Improving Hedging Decision for Financial Risks of Construction Material Suppliers Using Grey System Theory

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Abstract

Many companies in recent times have attempted to use derivatives to hedge the risks of the fluctuations in the price of materials in the global markets as well as variations in currency exchange rates and interest rates. This study investigates the relationship between derivatives and corporate financial statuses through grey relational analysis (GRA) and grey decision making (GDM). 28 types of financial ratios data were collected from 29 construction materials suppliers from Market Observation Post System and Taiwan Economic Journal in Taiwan over the last decade. The results of the combination of GDM and Five Forces of Financial analyses presented the suggested value of financial ratios which is suitable for derivatives usage. GRA and GDM could be a useful tool to predict the proper time to employ derivatives for companies' development, especially for some firms which lack experienced experts.

Keywords: Risk Hedge, Construction Material Suppliers, Derivatives, Grey System Theory

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Introduction

The construction industry faces international competition due to global market integration. Of all the kinds of companies in the industry, construction material suppliers are especially exposed to more serious financial risks because they usually have high debt capital structures and many of their goods, namely construction materials, are imported from other countries. As a result of these challenging conditions, sometimes suppliers must suspend their operations. For example, in Taiwan the majority of construction materials are imported, so suppliers are exposed to the challenges of materials import and fluctuations in prices. Some suppliers have to seek new materials sources because the mainland of China, as the second biggest source of imports for Taiwan, has optimized the construction materials industrial structure and reduced the dependence on exports significantly (Invest Taiwan 2011). The total price index of the construction industry has an ever-increasing trend, and the price of cement and metal, two main materials in the construction industry, have fluctuated wildly between 1998 and 2014 (Executive Yuan of Taiwan 2015).

For a variety of companies, how to mitigate the risks of fluctuating material prices, currency exchange rates, and market interest rates is an urgent question. Many scholars have been studying this question and found that risk mitigation is essential for firms operating in any market marked by high inflation and global competition (Battermann and Broll 2001). Many techniques have been developed to reduce risk (Ross et al. 2002), including the use of financial derivatives, which has become a popular and effective tool used not only by financial institutions but also in some other industries, for example, by construction corporations (Quek et al. 2007; Bartram et al. 2009). In general, the bigger and more international the companies are, the more willing to use derivatives they are (Chen and Lin 2010). The usage of derivatives heavily relies on the knowledge and experience of experts (Geczy et al. 1997). Thus small- and medium- sized enterprises are usually more reluctant to use derivatives for risk hedging because of the lack of experienced experts and the high employment cost for experts (Chen et al. 2010). As enterprises grow and global competition becomes fiercer, when a firm should start using derivatives creeps closer to the top of the company agenda. The above characteristics are also applicable to construction material suppliers in Taiwan because of the high risk derived from the importing the raw materials required for buildings and facilities and the difficulties of experts' employment. As an alternative of experts' knowledge, the financial statements, which could response honestly to all the strategies adopted by the firms, for example, derivatives usage.

The aim of this study is to examine the relationship of the financial derivatives and financial ratios of the listed construction material suppliers in Taiwan using grey system theory and in turn, offer some guidance on the proper time for derivatives usage to suppliers so as to replace the traditional subjective experts' recommendations. The research objects were made up of 29 construction material suppliers, including seven cement suppliers and 22 steel suppliers, and the financial statements of the above suppliers from 2005 to 2014 were used as the data source. Grey relational analysis (GRA) and grey decision-making (GDM), two contents of the grey system theory were employed as the analysis method. GRA will help reveal the relationship of derivatives usage and financial ratios and the most pivotal of the numerous financial ratios, though it couldn't determine their causality. GDM will contribute to indicate the perfect levels of the financial ratios proper to use derivatives. The validity of this approach, the combination of financial ratios and grey system theory will be proved.

Financial Ratio Analysis

The purpose of a financial statement is to indicate the historical and current situation of a firm so as to help managers understand the corporation's current situation in a timely manner and help investors estimate the corporation's value, predict future development and make decisions regarding which company is appropriate to invest their resources (Wahlen and Wieland 2011). Analysis of financial statements is a method widely used in various kinds of industries, especially in finance, to benchmark firms in the same industry (Cowen and Hoffer 1982). In the specific context of exploring two types of leverage, Nissim and Penman (2003) found that financial statement analysis can help to identify future profitability and calculate appropriate price-to-book ratios. Longinidis and Georgiadis (2011) proposed a Mixed-Integer Linear Programming (MILP) problem that combines financial analysis and demand uncertainty to improve strategic decision-making for designing supply chain networks. It has been demonstrated that financial statement analysis is more reliable than analysts' consensus recommendations likely to be most informative (Wahlen and Wieland 2011). Thus financial statement analysis has been a key tool of strategic decision-making for addressing firm performance challenges such as hedging risk. According to different requirements, a variety of combinations of financial ratios indexes has been used for systemic analysis of firm financial status (McLeaney and Atrill 2005). For example, Malíková and Brabec (2012) used four categories of financial ratios, specifically profitability, activity, liquidity, and debt ratios, for their evaluation criteria. Among the indexes, the financial five forces are a common combination, including profitability, stability, activity, growth, and productivity, which could be traced to Altman (1968), one of the previous well-known researchers about financial performance who laid a solid foundation for the development of financial five forces. The financial five forces are often used by firms due to their simplicity and capacity of assessing firms' conditions comprehensively. So we employ the financial five forces in this paper as well.

