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# Does enterprise risk management benefit manufacturing firms? Evidence from China

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**ABSTRACT**

It is observed that Enterprise risk management (ERM) framework has been adopted by some manufacturing firms in China in the past years. To investigate the effectiveness of ERM, data of A-share listed manufacturing firms in Shanghai and Shenzhen stock exchange during 2010-2019 are adopted from Wind database and CSMAR database, two large domestic databases, to examine the impact of ERM on value of manufacturing firms. Treatment effects model and genenralised method of moments (GMM) are employed to derive the empirical results. Our results show that adoption of ERM can add value to the firms, and firms benefit more from high-quality ERM program. Furthermore, the impact of ERM seems to be more significant among the manufacturing firms with smaller scale, or stronger institutional shareholding, or international business. Our findings encourage the manufacturing firms to implement ERM program and improve the program to achieve its targets.

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## 1. Introduction

This article tries to examine if the implementation of enterprise risk management (ERM) can benefit the manufacturing firms and increase the firm value. The results contain meaningful managerial implications for the manufacturing firms. It is widely acknowledged that various risks are conclusively challenges for the manufacturing firms (Paul et al., 2021). When the business becomes more and more globalised, uncertainty aroused from geopolitical conflicts become a significant threat (Rahman et al., 2021). The ongoing pandemic aggravates the situation by putting the firms in a new risk scenario (Sharma et al., 2020a, 2020b; Hoek & Loseby, 2021). According to a survey conducted by ISM (Institute for Supply Management), a professional supply management organisation worldwide, 75 percent of U.S. manufacturing companies experienced delayed resources and materials due to the COVID-19 pandemic, and for the first time in recent manufacturing history, demand, supply and workforce

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availability have been affected globally at the same time. Manufacturers, especially those heavily dependent on offshore production and foreign suppliers, were adversely affected. Risk management is gaining its importance within modern manufacturing firms amid the changing business environment.

Traditionally, the various risks were treated separately because each type of risks seemed to be quite different from others. However, in the past decades, due to the improvement of capability of identifying and treating the complex and correlated risks, there was a trend to treat various risks in an integrated and coordinated manner within firms, so called enterprise risk management (ERM) (Ai et al., 2018). The philosophy of integrated approach can also be observed when treating the risks in some financial fields (Biswas et al., 2019). During the past decades, more and more firms upgraded their strategies in risk management and adopted ERM. Many famous rating agencies also took ERM performance into account when evaluating a specific firm. Chinese manufacturing firms began to adopt ERM in the past several years. But did ERM benefit Chinese manufacturing firms and play a role in the rise of Chinese manufacturing industry in the global market? This article tries to answer the question by examining the effect of ERM on Chinese manufacturing firms' financial performance. To our best knowledge, this is the first research that focuses on ERM in manufacturing firms. The positive results derived from empirical studies may encourage the manufacturing firms to widely utilise ERM framework to manage their complex risks and promote the growth.

The remaining of this article is organised as follows: Section 2 is literature review, Section 3 constructs the theoretical relation between firm value and risk management, Section 4 presents the methodology and data, Section 5 gives the empirical results, Section 6 explores further about the impact of ERM program on firm value, Section 7 displays the heterogeneity among the firms, and Section 8 concludes the article.

## 2. Literature review

### 2.1. Challenges for risk management of manufacturing firms

Manufacturing firms, like many other business firms, are susceptible to various events (Margherita & Heikkila, 2021). These events include natural catastrophes (e.g., earthquakes, floods) and man-made disasters such as cyber attack, terrorism, adverse market condition, and supply chain crises (Saenz et al., 2018; Strandvik et al., 2018; Yang & Jiang, 2015). Coping with these challenges has gained wide attention among various firms (Turoff et al., 2013). Risk management plans ensure the survival of firm, steady income and continuous growth (Parker & Ameen, 2018; Rezaei Soufi et al., 2019). Scholars and practitioners have introduced several methods to achieve these goals. Activities include risk identification, risk evaluation, selection of appropriate risk management instruments, and continuous update of measures (Lo'Pez & Ishizaka, 2019; Schatter et al., 2019; Speight, 2011).

However, some scholars find that there are rarely structured risk management methods in the manufacturing industry (Kallman & Maric, 2004; Merna & Al-Thani, 2005). Kumar and Gregory (2013) comments that manufacturing industry was academically neglected in the literature of risk management, and practices of risk

management had not gained their development in the globalised manufacturing industry. Kumar and Gregory (2013) appeals that knowledge of various fields should be integrated to probe the sources of risks and process of risk management for the manufacturing firms. Enterprise risk management (ERM) is a distinct model for managing a sophisticated portfolio of corporate risks (Krause & Tse, 2016). ERM has been gaining its popularity as its strength were realised by an increasing number of firms (Ai et al., 2018; Hoyt & Liebenberg, 2011), and its effects in manufacturing firms are highly expected.

