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Analysis on the Efficiency of Risk Management in the Chinese Listed Companies

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Abstract: Since a firm's profitability is associated with a degree of risk taking, risk indicators have been extensively treated as exogenous variables and affected firm performance. The level of risk taking should be determined through internal control quality and firm-specific characteristics to effectively understand the relationship between risk management and firm performance. This study aims to investigate the effects of risk management efficiency on the production efficiency of Chinese listed companies from 2002 to 2016 using the two-step data envelopment analysis (DEA) approach. Empirical results indicate that risk management differs from traditional financial theory, which means that high-level risk would earn high expected returns. Firms with a low efficiency index of enterprises risk management will have low performance. In particular, internal controls were significantly improved after the 2008 financial crisis. Our overall results also suggest that information asymmetry is still a problem in financial markets. To achieve maximum benefits for shareholders and improve the quality of information disclosure, methods for enacting market regulations are still very important issues in China.

Keywords: Risk management efficiency; data envelopment analysis; information asymmetry

JEL Classification: G32; G34.0

1. Introduction

Ever since the financial crisis of 2008, enterprise risk management (ERM) has become an important topic. Proposed by the Committee of Sponsoring Organizations (COSO) in 2004, ERM refers to how a firm builds the risk management framework by combining corporate governance, business strategies, and financial management, to increase profitability and maximize the interests of its shareholders. In the existing risk management literature, although many studies have focused on investigating operating efficiency [1], evaluating the added value of risk undertaking [2], and measuring the risk exposures of business [3], they have ignored the effects of internal controls on different risk categories, further affecting firm performance. Therefore, as far as market investors are concerned, considering the corporate governance mechanism and firm-specific characteristics is necessary to have a proper understanding of the efficiency of risk management affecting changes in a firm's performance. In this study, the authors attempt to measure the efficiency of risk management and explore the relationship between ERM and operating performance.

With China's rapid economic development, the stock market in China has played an important role in the global financial markets. Over the period from January 1998 to April 2019, the number

of listed companies in China has grown from 851 to 3627, and the stock market capitalization has achieved a growth of approximately 36.83 times (The historical statistics comes from Standard & Poor's Global Stock Markets Factbook. The value of share trading in China increased from USD 231.3 billion to USD 8520 billion.). In particular, to enhance the monitoring quality and internal controls of listed companies after 2008, China's Ministry of Finance enacted the Basic Standards for Enterprise Internal Control and established a series of information disclosure and corporate governance standards. As mentioned above, these reformations in market systems aim to reduce the total risk exposures of listed companies and increase market depth. However, as China's economic growth has gradually slowed down, although the ERM for corporate sustainable management continued to become increasingly important, few studies have researched China's ERM strategy.

From the results of previous literature, some researchers have discussed the relationship between financial indicators and firm performance [4] or used accounting-based indicators to measure firm credit risk [5]. Furthermore, Sharma, Shebalkov, and Yukhanaev [6] mentioned that risk-based performance management has become a key indicator for effectively determining the financial health of a firm. Their conclusions also indirectly support our statements: firm performance depends on the effectiveness of ERM. Therefore, this study used the data envelopment analysis (DEA) model to examine the effects of ERM on firm performance. The DEA model can rapidly and conveniently compute the efficiency index of inputs to outputs and can be used to compare the efficiency among units to provide the most efficient inputs and outputs.

Using the above base, this study made several important contributions to the ERM literature. First, except for the business risk indicator, our paper extends that of [7], who investigated the efficiency effect of incorporating account credit and market risk by using the KMV model to estimate the default risk. The model not only considers accounting indicators but also incorporates market-based information. To completely understand firm performance, we also adopted stock returns and returns on assets to measure market-based and accounting-based performance. Second, in contrast with previous studies, we adopted a two-step DEA model to investigate the efficiency index of ERM incorporated into corporate governance and firm-specific characteristics, with the second step being to estimate the efficiency effects of firm performance given the efficiency index of the two risk indicators. The empirical results indicate that a firm with a poor ERM has lower firm performance. This finding differs from traditional financial theory, which posits that high risk undertaking will earn high expected returns. In particular, a healthy efficiency index of a firm is between 0.5 and 0.7.

Third, considering the reformation of monitoring mechanisms in China after 2008, this study further incorporated corporate governance into the first step of DEA estimation. The shareholdings of institutions and insiders are used to measure the degree of monitoring. We also divided the whole sample into two sub-sample periods: 2002–2009 and 2010–2016 and examined whether the reformation of information disclosure and internal controls has significantly improved a firm's profitability. To our knowledge, evidence to demonstrate the effects of improvement of internal controls in China is currently lacking. Therefore, this study will provide empirical results in more detail.