Derivatives Usage for Risk-Hedging

Risk-hedging instruments are related to conditions of companies, which could be reflected in the various financial ratios provided in financial statements. A derivative is an alternative financial investment derived from a traditional financial product and has a price that depends on the movement of the value or price of that underlying asset, which could be the stock price, stock price index, exchange rate, interest rate, the rate of return, and so on (McDonald 2006). Risk management has increasingly attracted the attention of companies and scholars, with a growing number of corporations, including non-financial firms as well as financial firms, selecting derivatives for risk-hedging, as confirmed by many studies (Sheng 2005; Panayides 2006; Bartram et al. 2009; Chen et al. 2012). Although derivatives are widely used in the US, the UK, Australia, and other countries (Nguyen and Faff 2002, Bailly et al. 2003, Kim et al. 2006), they were not introduced to the construction industry and other related industries until the 1990s (Holmes 2004).

To use derivatives in a proper manner, some studies identified the firm-specific factors relating to the extent of derivatives usage, including financial distress cost (Afza and Alam, 2011), debt ratios (Haushalter, 2000), cost of equity (Gay et al., 2011), cash flows (Stewart and Owhoso, 2005), quick ratios and coverage ratios (Bartram et al., 2009), and so on. Most of them are financial ratios. And that's another reason why we select financial ratios to indicate firms' financial conditions. There are also some techniques used for helping derivative usage. For example, Hyper Rectangular Composite Neural Networks (Chen et al. 2010) and SVM (Chen and Lin 2010) were employed for derivatives usage prediction. Although these two methods could show the prediction accuracy, it is difficult for companies to clarify their development directions so as to enhance the prediction accuracy (to use derivatives at a proper time to maximize their role). To solve this problem, this paper will use grey system theory as the method to unveil the relationship between derivatives usage and financial ratios, which lays the foundation that financial ratios could be employed to determine or predict when to use derivatives, to identify the proper time to use derivatives based on the suggested value of financial ratios, and to provide some guidance on derivatives usage for construction material suppliers in Taiwan.

Grey System Theory

In the grey system, information that exists in nature and is already known is classified as white, unknown information is regarded as black, and the third kind of information, which is unclear and uncertain but in known zones, is grey, interposed between black and white. The main idea of grey system theory is that although the objective system is complex and the data is scattered, the system always has its function and runs well. Hence, some potential principles must be hidden behind the complex image, and the key is to exploit and take advantage of them (Deng, 1987a). Soon after the theory was proposed, many scholars supported its validity and successfully applied it in some studies. Huang (2011) applied the grey system in the investigation of elders' opinions on telecare and determined the importance of over living quality and other six effects of telecare usage. Wang et al. (2014) established a grey Verhulst model to predict topics that would trend on the Internet and found that the average related error of the proposed model was less than 3%. Grey system theory had been applied in other fields such as agricultural irrigation (Deng, 1987b), air quality (Zhu, 2007), machine tools (Wang et al., 2006). As research and the application of grey system theory spread, related models were gradually developed. According to Liu et al. (2013), four particular models had become especially common, namely grey relational analysis, grey cluster evaluation, grey prediction, and a grey model for decision-making. Among them, the grey relational analysis was the most popular (Yin, 2013). Given its wide acceptance and ability to identify the primary relational factors in a system (Lin, 2000), the grey relational analysis is applied in the present study to examine the relationship between financial indexes and derivatives usage.

Financial Ratios Screening

In order to identify the relationship between derivatives usage and the financial conditions of construction material suppliers, this study made use of financial ratios analysis. Based on a survey of the literature on financial ratios analysis of firms in Taiwan or other locations, 28 financial ratios were chosen as the foundation for analysis, shown in Table 1.

Data Collection

The data used in the present study was from the listed companies from Taiwan Economic Journal and the Market Observation Post System. The data could be classified into two categories: information about derivatives usage and the financial ratios of listed companies. The subjects investigated were 29 listed construction material suppliers, including seven cement suppliers and 22 steel suppliers. The criterion for designating a company as a construction material supplier was based on whether it provides the market with cement, steel, shape steel and other construction materials. The period of study was from 2005 to 2014, based on the season as the unit of time. Information about firm derivatives usage was obtained from Market Observation Post System, while firm financial ratio data was drawn from the Taiwan Economic Journal. If a firm or its subsidiary used derivatives in any month of a season, it was considered to have used derivatives. Financial data over the course of the last decade was employed in this study to investigate the relationship between the most recent use of derivatives by construction material suppliers and financial ratios.

