classified into internal capital and external capital is the basic qualification of internal operation for construction companies. Hence, the financial structure which forms its business with high barriers to entry for other operators is a very significant element for construction companies.

At this point, the liability ratio and stockholders' equity ratio are selected for input indicators. Since the liability ratio and stockholders' equity ratio are inverse ratios to each other, this paper adopts the ratio of stockholders' equity for an input indicator based on the consideration of the same direction for all ratios. Furthermore, this paper uses the return of stockholders ratio as an output indicator for measuring contribution of capital inputs.

2. The weakness of operation

Consumers may purchase the real estate only with necessary financial ability because of its high price. The annual income of consumers and the economic boom will affect consumer awareness of purchasing real estate. Thus, construction companies must adjust their targets and strategies of operation depending in the changes of economic environment. This paper adopts the turnover rate of inventory which means selling condition as an input indicator. It can evaluate the result of operation for construction companies and also the assessment in usage of input resources. The operating income ratio is used as a corresponding output indicator.

In addition, construction companies require a much longer time to manufacture their products and receive capital back. Even though part of the capital will be received earlier from presale on products, construction companies still need large amounts of capital for construction costs. The costs are generally supported by short-term capital (current assets) or short-term financing (current liability) during the construction period. The current assets minus the amount of inventory and prepaid assets are known as quick assets. The quick assets are used to calculate the quick ratio which is obtained by quick assets divided by current liability. This ratio can strictly examine the ability of short-term financing. It is regarded as an output indicator for evaluating performance in the usage of short-term capital.

3. The opportunity of operation

Population usually concentrates in city areas where less land can be developed. Hence, construction companies often invest in the land as a long-term asset and develop it in adequate time. The land is also a mortgage tool for financing so as to gain cash. In addition, since the products are valuable, construction companies usually combine the proceeds of financial institutions to raise the interest of consumers to purchase the real estate. Firms then transfer the risk of collecting cash in accounts receivable to financial institutions and generate more cash flow. Therefore, this paper selects the turnover rate of accounts receivable as an input indicator, and the cash flow ratio as its corresponding indicator as an output item.

4. The threat to operation

Due to the threat that the construction period of real estate takes a great deal of time, the methods of integrated resources and the operating cycle of construction companies are affected. When the market is unstable or in recession, the profitability of construction companies will be easily affected, compared to other industries which have shorter operating cycles. In order to inspect the integrated results, the return of assets and operating income ratio are used as the output indicators.

In the analysis above, this paper determines input and output evaluation indicators as shown in Table 1. There are three input indicators: stockholders' equity ratio, turnover rate of inventory, and turnover rate of accounts receivable. In addition, there are five output indicators: return of stockholders' equity, operating income ratio, quick ratio, cash flow ratio, and return of assets. These input and output evaluation indicators are all used for evaluating the financial performance of construction companies.

5. Construction of Evaluation Method

After determining input and output evaluation indicators, this paper establishes the method of performance evaluation. The proposed method first refers to CCA to decline the numbers of original evaluation indicators for generating potential indicators, and standardizes these potential indicators to obtain the largest correlation between all indicators. The potential indicators are dependent and remain informative provided by the original indicators. Therefore, reduction of the distinguishing ability for performance evaluation caused by the correlation of indicators can be avoided. Finally, the proposed method uses the standardized potential indicators for DEA to calculate the efficiency values and sort financial performance. The proposed method of performance evaluation can be described as follows.

Phase 1: Declining original indicators and generating potential indicators.

This phase majorly solves the correlation problem of indicators. The correlation of evaluation indicators easily makes the performance of DMU to achieve the "efficiency frontier" line. Thus, it has to make all indicators with the largest correlation in order to extract the potential indicators, so as to raise the ability of distinguishing performance between efficiency and inefficiency.

Figure 2 presents the demonstration of the path for declining original indicators in usage of CCA. If there are *c* numbers of DMU_c ($c = 1,2,\ldots, n$), and the variables of DMU_c are divided into 2 groups: X_i (input indicators, $i = 1,2,\cdots, p$)and Y_r (output indicators, $r = 1,2,\cdots, g$) .