This paper is organized as follows: In the next section, we review past studies and make our hypotheses regarding the impact of corporate governance on different risk exposures. Section 3 defines the relevant variables, including firm-specific characteristics and monitoring mechanisms, and briefly introduces the DEA model. In Section 4, the data resource and basic statistics are described. Section 5 presents the main empirical results, and the final section concludes the paper.

2. Literature Review

2.1. The Determinants of ERM

The quality of corporate governance has a significant effective on firm performance and risk taking. The significantly positive effect induced by proper corporate governance mechanisms may improve internal controls and reduce total risk exposure. Finally, a firm's profitability would respond

to such effects. The process of business decision making also affects the effectiveness of ERM. With regard to ERM, the contents include an enterprise-level assessment, quantification, financing, and risk management. It enables firms to benefit from risk management that shifts the attention of the function of risk management from primarily defensive to increasingly positive and strategic. Therefore, ERM emphasizes that the organizational benefits of risk management can also create value for a firm. Similarly, Nocco and Stulz [8] argued that ERM can create value for shareholders and examine the practical issues caused by the implementation of enterprise risk management. However, compared to the abundance of studies on the influences of ERM in an emerging market, extensive studies such as [9] and [10] have explored the aspect of ERM implementation factors. Firms with high financial leverage are more likely to appoint a chief risk officer (CRO). In addition, the presence of a chief risk officer, board independence, chief executive officer (CEO), and chief financial officer (CFO) has been found to be positively related to support ERM. These authors have provided a relevant foundation for extending research about ERM.

Other factors that may affect the extent of ERM include firm-specific characteristics and quality of corporate governance, including the presence of a chief risk officer, leverage degree, profitability, international diversification, majority shareholder, size, and turnover [1]. Gordon, Loeb, and Tseng [11] indicated that five factors affect a firm's value: environmental uncertainty, industry competition, firm size, firm complexity, and board of directors' monitoring. Furthermore, Mensah and Gottwald [12] also presented that they found a significant relationship between the role of a CRO and an audit committee and the support of top management in relation to the implementation of ERM. Moreover, Wu and Li [13] explored the influence of changing the proportion of outsider directors on corporate governance in China, finding that the level of board independence is positively associated with firm performance. Huang and Wang [14] presented that board size has negative impacts on firm risk-taking in China. Finally, Wei and Chiu [3] also supported that a high degree of internal monitoring would reduce enterprise risk management. The increase in the proportion of independent directors and board size can improve the quality of ERM. In summary, the aforementioned conclusions clearly point out that the corporate governance mechanism plays an important role in the effectiveness of ERM.

Regarding the value of ERM programs added to a firm, Hoyt and Liebenberg [15] simultaneously selected the determinants of ERM and estimated the effect of ERM on firm value. They found a positive correlation between the implementation of ERM and a firm's value. On the other hand, Baxter et al. Baxter et al. [16] investigated whether ERM quality enhances performance. They argued that higher ERM quality is associated with greater complexity, fewer resource constraints, and better corporate governance. Controlling for such characteristics, higher ERM quality was found to be associated with improved financial performance and can enhance the management control for corporate governance. As a result, the manager's behavior for risk taking can be consistent with the company's strategic direction and high firm performance. Similarly, Grace et al. [2] and Al-Amri and Davydov [17] consistently supported that risk management can enhance a firm's operating performance. Al-Amri and Davydov [17] further noted the effectiveness of ERM's impact on operating risk as the basis for improving a firm's internal controls. Their conclusions allow us to unearth evidence on the efficiency effects of ERM toward the efficiency of firm performance.

2.2. Risk Measurement and Operating Efficiency

Although China plays the most important role in global economic activities, like those in other emerging markets, firms in China face more uncertain risks than firms in developed markets. With the high uncertainty of business risk and information transmission, recent studies have been paying more attention to the relationship between financial indicators and firm performance. For example, Su and He [18] found that in China, the relationship among ownership structure, corporate governance, and productive efficiency were the main factors related to promoting a firm's efficiency from 1999 to 2006. Chen [19] also found that such firm-specific characteristics as profitability, firm size, growth, and asset liquidity are factors that influence leverage. Similarly, Su, Li, and Wan [20] examined the

linkage with ultimate ownership, risk-taking, and firm value. They argued that the divergence between ultimate shareholders' control rights and cash flow rights would induce lower corporate risk-taking to protect their private benefits. To effectively measure default risk and operating efficiency, previous studies like that of Huang, Sheng, and Li [21] adopted the KMV model to measure credit risk, and the DEA model can be used to evaluate the efficiency of enterprise performance. Intuitively, risk exposure should depend on firm-specific characteristics and the quality of internal control, thus further affecting the operating direction and firm's performance. Therefore, most studies have focused on examining the relationships between corporate governance and risk exposures [22,23]. They have all consistently supported that better governed firms are strongly associated with lower default risk.