Grey System Analysis for Derivatives Usage

Grey System Theory can be used when information about a system is not certain or sufficient, or the data is unavailable. This theory has six key aspects, namely Grey Generating (GG), grey relational analysis (GRA), grey model construction (GMC), grey prediction (GP), grey decision making (GDM), and grey control (GC) (Wen, 2007). This study applies GG to process the collected data, GRA to measure the relational grade of derivatives usage with financial indexes, and then GDM to determine when the use of derivatives should commence. These three methods are presented in more detail in the following sections.

Grey Generating

The heart of GG is transforming the original data $x_n^0(k)$ into $x_n^*(k)$ in order to reduce the randomness of the data and increase its visibility. There are some methods for executing GG. According to Zhang (2000), the appropriate transformation method to use will depend on the characteristics of the original data. Namely:

(1) For certain factors, if the value is the-larger-the-better, the transformation formula is as follows:

$$x_i^*\left(k\right)=\frac{x_i^0\left(k\right)}{\max\limits_{all\ i} x_i^0\left(k\right)} \tag{1}$$

(2) For other certain factors, if the value is the-smaller-the-better, the transformation formula is as follows:

$$x_i^*\left(k\right)=\frac{-x_i^0\left(k\right)}{\min\limits_{all\ i} x_i^0\left(k\right)}+2 \tag{2}$$

(3) For other factors, if the value is the-closer-to-the-desired-value-the-better, the transformation formula is as follows:

$$x_i^*\left(k\right)=\begin{cases}\dfrac{x_i^0(k)}{OB}, & if\ \ x_i^0(k)\le OB\\ -\dfrac{x_i^0(k)}{OB}+2, & if\ \ x_i^0(k)>OB\end{cases} \tag{3}$$

Where

$x_i^*(k)$ is the sequence generated by GG; $x_i^0(k)$ is the original sequence corresponding to $x_i^*(k)$; $\underset{all\ i}{max}\, x_i^0(k)$ is the maximum of the original sequence; $\underset{all\ i}{min}\, x_i^0(k)$ is the minimum of the original sequence, and OB is the desired value.

Grey Relational Analysis

GRA is a method for analyzing the relational grade of discrete sequences. It can indicate the relationships between samples and reveal the features of a system even when the number of observations in a sample is not abundant. In this study, GRA is employed to analyze the relationship of derivatives usage and financial ratios. The general calculation steps for GRA are as follows:

1. Selecting the Reference Sequence

Generated by GG, $x_i^*(k)$ can be used for GRA, which can include the overall $x_i^*(k)$ or a local one. The reference sequence for overall GRA is every sequence $x_i^*(k)$; while the reference sequence for local GRA is just one selected sequence. In this study, local GRA is employed. Let x_0^* and x_i^* represent the reference sequence and the comparison sequences respectively. Among which, the reference sequence x_0^* is generated by the set of ideal object values of all the factors via GG.

2. Calculating the Grey Relational Distance Value

Grey relational distance value Δ_{oi} is the k-th absolute difference between x_0^* and x_i^*. That is,

$$\Delta_{oi} = \left| x_0^*(k) - x_i^*(k) \right| \quad (4)$$

The maximum and minimum of Δ_{oi} are denoted by Δ_{max} and Δ_{min} respectively:

$$\Delta_{\max} = \max(\Delta_{oi}) \quad (5)$$

$$\Delta_{\min} = \min(\Delta_{oi}) \quad (6)$$

3. Calculating Grey Relational Coefficient

According to Deng (1989), the grey relational coefficient $\gamma\left(x_i(k), x_j(k)\right)$ can be obtained on the basis of the grey relational distance value Δ_{oi} and its maximum and minimum. The calculation formula is as follows:

$$\gamma\left(x_i\left(k\right), x_j\left(k\right)\right) = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{oi} + \zeta\Delta_{\max}} \quad (7)$$

Where

$\zeta \in (0,1)$ is the distinguished coefficient. Its aim is to adjust the correlation between the measured value Δ_{ij} and the background value Δ_{max}. The different ζ will result in different grey relational coefficients and in turn result in different grey relational grades. In spite of this, these differing values do not change the order of grey relational grades. Therefore, in this study 0.005 is adopted as the distinguished coefficient so as to make the difference between the maximum and minimum of grey relational grades the largest, enabling the grey relational grades of the financial indexes to be more clearly distinguished.

4. Calculating Grey Relational Grade

According to Deng (1989), the grey relational grade Γ is the average of the grey relational coefficients. The formula is as follows:

$$\Gamma_{ij} = \frac{1}{n}\sum_{k=1}^{n}\gamma\left(x_i\left(k\right), x_j\left(k\right)\right) \tag{8}$$

Grey Decision Making

Grey decision making entails selecting the best solution from alternatives via particular methods based on some information, experience, objective conditions, and environment so as to achieve one or several specific goals. By the data adopted, this study employs grey situation decision making (GSDM) as the decision method to select the good examples of the firms.

