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DEVELOPING AN ANALYTICAL MODEL FOR THE OPTIMAL CAPITAL STRUCTURE OF THE BUILDING COMPANY

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Key words: capital structure, building industry, grey system, correlation analysis.

ABSTRACT

The characteristics and accounting principles of the building industry is different from those of other industries, so few studies have discussed the capital structure of the building industry. In this paper, the grey system theory and Pearson correlation analysis are used to study the capital structure (debt ratio) of building companies and its relationship with the company's tax rate, non-debt tax shield, and operational risk, respectively. The results show that for building companies, non-debt tax shield has a positive correlation with the capital structure, whereas the operational risk has a very low correlation with the capital structure. The aforementioned results are different from those of previous researches on other industries. This paper also builds an analytical model for the optimal capital structure of building companies, which can serve as an evaluation tool when governments and lending institutions need to evaluate the financial stability of a building company.

I. INTRODUCTION

The operating goal of companies nowadays is to maximize the market value of the firm. The firm's source of fund is composed of internal equity and external debt. Capital structure refers to the way that a corporation finances its assets through some combination of equity and debt. The capital structure is highly relevant to the firm's safety and growth, as well as the debt-holders' safeguard. How to plan different sources of funding to maintain a proper capital structure is an important issue for managers.

In the traditional capital structure [7], the operating revenue is assumed not influenced by the changes in financial leverage, and then the firm's increase in liabilities will lead to a decrease in the cost of capital. The cost of capital will decrease until a certain point, at which the cost of capital will increase and the firm value will decrease. By optimizing the capital structure and adjusting the weighted average cost of capital to the lowest point, firm managers can bring the firm value to its highest value.

In the M-M theory [18], in the absence of corporation tax and individual income tax, the average cost of capital is not affected by the change of debt ratio. That is, the firm value is not related to the capital structure. As to the effect of tax shield [19], because the interest expense of debt is tax deductable, the weighted average cost of capital will decrease and the firm value will increase when the debt ratio increases. Studies on the capital structure drew the attention of many scholars, and other factors were put into consideration, such as individual income tax [17], bankruptcy costs [12], information asymmetries [20], and agency costs [11]. The two mainstream theories of capital structure are the static trade-off theory and the pecking order theory.

According to the static trade-off theory, the firm will determine an optimal level of leverage to minimize the cost of capital after evaluating the tax benefits of debt versus the associated bankruptcy and agency costs. The higher the firm's leverage is, the higher the interest expense becomes, and thus the higher the risk of bankruptcy is. Studies have shown that when the marginal tax gain caused by debt equals the marginal bankruptcy cost, the firm value is at its highest [2, 13, 25]. The firm value will decline as the debt gradually increases, and thus firms can use the optimal capital structure. Considering the factors that affect the capital structure of firms from the viewpoint of the dynamic capital structure choice [21], the existence of long-term target debt ratio is found and the fast speed to adjust to the long-term target debt ratio is confirmed.

In the pecking order theory [20], under the condition of asymmetric information, firms consider the information cost and the transaction cost in the choice of its actual financing method. To minimize problems caused by external information asymmetry, corporate finance uses internal funding first, debt financing next, and equity financing last. The pecking order theory explains that firms with high profitability have enough internal funding to use freely without the need of external finance, and thus they maintain lower debt ratio and

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financial leverage. On the other hand, firms with low profitability need external finance. And, since the cost of equity is higher than the cost of debt, the main external finance is debt, which causes higher debt ratio. From the analysis of the source of finance in American investing cases [15], most capital comes from debt and retained earnings, and the debt capacity depends on the amount of the firm's self-owned capital.

Studies on capital structure are mostly done on the overall industry, the financial industry, or high tech industry. As for the construction industry, only studies on the capital structure of BOT concessionaires are available [30, 31]. Yet construction companies are often the sponsors of BOT concessionaires, and a sponsor without a sound capital structure will induce financial crisis which eventually harms the concessionaires. This paper has two goals. One is to understand the factors that affect the capital structure of building companies. And, the other is to find the optimal capital structure decision model of building companies to serve as an evaluation tool for governments and lending institutions.

II. LITERATURE REVIEW

1. Factors that Decide Cpaital Structure

The factors that decide capital structure include change of revenue, growth opportunity, firm size, non-debt tax shield, profitability, and industry characteristics. Heshmati [10] and Hans [9] believed that unstable revenue prevents the firms from paying interest as scheduled, which causes the risk of bankruptcy and thus the risk of default. Titman and Wessels [27] indicated that the higher the firm's potential for growth is, the more inclined managers are to finance with debt in order to maximize their wealth, and thus the debt ratio and the firm's growth are thought to have a positive relation. Several researchers believed that the firm size is related to the cost of equity or cost of debt [14, 24, 27]. Small companies have higher capital raising costs than big companies, so small companies prefer short-term borrowing, and hence the firm size has a negative relation with the short-term borrowing ratio. Firm size is positively related to corporate bonds but negatively related to the bank debt.