In evaluating the operating efficiency of a firm, current studies, such as those by Shewell and Migiro [24] and Sakouvogui and Shaik, [25] have utilized data envelopment analysis (DEA) proposed by Farrell [26] and Charnes, Cooper, and Rhodes [27] to estimate the relative efficiency of multiple decision-making units (DMUs) and to solve financial issues. Based on financial information, the advantages of DEA provide the level of optimal unit cost for any given output. Most of the current literature has also combined the DEA approach with maximum likelihood estimation to investigate economic efficiency. Hwang and Kao [28] and Barth et al. [29] investigated the effects of relevant variables on cost efficiency measures using different regression models in the second stage. These studies imply that economic efficiency is affected by firm-specific characteristics. From the perspectives of traditional finance, a firm with high risk is expected to earn a high expected return. Furthermore, any risk taking should be determined by internal controls and the firm's operation decision. However, to the best of our knowledge, little research has been done into the effects of risk-taking on firm efficiency. Therefore, in this study, we attempted to use standard deviation of yearly stock return and the default risk estimated by the KMV model to capture the ERM's quality, namely the efficiency of ERM, and to further examine the relationship between ERM and operating efficiency.

3. Methodology

3.1. The Input Variables of the First Step of the DEA Approach

This study measures the relative efficiencies of a firm in China using the input-oriented BCC model. Based on [26], Charnes, Cooper, and Rhodes [27] evolved the CCR model, which is a linear model combined with the concept of proportion to measure relative efficiency and used in the approach of constant returns to scale. However, the CCR model could not explain that the DMU of weak efficiency was caused by technical inefficiency or scale inefficiency. Therefore, Banker, Charnes, and Cooper [30] presented the BCC model, which assumed the approach of variable returns according to the scale, that is, a partial increase in inputs will not cause a relative increase in outputs. The BCC model is capable of measuring pure technical efficiencies. Then, calculating the proportion of the CCR values and BCC values to each other can acquire the scale efficiency values. According to past studies, the CCR model is obtained by calculating the ratio of the weighted output to the weighted input maximum. In this study, we adopted a two-step DEA-BCC model to do our objectives. In first-step DEA model, we estimated the efficiency index of ERM incorporated into corporate governance and firm-specific characteristics, with the second step being to estimate the efficiency effects of firm performance given the efficiency index of the two risk indicators. In this study, the set of input variables includes two components: One is corporate governance, which are Foreign shareholdings (FH), Domestic shareholdings (DH) and Insider holdings (INH). Another one is firm-specific characteristics, which are Size (SIZE), Leverage (LEV), Opacity (OPA), Liquidity (LIQ), Slack (SLACK), Sales Growth (SG), and Operating Cost (OC). The total number of DMUs is 737. The inputs in first-step DEA have ten variables and the definitions are as follows:

1. Institutional holdings (FH, DH)

One factor adoption ERM program is considered the press from external monitoring. The related studies are like [31–33]. In general, the shareholding of institutions has more influence than individual

shareholders and is expected to put considerable pressure on the implementation of an ERM program. As a result, this study expected that firms with a high percentage of institutional shareholding would be more likely to have a better ERM quality and separates them into foreign (FH) and domestic (DH) institutional holdings.

2. *Insider holdings (INH)*

Using the percentage of shares owned by insiders for variables in ERM is due to cross-sectional differences in managerial incentives. The past literature anticipated that low levels of insider ownership would effectively regulate the interests between managers and shareholders. However, McConnell and Servaes [34] argued that high levels of ownership have had the opposite effect on firm value. To grasp the effects of corporate governance on the efficiency of risk-taking, this study further considered the percentage of insider's shareholding in China as a proxy for internal monitoring indicators.

3. *Size (SIZE)*

Colquitt, Hoyt, and Lee [35] argued that large firms were more likely to adopt integrated risk management processes than smaller firms. Therefore, we use the natural log of the book value of total assets to control size effect.