According to Deng (1987a), the Grey Situation S_{ij} is the combination of Event a_i and Game b_j, meaning that the latter is employed to deal with the former. Hence,

$$S_{ij} = (a_i, b_j) \tag{9}$$

The perspective of assessing the situation effect (or game effect) is represented as Target p. Then the sample effect of Game b_j (to deal with Event a_i) in Target p could be denoted as u_{ij}^p. Let M be map, and r_{ij}^p be the image of u_{ij}^p under M, that is, $M(u_{ij}^p) = r_{ij}^p$. Let the whole of u_{ij}^p be u^p, that of r_{ij}^p be r^p and X^+ be Positive Polar Space. M meets the following condition:

(1) $M(u_{ij}^p) = r_{ij}^p \in r^p \rightarrow r_{ij}^p \in [0,1]$;

(2) $r_{ij}^p \in X^+$.

For Situation S_{ij}, if there are ℓ Targets, that is, $p = 1,2,\ldots,\ell$, under the corresponding M,

$M(u_{ij}^p) = r_{ij}^p$, that is, $r_{ij}^1, r_{ij}^2, \ldots, r_{ij}^\ell$, a certain integrated value can be represented as r_{ij}^Σ, for example,

$$r_{ij}^{\Sigma} = \frac{1}{\ell}\sum_{\mathrm{p}=1}^{\ell} r_{ij}^{p} \tag{10}$$

According to the above definition, the measure vectors (sequence) of some combined effects can be denoted as r_i^Σ, namely,

$$r_i^{\Sigma} = \left[r_{i1}^{\Sigma}, r_{i2}^{\Sigma}, \ldots, r_{im}^{\Sigma}\right] \tag{11}$$

For this study, the steps for GSDM are as follows:

1. Determine the sample value of alternatives.

The 28 financial indexes (shown in Table 2) collected from Taiwan Economic Journal are employed in this study.

2. Define the event, game, situation, target, and sample.

Event: Financial statuses of construction material suppliers;

Game: 621 alternatives of the selected firms in the selected seasons;

Situation: 621 alternatives in the financial status of each of the construction material suppliers;

Target: 28 financial indexes.

3. Process the samples via GG.

The processing method used is as described by Zhang (2000).

4. Make the decision.

The formula for the decision index is as follows:

$$r_{ij}^{\Sigma} = \frac{1}{\ell} \sum_{p=1}^{\ell} r_{ij}^{p} \tag{12}$$

Empirical Research

The grey system theory is built to analyze data that do not meet normal distribution. Validating the approach has been given in Deng's study (Deng 1989). According to the above, we conducted GRA to identify the relationship of derivatives usage and financial development and GDM to suggest when to use derivatives based on the data of 29 listed companies from 2005 to 2014. This section demonstrated the tool's utility using financial indexes and five forces analysis.

Grey Relational Analysis of 28 Financial Indexes to Derivatives Usage

Based on the collected data, the grey relational grades of the 28 financial ratios to derivatives usage were obtained by performing GRA as detailed above and as shown in Table 3.

Among all the financial ratios, the grey relational grades of operation expenses ratio, debt ratio, ratio of fixed assets to total assets and fixed ratio to derivatives usage are much smaller than that of the other financial indexes, which means the relationship between those four financial indexes and derivatives usage is not so close. Thus there appears to be a value that could be used to distinguish between a high or low relationship between the grey relational grade of the ratio of net worth to total assets and that of operation expenses ratio. In this study, 0.9 is selected as the relational grade threshold of the 28 financial indexes. Specifically, when the grey relational grade is over 0.9, the relationship is considered to be high. Otherwise, it is deemed a low relationship. Based on this definition, among the 28 financial indexes, the relationship of the 4 financial indexes listed above is low and that of the others is high, which lays the foundation for assessing when to start to use derivatives based on the level of the financial ratios in the following section.

Among the four financial indexes with a low relationship with derivatives usage, the low grey relational grade of operation expenses ratio means that derivatives usage is not related to operation expenses ratio so much. It could be inferred that derivatives usage will not have much of relation with the ratio of operation expenses to profit. Debt ratio represents the relationship between total debts and total assets and can be used for evaluating the presence of a potential financial crisis. The low relationship between derivatives usage and debt ratio implies that the former won't markedly concern with the latter, and thus having little connection with on a prospective financial crisis.

When the ratio of fixed assets to total assets is big, the flexibility of a firm's funds is limited. The low grey relational grade shows that the function of derivatives usage has nothing to do with the ratio of fixed assets to total assets and thus does not observably correlate with the flexibility of funds either. The fixed ratio, as the ratio of net fixed assets to owners' equity, indicates the investment scale and solvency of a firm. The more fixed assets are, the fewer current assets are available for fulfilling long-term financial obligations, thus diminishing solvency. Therefore, the low relational grade demonstrates derivatives usage has a little connection with fixed assets, solvency, or the ratio of net fixed assets to owners' equity.