### 2.2. Factors which affect the adoption of ERM

When more and more firms implemented ERM, some researchers became interested in the factors which affect the adoption of ERM (Ai et al., 2018). Lurtz and Kreutzer (2017) argue that application of ERM in non-profit organisations is necessary when trying to maintain the beneficiaries/clients' interests over the longer term. Beasley et al. (2015) find that certain board and risk management practices are associated with perceptions that ERM provides strategic advantage (consistent with resource dependence theory). Liebenberg and Hoyt (2003) identify that large-scale, complex firms are prone to adopt ERM, and a position of chief risk officer (CRO) is more common to see in the high-leverage firms. Kleffner et al. (2003) find that the independent role of risk manager, the encourage from the board of directors, and the compliance of securities transactions are also positively associated with the adoption of ERM within a firm. Those with higher S&P rating and better financial resources are more prone to adopt ERM too (Baxter et al., 2013). Pagach and Warr (2011) find that firms with large scale, more volatile revenues and stronger institutional investors tend to adopt ERM. Maier et al. (2016) believe that the social mission of a non-profit organisation could be the obstacle for adopting the ERM framework. Chen et al. (2019) verify that the organisation culture factors of Outcome Orientation (valuing achievements and results) and Innovation (valuing receptivity and adaptability to change) are associated with the maturity of the not-for-profits' ERM program. Some literature investigate the determinants of effective ERM program in company, such as the perception of the executive team (Blanco-Mesa et al., 2019).

### 2.3. Impact of ERM on firm value

Another strand of literature study the effects of ERM. Hang et al. (2020) discovers that risk management activities can promote the firm value, with the capital structure as a mediation. Lin et al. (2017) identify that an ERM program considering pension effect integrates the risks of the operation and pension divisions and, thus, achieves diversification benefits between and within these two divisions, and certain pension hedging strategies can impact the firm's net value under the ERM framework. Generally, a positive correlation between ERM adoption and firm value is found in literature (e.g., Ai et al., 2018; Gatzert & Martin, 2015). Farrell and Gallagher (2015) confirms that firm value is 25% higher for those with mature ERM program. The benefits of ERM include reducing volatility of return and stock price, cutting down

the costs of capital from external sources, improving capital efficiency and operational flexibility, and lowering risk management costs through the synergy effects of ERM (Ai et al., 2018). Grace et al. (2015) specifies some effective ERM measures which could contribute to the firm value, including using economic capital models, employing cross-department risk manager, and requiring the risk manager report directly to the board of directors or chief executive officer. Eckles et al. (2014) and Berry-Stölzle and Xu (2018) identify that ERM helps reduce the cost of risks for a firm. Ai et al. (2018) finds that firms with multiple product lines can increase financial performance and promote the share price by implementing ERM. Naseem et al. (2020) discovers that ERM positively moderates the relation between social responsibility and the financial performance of firms. Johnston and Soileau (2020) discover that ERM can reduce accruals estimation errors in firm management. Malik et al. (2020) find that effectiveness of ERM significantly and positively affects firm performance and a strong board-level risk committee (BLRC) governance increases the firm performance effects of ERM. Meanwhile, some literature provide contradictory evidences on the effect of ERM. For instance, González et al. (2020) identify that the relation between adoption of ERM and the performance of Spanish companies is not significant as expected. Nasr et al. (2019) provide empirical evidence which suggest that the adoption of ERM program influence the long-term performance of a firm, rather than its short-term performance.

The risks for the manufacturing firms are extensive and complex, but there were few researches about ERM utilisation in manufacturing firms yet. This article contributes to the literature by providing evidence from manufacturing industry. Besides, according to our limited knowledge, this is the first research to use two measures of ERM to cross check the effects of ERM for firms. Based on our empirical results, manufacturing firms are generally encouraged to adopt ERM to manage risks effectively and efficiently. As the chaos caused by the COVID-19 pandemic could have a mid-term or long-term impact on manufacturing firms (Queiroz et al., 2020), risk management implications derived from this research is especially valuable.

## 3. A theoretical analysis on risk management and firm value

The growth opportunity of a firm is generally realised through continuous investments with funds from either internal sources or external sources. According to the theory of pecking order, the funds from external source is usually at higher costs. When the assets are exposed to loss and the stock of internal funds are endangered, the future investment is subject to variation, and the firm value is affected accordingly.

Following Froot et al. (1993), we consider a firm with two-period financing decision and investment. In the first period, the firm has a liquid assets $w$. The firm will set its investment plan and financing strategy at this time. In the second period, the investment will be realised and the financial results will be distributed to various investors.