4. *Leverage (LEV)*

As for the perspectives of agency problems, managers tend to engage ERM and reduce financial leverage to protect self-benefits. Therefore, Pagach and Warr [36] believed that the linkage between ERM implementation and leverage degree is ambiguous. In contrast, Liebenberg and Hoyt [9] argued that firms with greater financial leverage were more likely to have a chief risk officer. To control the influence, the ratio of book values of asset to liabilities was also considered in the first step of the DEA model.

5. *Opacity (OPA)*

Liebenberg and Hoyt [9] found that a firm with relatively high opacity could get more benefits from ERM programs that deliver risk management goals and strategies to outsiders. Likewise, Pagach and Warr [36] assumed that the adoption of ERM was related to the opacity of firm assets because relatively opaque assets are tough to liquidate so as to avoid financial distress. We calculated the ratio of book values of intangible assets to total assets.

6. *Liquidity (LIQ)*

In general, if a corporate has a relatively high level of liquidity, the opportunity for financial distress will be smaller. In this study, we used net working capital to total assets as the proxy for liquidity, which we calculated as the value of current assets minus current liabilities, divided by assets.

7. *Slack (SLACK)*

The research of [36] proposed that a firm with a proper ERM program could mitigate the probability of financial distress. Such is expected in the key input variable. The ratio of cash and marketable securities to total assets could be used in our model.

8. *Sales Growth (SG)*

According to [15], sales growth rate is an important indicator for a firm. A higher sales growth rate may bring about better performance. This paper also uses sales growth at the lag one period as a proxy for future growth opportunities.

9. *Operating Cost (OC)*

We also measured the ratio of the operating costs to total assets. The operating cost represents the cost of a company for generating products. If the ratio of the operating cost accounts for more than total assets, this indicates that the enterprise should pay more attention to controlling costs.

3.2. The Output Variables of the First Step of the DEA-BCC Model

Given that the efficiency of risk management depends on the corporate governance and firm-specific characteristics, the study selected the two risk indicators to be output variables in the first step of DEA approach. We separate risk exposures into default risk (DR) and business risk (BR). The default risk by the KMV model is calculated as follows.

3.2.1. Default Risk (DR)

Step 1: Estimating the value and volatility of a firm’s assets. According to [37], the following formulas are applicable:

$$V_E = V_A N(d_1) - Le^{-rt} N(d_2) \tag{1}$$

$$\sigma_E = \frac{V_A \sigma_A N(d_1)}{V_E} \tag{2}$$

Using the above formula, a firm’s asset value (V_A) and standard deviation of return on assets (σ_A) could be solved by joint method. The other information can be found in accounting financial statements, such as equity market value (V_E), standard deviation of return on equity market value (σ_E), book value of liabilities (L), risk-free interest rate (r), and debt maturity (t).

Step 2: Calculating distance to default (DD). The default point (DPT) was found to be approximately equal to short-term debt plus one-half long-term debt. The distance to default (DD) is the standard deviation between the average value of assets in a year and a default point. The calculation is as follows:

$$DD = \frac{\ln\left(\frac{V_A}{L}\right) - \ln\left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}} \tag{3}$$

Step 3: Estimating expected default frequency (EDF_1) of one year by distance to default. Based on DD, the probability that the market values of a firm’s asset will be lower than those of the liabilities at maturity is measured in accordance with the risk neutral method. The procedure is as follows:

$$EDF_1 = \text{Prob}\left(V_A^1 \leq L_1 \mid V_A^0 = V_A\right) = \text{Prob}\left(\ln V_A^1 \leq \ln L\right) \tag{4}$$

After being represented in compliance with the Ito Process, the market values of a firm’s asset can be expressed in logarithmic form. Assuming that the asset returns follow normal distribution, we obtain EDF_1 of one year.

3.2.2. Business Risk (BR)

In the business risk indicator, we used the standard deviation of three years of stock return to describe the degree of business risk. If low volatility is expected, then executing ERM is successful.