On the basis of the formula of debt ratio, the ratio of fixed assets to total assets, and fixed ratio, when fixed assets or debts appeared as the numerator of a financial index, its relational grade was low. It could be reasoned that a firm's fixed asset composition and the number of debts were not highly relevant to derivatives usage.

Grey Relational Analysis of the Financial Five Forces to Derivatives Usage

To facilitate the leaders who may put emphasis on the firms' profitability or another aspect, this study conducted grey relational analysis of the financial five forces to derivatives usage. Drawing upon several previous studies, this study classified the 28 financial indexes into the financial five forces. The grey relational grade of the financial five forces to derivatives usage could be obtained by calculating the average relational grade of the corresponding financial indexes contained in the financial five forces respectively, as shown in Table 3.

Among the five forces, the grey relational grade of stability is far lower than that of other four forces. Stability is an index that represents whether the operation of a firm is stable, the operations scheduling is reasonable, the financial structure is reasonable, and the solvency is adequate. It is very risky for a firm to have low stability even if profitability is high. Therefore, stability is the foundation of a firm's sustainable development. The low average grey relational grade indicates that derivatives usage has nothing to do with stability, which meant nothing to do with the grade of stability and on solvency. Thus, it could be concluded that derivatives usage would not contribute to a firm's unsustainable development markedly.

Grey Decision Making Based on Financial Indexes

Based on the relationship of derivatives usage to each financial ratio or five forces revealed by GRA, GDM was conducted based on financial indexes to indicate the proper financial conditions of construction material suppliers for derivatives usage. After calculating and classifying the decision index r_{im}^{Σ}, it was found that the value of the decision index r_{im}^{Σ} ranged in three intervals, [0.3621, 0.1539], [-0.003, -3.4238] and [-20.9947, -51.8356]. In the first interval, there were 9 games b_j that could be regarded as the best status for the firms' financial condition and then the outstanding examples to other suppliers and they all had taken advantage of derivatives; In the second interval, there were 603 games, in which firm financial status was neither the best nor the worst; In the third interval, there were 9 games that could be regarded as the worst status and the counter examples for other firms and they hadn't used derivatives. According to the comparison of the firms with the best financial status and those with the worst status in each interval, it could be concluded that it was practically meaningful for firms' financial status to make use of derivatives.

Grey Decision Making Based on Financial Five Forces

In this section, grey decision making was employed to determine when firms emphasized different financial five forces. The averages of each financial ratio under the best financial conditions were calculated to suggest the proper level of financial ratios, shown in Table 4.

Like GDM based on all financial indexes, the decision index values r_{im}^{Σ} of GMD for the stability force ranged in three intervals [0.747, 0.674], [-0.438, -9.472] and [-65.503, -161.751], with all the games in the first interval having used derivatives, while those in the third did not include derivatives usage. Hence, the analysis indicated that it is advantageous for firms that placed emphasis on stability to use derivatives. Then the average of each ratio of games in the first interval and that of each ratio of all games were calculated respectively. The average of current ratio of the games with the best status was 476.88, over two times larger than that of all games, while the average of quick ratio of the games with the best status was 286.85, about three times larger than that of all games. Whether the financial status was the best or average, the current ratio was greater than the quick ratio. Taking into account the differences in definitions between current ratio and quick ratio, it was supposed that firms with better financial status had more inventories, prepayments, and deferred expenses.

For productivity, the financial status of the first 100 games was the best, of which all had adopted derivatives, while that of the last 100 games was the worst, of which 91 games did not include derivatives. This strongly suggested that it was beneficial to introduce derivatives to firms that put an emphasis on productivity. After taking the average of each financial index of the first 100 games and that of all games as the comparison criterion, it could be seen that when ROA before tax, interest, and depreciation was 3.44, over 3 times larger than the average value of all games 0.97, the financial status was the best; when ROA after tax and before interest was 2.25, about 3 times larger than the average value of all games 0.69, the financial status was also the best. The difference was not so large for either under the best status (0.52) or that of the average (0.27). The difference between these two indexes was whether depreciation was considered or not, so we could believe that depreciation was similar for all firms. But a bit larger difference of these two indexes under the best status implied the firms with better financial status tended to improve their production tools sustainably, resulting in more depreciation.

For growth, like productivity, the evidence also indicated that it was beneficial to employ derivatives for firms that focused on growth. After comparing the four growth ratios under the best status with each of their averages, it could be found that the firms with better financial status paid more attention to the growth of retained net profit than to operation revenue and manifest greater growth in profit, but they also were faced with the heavier tax pressure.

As seen with productivity, the evidence suggested that derivatives were useful for firms emphasizing profitability. Comparing the six ratios under the best status with the respective averages, it could be inferred that the difference of the ratio of operating profit to employed capital and ratio of net pre-tax profit to employed capital with the best financial status (9.14 and 9.61 respectively) was bigger than that of the averages of these two indexes (2.66 and 2.73 respectively). The difference between these two indexes resulted from non-operating gains and losses, like investment income and loss, which were not brought by firms' operation. The bigger difference of the two indexes with the best status than that of the average of the two indexes implied that firms with better financial status had more non-operating gains and losses, meaning that they were more likely to conduct some non-operating activities than firms with worse status. So we could conclude firms with better financial status put more emphasis on non-operating activities than firms with worse status.