To realise the investment, the firm needs to raise funds $I$, in which part, say $w$, would be financed from internal sources and the rest, say $e$, could come from external sources

(thus $I = w + e$). The extra costs of external financing are stated as $C = C(e)$ and $C_e \geq 0$, indicating an increasing function of the amount of external funds.

When the firm is faced with the uncertainty of loss in the first period, the amount $w$ would be a random number. In this case, risk management for reducing the risk is a reasonable choice if the transaction fee is acceptable. For simplicity, we assume the hedging fee is zero here. It is easy to see that risk management is preferable when profits are a concave function of internal wealth.

The firm makes investment decision to maximise net expected profits in the first period (see Equation (1)):

$$P(\mathrm{w}) = \underset{I}{\mathrm{MAX}}\left[F(I) - C(e)\right] \tag{1}$$

where $\mathrm{P}(w)$ is net expected profits, $\mathrm{F}(I)$ is net present value of investment expenditures $I$, and $\mathrm{C}(e)$ are costs of external financing. $\mathrm{F}(I)$ is computed as Equation (2):

$$\mathrm{F}(I) \;=\; \mathrm{f}(I) \;-\; I \tag{2}$$

where $\mathrm{f}(I)$ is investment output function and $I$ is investment expenditures. The first-order condition of Equation (1) can be stated as Equation (3):

$$F_I = f_I - 1 = C_{\mathrm{e}} \tag{3}$$

where $F_I$ and $f_I$ are the first derivative of $\mathrm{F}(I)$ and $\mathrm{f}(I)$, respectively, and $C_e$ is the first derivative of $\mathrm{C}(e)$. The second derivative for the problem (1) is given by Equation (4):

$$\mathrm{P}_{ww} = \mathrm{f}_{II}\left(\frac{\mathrm{d}I^*}{\mathrm{d}w}\right)^2 - C_{ee}\left(\frac{\mathrm{d}I^*}{\mathrm{d}w} - 1\right)^2 \tag{4}$$

where we use the fact that when $w$ is given, $\mathrm{d}e/\mathrm{d}I = 1$ in the second period. $\mathrm{f}_{II}(^*)$ and $C_{ee}(^*)$ are evaluated at $I = I^*$ in Equation (4). Equation (4) can be rewritten by applying the Implicit Function Theorem to Equation (3) to yield

$$\mathrm{P}_{ww} = \mathrm{f}_{II}\frac{\mathrm{d}I^*}{\mathrm{d}w} \tag{5}$$

Assumption of pecking order of financing indicates that $\frac{\mathrm{d}I^*}{\mathrm{d}w}$ is positive, thus as long as marginal returns on investment is decreasing ($\mathrm{f}_{II} < 0$), which is widely applicable in reality, risk management can improve the profits and increase the firm value.

ERM is a structured method with a holistic view to manage various risks faced by the firms. The basic idea behind this method is to use natural hedging by pooling various loss exposures together, so that the total risk can be reduced more economically. Implementation of ERM can help realise the growth opportunity, among other benefits, and increase the firm value.

## 4. Methodology and data

### 4.1. Empirical models

This article employs treatment effects models to investigate the relation between ERM adoption and the firm value. The rationale behind this approach is that there may be reciprocal causation between these two variables as we know that ERM could promote the firm value, but firms with higher value might also have stronger tendency to adopt ERM. According to Maddala (1983), the treatment effect model is composed of two parts, the principle regression model is:

$$Q_{it} = \delta_{it} ERM_{it} + X_{it}\beta_{it} + \epsilon_{it} \quad (6)$$

where $Q_{it}$ is the value of firm $i$ in year $t$, $ERM_{it}$ is a dummy variable which indicates if firm $i$ implements ERM in year $t$, when firm $i$ implement ERM in year $t$, then $ERM_{it} = 1$, otherwise $ERM_{it} = 0$. $X_{it}$ represents the control variables.

$$ERM^{*}_{it} = \gamma_{it}\omega_{it} + u_{it} \quad (7)$$

Equation (7) is called treatment equation. $ERM^{*}_{it}$ is the treatment variable which indicate the probability the firm implemented ERM in year $t$, $\omega_{it}$ represents the factors which could affect the decision of the firm to adopt ERM. Variables in $\omega_{it}$ and $X_{it}$ can overlap with each other, but $\omega_{it}$ and $X_{it}$ should not be identical, at least one variable in $\omega_{it}$ is not included in $X_{it}$.

### 4.2. Definition of variables

The dependent variable is firm value. We use Tobin's Q, calculated as the annual market value of the firm divided by its total assets, as a proxy for firm value. Tobin's Q represents the expectation of the investors for the firm. Higher value of Tobin's Q means that the investors believe the firm is very competitive in the future market and the return will be good. Focussing on the potential effect might be appropriate because the impact of ERM could come with hysteresis.