3.3. The DEA-BCC Model

To do our objectives, we assume that there are 737 DMUs, where each $DMU_j = (DMU_1, DMU_2, \dots, DMU_k, \dots, DMU_{737})$ produces the same two outputs of default risk and business risk in different amounts, using the same ten inputs, $X_{ij} = (FH, DH, INH, SIZE, LEV, OPA, LIQ, SLACK, SG, OC)$. In Equation (5), The BCC model is mathematically shown as follows:

$$\text{Max. } h_k = \frac{\sum_{r=1}^2 U_r Y_{rk} - \mu_0}{\sum_{i=1}^{10} V_i X_{ik}} \tag{5}$$

$$\text{s.t. } \frac{\sum_{r=1}^2 U_r Y_{rj} - \mu_0}{\sum_{i=1}^{10} V_i X_{ij}} \leq 1, j = 1, \dots, 737 \tag{6}$$

$$U_r, V_i \geq \varepsilon > 0 \tag{7}$$

In the BCC model, μ_0 presents positive or negative value. It is used to describe the type of returns to scale. If μ_0 is large than one, it presents decreasing returns to scale. If μ_0 is less than one, it presents increasing returns to scale. If μ_0 is equal to one, it will present constant returns to scale. In addition, Y_{rk} and X_{ik} represent the output r and input i of k th decision unit, respectively. U_r and V_i represent the weight of the related output r and input i . Therefore, the efficiency of ERM of each decision unit with BCC model through the conversion of linear programming and duality is solved as follows:

$$\text{Min. } W_k = \theta - \varepsilon \left(\sum_{i=1}^{10} S_i^- + \sum_{r=1}^2 S_r^+ \right) \tag{8}$$

$$\begin{aligned} \text{s.t. } & \sum_{j=1}^{737} \lambda_j X_{ij} - \theta X_{ik} + S_i^- = 0, \quad i = 1, 2, \dots, 10 \\ & \sum_{j=1}^{737} \lambda_j Y_{rj} - S_r^+ = Y_{rk} \\ & \sum_{j=1}^{737} \lambda_j = 1 \\ & \lambda_j, S_i^-, S_r^+ \geq 0 \end{aligned} \tag{9}$$

where Equation (8), θ denotes the intensity factor. It is used to measure the degree of adjusted proportion of input. S_i^- and S_r^+ are slack-based measures of input i and output r . The slack variables can capture the pure technical inefficiency. Finally, the condition, $\sum_{j=1}^{737} \lambda_j = 1$, can satisfy the convexity of production frontier.

3.4. The Input and Output Variables of the Second Step of the DEA-BCC Model

According to [38], the first step in this study combines corporate governance variables and firm-specific characteristics as the DEA inputs to evaluate the efficiency of default risk and business risk as the DEA outputs. The results indicate the relationship between an enterprise’s management and relative risk efficiency, which is the lower the better for enterprises. Next, the second step of DEA-BCC model furthers the linkage regarding efficiency of risk management and a firm’s performance. We used the efficiency index of risk management from the estimation of the first step of DEA-BCC model as an input variable of the second step of DEA-BCC model to analyze how the level of risk management efficiency affects profitability. In addition, the returns on assets and stock return were treated as output variables of the second step of model outputs. The two variables are defined as follows.

Firm’s Performance (ROA, SR)

The ERM aims to have stable retained earnings and maximize a firm’s value. This study used returns on assets (ROA), which was calculated as net income divided by total assets and such market-based indicators as stock returns (SR), which was calculated as yearly percentage of current stock price to stock price at the lag one period to measure operating performance.

4. Data

The purpose of this study was mainly to investigate the relative efficiency of Chinese listed companies using the DEA model and take risk as a media factor into consideration. For a comprehensive investigation, the sample data was collected from the Taiwan Economic Journal database (TEJ). Data were excluded if incomplete or missing. The relevant variables included the aspect of corporate governance, firm-specific characteristics, and risk. Furthermore, the sample period covers from 1999 through 2016. To estimate the default risk and business risk, we calculated the standard deviation of three years of yearly stock returns. As a result, the complete data was selected from a period of 2002–2016 for fifteen years. The total number of companies was 737 companies and 11,055 observations.

Descriptive statistics for the variables are reported in Table 1. As provided in Table 1, the preliminary results indicated that the percentages of shareholdings of foreign institutions, domestic institutions, and insiders are quite different among Chinese companies. It presents a large standard deviation. That is to say, the degree of external and internal monitoring among firms implies that the ERM quality differs significantly. In the risk-taking indicators, according to the results of default risk and business risk, it clearly states that some Chinese firms may suffer from high uncertainty of operating performance and high volatility of stock price. From the view of information asymmetry, market investors suffer immense loss if the financial reports do not present the financial situation. Therefore, we suggest that the implementation of internal controls is necessary to improve information quality. Similar results are also presented in ROA and stock return, where the standard deviation is larger significantly. On average, the mean performance is just 1.97% in ROA and 0.36% in SR, but the volatilities of firm performance are 18.94% and 25.53%. Our findings also support investigating whether the reformation of internal controls can effectively improve the benefits of the ERM program on firm performance. Before the first step of the DEA model estimation, the correlation between firm-specific characteristics and risk indicators is presented in Table 2. The firm-specific characteristics do not appear to have a high relation to risk indicators. That is to say, financial information may not effectively respond to the degree of risk-taking.