The benefit of making use of derivatives was also evident for firms that put an emphasis on activity. Compared to the average of each of the five ratios of the first 100 best games, the five ratios value under the best status was not much bigger, except for accounts receivable turnover.

When accounts receivable turnover was 5.99, much greater than the average 3.33, the financial status was the best. Thus it was recommended that accounts receivable turnover should be six and concluded that the firms with better financial status would put more emphasis on accounts receivable turnover, which indicated the liquidity and management level of accounts receivable.

Conclusion

Derivatives, as a commonly used risk hedging tool, need to be used at a proper time to make the fullest possible contributions. In general, their usage relies on experienced experts, who are too expensive to be hired by some construction materials suppliers. To tackle this problem, we analyzed the relationship between derivatives usage and financial status combined with financial five forces by applying grey relational analysis, using the data on seven cement suppliers and 22 steel suppliers from 2005 to 2014. According to the grey relational grade of the 28 ratios, it was found that in terms of the 28 selected ratios, for the operation expenses ratio, debt ratio, ratio of fixed assets to total assets and fixed ratio, there was a low relationship to derivatives usage, and for the five forces, only stability was not much relevant to derivatives usage. Then grey decision making was applied to determine the proper conditions for optimal use. The game results demonstrated that suppliers in better financial condition would choose to use derivatives whether they pursued comprehensive finance improvement or emphasized one of the financial five forces. Moreover, the optimum level of the 28 financial ratios was suggested to reach the best financial status and it was proved that the approach, the combination of financial ratios and grey system theory, was less subjective than experts' recommendation and effective to guide firms to use derivatives at a proper moment, especially for some small- to medium- firms which lack experienced experts. And it also could provide these firms with some specific and helpful guidelines for companies' development.

One limitation of this study is that this study only analyzed listed construction material suppliers. Thus future research could focus on derivatives usage for suppliers of other material, unlisted firms, or firms in other fields, such as construction companies. Moreover, this method just examined statistical relationships but it is unsuitable to investigate causality. Future studies that delve deeper into analyzing specific causal interactions could provide additional useful insight.

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Table 1. The selected financial ratios

Financial Ratio	Formula	References
Ratio of net pre-tax profit to employed capital	Ratio of net pre-tax profit to employed capital =ratio of net pre-tax profit to employed capital =net pre-tax profit /(common stock + preferred stock + stock received in advance +reserve for capital increment)×100%	Wang and Lee (2008) Jung and Hwang (2011), Malíková and Brabec (2012)
Net pre-tax profit ratio	Net pre-tax profit ratio＝net operation pre-tax income / net operation revenue×100%	Wang and Lee (2008), Öcal et al.(2007), Wang(2008) Wang and Lee(2010)
Gross operating margin ratio	Gross operating margin ratio＝operating margin / operation revenue×100%	Wang and Lee (2008), Klingenberg et al. (2013), Kung and Wen (2007), Öcal et al. (2007), Wang (2008), Chen and Du (2009), Delen et al. (2013) Wang and Li(2007)
Ratio of operating profit to employed capital	Ratio of Operating profit to employed capital = operation income /(common stock + preferred stock + stock received in advance +reserve for capital increment)×100%	Wang and Lee (2008), Bae (2012), Malíková and Brabec (2012)
Operation profit ratio	Operation profit ratio＝operating margin / net operation revenue×100%	Lee et al.(1996), Wang and Lee(2008), Xu et al. (2014), Delen et al. (2013) Wang and Lee (2010)
Operation expenses ratio	Operation expenses ratio＝operation cost / net operation revenue×100%	Wang and Lee (2008), Xu et al. (2014), Delen et al. (2013)
Interest coverage ratio	Interest coverage ratio＝net profit before income tax and interest expense / current interest expense	Mayers et al. (1982), Gay and Nam (1998), Xu et al. (2014), Chen (2011), Delen et al. (2013), Pech et al. (2015) Wang and Li (2007)
Fixed ratio	Fixed ratio＝net fixed assets / owners' equity×100%	Wang and Lee (2008), Öcal et al. (2007), Wang (2008), Wang and Lee (2010)
Ratio of fixed assets to total assets	Ratio of fixed assets to total assets＝fixed assets / total assets×100%	Öğüt (2012), Chen and Du (2009), Chen (2011)
Current ratio	Current ratio＝current assets / current liabilities×100%	Nance et al. (1993), Wang and Lee(2008), Kung and Wen (2007), Mate-Sanchez (2012), Öcal et al. (2007), Wang (2008), Chen and Du (2009), Chen (2011), Lin et al. (2011), Jung et al. (2011), Yee and Cheah (2006)
Debt ratio	Debt ratio＝total liabilities / total assets×100%	Wang and Lee (2008), Kung and Wen (2007), Öğüt (2012), Mate-Sanchez (2012), Xu et al.(2014), Wang (2008), Chen and Du (2009), Chen (2011), Lin et al. (2011), Delen et al. (2013) , Jung et al. (2011)
Ratio of net worth to total assets	Ratio of net worth to total assets = net worth / total assets	Kung and Wen (2007)