ERM is set as the core explanatory variable. ERM is a dummy variable with value 1 or 0. Like many previous literature, this article uses text analysis approach to determine the value of ERM. Specifically, a database of financial documents called WinGo is utilised to analyse the annual reports of the firms. The keywords 'enterprise risk management' 'integrated risk management' 'chief risk officer' 'risk management committee' 'ERM' 'CRO' which are deemed to characterise ERM are searched through the documents, if there is (are) positive result(s), then $ERM_{it}$ will be assigned with value 1, otherwise 0. Manual checks were also conducted to verify the results. A positive coefficient $\beta_{it}$ of $ERM_{it}$ in Equation (6) will indicate that the impact of ERM on firm value is positive.

The control variables in Equations (6) and (7) are listed in Table 1, many previous literature are referred to in determining the control variables (e.g., Berry-Stölzle & Xu, 2018; Farrell & Gallagher, 2015; Hoyt & Liebenberg 2011; Pagach & Warr, 2011).

**Table 1.** Definition and possible effect of the variables.

| Name | Description | Effects on firm value | Effects on ERM engagement |
|---|---|---|---|
| Q | Tobin's Q, calculated with $Q_{i,t}$ = market $value_{i,t}$/Total $assets_{i,t}$ for firm i in year t | / | / |
| ERM(/ERMI) | Enterprise risk management (ERM) or enterprise risk management index (ERMI). ERM is a dummy variable, $ERM_{i,t} = 1$ when the firm i has implemented ERM in year t, otherwise $ERM_{i,t} = 0$. The value of ERMI is calculated according to Gordon et al. (2009) | Positive (McShane, 2011; Hoyt & Liebenberg, 2011; Farrell & Gallagher, 2015) | / |
| Size | Scale of the firm, represented with logarithm of the total assets. | Negative (Hoyt & Liebenberg, 2011; Lang & Stulz, 1993) | Positive (Beasley et al., 2005) |
| Lev | Financial leverage ratio. $Lev_{i,t}$ = book value of $debt_{i,t}$/ market value of $equity_{i,t}$ | Ambiguous (Saurabh & Sharma, 2015) | Positive (Pagach & Warr, 2011; Liebenberg & Hoyt, 2003) |
| Growth | Year on year growth rate of business, $Growth_{i,t}$ = sales $volume_{i,t}$/(sales $volume_{i,t}$-sales $volume_{i,t-1}$) | Positive (Titman & Wessels, 1988) | Ambiguous (Farrell & Gallagher, 2015) |
| Div_int | Diversity of business. $Div\_int_{i,t}$ = 1 when firm i has international business in year t, otherwise, $Div\_int_{i,t}$ = 0 | Positive (Bharadwaj et al., 1999) | Positive (Hoyt & Liebenberg, 2011) |
| ROA | Return on assets. $ROA_{i,t}$ = [net income + interest * (1-tax rate)]/total $assets_{i,t}$ | Positive (Hoyt & Liebenberg, 2011) | / |
| Dividend | Distribution of dividend. $Dividend_{i,t}$ = 1 when firm i distributed dividend in year t, otherwise, $Dividend_{i,t}$ = 0 | Ambiguous (Lang & Stulz, 1993) | |
| Beta | Market risk | Negative (Farrell & Gallagher, 2015) | |
| BMV | Book to market value. $BMV_{i,t}$ = book $value_{i,t}$/market $value_{i,t}$ | / | Positive (Hoyt & Liebenberg, 2003) |
| Event | If there is any events concerning mergers and acquisition, and other activities about buying or selling assets for firm i in year t. $Event_{i,t}$ = 1 when the above statement is true, otherwise, $Event_{i,t}$ = 0 | | Negative (Berry-Stölzle & Xu, 2018) |
| Opacity | Opacity of the assets. $Opacity_{i,t}$ = invisible $assets_{i,t}$/book value of total $assets_{i,t}$ | | Positive (Hoyt & Liebenberg, 2011) |
| VC | Variation of market value. $VC_{i,t}$ = (market $value_{i,t}$ - market $value_{i,t-1}$)/market $value_{i,t-1}$ | | Negative (Pagach & Warr, 2011) |
| Institution | Ratio of share held by the institutions | | Positive (Hoyt & Liebenberg, 2011) |
| Volatility | Volatility of the revenue, represented with the variance of the rate of return earned by reinvesting the cash dividend in the stock markets | | Ambiguous (Pagach & Warr, 2011) |

(*continued*)

Table 1. Continued.

| Name | Description | Effects on firm value | Effects on ERM engagement |
|---|---|---|---|
| Slack | Degree of financial slack. $Slack_{i,t}$ = cash plus $security_{i,t}$/total $assets_{i,t}$ | | Ambiguous (Pagach & Warr, 2011) |
| CV | Variation of EBIT. $CV_{i,t}$ = $(EBIT_{i,t}-EBIT_{i,t-1})/EBIT_{i,t-1}$ | | Ambiguous (Pagach & Warr, 2011) |

Source: Authors' design and calculation.