Non-debt tax shield is called so because it is not a tax credit derived from debt items, for example, the firm can file the depreciation expense as a tax credit item to reach a tax shield effect, or R&D investment can serve as tax credit and receive subsidiary. DeAngelo and Masulis [6] and Balakrishnan and Fox [1] believed that non-debt tax shield to have a negative relation with debt ratio. Firms of high profitability have a higher possibility of retaining higher retained earnings, which means they won't have to use debt financing until their abundant internal fund is used up. According to the pecking order theory, debt ratio is negatively related to profitability. Several researchers have reported that a firm of high profitability can satisfy the funding needs within itself and free the firm of many debts [16, 27]. Thus, the higher the profitability of a firm is, the lower its debt ratio is.

Different industries have different business risks, product life cycles, business cycles, and assets, so industry characteristics are important factors to determine a firm's debt ratio [23]. Through one-way analysis of variance to determine whether industry type affects capital structures, it is confirmed that capital structures of different industries are significantly different [3, 22]. The companies within the same industry have more similar capital structures than companies from different industries, and the relative order of debt ratios between industries has a tendency to stay constant [2]. According to the investigation of the a firm's financing decision from the viewpoint of agency cost and tax [28], the higher the effective corporate tax rates and fixed assets to total assets ratio are, the more often firms choose to finance with debt. Chung [5] studied the relation between a firm's industry type and financing policy, and he concluded that firms with high fixed asset ratio have a tendency to have long-term debt. The building companies analyzed in this paper belong to the same industry and have similar firm sizes. Thus the variables "industry characteristics" and "firm size" are fixed. The uncertainties caused by change of revenue, growth opportunity, and profitability are jointly named "operational risk".

2. Industry and Financial Characteristics of the Building Industry

The industry and financial characteristics of the building industry are different from those in manufacturing industries, and they are listed as follows:

Firstly, the elasticity of demand and supply is low. Due to the long operation cycle from exploitation to completion, excess of supply or demand often occurs from change in prosperity and regulations. Since revenue is unstable, the firm's profitability is also unstable.

Secondly, the inventory to total asset ratio is relatively high. The inventories in the building investment industry include land, construction in progress, and houses for sale, which make up for most of the total asset. In addition, the time for inventory to realize in cash is long, so the building industry relies highly on short-term loans from banks.

Thirdly, the non-debt tax shield is low. Non-debt tax shield includes depreciation, amortization, and R&D investment, all of which are low in building companies. Building companies have lower depreciation compared with other fields. This is because the only fixed assets of building companies are buildings and land for rent or operation, which have long depreciable lives. R&D investment is also relatively low in building companies, because large investments in technology renewal are not needed.

Fourthly, the actual rate of income tax is low. In most industries, land is only one of the factors of production, but in the building industry, land is the most important production material and also the final product. Since land profit is tax deductable, building companies pay a great deal less on income tax.

Fifthly, the indirect cost of bankruptcy is low. Indirect costs of bankruptcy are the losses caused by assets being sold in the process of bankruptcy liquidation. Related literatures consider the characteristics of an asset to affect the value of it being used for its next-best purpose, which affects the indirect bankruptcy cost. The assets of building companies are mostly buildings and lands, which have a very active market, thus the indirect cost of bankruptcy is relatively low.

III. THE OPTIMAL CAPITAL STRUCTURE MODEL

Based on the single-period model [4], an optimal capital structure model will be developed herein. As to the bankruptcy cost considered herein, it includes the direct and indirect costs of bankruptcy [12, 13, 26].

1. Assumptions and Definitions of Variables

For the development of model, the following assumptions are made. (1) Investors are risk-neutral; (2) The firm faces a constant tax rate; (3) Interest payments are fully deductable in calculating the firm's end-of-period tax bill; (4) There exists non-debt tax shields, such as accelerated depreciation, amortization, and R&D investment that reduce the burden of tax; (5) Unused tax credits are not transferrable either through time or across firms; and (6) The firm will incur various costs associated with financial distress should it fail to meet, in full, the end-of-period payment promised to its bondholders.

In addition, variables are defined as follows. (1) X is the firm's value before taxes and debt payment and the variable X follows some kind of probability distribution. (2) Y is the amount of money paid due to debt, including interest and capital. (3) $f(\mathrm{x})$ is the probability density function (PDF) of variable X. The higher the dispersion of variable X, the higher the operational risk of the firm is. (4) kX is the bankruptcy cost. The money reclaimed by stockholders and bondholders in bankruptcy is necessarily less than what could have been reclaimed before bankruptcy. The bankruptcy cost includes direct bankruptcy cost (payments to the attorney, accountant, reorganizer, and liquidator), indirect bankruptcy cost (the losses caused by assets being sold in the process of bankruptcy liquidation), and tax credits that could have been enjoyed in the absence of bankruptcy. (5) φ is the firm's non-debt tax shield (i.e. the tax credits obtained from things other than debt, including depreciation, amortization, and R&D investment). And, (6) t is the tax rate of the firm's income tax.

2. Inference of the Optimal Capital Structure Model

The capital structure is composed of the firm's equity and debt. When the debt expires, stockholders can have the residual value after subtracting the debt if the market value of the firm's assets is higher than the debt. If the asset value is lower than the debt, stockholders will choose bankruptcy and limited liability, and the firm's assets will go to the bondholders. According to the different cases of tax rates and non-debt tax shield, the optimal capital structure is inferred as follows.