By using CCA, it can calculate the canonical variance of W_α and T_α ($\alpha = 1,2,\cdots, m$) . The largest correlation coefficient of W_α and T_α is called canonical correlation coefficient, ρ_α . The square of ρ_α is called eigenvalue. The eigenvalue up to the significant level is selected for acquiring *m* numbers of input canonical variance ($W_1,\cdots,W_m$) and output canonical variance ($T_1,\cdots,T_m$) . The numbers of *W* and *T* which are represented in *m* are X_i and Y_r, $m = min\ (p, g)$.The canonical variance of α_p^{th} in X_i group is called W_α , $W_\alpha = \sum_{i=1}^{p} a_{i\alpha} X_{i\alpha}$. The canonical variance of α^{th} in Y_r group is called T_α, $T_\alpha = \sum_{r=1}^{g} b_{r\alpha} Y_{r\alpha}$.

The meaning of the procedure separately declines the *p* original indicators of *X* and *g* original output indicators of *Y to* the *m* potential indicators of input and output, $W_1,\cdots,W_m$ and $T_1,\cdots,T_m$. The correlation of declined potential indicators is up to the simplest relationship, and independence.

This paper then selects the weight-values of canonical linear combinations, a_{ij} and b_{rj} , to perform the standardization which makes the values of original indicators become the values of potential input indicators, and potential output indicators by using the formula:

$$W_{\alpha c} = \sum a_{i\alpha} \frac{(X_{ic} - \overline{X_i})}{s_i} \quad \text{and} \quad T_{\alpha c} = \sum b_{r\alpha} \frac{(Y_{rc} - \overline{Y_r})}{s_r} .$$

In the formula, s_i and s_r represent the standard deviation of input indicator for the i^{th} variable and output indicator for the r^{th} variable.

Due to the strict requirement of positive value for input and output variables in usage of DEA, The values of $W_{\alpha c}$ and $T_{\alpha c}$ obtained from the above

formulas need to be adjusted in order to comply with the requirement. This paper refers to the method of Mazur (1995) and regulates the potential indicators. If the value of potential indicators is positive, they will be transferred to obtain the value of linear by using Eq. 1. Conversely, if the value of potential indicators is negative, they will be transferred to obtain the value of linear by using Eq. 2. The range for transferring the value of indicators is between 0 and 100 in accordance with the limitation of DEA. Moreover, the T_{jc}^{*} can be transformed in the same way.

$$W_{\alpha c}^{*} = \frac{W_{\alpha c} - W_{\alpha}^{-}}{W_{\alpha}^{+} - W_{\alpha}^{-}} \times 100 \cdots (1)$$

$$W_{\alpha c}^{*} = \frac{W_{\alpha}^{-} - W_{\alpha c}}{W_{\alpha}^{+} - W_{\alpha}^{-}} \times 100 \cdots (2)$$

In the formula,

- $W_{\alpha c}^{*}$ is the linear transferring value of the α^{th} potential indicator for the c^{th} DMU
- $W_{\alpha c}$ is the original value of α^{th} input potential indicator for the c^{th} DMU
- W_{α}^{+} is the maximum value of α^{th} potential indicator
- W_{α}^{-} is the minimum value of α^{th} potential indicator

Phase 2: Calculating efficiency value and sorting performance priority

In Phase 2, it brings the standardized potential indicators represented in $W_{\alpha c}^{*}$ and $T_{\alpha c}^{*}$ in DEA then carries out the performance analysis with the software of IDEAS. The efficiency values of all DMUs will be obtained through the calculation of DEA, as presented in Eq. 3.

$$\max \quad E_c = \frac{\sum_{r=1}^{p} u_r T_{\alpha c}^{*}}{\sum_{i=1}^{g} v_i W_{\alpha c}^{*}}$$

$$s.t. \quad \frac{\sum_{r=1}^{g} u_r Y_r}{\sum_{i=1}^{p} v_i X_i} \le 1, \qquad (3)$$

$$u_r, v_i > 0, i = 1, \cdots p, r = 1, \cdots g$$

In the formula, u_r, v_i are relative weights gained by using DEA..

After execution of DEA, the efficiency value and number of apotheoses are obtained for each DMU. The former can distinguish performance in terms of efficiency (E_c=1) and inefficiency (E_c<1) for each DMU. In other words, the size of the efficiency value is referred for sorting performance. The number of apotheoses means the times the particular efficient DMU is used to compare with that of other DMUs. The performance priority will be according to the number of apotheoses when DMUs have the same efficiency value. For example, there are two DMUs that have the same efficiency value of 1; more apotheoses of DMU would be in front of the lesser one. Therefore, the evaluation results of performance for all DMUs can be sorted according to the size of efficiency value and the number of apotheoses.