Table 1. Descriptive statistics.

Variable	Mean	Std.	Min.	25%	50%	75%	Max.
Panel A: firm-specific characteristics							
SIZE	6.4699	0.5693	4.2537	6.0807	6.4325	6.8129	8.9194
LEV	0.5479	0.3832	0.0071	0.3921	0.5416	0.6702	16.3290
OPA	0.0493	0.0699	0	0.0088	0.0276	0.0600	0.7975
LIQ	0.0707	0.3766	-14.1221	-0.0724	0.0827	0.2456	0.9592
SLACK	0.1473	0.1083	0	0.0725	0.1223	0.1944	0.9794
SG	0.4900	10.0277	-585.8763	-0.0509	0.0998	0.2847	466.1570
OC	0.5309	0.5388	-0.0026	0.2055	0.6816	0.6816	8.8678
Panel B: Corporate governance variables							
DH	0.1170	0.1902	0	0	0.0002	0.1778	0.9132
FH	0.0063	0.0415	0	0	0	0	0.6378
INH	0.0011	0.0134	0	0	0	2.3×10^{-7}	0.3993
Panel C: Risk and performance indicators							
DR	0.0099	0.0866	0	4.95×10^{-57}	2.66×10^{-19}	1.26×10^{-7}	1
BR	0.5627	0.5533	0.0006	0.1858	0.3730	0.7842	7.1580
ROA	0.0197	0.1894	-8.7533	0.0070	0.0243	0.0502	7.4451
SR	0.0036	0.2553	-0.9977	-0.1450	-0.0211	0.1560	1.1180

Note. The symbols DR and BR denote the default risk and business risk, respectively. ROA and SR present the return on assets and yearly stock return as the proxies: accounting-based and market-based performance. In the firm-specified characteristics, SIZE, LEV, OPA, LIQ, SLACK, SG, and OC individually denote firm size, leverage, opacity, capital liquidity, sale growth, and operating cost. Finally, DH, FH, and INH are corporate governance variables.

Table 2. Correlation between firm-specific characteristics and risk indicators.

	SIZE	LEV	OPA	LIQ	SLACK	SG	OC	DH	FH	INH	BR	DR
SIZE	1											
LEV	-0.0159	1										
OPA	-0.1075	-0.0198	1									
LIQ	0.1062	-0.8192	-0.1451	1								
SLACK	0.0023	-0.1214	-0.1124	0.2792	1							
SG	0.0133	0.0126	-0.0055	0.0070	-0.0115	1						
OC	0.0641	0.0641	-0.0840	-0.0227	0.1485	0.0034	1					
DH	-0.2604	0.0585	0.0122	-0.0531	-0.0645	0.0097	-0.0521	1				
FH	0.0100	-0.0119	-0.0263	-0.0005	-0.0442	-0.0017	0.0349	0.0104	1			
INH	0.0356	-0.0013	-0.0259	0.0322	0.0048	0.0263	-0.0244	-0.0030	-0.0096	1		
BR	0.0228	0.0268	0.0423	-0.0123	0.0302	0.0067	0.0285	-0.0622	0.0107	0.0050	1	
DR	-0.0632	0.2837	0.0030	-0.2707	-0.0570	0.0064	-0.0047	0.0600	-0.0090	-0.0077	-0.0139	1

Note: The symbols DR and BR denote the default risk and business risk, respectively. In the firm-specified characteristics, SIZE, LEV, OPA, LIQ, SLACK, SG, and OC individually denote firm size, leverage, opacity, capital liquidity, sale growth, and operating cost. Finally, DH, FH, and INH are corporate governance variables.

5. Empirical Results

The estimated results from the two-step DEA model in 2016 are reported in Tables 3 and 4. After inputting the factors of corporate governance and firm-specific characteristics, Table 3 presents 50 inefficient companies. Given the relevance of ERM, we found that the ERM program did not bring essential benefits to firm performance. The overall results suggest that firms with a high efficiency index of risk-taking should reorganize the ERM program, including the improvement of corporate governance mechanisms and adjustments to financial structure. This suggestion is inconsistent with the view of traditional theory. High risk-taking does not present high firm performance. One possible reason may be that the firm performance does not completely respond to the information of corporate governance and financial reports, while another is the effects of non-tradable share stock in China. A firm with a high proportion of non-tradable shares may have high information asymmetry.