Ratio of net worth to fixed assets	Ratio of net worth to fixed assets＝net worth / fixed assets×100%	Pech et al.(2015)
Quick ratio	Quick ratio＝quick assets / current liabilities×100%	Kung and Wen (2007), Öcal et al. (2007), Wang(2008), Delen et al. (2013), Wang and Li (2007)
Inventory turnover	Inventory turnover＝sales (operating) cost / average inventory Average inventory = (beginning inventory + ending inventory) / 2	Klingenberg et al. (2013), Öcal et al. (2007), Xu et al. (2014), Chen and Du (2009), Chen (2011), Delen et al. (2013) Wang and Li (2007)
Fixed asset turnover	Fixed asset turnover＝net product sales revenue / average net fixed assets Average net fixed assets＝(net beginning fixed assets + net ending fixed assets)/2	Wang and Lee(2008), Öcal et al.(2007) Xu et al.(2014), Wang (2008), Chen and Du (2009), Chen (2011), Delen et al. (2013) Wang and Li (2007)
Turnover of capital	Turnover of capital＝net operating income / average owners' equity Average owners' equity = (beginning owners' equity + ending equity owner) / 2	Wang and Lee(2008), Öğüt(2012), Öcal et al.(2007), Chen and Du (2009), Chen (2011), Delen et al. (2013) Wang and Li (2007)
Accounts receivable turnover	Accounts receivable turnover＝net operating income / average accounts receivable Average accounts receivable = (beginning accounts receivable + ending accounts receivable) / 2	Gombola (1987), Nance et al. (1993), Öcal et al. (2007), Xu et al.(2014), Chen and Du (2009), Chen (2011), Delen et al. (2013) Wang and Li (2007)
Total assets turnover	Total assets turnover＝net operating income / average total assets Average total assets = (beginning total assets + ending total assets) / 2	Wang and Lee (2008), Klingenberg et al. (2013), Mate-Sanchez (2012), Öcal et al. (2007), Xu et al. (2014), Wang (2008), Chen and Du (2009), Chen (2011), Delen et al.(2013) Wang and Li (2007)
Growth ratio of retained net profit	Growth ratio of retained net profit＝(current retained net profit - retained net profit in the same period last year)/ retained net profit at the same period last year ×100%	Xu et al. (2014)
Growth ratio of net pre-tax profit ratio	Growth ratio of net pre-tax profit ratio＝(current net pre-tax profit - net pre-tax profit in the same period last year)/ net pre-tax profit in the same period last year×100%	Kung and Wen (2007), Öcal et al. (2007) Chen (2011)
Growth ratio of net post-tax profit ratio	Growth ratio of net post-tax profit ratio＝(current net post-tax profit - net post-tax profit in the same period last year)/ net post-tax profit in the same period last year×100%	Kung and Wen (2007)
Operation revenue growth ratio	Operation revenue growth ratio＝(current operation revenue / operation revenue in the same period last year -1)×100%	Kung and Wen (2007), Öcal et al. (2007), Xu et al. (2014), Chen and Du (2009), Chen (2011), Delen et al. (2013) Wang and Li (2007)
Post-tax pre-interest ROA	Post-tax pre-interest ROA＝(retained net profit＋interest expense×(1- tax rate))/ average assets×100%	Avkiran (2011), Kung and Wen (2007) Xu et al. (2014)
Post-tax pre-interest pre-	Post-tax pre-interest pre- depreciation ROA＝	Avkiran (2011), Kung and Wen

depreciation ROA	post-tax pre-interest pre- depreciation retained profit / average assets×100%	(2007), Xu et al. (2014)
Pre-tax pre-interest pre-depreciation ROA	Pre-tax pre-interest pre-depreciation ROA＝pre-tax pre-interest pre-depreciation retained profit / average assets×100%	Xu et al.(2014), De Franco et al. (2011) Wang and Li(2007)
Post-tax ROE	Post-tax ROE＝net post-tax profit / shareholders' equity	Kung and Wen (2007) Kwag and Kim (2013)
ROE of retained profit	ROE of retained profit＝post-tax retained profit / shareholders' equity	Kwan and Kim (2013)