### 4.3. Sample and data

To investigate the impact of ERM on the firm value in the manufacturing industry, this article studies the A-share listed manufacturing firms in Shanghai and Shenzhen stock exchange during 2010-2019. The data of these firms are derived from Wind database and CSMAR database. Firms under special treatment (usually labelled as *ST) by China Security Regulatory Commission (CSRC) are deleted, and the samples with missing data are deleted as well. Finally, we got 8386 observations. To avoid unfavourable effect of extreme value, the data are winsorized at quantile 1% and 99%.

### 4.4. Descriptive statistics

Logarithm has been taken where necessary. The results of descriptive statistics are shown in Table 2, the mean of Tobin's Q is 2.341, indicating that investors have great faith on the development of the listed manufacturing firms. The mean of ERM is 0.222, indicating that on average ERM is adopted by 22.2% observations. All the data fall within the reasonable range.

## 5. Empirical results

The regression results of Equations (6) and (7) are shown in Table 3. The column (1) and (2) are the results with Two-step approach, and column (3) and (4) with Maximum Likelihood Estimation (MLE) approach for comparison.

According to the results of Two-step approach regression, the coefficient of variable ERM is 0.886 and is significant at 1% level, indicating that on average the firms with ERM program have higher firm value than those without. The estimation results with maximum likelihood estimation (MLE) approach also support above conclusion. The reasons behind the results could be: reduced costs in managing risks (Eckles et al., 2014); lower capital costs as ERM enable the firm to disclose high quality information to the investors (Berry-Stölzle & Xu, 2018); or lower volatility of risk-adjusted revenue after the implementation of ERM (Florio & Leoni, 2017). Of course, the added value may also come from the realised investment due to risk management as our theoretical analysis indicates. The empirical results are consistent with those of many prior researches, e.g., Gatzert and Martin (2015), Ai et al. (2018) and Naseem et al. (2020), though most of these researches focussed on financial firms. However, our results are contrary to González et al. (2020) which took samples from non-financial Spanish listed companies and found that the adoption of ERM is not associated with a change in the performance of Spanish companies nor does it reduce the

**Table 2.** Descriptive statistics of variables.

| Variable | Mean | Std. Dev. | Min | Max | Median |
|---|---|---|---|---|---|
| Q | 2.341 | 1.499 | 0.856 | 8.801 | 1.855 |
| ERM | 0.222 | 0.416 | 0 | 1 | 0 |
| beta | 1.025 | 0.303 | 0.299 | 1.833 | 1.021 |
| div int | 0.735 | 0.441 | 0 | 1 | 1 |
| Dividend | 0.713 | 0.453 | 0 | 1 | 1 |
| Growth | 0.149 | 0.265 | −0.408 | 1.343 | 0.110 |
| Lev | 3.103 | 2.312 | 1.165 | 14.62 | 2.325 |
| ROA | 6.937 | 5.273 | 0.078 | 27.13 | 5.509 |
| Size | 22.352 | 1.163 | 20.094 | 25.791 | 22.219 |
| BMV | 0.458 | 0.292 | 0.064 | 1.556 | 0.389 |
| CV | 0.162 | 0.887 | −0.502 | 6.195 | −0.105 |
| event | 0.776 | 0.417 | 0 | 1 | 1 |
| Institution | 0.428 | 0.218 | 0.006 | 0.867 | 0.443 |
| Opacity | 0.045 | 0.035 | 0.001 | 0.199 | 0.037 |
| Slack | 0.028 | 0.208 | −0.453 | 0.52 | 0.020 |
| VC | 0.145 | 0.552 | −0.554 | 2.629 | 0.012 |
| Volatility | 0.447 | 0.136 | 0.224 | 0.853 | 0.419 |

Source: Authors' estimation.