The gross return to stockholders:

(1) When $Y > X$, the gross return to stockholders = 0
(2) When $Y + \varphi > X > Y$, the gross return to stockholders = X-Y
(3) When $X > Y + \varphi$, the gross return to stockholders = $(X\text{-}Y)(1\text{-}t) + \varphi t$

Multiplying the above cases by the PDF of X gives the market value of the firm's stocks:

$$S = \int_{Y}^{Y+\varphi} f(X)(X-Y)dX + \int_{Y+\varphi}^{\infty} f(X)\left[(X-Y)(1-t)+\varphi\, t\right]\cdot dX \tag{1}$$

The gross return to bondholders:

(1) When $X > Y$, the gross return to bondholders = Y
(2) When $Y > X$, the gross return to bondholders = $(1 - k)\, X$

In a like manner, multiplying the above cases by the PDF of X yields the evaluation of market value of the firm's bonds:

$$B = \int_{0}^{Y}(1-k)\, f(X)X \cdot dX + \int_{Y}^{\infty} f(X)YdX \tag{2}$$

Market value of the firm of the single period model:

The firm value comes from stock value and bond value. The firm value is:

$$\begin{aligned} V = S + B = & \int_{Y}^{Y+\varphi} f(X)(X-Y)dX \\ & + \int_{Y+\varphi}^{\infty} f(X)\left[(X-Y)(1-t)+\varphi\, t\right]dX \\ & + \int_{0}^{Y}(1-k)\, f(X)XdX + \int_{Y}^{\infty} f(X)YdX \end{aligned} \tag{3}$$

The optimal capital structure is the debt value that maximizes firm value. Differentiating firm value to debt gives

$$\frac{\partial V}{\partial Y} = \left[1 - F(Y+\phi)\right]\cdot t - Ykf(Y) = V_Y \tag{4}$$

When $V_Y = 0$, the firm value is at its maximum. That is, Y is the optimal debt.

IV. DESCRIPTION OF THE GREY SYSTEM THEORY

This paper uses cross-sectional analysis to analyze the relationship between capital structure and its factors in different companies of the same year. The parameters of all sample companies are observed to gather statistics of their relationship. The relational analysis in the Grey System Theory is used. The main goal is to find the relationship between capital structure and its affecting factors, to see whether the relation is positive or negative, and to what extent.

1. Theoretical Framework

The Grey System Theory studies systems with unclear information and incomplete data by making relational analysis and model construction. Its main function is to deal with uncertainty, multi-input, discrete data, and incomplete data. In the System Theory, the completeness of messages provided by systems is often expressed with different shades of color. White systems represent systems with completely clear messages, and black systems represent systems with messages that are totally unknown or unclear. Grey systems represent systems with partially clear and partially unclear messages. White Systems and Black Systems are not totally independent from each other; or rather they are Grey-Box Systems that blend together. The Grey-Box was expanded to the Grey System which uses white messages to obtain solutions. The evolution process of Grey System into White Systems is called bleaching or diluting.

There are six methods in the Grey System Theory. (1) Grey Generating: a method for finding hidden rules inside the data message. (2) Grey Relational Analysis: a method for testing the relation of discrete series. (3) Grey Model: a process to establish a set of grey difference and grey differential models using generating data. (4) Grey Prediction: to predict based on the Grey Model. (5) Grey Decision Making: it is the prediction of grey elements using the concepts and methods of Grey System. And, (6) Grey Control: it uses data to predict and control future behavior. This is a new control method similar to Artificial Intelligence and has the ability to self-adjust.

2. Difference between Grey System Theory and Mathematical Statistics

Probability and statistics, or treating data with statistical rules, is the usual way to solve the uncertainty in system randomness. In mathematical statistics, the larger the sample size is, the better the statistical analysis is. Yet in actual situations, two situations are often encountered. First, many systems don't have typical distributions even with a large sample size. Rather they have non-typical randomness, which is hard to deal using statistical methods. Second, many Grey Systems don't have physical prototype, making it hard to judge the messages. In addition, scarce data makes it hard to deal using statistical methods.

The grey process does not have the aforementioned limitations. In fact, using the theories and methods of the grey system to analyze data finds order in disorder. Other ways to solve uncertainty in fuzzy systems is Fuzzy Math, Fuzzy System, and Fuzzy Control. In large systems, the solution found using mathematics and control theories is often impossible. This is because the complicatedness and accuracy of a system cannot coexist. In fact, large systems often lack complete information, which is to say that the hugeness and complexity is just the symptom, not the nature of a system. The nature of a system is grey. This explains why other theories are required to deal with large systems, and this is how the Grey System Theory developed. Traditional mathematical statistics handles the relationship between variables, and requires any two variables to have mutual effects on each other. Apart from needing a great quantity of data, mathematical statistics also requires finding the functional relationship to make calculations, and thus it suffers from the following three disadvantages. First, it needs a great quantity of data. Second, the data must be normally-distributed. Third, changing factors cannot be too many.

Due to the aforementioned disadvantages, it is often hard to find the solution. The Grey Relational Analysis has the advantage of analyzing with scarce data and many factors, which makes up for the disadvantages of statistics. With the development of technology, people not only need to make qualitative analyses, but also quantitative analyses, of society, economic, and ecological systems. These systems don't have physical prototypes, and thus its mechanism, principle role, relation between factors, structure, etc are undefined. People can only use logic, concepts, and other criteria to verify the system's structure, relationship, mechanism, etc. Although this kind of verification helps understanding the system, it is also very limited, and thus no complete theory has been formed yet. The Grey System Theory is the solution to further understand these kinds of systems.