6. Case Study and Result Discussion

In this case study, the model of performance evaluation constructed by this paper is used to calculate efficiency value and sort financial performance of construction companies for different evaluating periods. The listed and over-the-counter construction companies in Taiwan are adopted as evaluating objectives. It also compares the results of evaluation for short-term, mid-term, long-term periods and summarizes the influences occurring in different evaluating periods caused by evaluation indicators. This experiment can verify that the model effectively evaluates the performance of construction companies and provides useful information for company operations during different evaluating periods.

6.1 The periods and objectives of evaluation

The operating cycle of a real estate project which is developed by the listed and over-the-counter construction companies in Taiwan needs 3 to 5 or more years to develop from planning to construction, and to sale. Hence, the result for outcomes in usage of input resources may be obtained after a long time. Because of this point, the financial data of over three years is collected. It is divided into the short-term (3 years), mid-term (5 years), and long-term (10 years) for application.

To maintain the homogeneity of evaluated companies and data consistency, this model selects the listed and over-the-counter construction companies whose architecture revenues are used for

the main operating revenues, and over 80% of integrated operating revenues as research objectives. There are 27 companies selected which comply with the requirement. Their financial ratios are collected from 1999 to 2008 as research data to evaluate performance of construction companies.

6.2 Application of Evaluation Model

According to Section 4, this model selects three input evaluation indicators: stockholders' equity ratio, turnover rate of inventory, and turnover rate of accounts receivable, and five output evaluation indicators: return of stockholders' equity, quick ratio, operating income ratio, cash flow ratio, and return of assets. Then, the model uses CCA for modification of indicators correlation, as shown in Fig.3. It declines two groups of input and output indicators which include three input indicators X_i and five output indicators Y_r into three pairs of potential indicators W_α and T_α in order to obtain the largest correlation between two groups of original indicators.

Furthermore, the model estimates parameters by using the statistic software SPSS to calculate the coefficients of each individual indicator which are called Canonical Weights. The larger the absolute weight of an indicator, the more it contributes. For example, the weights of potential indicators for long-term period (10 years) are summarized in Table 2. The potential indicators of input (W_1^*, W_2^*, W_3^*), and output (T_1^*, T_2^*, T_3^*) are presented as follows:

$$W_1^* = -0.966X_1 + 0.156X_2 - 0.258X_3$$
$$W_2^* = -0.189X_1 + 0.138X_2 + 0.981X_3$$
$$W_3^* = -0.194X_1 + 0.993X_2 + 0.080X_3$$
$$T_1^* = -0.894Y_1 + 0.567Y_2 + 0.583Y_3 + 0.187Y_4 - 1.274Y_5$$
$$T_2^* = -0.803Y_1 - 1.218Y_2 - 0.198Y_3 + 0.279Y_4 + 1.771Y_5$$
$$T_3^* = 0.728Y_1 - 0.462Y_2 + 0.557Y_3 - 0.907Y_4 + 0.578Y_5$$

The indicator of X_1 represents the stockholders' equity ratio which importantly affects the first group in all input indicators. The indicator of X_3 which represents the turnover rate of inventory has the greatest impact towards the second group, and the indicator of X_2 which represents the turnover rate of accounts receivable significantly affects the third group. In addition, the indicators Y_1 and Y_5 represent the return of stockholders' equity and return of assets respectively which mostly impact the first group output indicators. The indicators Y_2 and Y_5 represent the quick ratio and return of assets correspondingly, having more influence on the second group. The indicators Y_1 and Y_4 represent the return of stockholders' equity and cash flow ratio in that order which significantly affect the third group.

However, since the declined potential indicators do not have any meaning, they must rely on the degree of relationship between potential indicators and original indicators for naming purposes in order to assist the following analysis.

For example, in Fig. 3, the biggest percentage value of indicator X_2 (0.993) represents the turnover rate of accounts receivable in all the potential indicators of W_3^* for explaining input items. It means that the higher the turnover rate is of accounts receivable, the better the ability to collect cash. The generation of accounts receivable represents completion of product sales for acquiring cash quickly. This is helpful for planning and management of capital. Thus, W_3^* is named as "the ability of realizing cash value".