**Table 3.** Estimation results of treatment effects model (two-step/MLE).

| | Two-step | | MLE | |
|---|---|---|---|---|
| Variables | ERM | Q | ERM | Q |
| ERM | | 0.886*** (3.85) | | 0.927*** (57.34) |
| Growth | −0.176*** (−2.87) | 0.275*** (5.36) | −0.335*** (−6.08) | 0.401*** (7.11) |
| Lev | −0.015 (−1.46) | 0.093*** (15.39) | −0.035*** (−4.18) | 0.104*** (15.13) |
| Size | 0.158*** (6.89) | −0.567*** (−31.04) | 0.212*** (11.34) | −0.628*** (−45.30) |
| div_int | −0.163*** (−4.61) | −0.026 (−0.84) | −0.109*** (−3.34) | 0.007 (0.21) |
| BMV | 0.142** (2.05) | | −0.729*** (−13.56) | |
| CV | −0.061*** (−2.75) | | 0.033** (2.14) | |
| event | −0.032 (−0.85) | | 0.068*** (2.60) | |
| Institution | 0.820*** (10.14) | | 0.629*** (10.94) | |
| Opacity | −0.794* (−1.71) | | −0.218 (−0.67) | |
| VC | −0.011 (−0.36) | | 0.136*** (5.86) | |
| Volatility | 0.203 (1.56) | | 0.231** (2.25) | |
| Slack | −0.006 (−0.06) | | 0.004 (0.05) | |
| beta | | −0.285*** (−6.59) | | −0.191*** (−4.71) |
| Dividend | | −0.177*** (−6.33) | | −0.116*** (−4.49) |
| ROA | | 0.089*** (35.53) | | 0.071*** (29.73) |
| Year fixed effects | Yes | Yes | Yes | Yes |
| Constant | −4.570*** (−9.26) | 14.646*** (40.40) | −5.274*** (−12.88) | 15.577*** (49.54) |
| lambda | | −0.436*** (−3.25) | | – |
| Wald test | | – | | 2989.30*** |
| Observations | 8,386 | 8,386 | 8,386 | 8,386 |

z-Statistics in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Source: Authors' estimation.

probability of bankruptcy. Thus our study adds important evidence on the effects of ERM for the non-financial firms.

The results also show that the coefficients of most variables are consistent with previous literature. In general, the results with two-step approach and MLE are quite similar to each other, so it is safe to believe that the estimations are robust. The significance of inverse Mills ratio (IMR) (lamda) indicates that the self-selection issue, where those high-value firms may tend to adopt ERM, exists and the treatment effects model is appropriate for the estimation.

## 6. Further investigation with index of ERM quality

### 6.1. Construction of ERM quality index

In the previous estimation, we use a dummy variable to represent the adoption of ERM program. The disadvantage of this approach lies in that we know little about the quality (or intensity) of ERM program and its effects in a specific firm. To further investigate the impact of ERM on firm value, we try to quantify the quality of ERM and study its impact on firm value.

According to COSO (2004), the ERM program should be geared to achieve four targets of the firm regarding strategies, operations, reporting, and compliance. Accordingly, the quality of ERM program can be gauged from the above-mentioned four aspects. This article follows Gordon et al. (2009) to measure the quality of ERM program. Specifically, 2 indices are used to reflect each target, and 8 indices of 4 targets in total are then added up to create the ERM index (ERMI), Equation (8) illustrates the composition of ERMI.

$$\begin{aligned} ERMI_{it} = {} & Strategy_{1it} + Strategy_{2it} + Operation_{1it} + Operation_{2it} \\ & + Report_{1it} + Report_{2it} + Compliance_{1it} + Compliance_{2it} \end{aligned} \tag{8}$$

The indices used to compute ERMI are listed in Table 4, interested reader can refer to Gordon et al. (2009) for details.

The descriptive statistics of ERMI are reported in Table 5. Generally, the number of firms which were confirmed to have implemented ERM increased during 2013–2019. The mean of ERMI varies during the time span, but the trend is not clear.

### 6.2. Model selection and regression results

The Generalized Method of Moments (GMM) approach is employed to run the regression. The equation estimated is:

$$\begin{aligned} Q_{it} = {} & \beta_0 Q_{it-1} + \beta_1 ERMI_{it} + \beta_2 Size_{it} + \beta_3 Lev_{it} + \beta_4 ROA_{it} \\ & + \beta_5 Growth_{it} + \beta_6 Dividend_{it} + \beta_7 div\_int_{it} + \beta_8 beta_{it} + u_i + v_{it} \end{aligned} \tag{9}$$

where $Q_{it-1}$ is a lagged term of dependent variable, $ERMI_{it}$ is the ERM index, $u_i$ is a fixed effect term for firm i, $v_{it}$ is the residual, other control variables are as in Equation (6).

Equation (9) is estimated with System GMM method. The regressions are conducted from reduced model to full one with control variables being added gradually. The estimation results are reported in Table 6. The estimation results are generally stable when the model is nearly complete. ERMI is positively associated with firm value at 5% significance level in full model, indicating that high-quality ERM program will result in higher firm value. Our results are consistent with COSO (2004) and most previous empirical studies (e.g., Baxter et al., 2013; Farrell & Gallagher, 2015) about the fact that the higher the degree of ERM implementation, the more effective it is.