Regarding the relative efficiency of the TOP 50 companies, compared to the LOWER 50 companies, the efficiency index of the two-step DEA model presents quite different findings. This study aimed to evaluate firm performance in China. We observed that the first step results lie in the range of 0.5 to 0.7, clearly indicating that some companies have proper ERM and make high efficiency of firm profitability. In other words, the ERM can help a firm achieve the optimum efficiency in firm performance.

To examine whether the reformation of internal controls has significant effects, according to the results of relative efficiency of the lower 50 companies, we re-sorted the stock number and found the same companies before/after 2009. The whole sample was divided into two subsample periods: 2002–2009 and 2010–2016. The group of lower relative efficiency still has 18 companies. Table 5 reports the estimated results. Empirical results indicate that these companies presented a high level of risk-taking. After the 2008 financial crisis, during the period from 2010 to 2016, most companies clearly demonstrated the phenomenon of increases in efficiency of ERM and firm performance. This finding indicates that these companies with weak ERM programs began to pay attention to improving risk management and profitability after 2009, but these results also suggest that the maximum benefits of internal controls reformation still need to be improved.

Table 3. Results of the LOWER 50 companies from the two-step DEA model.

No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.	No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.
1	1.0000	0.5877	26	0.9590	0.6107
2	1.0000	0.5820	27	0.9564	0.6048
3	1.0000	0.5822	28	0.9550	0.6045
4	1.0000	0.5823	29	0.9537	0.6104
5	1.0000	0.5774	30	0.9420	0.6136
6	1.0000	0.5801	31	0.9246	0.6301
7	1.0000	0.5839	32	0.9236	0.6255
8	1.0000	0.5779	33	0.9232	0.6310
9	1.0000	0.5855	34	0.9221	0.6265
10	1.0000	0.5774	35	0.9221	0.6372
11	1.0000	0.5781	36	0.9215	0.6265
12	1.0000	0.5829	37	0.9200	0.6313
13	1.0000	0.5776	38	0.9178	0.6291
14	1.0000	0.5774	39	0.9134	0.6414
15	1.0000	0.5782	40	0.9131	0.6355
16	1.0000	0.5792	41	0.9110	0.6347

Table 3. Cont.

No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.	No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.
17	1.0000	0.5781	42	0.9092	0.6418
18	1.0000	0.5818	43	0.9085	0.6355
19	0.9986	0.5857	44	0.9067	0.6368
20	0.9974	1.0000	45	0.9065	0.6428
21	0.9931	0.5820	46	0.9057	0.6511
22	0.9876	0.5846	47	0.9053	0.6446
23	0.9840	0.5899	48	0.9026	0.6523
24	0.9782	0.5935	49	0.9026	0.6412
25	0.9675	0.5967	50	0.8994	0.6467

Note: The 'Effic of Risk Manag' presents the efficiency index of risk management. In the first step of DEA-BCC model, this study combines corporate governance variables and firm-specific characteristics as the input variables to evaluate the efficiency of default risk and business risk as the output variables. According to the results of first step estimation of DEA-BCC model, the efficiency index of risk management is further used to be the input variable in second step estimation. Given that the two output variables in second step are returned on assets and stock return, the 'Effic of Oper Perfor' in column 3 and column 6 reports the firm's operating efficiency.

Table 4. Results of the TOP 50 companies from the two-step DEA model.

No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.	No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.
1	0.9974	1.0000	26	0.6392	0.9033
2	0.5774	1.0000	27	0.6552	0.9028
3	0.5797	0.9959	28	0.6402	0.9025
4	0.5916	0.9858	29	0.6404	0.9020
5	0.6050	0.9649	30	0.6405	0.9015
6	0.6136	0.9410	31	0.6423	0.9013
7	0.6153	0.9384	32	0.6521	0.8990
8	0.6172	0.9355	33	0.6495	0.8969
9	0.6183	0.9345	34	0.6447	0.8955
10	0.6219	0.9288	35	0.6449	0.8953
11	0.6273	0.9271	36	0.6468	0.8927
12	0.6236	0.9259	37	0.6519	0.8898
13	0.6283	0.9259	38	0.6522	0.8895
14	0.6246	0.9258	39	0.6492	0.8893
15	0.6268	0.9250	40	0.6501	0.8881
16	0.6247	0.9242	41	0.6538	0.8856
17	0.6307	0.9220	42	0.6520	0.8855
18	0.6303	0.9210	43	0.6531	0.8840
19	0.6271	0.9206	44	0.6533	0.8838
20	0.6296	0.9171	45	0.6547	0.8819
21	0.6359	0.9145	46	0.6553	0.8811
22	0.6365	0.9092	47	0.6664	0.8809

Table 4. Cont.