In the same way, the higher contributions of evaluation indicators in all potential indicators can be found for naming other potential indicators. The potential indicators of W_2^* and W_1^* are named as "the ability of marketing for products" and "the ability of capital management". Furthermore, for the potential indicators of output, T_3^*, T_2^* and T_1^* are named as "the ability of management in cash", "the profitability of assets", and "the ability of usage in capital and assets".

The denotation of strategy is generated after the naming of potential indicators. The first pair of potential indicators (W_1^*, T_1^*) can be adopted to analyze the ability of capital planning and management. The second pair of potential indicators (W_2^*, T_2^*) can be used to explain the ability of marketing and profitability of assets. The third pair of potential indicators (W_3^*, T_3^*) can be applied to explore the ability of obtaining cash from sale of product and management of cash flow.

The model standardizes three groups of potential indicators in order to calculate the values of potential indicators for 27 evaluated construction industry (DMUs), as shown in Table 3. Then, the model transfers the three pairs of potential indicators,

(W_1^*, T_1^*), (W_2^*, T_2^*) and (W_3^*, T_3^*) by using linear transformation which is described as Equations 1 and 2 to make them become positive. This transformation does not affect the correlation of potential indicators. Lastly, the result of transformation is used to calculate efficiency value and counts the number of apotheoses for each DMU in usage of DEA. The performance priority for all DMUs is obtained according to the size of efficiency value and the number of apotheoses which are shown in Table 4.

Table 4 indicates the efficiency value, number of apotheoses for DMUs, and the result of performance priority for a long-term evaluating period. The results for other the two periods, short-term and mid-term, are also summarized in Table 4.

6.3 Discussion of Analysis Results

Even though the results of performance priorities are obtained through the case study, this paper still inspects the meaning of original indicators for explaining the performance change of DUMs in different periods. Therefore, the analysis results will comply with the naming of potential indicators and will find the major indicator to affect the performance of different periods.

In the evaluation results of the short-term period, there are five DMUs with the efficiency value of 1. They are DMU 1, 5, 20, 23 and 27. Because of the number of apotheoses of DMU 20 up to 27 times, it is sorted to be the first among all DMUs. In DMU 20, the input indicator, turnover rate of inventory, and its related output indicator, quick ratio, are much better than that of other DMUs with the same efficiency value of 1. The rest of other input indicators of DMU 20 are similar to that of other DMUs with the same efficiency value of 1.

There are seven DMUs which have the efficiency value of 1 in the performance analysis of the mid-term period. They are DMU 1, 5, 6, 15, 16, 23, and 27 in which DMU 23 is the first priority of performance among all DMUs. The influence caused by short-term current evaluation indicators is diluted by extension of the evaluating period in the evaluation result of mid-term period, but the impacts caused by other non-current evaluation indicators for performance are gradually reflected. For example, the influence caused by the financial plan of stockholders' equity ratio is progressively presented in performance. Even though DMU 15 and 16 belong to DMU with a worse performance in the short-term period, they are upgraded in the performance of the mid-term period due to the influence caused by capital planning. Especially for DMU 16 which is sorted in the 20^{th} for the short-term period due to bad current indicators; it is sorted in the third position for performance priority of the mid-term period after referring to 21 times of apotheosis. This result indicates that the indicator of financial structure is also regarded as significant input from the rest of the DMUs which have an efficiency value of 1.

In addition, the influence between current assets (turnover rate of inventory) and quick assets (quick ratio) is gradually zooming out when the turnover rate of production and completion of products slowly appear in the mid-term period. This condition results in raising the percentage of stockholder capital for relieving the pressure of short-term liability in the mid-term period. This issue can be proven by DMU 18 and 20. They are separately sorted in the 7^{th} and 1^{st} in the short-term period for performance, then downgraded to the 27^{th} and 23^{th} in the evaluation of the mid-term period respectively. Moreover, DMU 16 and 14 are separately sorted in the 20^{th} and 18^{th} for performance of the short-term period, and upgraded to the 3^{rd} and 8^{th} in the mid-term performance.