**Table 4.** Construction of ERMI.

| Targets of ERM | Index | Explanation |
|---|---|---|
| Strategy | $Strategy_{it1} = \frac{Sales_{it} - \mu_t}{\sigma_t}$ | $Sales_{it}$ represents the sales volume of firm i in year t, $\mu_t$ the average sales volume of the industry in year t, $\sigma_t$ the variance of sales volume for the industry in year t. |
| | $Strategy_{it2} = \frac{\Delta\beta_{it} - \mu_{\Delta\beta t}}{\sigma_{\Delta\beta t}}$ | $\Delta\beta_{it}$ is the annual change of systemic risk ($\beta$) for firm i in year t, $\mu_{\Delta\beta}$ the average change of systemic risk ($\beta$) for the industry in year t, $\sigma_{\Delta\beta t}$ the variance of $\Delta\beta_t$ of the industry in year t. |
| Operations | $Operation_{1it} = (Sales_{it})/(Total\ Assets_{it})$ | $Sales_{it}$ represents the sales volume of firm i in year t, $Total\ Assets_{it}$ the total assets of firm i in year t. |
| | $Operation_{2it} = (Sales_{it})/(Employee_{it})$ | $Sales_{it}$ represents the sales volume of firm i in year t, $Employee_{it}$ the number of employee for firm i in year t. |
| Reporting | $Report_{1it} = Material\ Weakness_{it} + Auditor\ Opinion_{it} + Restatement_{it}$ | $Material\ Weakness_{it}$ represents material weakness in the financial statement for firm i in year t, $Auditor\ Opinion_{it}$ there is opinions by qualified auditors for firm i's financial statement in year t, $Restatement_{it}$ there is restatement of the financial statement for firm i in year t. The value of each of these three items is −1 or 0. |
| | $Report_{2it} = \frac{\lvert Normal\ Accurals_{it}\rvert}{\lvert Normal\ Accurals_{it}\rvert + \lvert Abnormal\ Accurals_{it}\rvert}$ | $Normal\ Accurals_{it}$ is the normal accruals for firm i in year t, $Abnormal\ Accurals_{it}$ the abnormal accruals for firm i in year t. |
| Compliance | $Compliance_{1it} = \frac{Auditor\ Fees_{it}}{Total\ Assets_{it}}$ | $Auditor\ Fees_{it}$ is the auditor fees for firm i in year t, $Total\ Assets_{it}$ the total assets of firm i in year t. |
| | $Compliance_{2it} = \frac{Settlement\ Net\ Gain_{it}}{Total\ Assets_{it}}$ | $Settlement\ Net\ Gain_{it}$ is the settlement net gain for firm i in year t, $Total\ Assets_{it}$ the total assets of firm i in year t. |

Source: Gordon et al. (2009).

**Table 5.** Descriptive statistics for ERMI during 2013–2019.

| Year | N | Mean | SD | Min | Max | Median |
|---|---|---|---|---|---|---|
| 2013 | 578 | 1.215 | 1.229 | −1.565 | 4.694 | 1.124 |
| 2014 | 637 | 1.100 | 1.106 | −1.565 | 4.694 | 1.022 |
| 2015 | 746 | 1.107 | 1.159 | −1.565 | 4.694 | 1.157 |
| 2016 | 797 | 0.846 | 1.114 | −1.565 | 4.694 | 0.728 |
| 2017 | 860 | 1.095 | 1.174 | −1.565 | 4.694 | 1.060 |
| 2018 | 860 | 1.206 | 1.058 | −1.565 | 4.694 | 1.138 |
| 2019 | 927 | 1.272 | 1.059 | −1.565 | 4.694 | 1.192 |

Source: Authors' estimation.

## 7. Heterogeneity analysis

### 7.1. Scale of the firm

Scale of firm may be a significant factor for ERM to take effects. For instance, smaller firms are usually less mature in management, ERM may produce great value by improving management and facilitating strategy planning. While large firms usually have more lines of business and complicated risks, coordination through ERM would also be valuable (Ai et al., 2018; Liebenberg & Hoyt, 2003). The observations are divided into two groups by the mean of the scale, and regressions are run respectively.