3. Grey Relational Analysis

The objective of Grey Relational Analysis is to find the main relationship between each factor in the system, to find the important determinant that affects the target value, and to control the main characteristics and induce the system to develop quickly and effectively. The Grey Relational Analysis compares the changes in a system's development and uses the four theorems based on the space theory: normative, dual symmetry, holistic, and proximity, to find the correlation coefficient and correlation of the reference series and several comparative series. The Grey Relational Analysis can materialize, quantify, model, and optimize both abstract and real systems. It serves as a communication means between social science and natural science, and can be applied broadly.

V. DATA AND EMPIRICAL RESULTS

This paper uses cross-sectional analysis to analyze the relationship between capital structure and non-debt tax shield, variation of firm value, tax rate, and other factors in different companies of the same year. The parameters of all sample companies are observed and calculated to gather statistics of their relationship. The sample size of this empirical data is less than 30, so the grey system theory is used as a research method. The main goal is to find the relationship between the affecting factors and the capital structure, including whether the relation is positive or negative and to what extent.

1. Description of Data

The data in this empirical study are obtained from annual financial reports or open specifications of listed building companies. The interest market value data is obtained from Taiwan Stock Exchange. The object of study is limited to building companies. The construction stocks in Taiwan include construction companies and building companies. This paper chooses building companies based on the operation proportion stated on open specifications. Building companies with operation proportion in building, rent, or sale (including parking space) higher than 85% are chosen for this study. A total of 23 significant samples are used herein.

2. Definition of Variables in Empirical Study

With reference to other empirical studies and consideration on feasibility of data collection, four variables used herein are defined as follows:

(1) Capital structure (debt ratio)

The existence of optimal capital structure can simultaneously maximize the total market value and minimize the average cost of capital. Most scholars use the market value and not the book value as the benchmark of capital structure. In this empirical study, capital structure is defined as:

$$\text{Capital structure} = \text{total debt}/(\text{equity marker value} + \text{total debt}) \quad (5)$$

(2) Operational risk

Operational risk represents the uncertainty of the company's future surplus. In this study the coefficient of variation of EBIT is used to measure the operational risk, and is defined as:

$$\text{Operational risk} = \text{standard deviation of EBIT}/\text{average of EBIT} \quad (6)$$

(3) Non-debt tax shield

The non-debt tax shield is defined as:

$$\text{Non-debt tax shield} = (\text{depreciation} + \text{amortization})/\text{total asset} \quad (7)$$

(4) Tax rate

The building industry has long operation cycles and thus using percentage-of-completion method to recognize revenue will cause the operational revenue to have big variations, which will in turn affect the income tax rate. The effective rate is defined as:

$$\text{Effective tax rate} = \text{income tax}/\text{earning before tax} \quad (8)$$

And, the adjusted income tax rate is defined as:

$$\text{Adjusted income tax rate} = (\text{current effective tax rate} + \text{pre effective tax rate})/2 \quad (9)$$

Table 1. Statistical results of variables.

Variable	Median	Mean	Standard Deviation	Coefficient of variation	Max. value	Min. value
Capital structure	0.3770	0.38439	0.11741	0.305	0.6090	0.1900
Adjusted tax rate	0.0099	0.04195	0.08823	2.103	0.3441	-0.0365
Non-debt tax shield	0.0008	0.00112	0.00097	0.866	0.0037	0.0003
Operational risk	0.8200	1.30391	1.22268	0.938	5.1400	0.1700

Table 2. Correlation between capital structure and each of the other three variables.

Correlation coefficient		
Tax rate	Non-debt tax shield	Operational risk
0.26	0.413	-0.104

3. Descriptions of Statistic Analysis

The statistics of the samples used in this paper are summarized Table 1.

From Table 1, the following points can be concluded. (1) The capital structures of different building companies differ greatly from one another. A possible reason is that this research uses market value as the base for the calculations of capital structure. In recession, investors tend to give lower evaluations to companies with high debt and higher evaluations to those with low debt, which causes the big difference in capital structures between different companies. (2) The average adjusted tax rate is only about 1%. This is due to regulations that state land income tax deductable, giving building companies low tax rates. (3) Building companies have low non-debt tax shield/total asset ratios, most of them lower than 0.001. This reflects the low fixed assets and its long depreciable life in the building industry. (4) The maximum value and minimum value of operational risk in building companies are ranged widely apart. This reflects the huge effect the environment of the economy has on building companies in recent years.

Results of the Pearson correlation analysis are presented in Table 2.

It can be inferred from the correlation analysis results that the correlation of capital structure and non-debt tax shield is the highest, followed by the correlation between capital structure and tax rate, and finally the correlation is the lowest between capital structure and operational risk. The non-debt tax shield and adjusted tax rate are positively related and the operational risk is negatively related.

4. Grey Relational Analysis

In this empirical study, the sample size is 23, which does not reach the usual demand of a sample size of at least 30. The Grey System Theory does not have sample size limitations, and thus the Grey Relational Analysis is used to verify Pearson's analysis results. The mathematics of the Grey Relational Analysis is as follows:

(1) Data processing $X_i(k) = (X(1), X(2),…, X(k))$ to establish each data series.