Since a variety of assets and resources are accumulated through time, the evaluation of performance for the mid-term period is expected to assess the ability for management of assets and raise the probability of assets. For example, although the quick ratio of DMU 18 increases, its turnover rate of accounts receivable decreases. This result indicates that DMU 18 may exploit other short-term liabilities to satisfy the requirements of short-term capital instead of raising sales for acquiring cash. It means that the operation decision of products is not performed well. For the analysis of DMU 21, the cash flow of output indicators is the best performance in the short-term period, but the percentage of this indicator almost decreases by half for mid-term performance. The percentage for capital of stockholders and quick ratio for this DMU also decreases. The result of the analysis indicates that DMU 21 gradually ignores effectively cash flow management of capital by the extension of the

evaluating period. The performance priority of DMU is seriously downgraded to the 26th in the mid-term period from the 9th in the short-term period.

In the evaluation results of long-term period performance, there are 15 DMUs with the efficiency value of 1. They are DMU 1, 2, 3, 4, 5, 10, 11, 12, 13, 17, 18, 20, 22, 24 and 25. The first performance priority is DMU 11. However, in the performance analysis of short-term or mid-term periods, the 12 DMUs which include DMU 2, 3, 4, 10, 11, 12, 13, 17, 18, 22, 24, and 25 are not efficient DMUs and their efficiency values do not reach 1. This result indicates that the performance of the long-term period is obviously affected by the stockholders' equity ratio. Furthermore, the current indicators are maintained for effective input and output. Even so, DMUs without good performance in the short-term and mid-term periods will only be promoted to be efficient when the source of capital is adequately planned and managed. Hence, whether the capital is well planned or not becomes a significant indicator for affecting long-term period performance.

In addition, the DMUs with the efficiency value of 1 are compared with each other, so as to find the differences among turnover rate of inventory, turnover rate of accounts receivable and quick ratio. These differences come from the ability of marketing products to generate cash. Then, the impact caused by these indicators is obviously enlarged from the changes for the cash flow ratio of the long-term period. Therefore, the influence of performance for the long-term period is positive affected by the turnover of inventory products or days of sales depending on the extension period, such as DMU 1 and 11. With the extended evaluation period, the ability of capital usage is fully presented for improving the cash flow ratio. Hence, the related ratios of planning and usage for capital evidently affect the evaluation results of long-term performance. For example, the cash flow ratio of DMU 1 and 13 are the first and second priority in all DMUs.

As discussed above, the first priority of performance for the short-term, mid-term and long-term periods is DMU20, DMU23, and DMU11 respectively. These three DMUs are the benchmark companies for other DMUs in the different evaluating periods. The evaluation indicators of benchmarking companies are used for setting operation targets which are compared to other DMUs in different evaluating periods.

When management of construction companies pursues short-term performance, it is significantly affected by marketing of products. The companies especially focus on the ability of financing in short-term liability during operating periods and the probability of resources for each asset, too. With the extension of the operational period, the companies accumulate a variety of input resources and rely deeply on capital. Apart from the accumulation of operating assets, the companies are still confronted with short-term liability during operating periods. They should focus on the significant impact of performance during mid-term and long-term periods caused by capital management when the turnover rate of inventory slows down during the extended period. Therefore, it can effectively use the input resources to exploit the results of output.

7. Conclusion

This paper proposes a new model of performance evaluation which can filter the representative evaluation indicators of input and output according to the operational characteristics of construction companies and modify the indicators' correlation for ensuring the ability to distinguish performance evaluation. This model not only effectively assesses the performance of construction companies but also suggests valuable improvements for company operations.

The result of the case study indicates that the model can successfully accomplish the performance evaluation of short-term, mid-term and long-term periods for 27 listed (over-the-counter) construction companies in Taiwan. It can support the construction company with the first priority of performance for every different evaluating period as the benchmark, and therefore, use the benchmark company to be a learning target for other companies to draft operating decisions. In addition, the result also points out that it is more affected by marketing of products when the companies pursue short-term performance. They have to focus especially on the turnover rate of inventory and collecting cash in accounts receivable, and also be aware of the ability of short-term financing. If the companies pursue the

performance of mid-term and long-term periods which are affected by the planning and management of capital, they should notice the percentage of stockholders' equity for stabilizing the superior financial structure and planning the usage of assets.