**Table 6.** Estimation results with GMM models.

| Variables | (1) Q | (2) Q | (3) Q | (4) Q | (5) Q | (6) Q | (7) Q | (8) Q |
|---|---|---|---|---|---|---|---|---|
| L.Q | 0.885*** | 0.665*** | 0.578*** | 0.699*** | 0.687*** | 0.693*** | 0.680*** | 0.693*** |
| | (7.61) | (9.50) | (8.14) | (5.90) | (6.21) | (5.93) | (6.22) | (6.62) |
| ERMI | 0.620 | −0.007 | 0.027 | 0.362* | 0.340* | 0.407** | 0.382* | 0.341** |
| | (1.27) | (−0.06) | (0.22) | (1.88) | (1.95) | (2.02) | (1.94) | (2.42) |
| Growth | | 0.894** | 0.163 | −1.192 | −1.310 | −1.709 | −1.722 | −1.870** |
| | | (2.14) | (0.35) | (−1.12) | (−1.28) | (−1.51) | (−1.58) | (−1.99) |
| ROA | | | 0.065*** | 0.071* | 0.077** | 0.069* | 0.066* | 0.058* |
| | | | (3.29) | (1.76) | (2.10) | (1.89) | (1.83) | (1.70) |
| Dividend | | | | −0.610* | −0.629* | −0.590 | −0.633* | −0.467 |
| | | | | (−1.67) | (−1.65) | (−1.55) | (−1.66) | (−1.36) |
| Size | | | | | 0.033 | −0.001 | 0.002 | 0.042 |
| | | | | | (0.27) | (−0.01) | (0.01) | (0.31) |
| Lev | | | | | | −0.091 | −0.067 | −0.045 |
| | | | | | | (−1.40) | (−1.05) | (−0.70) |
| div_int | | | | | | | 0.440 | 0.473 |
| | | | | | | | (1.04) | (1.17) |
| beta | | | | | | | | 0.684** |
| | | | | | | | | (2.02) |
| Time − fixed effect | YES | YES | YES | YES | YES | YES | YES | YES |
| AR(1) | 0.021 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AR(2) | 0.119 | 0.441 | 0.358 | 0.149 | 0.18 | 0.222 | 0.26 | 0.229 |
| Hansen test | 0.374 | 0.176 | 0.732 | 0.838 | 0.891 | 0.75 | 0.826 | 0.924 |

t-Statistics in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
Source: Authors' estimation.

**Table 7.** Heterogeneous effects of ERM.

| Variables | (1) Smaller-size firms Q | (2) Larger-size firms Q | (3) Weaker institutional shareholding Q | (4) Stronger institutional shareholding Q | (5) Firms without international business Q | (6) Firms with international business Q |
|---|---|---|---|---|---|---|
| ERMI | 0.339* (1.76) | 0.164 (1.26) | 0.145 (0.65) | 0.252* (1.80) | 0.323 (1.19) | 0.272* (1.85) |
| Control variables | YES | YES | YES | YES | YES | YES |
| Time fixed effect | YES | YES | YES | YES | YES | YES |

t-Statistics in parentheses.
*$p < 0.1$.
Source: Authors' estimation.

Results in column (1) and (2) of Table 7 show that the impact of ERM is positive in smaller firms at 10% significance level, but the effect are not significant for large firms.

### 7.2. Institutional ownership

It is widely believed that the institutional shareholders are more rational than individual shareholders, and ERM programs are expected to be welcomed and well performed in the firms where institutional shareholders have stronger influence. From column (3) and (4) of Table 7, we see that the impact of ERM on firm value is significant at 10% level in firms with higher proportion of institutional shareholding, but this effect disappears in the observations with weaker institutional shareholding. Our results are consistent with Pagach and Warr (2011).

### 7.3. International business

International business will increase the hardship of management coordination across the borders and lower the efficiency (Laeven & Levine, 2007). Moreover, the risks faced by the firm will be much more complex. As Ai et al. (2018) pointed out, the effect of risk management is closely related with the nature of risks, such as complexity. The results in columns (5) and (6) of Table 7 show that ERM significantly contributes to firm value within the firms with international business, while the effect is statistically insignificant for the firms without international business.

## 8. Conclusion

This article employs data of Chinese manufacturing firms listed in A share of Shenzhen and Shanghai stock exchange during 2010–2019 to examine the relation between implementation of ERM and firm value, empirical results show that the Chinese manufacturing firms which adopted ERM program generally have higher value than those did not, ERM was a key factor to promote the financial performance of firm. Our study also finds that firm value was positively associated with the quality of ERM program measured by how well the ERM program served its targets. The effect of ERM implementation displays heterogeneity across firms with various characteristics. Specifically, firms of smaller scale, stronger institutional shareholding, and/or having international business can benefit more from ERM program. Our results contain important managerial implications. For instance, manufacturing firms should consider upgrading the risk management mode to ERM so that the risks can be managed more effectively and efficiently, and manufacturing firms can benefit most from implementing high-quality ERM.

Contributions of this article to the literature include providing empirical evidence of effects of implementing ERM in manufacturing firms which was rarely seen in previous literature, constructing two ERM related indicators with various methods, and discovering the heterogeneous effects of ERM in various manufacturing firms. The limitations of this article mainly lie in the inaccuracy of the core indicators constructed with text analysis approach or complex financial indices, and the lack of mechanism analysis about how the ERM impacts the financial performance of a manufacturing firm. Accordingly, future research can try to find better indicators to represent ERM or ERM quality and provide more evidence on this topic. Meanwhile, the relation between ERM and some specific firm activities, such as R&D or financing, can be studied to improve the understanding about the mechanism between ERM and firms' financial performance.

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No potential conflict of interest was reported by the authors.

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