Table 2. The characteristics of the 28 financial indexes

Financial Indexes	Characteristic	Financial Indexes	Characteristic
Ratio of net pre-tax profit to employed capital	The-larger-the-better	Inventory turnover	The-larger-the-better
Net pre-tax profit ratio	The-larger-the-better	Fixed asset turnover	The-larger-the-better
Gross operating margin ratio	The-larger-the-better	Turnover of capital	The-larger-the-better
Ratio of Operating profit to employed capital	The-larger-the-better	Accounts receivable turnover	The-larger-the-better
Operation profit ratio	The-larger-the-better	Total assets turnover	The-larger-the-better
Operation expenses ratio	The-smaller-the-better	Growth ratio of retained net profit	The-larger-the-better
Interest coverage ratio	The-larger-the-better	Growth ratio of net pre-tax profit ratio	The-larger-the-better
Fixed ratio	The-smaller-the-better	Growth ratio of net post-tax profit ratio	The-larger-the-better
Ratio of fixed assets to total assets	The-smaller-the-better	Operation revenue growth ratio	The-larger-the-better
Current ratio	The-larger-the-better	Post-tax pre-interest ROA	The-larger-the-better
Debt ratio	The-smaller-the-better	Post-tax pre-interest pre-depreciation ROA	The-larger-the-better
Ratio of net worth to total assets	The-larger-the-better	Pre-tax pre-interest pre-depreciation ROA	The-larger-the-better
Ratio of net worth to fixed assets	The-larger-the-better	Post-tax ROE	The-larger-the-better
Quick ratio	The-larger-the-better	ROE of retained profit	The-larger-the-better

Table 3. The grey relational grade of the financial ratios and financial five forces to derivatives usage

Financial Five Force	Financial Ratio	Grey Relational Grade of Financial Ratio	Financial Ratio Ordering	Average Grey Relational Grade of Financial Five Force	Financial Five Force Ordering
Profitability	Ratio of net pre-tax profit to employed capital	0.9760	14	0.9296	4
	Net pre-tax profit ratio	0.9599	6		
	Gross operating margin ratio	0.9790	23		
	Ratio of Operating profit to employed capital	0.9787	10		
	Operation profit ratio	0.9790	9		
	Operation expenses ratio	0.7005	25		
Stability	Interest coverage ratio	0.9995	1	0.7823	5
	Fixed ratio	0.3193	28		
	Ratio of fixed assets to total assets	0.4884	27		
	Current ratio	0.9775	12		
	Debt ratio	0.5901	26		
	Ratio of net worth to total assets	0.9238	24		
	Ratio of net worth to fixed assets	0.9727	16		
	Quick ratio	0.9869	5		
Activity	Inventory turnover	0.9739	15	0.9676	3
	Fixed asset turnover	0.9710	17		
	Turnover of capital	0.9602	22		
	Accounts receivable turnover	0.9701	18		
	Total assets turnover	0.9626	21		
Growth	Growth ratio of retained net profit	0.9989	2	0.9943	1
	Growth ratio of net pre-tax profit ratio	0.9989	3		
	Growth ratio of net post-tax profit ratio	0.9962	4		
	Operation revenue growth ratio	0.9831	7		
Productivity	Post-tax pre-interest ROA	0.9802	8	0.9737	2
	Post-tax pre-interest pre-depreciation ROA	0.9643	20		
	Pre-tax pre-interest pre-depreciation ROA	0.9689	19		
	Post-tax ROE	0.9769	13		
	ROE of retained profit	0.9783	11		

Table 4. The suggested level of the financial ratios

Financial Five Force	Financial Ratio	Average of Ratio Level under the Best Status	Average of Ratio Level of All Games	Suggested Ratio Level
Profitability	Ratio of net pre-tax profit to employed capital	9.61	2.73	9.6
	Net pre-tax profit ratio	13.78	2.50	13.8
	Gross operating margin ratio	17.14	7.03	17
	Ratio of Operating profit to employed capital	9.14	2.66	9.1
	Operation profit ratio	10.10	2.14	10
	Operation expenses ratio	7.55	4.94	7.6
Stability	Interest coverage ratio	70.47	220.74	70
	Fixed ratio	0.04	0.32	0.04
	Ratio of fixed assets to total assets	0.04	0.35	0.04
	Current ratio	476.88	191.72	477
	Debt ratio	8.35	49.24	8.4
	Ratio of net worth to total assets	0.92	0.51	0.9
	Ratio of net worth to fixed assets	18.27	-46.51	18
	Quick ratio	286.85	94.54	287
Activity	Inventory turnover	1.16	1.20	1.2
	Fixed asset turnover	1.24	0.94	1.2
	Turnover of capital	5.99	3.33	6
	Accounts receivable turnover	0.34	0.25	0.3
	Total assets turnover	0.88	0.55	0.8
Growth	Growth ratio of retained net profit	639.83	181.44	640
	Growth ratio of net pre-tax profit ratio	269.51	-23.71	269.5
	Growth ratio of net post-tax profit ratio	-31.72	-138.08	-32
	Operation revenue growth ratio	5.83	5.13	5.8
Productivity	Post-tax pre-interest ROA	2.25	0.69	2.2
	Post-tax pre-interest pre-depreciation ROA	2.79	0.96	2.8
	Pre-tax pre-interest pre-depreciation ROA	3.44	0.97	3.4
	Post-tax ROE	4.21	0.97	4.2
	ROE of retained profit	4.14	0.62	4.1