The research in this paper not only provides a valuable analysis tool for assessing the performance of construction companies reasonably, but also offers useful information for practical operations. It will be helpful for investors, financial institutions, construction companies and people who are interested in engaging in the industry of constructions.

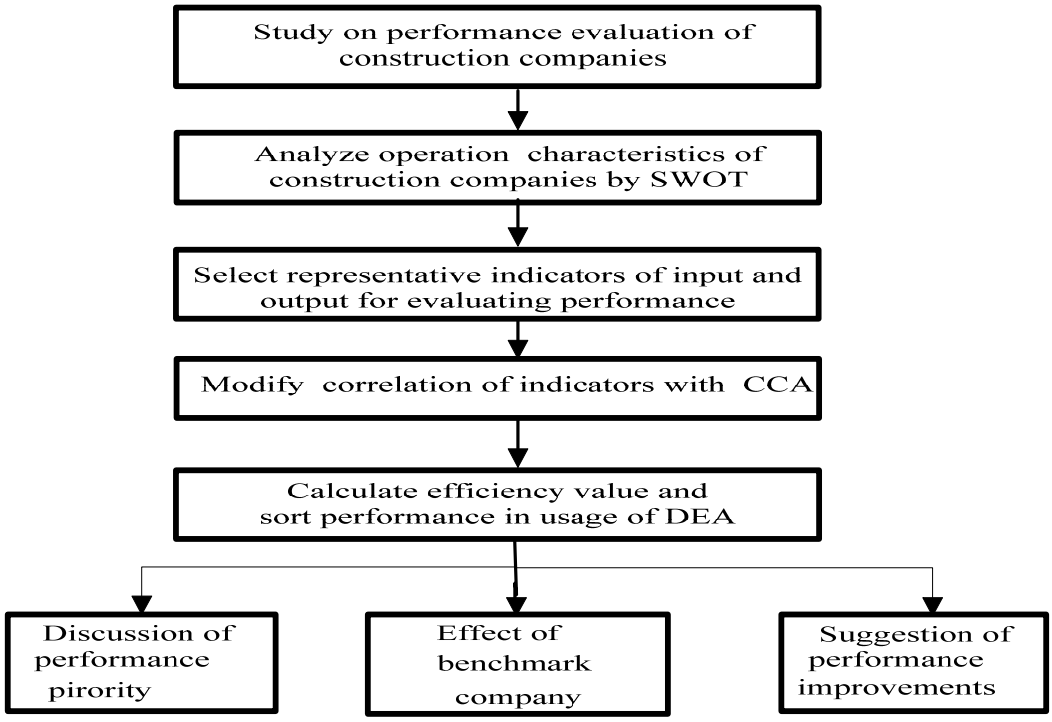

Fig. 1 Flowchart of performance evaluation model for construction companies

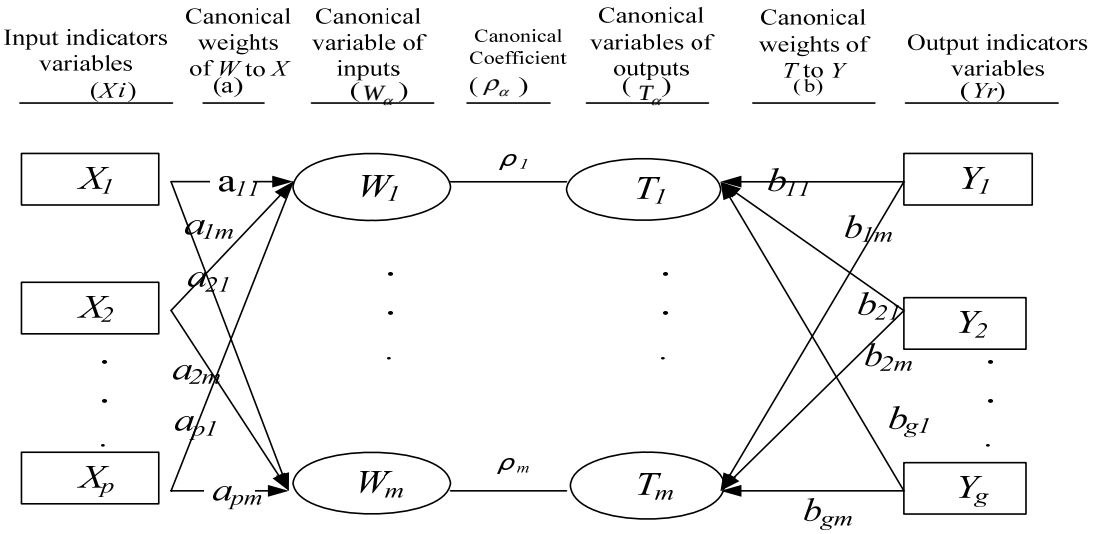

Fig. 2 Path of declining original indicators variables by using CCA

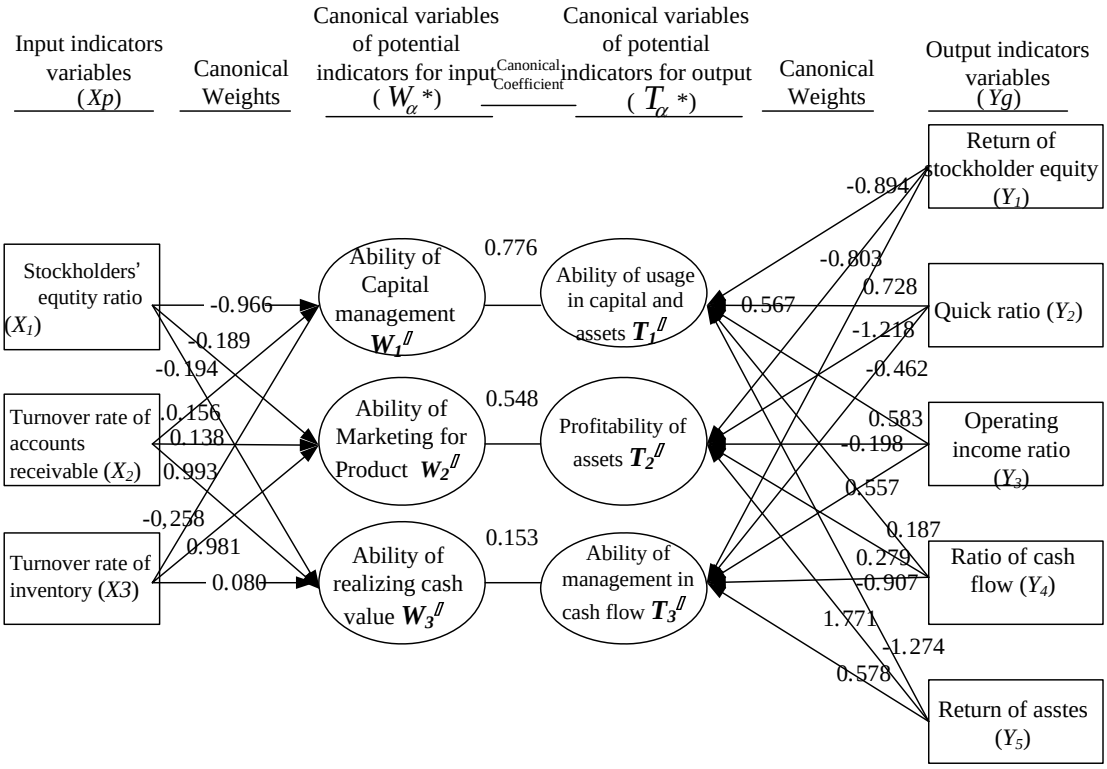

Fig. 3 Analysis of potential indicators for construction companies

Table 1 Financial ratios analyzed by using SWOT

SWOT Analysis		**Indicators of financial ratios**	
		inputs	**outputs**
Internal qualifications of business	Strength	Stockholders' equity ratio	Return of stockholders' equity
	Weakness	Turnover rate of inventory	Operating income ratio
			Quick ratio
External environments of business	Opportunity	Turnover rate of accounts receivable	Cash Flow Ratio
	Threat		Return of assets
			Operating income ratio

Table 2 Canonical Weights values of input and output potential indicators

Potential indicators of inputs	**inputs**			**Potential indicators of outputs**	**outputs**				
	X_1	X_2	X_3		Y_1	Y_2	Y_3	Y_4	Y_5
W_1*	-0.966	0.156	-0.258	T_1*	-0.894	0.567	0.583	0.187	-1.274
W_2*	-0.189	0.138	0.981	T_2*	-0.803	-1.218	-0.198	0.279	1.771
W_3*	-0.194	0.993	0.080	T_3*	0.728	-0.462	0.557	0.907	0.578