No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.	No.	Effic. of Risk Manag.	Effic. of Oper. Perfor.
23	0.6459	0.9091	48	0.6560	0.8802
24	0.6371	0.9074	49	0.6592	0.8785
25	0.6370	0.9064	50	0.6617	0.8782

Note: The 'Effic of Risk Manag' presents the efficiency index of risk management. In the first step of DEA-BCC model, this study combines corporate governance variables and firm-specific characteristics as the input variables to evaluate the efficiency of default risk and business risk as the output variables. According to the results of first step estimation of DEA-BCC model, the efficiency index of risk management is further used to be the input variable in second step estimation. Given that the two output variables in second step are returned on assets and stock return, the 'Effic of Oper Perfor' in column 3 and column 6 reports the firm's operating efficiency.

Table 5. Comparison of improvement of the lower 18 companies after 2009.

No.	2002–2009		No.	2010–2016	
	Effic. of Risk Manag.	Effic. of Oper. Perfor.		Effic. of Risk Manag.	Effic. of Oper. Perfor.
1	0.9439	0.6226	1	0.9344	0.6317
2	1.0000	0.5881	2	0.9622	0.6180
3	0.9340	0.6297	3	0.9119	0.6369
4	0.9928	0.6067	4	0.9990	0.5860
5	0.9665	0.6085	5	0.9497	0.6215
6	0.9587	0.6185	6	0.9018	0.6537
7	0.9186	0.6386	7	0.9028	0.6501
8	0.9495	0.6207	8	0.9283	0.6276
9	0.9388	0.6333	9	0.9787	0.6053
10	0.9754	0.6537	10	0.9040	0.6472
11	0.9547	0.6308	11	0.9484	0.6189
12	0.9611	0.6100	12	0.9884	0.5956
13	0.9184	0.6445	13	0.9001	0.6523
14	0.9362	0.6331	14	0.9109	0.6454
15	0.9543	0.6177	15	0.9934	0.5918
16	0.9518	0.6177	16	0.9129	0.6424
17	0.9581	0.6185	17	0.9260	0.6386
18	0.9328	0.6340	18	0.9975	0.5905

Note: The 'Effic of Risk Manag' presents the efficiency index of risk management. In the first step of DEA-BCC model, this study combines corporate governance variables and firm-specific characteristics as the input variables to evaluate the efficiency of default risk and business risk as the output variables. According to the results of first step estimation of DEA-BCC model, the efficiency index of risk management is further used to be the input variable in second step estimation. Given that the two output variables in second step are returned on assets and stock return, the 'Effic of Oper Perfor' in column 3 and column 6 reports the firm's operating efficiency.

6. Conclusions

Using the two-step DEA approach, this study provides an analysis of relative efficiency of risk-taking and firm performance in Chinese listed companies. Considering China's Ministry of Finance has enacted the Basic Standards for Enterprise Internal Control to aggressively improve information disclosure and corporate governance, we attempted to examine whether the reformation of information disclosure and internal controls could significantly improve a firm's profitability. In particular, this study infers that, except for firm-specific characteristics, the effects of corporate governance quality on risk-taking are negatively significant, further resulting in increases in the firm's profitability. To obtain our objectives, this study used the KMV model to estimate the default risk and calculate the standard deviation of stock return to measure business risk.

Empirical results indicate that firms with a low efficiency index of ERM will have low performance. This finding differs with traditional financial theory, in which high risk undertaking will earn high expected returns. In the whole sample, the best efficiency index of ERM of a firm lies between 0.5 and 0.7. Furthermore, the sample is divided into two sub-sample periods: 2002–2009 and 2010–2016, to examine whether the reformation of information disclosure and internal controls can significantly improve a firm’s profitability. Overall results showed that internal controls significantly improved after the 2008 financial crisis. We also suggest that the problem of information asymmetry still exists in financial markets. To achieve the maximum benefits of shareholders and improve the quality of information disclosures, methods for enacting market regulation is still a vital issue in China.

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