The data must meet the following conditions to be a comparable series: (i) Non-dimensional: Regardless of the factor measure, the data must be dimensionless. (ii) Scaling: $X_i(k)$ in each series must be of the same level or the level difference must not exceed 2. (iii) Polarization: The descriptions of factors within each series must be the same direction.

In order for the series to be comparable for the Grey Relational Analysis, "Grey Relation Generating" must be used. Grey Relation Generating is categorized into the following three kinds:

(a) The larger the better:

$$X_i^*(k) = [X_i(k)\text{-min } X_i(k)]/[\text{max } X_i(k)\text{-min } X_i(k)] \quad (10)$$

(b) The smaller the better:

$$X_i^*(k) = [\text{max } X_i(k)\text{-}X_i(k)]/[\text{max } X_i(k)\text{-min } X_i(k)] \quad (11)$$

(c) The closer to the target the better:

$$X_i^*(k) = 1\text{-}[X_i(k)\text{-OB}]/\text{max } [\text{max } X_i(k)\text{-OB, OB- min } X_i(k)] \quad (12)$$

In this study, (a) the larger the better and (b) the smaller the better are used on the data, and the results are shown in Table 3.

(2) Calculate the factor difference $\Delta oj = ||X_o(k)\text{-}X_i(k)||$, j = 1, 2, ..., m, k = 1, 2, ..., n. The factor difference in each series is presented in Table 4. It was found that using "the larger the better" and "the smaller the better" produced the same factor differences.

(3) Finding the max difference and min difference

$$\Delta_{\min} = \min_j \min_k \left\| X_0(k) - X_j(k) \right\| \quad (13)$$

$$\Delta_{\max} = \max_j \max_k \left\| X_0(k) - X_j(k) \right\| \quad (14)$$

Table 3. Data of the Grey Relational Analysis.

The larger the better				The smaller the better			
Capital structure X_0	Adjusted tax rate X_1	Non-debt tax shield X_2	Operational risk X_3	Capital structure X_0	Adjusted tax rate X_1	Non-debt tax shield X_2	Operational risk X_3
0.3699	1.0000	0.7918	0.1227	0.6301	0.0000	0.2082	0.8773
0.0597	0.1363	0.0850	0.0563	0.9403	0.8637	0.9150	0.9437
0.4463	0.0959	0.1496	0.2978	0.5537	0.9041	0.8504	0.7022
0.6730	0.1945	0.0704	0.0000	0.3270	0.8055	0.9296	1.0000
0.6325	0.2333	0.4135	0.1087	0.3675	0.7667	0.5865	0.8913
0.9761	0.5067	1.0000	0.0543	0.0239	0.4933	0.0000	0.9457
0.1384	0.1219	0.6745	0.5634	0.8616	0.8781	0.3255	0.4366
0.4749	0.0959	0.1144	0.2334	0.5251	0.9041	0.8856	0.7666
0.9523	0.6740	0.2581	0.1690	0.0477	0.3260	0.7419	0.8310
0.3962	0.0882	0.1525	0.2374	0.6038	0.9118	0.8475	0.7626
0.1289	0.1626	0.0117	0.6660	0.8711	0.8374	0.9883	0.3340
1.0000	0.0672	0.7977	0.4487	0.0000	0.9328	0.2023	0.5513
0.6325	0.3158	0.0000	0.1308	0.3675	0.6842	1.0000	0.8692
0.5656	0.0000	0.1026	0.0966	0.4344	1.0000	0.8974	0.9034
0.2601	0.0431	0.1584	0.4125	0.7399	0.9569	0.8416	0.5875
0.0000	0.1887	0.0440	0.0121	1.0000	0.8113	0.9560	0.9879
0.5465	0.1151	0.0088	0.0382	0.4535	0.8849	0.9912	0.9618
0.6253	0.0878	0.2493	0.2616	0.3747	0.9122	0.7507	0.7384
0.1647	0.1384	0.0674	0.0221	0.8353	0.8616	0.9326	0.9779
0.4320	0.2678	0.1877	0.0785	0.5680	0.7322	0.8123	0.9215
0.4511	0.1078	0.0499	1.0000	0.5489	0.8922	0.9501	0.0000
0.5060	0.0385	0.1906	0.0744	0.4940	0.9615	0.8094	0.9256
0.2387	0.0624	0.2639	0.1630	0.7613	0.9376	0.7361	0.8370

From Table 4, the maximum difference is 0.9328, and minimum difference is 0.0033.

(4) Setting the identification coefficient ζ (between 0 and 1) according to actual needs

The main function of the identification coefficient (ζ) is to compare the background value and the test object, and its magnitude can be adjusted according to actual need. It has been proven that the variant identification coefficient will only change the relative value, and not the sorting of Grey Relation. Normally ζ is set around 0.5, but it can adjust to add differences. The ζ value in this empirical study is set as 0.5.

(5) Finding the grey relational coefficient

$$\gamma\left(X_0(k), X_j(k)\right) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{0j}(k) + \zeta\Delta_{\max}},\ j = 1, 2, 3;$$

$$k = 1, 2, ..., 23 \quad (15)$$

The grey relational coefficients are shown in Table 5.