Table 3 Adjusted values of three group potential indicators (10years)

DMU	W_1*	W_2*	W_3*	T_1*	T_2*	T_3*
1	-6.25	0.56	1.44	-4.51	-2.29	0.06
2	-2.73	1.29	1.12	-0.59	0.57	0.08
3	-3.69	1.45	1.09	-0.26	0.36	0.36
4	-3.33	1.89	0.78	-0.41	0.39	0.36
5	-5.34	1.82	1.28	-2.43	0.59	-2.42
6	-4.14	1.3	1.47	-0.28	0.19	0.22
7	-2.75	2.44	1.24	-0.44	0.38	0.33
8	-4.1	1.01	2.34	-1.4	-0.96	0.61
9	-2.25	1.45	4.26	0	-0.11	-0.24
10	-3.52	0.99	1.55	-0.69	0.69	0.25
11	-4.95	1.16	1.58	-0.75	0.71	-0.2
12	-3.49	1.56	1.02	-0.64	0.54	0.28
13	-2.95	3.32	0.8	-0.75	1.7	-3.8
14	-3.44	2.56	0.98	-0.66	0.34	0.4
15	-2.96	2.15	2.48	-0.62	0.45	0.44
16	-2.96	2.18	1.42	-1.21	1.08	0.67
17	-5.33	4.09	1.58	-1.92	2.11	0.98
18	-4.09	4.45	1.03	-1.22	0.55	0.67
19	-3.07	2.14	1.14	-0.85	0.74	0.68
20	-2.79	2.97	0.9	0.81	-1.06	-0.16
21	-4.86	3.15	2.33	-1.76	2.16	0.56
22	-2.95	1.23	1.27	-0.27	0.28	0.3
23	-4.77	1.71	3.78	-1.15	0.91	0.4
24	-3.07	1.88	1.03	-1.16	1.28	0.86
25	-4.69	3.31	1.37	-2.59	2.73	0.81
26	-4.39	2.55	2.09	-0.77	0.43	-0.15
27	-3.25	3.54	4.42	-1.03	0.92	0.57

W_1* , W_2* , W_3 are adjusted values of standardized potential input indicators
T_1* , T_2* , T_3 are adjusted values of standardized potential input indicators

Table 4 Evaluation results for short-term, mid-term and long-term performance

DMU	Short-term performance			Mid-term performance			Long-term performance		
	Efficient value	number of apotheosis	Performance priority	Efficient value	number of apotheosis	Performance priority	Efficient value	number of apotheosis	Performance priority
1	1	23	2	1	1	7	1	18	2
2	0.709	0	23	0.799	0	16	1	2	11
3	0.819	0	12	0.788	0	18	1	6	6
4	0.631	0	24	0.649	0	24	1	17	3
5	1	4	5	1	24	2	1	4	8
6	0.981	0	6	1	13	4	0.982	0	16
7	0.713	0	22	0.887	0	12	0.679	0	24
8	0.831	0	11	0.725	0	21	0.875	0	19
9	0.583	0	27	0.794	0	17	0.656	0	25
10	0.921	0	8	0.913	0	9	1	4	8
11	0.773	0	16	0.876	0	13	1	21	1
12	0.758	0	19	0.705	0	22	1	2	11
13	0.589	0	26	0.900	0	10	1	1	13
14	0.770	0	18	0.973	0	8	0.890	0	18
15	0.771	0	17	1	9	5	0.468	0	26
16	0.732	0	20	1	21	3	0.729	0	22
17	0.886	0	10	0.599	0	25	1	10	4
18	0.941	0	7	0.589	0	27	1	3	10
19	0.799	0	13	0.890	0	11	0.804	0	21
20	1	27	1	0.698	0	23	1	1	13
21	0.908	0	9	0.592	0	26	0.920	0	17
22	0.618	0	25	0.808	0	15	1	1	13
23	1	5	4	1	26	1	0.835	0	20
24	0.797	0	14	0.730	0	20	1	5	7
25	0.720	0	21	0.777	0	19	1	7	5
26	0.784	0	15	0.813	0	14	0.695	0	23
27	1	20	3	1	5	6	0.403	0	27

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