(6) Finding the grey relational grade

$$\gamma\left(X_0, X_j\right) = \frac{1}{n}\sum_{k=1}^{n}\gamma\left(X_0(k), X_j(k)\right) \quad (16)$$

The grey relational grade is the average grey relational coefficient in each series.

Table 4. The factor difference in each series.

The larger the better				The smaller the better			
Item	Δ01	Δ02	Δ03	Item	Δ01	Δ02	Δ03
$k = 1$	0.6301	0.4219	0.2472	$k = 1$	0.6301	0.4219	0.2472
$k = 2$	0.0766	0.0254	0.0033	$k = 2$	0.0766	0.0254	0.0033
$k = 3$	0.3504	0.2967	0.1485	$k = 3$	0.3504	0.2967	0.1485
$k = 4$	0.4786	0.6026	0.6730	$k = 4$	0.4786	0.6026	0.6730
$k = 5$	0.3991	0.2190	0.5238	$k = 5$	0.3991	0.2190	0.5238
$k = 6$	0.4694	0.0239	0.9218	$k = 6$	0.4694	0.0239	0.9218
$k = 7$	0.0165	0.5361	0.4250	$k = 7$	0.0165	0.5361	0.4250
$k = 8$	0.3790	0.3606	0.2415	$k = 8$	0.3790	0.3606	0.2415
$k = 9$	0.2783	0.6942	0.7833	$k = 9$	0.2783	0.6942	0.7833
$k = 10$	0.3080	0.2437	0.1588	$k = 10$	0.3080	0.2437	0.1588
$k = 11$	0.0337	0.1171	0.5371	$k = 11$	0.0337	0.1171	0.5371
$k= 12$	0.9328	0.2023	0.5513	$k = 12$	0.9328	0.2023	0.5513
$k = 13$	0.3166	0.6325	0.5017	$k = 13$	0.3166	0.6325	0.5017
$k = 14$	0.5656	0.4630	0.4691	$k = 14$	0.5656	0.4630	0.4691
$k = 15$	0.2170	0.1018	0.1523	$k = 15$	0.2170	0.1018	0.1523
$k = 16$	0.1887	0.0440	0.0121	$k = 16$	0.1887	0.0440	0.0121
$k = 17$	0.4314	0.5377	0.5083	$k = 17$	0.4314	0.5377	0.5083
$k = 18$	0.5375	0.3760	0.3637	$k = 18$	0.5375	0.3760	0.3637
$k = 19$	0.0263	0.0972	0.1425	$k = 19$	0.0263	0.0972	0.1425
$k = 20$	0.1641	0.2443	0.3535	$k = 20$	0.1641	0.2443	0.3535
$k = 21$	0.3433	0.4012	0.5489	$k = 21$	0.3433	0.4012	0.5489
$k = 22$	0.4675	0.3154	0.4315	$k = 22$	0.4675	0.3154	0.4315
$k = 23$	0.1763	0.0253	0.0757	$k = 23$	0.1763	0.0253	0.0757
Max	0.9328	0.6942	0.9218	Max	0.9328	0.6942	0.9218
Min	0.0165	0.0239	0.0033	Min	0.0165	0.0239	0.0033

Table 5. The grey relational coefficients.

Item	Δ01	Δ02	Δ03
$k = 1$	0.4285	0.5289	0.6584
$k = 2$	0.8652	0.9555	1.0000
$k = 3$	0.5752	0.6156	0.7640
$k = 4$	0.4972	0.4395	0.4123
$k = 5$	0.5427	0.6854	0.4744
$k = 6$	0.5020	0.9582	0.3384
$k = 7$	0.9729	0.4686	0.5270
$k = 8$	0.5557	0.5681	0.6637
$k = 9$	0.6309	0.4048	0.3759
$k = 10$	0.6067	0.6616	0.751
$k = 11$	0.9394	0.8050	0.4682
$k = 12$	0.3358	0.7026	0.4616
$k = 13$	0.5999	0.4275	0.4853
$k = 14$	0.4552	0.5055	0.5022
$k = 15$	0.6874	0.8270	0.7592
$k = 16$	0.7171	0.9205	0.9818
$k = 17$	0.5233	0.4679	0.4820
$k =18$	0.4680	0.5577	0.5660
$k = 19$	0.9535	0.8334	0.7714
$k = 20$	0.7450	0.6610	0.5730
$k =21$	0.5802	0.5415	0.4627
$k = 22$	0.5031	0.6009	0.5232
$k = 23$	0.7310	0.9557	0.8666
Grey relational grade	0.6268	0.6562	0.6030

Table 6. Values of σ_i and σ_k for each variable.

Item	Capital structure	Tax rate	Non-debt tax shield	Operational risk
σ_k	1012	1012	1012	1012
σ_i	5.34	15.25	15.66	-4.62
Correlation to Capital Structure		Positive correlation	Positive correlation	Negative correlation

Table 7. The empirical and theoretical results.

Item	Tax rate	Non-debt tax shield	Operational risk
Theoretical	+	−	−
Empirical	+	+	−

(7) Finding the grey relational order

The results of this study is: X_2(non-debt tax shield) > X_1(adjusted tax rate) > X_3(operational risk).

5. Grey Relational Analysis-Polarity Analysis

The Grey Relational Order can only reflect the important factors that affect the target value, and not the polarity of the relationship. Fu [8] provided the following method to distinguish factor relation characteristics.

The σ_k and σ_i are defined as:

$$\sigma_k = \sum_{k=1}^{n} k^2 - \left(\sum_{k=1}^{n} k\right)^2 / n \tag{17}$$

$$\sigma_i = \sum_{k=1}^{n} kXi(k) - \sum_{k=1}^{n} X_i(k) \sum_{k=1}^{n} k/n \tag{18}$$

If $\mathrm{sgn}(\sigma_i/\sigma_k) = \mathrm{sgn}(\sigma_j/\sigma_k)$ where sgn is a symbol function, then X_i and X_j are positively related. If $\mathrm{sgn}(\sigma_i/\sigma_k) = -\mathrm{sgn}(\sigma_j/\sigma_k)$, then X_i and X_j are negatively related. According to above equations, the values of σ_i and σ_k for each variable are presented in Table 6.

The conclusions of the Grey Relational Analysis are:

(1) Level of relation to capital structure: X_2(non-debt tax shield) > X_1(adjusted tax rate) > X_3(operational risk). (2) Polarity of relation: X_2(non-debt tax shield) and X_1(adjusted tax rate) are positively correlated to capital structure, and X_3(operational risk) is negatively correlated to capital structure.

6. Conclusion of Analysis Results

The results of relational analysis derived from the Grey System Theory and from statistics are the same. The empirical results and the theoretical results are compared in Table 7.

The empirical results for tax rate and operational risk are the same as the theoretical results. As for the non-debt tax shield, it bears different results theoretically and empirically, and yet it has the highest relativity to the capital structure out of all three. A plausible explanation is that companies with high percentages of rent business have more fixed assets and higher depreciation amounts; this is probably because the income of renting houses is stable, so companies are willing to finance with higher debt. The result is that companies with high non-debt tax shield also have high level of debt.

VI. CASE STUDY

Applying the framework derived from section III to an example building company, we will find the optimal capital structure of this company. The building company used herein as an example here is well-performed and mainly deals with building national housing, operating parking lots, and selling commercial buildings. It has built almost 50,000 houses of all types and is well-known in Taiwan.

The assumptions made in section III are single-period models. To make actual estimations, the single-period models must be expanded into multi-period continuous models. The firm value comes from adding up the discounted value of future cash inflows, and the debt value comes from the discounted value of each period's debt outflow. The comparison between single-period and multi-period discounted model is shown in Table 8.

Table 8. Comparison of model parameters.

Item	Single-period model	Multi-period discounted model
X	The firm's value before taxes and debt payment	The firm's market value
Y	The amount of money paid due to debt	Debt market value
φ	Non-debt tax shield of each period	Total discounted value of each period Non-debt tax shield
$f(X)$	The PDF of the firm's value before taxes and debt payment	The PDF of the firm market value

1. Estimation of Probability Density Function of Company Value

The historical stock prices of the sample companies in this empirical study are obtained from Taiwan Stock Exchange. This study uses the K-S test because its precision is better than the chi-square goodness-of-fit test for continuous probability distributions. The K-S method does not have the limitation of theoretical number of times ≥5, and retains the originality of the data. The test result does not reject the hypothesis of the data being a normal distribution. Thus we can say that the population loss ratio fits the normal distribution with μ = 25,456 million and σ = 3,490 million.

2. Estimation of Bankruptcy Cost

Estimation of Indirect Bankruptcy Cost:

In this paper, indirect bankruptcy cost is defined as the losses caused by assets being sold in the process of bankruptcy liquidation. According to the characteristics of building companies, assets can be divided into the following four categories: (1) land, (2) house for sale, (3) construction in progress, and (4) other assets. The indirect bankruptcy costs of these four types of assets are studied here.

Analyzing building companies that were forced to sell land or house assets to cut down debt during financial crisis, it was possible to calculate the indirect bankruptcy cost of land. The average loss ratio was 24.45%, with standard deviation 10.85%, and this result passed the normal distribution test. Survey of the unit price of foreclosed home and new houses gave us an idea of the indirect bankruptcy cost of houses for sale. The average loss percentage was estimated to be about 15.9%. The handling of construction in progress differs from case to case. Thus experts were interviewed to estimate the indirect bankruptcy cost of constructions in progress in the company used for case study, and the result was 35%. Other assets of the company used for case study mainly include: short-term investment, and long-term investment. The short-term investment mainly consists of stocks of listed companies. The long-term investment mainly consists of an investment in a financial tower, which is calculated into the bankruptcy cost of construction in progress. The indirect bankruptcy cost of other assets is estimated to be 10%.

Estimation of Direct Bankruptcy Cost:

According to Kim [12], direct bankruptcy cost is defined as the costs that must be paid in the process of reorganization and liquidation. The study of Warner [29] indicated that the larger the size of the company is, the less important the direct bankruptcy cost is. This is referred as the size effect of direct bankruptcy cost. Expert interviews with lawyers with experience in bankruptcy cases verified the existence of the size effect. Considering the size of the company used for case study and the time needed for it to deal with bankruptcy, the direct bankruptcy cost is estimated to be about 1%.

Loss of Tax Credits that Could Have Been Enjoyed in the Absence of Bankruptcy:

Once it encounters bankruptcy, the company loses many benefits. One example is that tax regulations provide tax credit, which, if the firm continues its operation, adds to the after-tax profit and cash flow. The tax benefit is accounted as the deferred tax asset. According to the financial report, the deferred tax asset amount is NT$78,390,000, which makes up 0.32% of the total asset.

The estimated total bankruptcy cost of the company used for case study is as Table 9. The estimated direct bankruptcy cost is 1%, the estimated indirect bankruptcy cost is 24.5%, and the estimated bankruptcy cost makes up 25.5% of the total asset.

3. Tax Rates Used

Analyzing the income tax information in financial reports of the sample companies, it was found that the deduction of

Table 9. The estimated total bankruptcy cost of the company used.

Item		Estimated value	Weight of asset	Estimated bankruptcy cost
Indirect bankruptcy cost	House	24.5%	40.1%	9.82%
	Land	15.9%	17.8%	2.83%
	Construction in progress	35%	29.3%	10.26%
	Other	10%	12.8%	1.28%
	Deferred income tax assets			0.32%
Direct bankruptcy cost				1%
Total				25.5%

Table 10. Summary of parameters of the case study.

Item	Estimation
Bankruptcy cost	25.5%
Income tax rate	8%
Non-debt tax shield	1,280
PDF of market value	Normal distribution, μ = 25,456, σ = 3,490

land income tax drastically lowers the taxable income. The average income tax rate for the company used for case study in recent 10 years is 8%, which is lower than the statutory profit organization income tax rate of 25%. The income tax rate of the company used for case study is therefore estimated to be 8%.

4. Non-debt Tax Shield

Non-debt tax shield does not cause actual cash outflow, thus the cash can be observed on the statement of cash flows. Using the example of a company used for case study, the following observations can be made on its cash flow table: depreciation, amortization, investment loss, and pension. R&D investment can be observed from the operation cost details. The average cash of non-debt tax shield in recent four years is NT$1,280,000,000. We use this value to calculate the non-debt tax shield.

5. Solution of the Optimal Capital Structure

The parameters of the case study are summarized in Table 10.

Putting the estimated parameters and the presumed debt amount into the equation of firm value, X (firm value) was found through computer simulation to be a normal distribution with mean = 25,456 million and standard deviation = 3,490 million. The debt and firm value relation is plotted in Fig. 1.

The estimated optimal equity amount to debt amount ratio for the company used for case study is 6,660 (million):18,800 (million), i.e., 0.26:0.74, yet the present ratio is actually 17,590 (million): 3,691 (million), i.e. 0.83:0.17. The present debt is far lower than the estimated optimal debt found in this

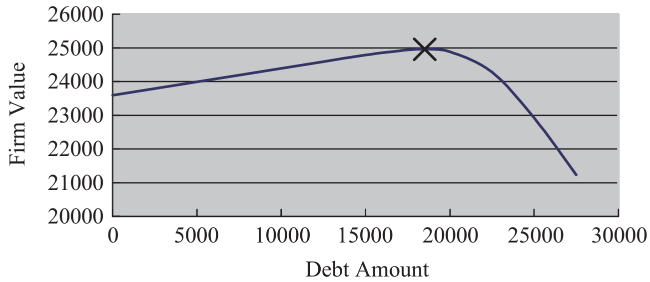

Fig. 1. Relation between sample company's debt and firm value.

study, which shows that the company used for case study uses very conservative financial strategies. The optimal capital structure model offers the financial decision-makers an objective method of making financial decisions.

VII. CONCLUSIONS

This paper uses the Grey System Theory and Pearson correlation analysis to study the capital structure of building companies and its relationship with the company's tax rate, non-debt tax shield, and operational risk, respectively. Results show that in building companies, the capital structure is positively correlated to the non-debt tax shield and the adjusted tax rate, while negatively correlated to the operational risk. The non-debt tax shield has the highest level of relation to capital structure, and the operational risk has the lowest.

The result that the capital structure is positively related to the non-debt tax shield in the building industry is different from the results in previous researches. This is due to the fact that the R&D investment is very low in the building industry, and the non-debt tax shield comes mainly from the depreciation of the fixed asset. Therefore, the higher the non-debt tax shield is, the higher the fixed asset ratio is. The fixed asset to total asset ratio is positively related to the capital structure.

Different from other industries, the building industry's operational risk is lowly connected to the capital structure. The inventories of the building industry include the construction site, constructions-in-progress, and houses for sale, which make up a big percentage of the total asset. If the building company faces bankruptcy, the active liquidation market keeps the indirect bankruptcy cost low, which makes it easy to get finance from banks.

Building companies have low actual tax rate and low non-debt tax shield. However, due to low asset particularity and low bankruptcy cost, the empirical results of the optimal capital structure theory show that the optimal capital structure in the building industry is high. This reveals that among the factors that determine the capital structure of building companies, low bankruptcy cost is the most important one.

The results of this paper show that the industry and financial characteristics of the building industry indeed affects the optimal capital structure of building companies. The analytical model developed in this paper for the optimal capital structure of building companies can serve as an evaluation tool for governments when building companies are sponsors of BOT concessionaires and for lending institutions to evaluate the financial stability of a building company.

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