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Reprint of: The impact of enterprise risk management on the marginal cost of reducing risk: Evidence from the insurance industry ☆

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ABSTRACT

We test the hypothesis that practicing enterprise risk management (ERM) reduces firms' cost of reducing risk. Adoption of ERM represents a radical paradigm shift from the traditional method of managing risks individually to managing risks collectively allowing ERM-adopting firms to better recognize natural hedges, prioritize hedging activities towards the risks that contribute most to the total risk of the firm, and optimize the evaluation and selection of available hedging instruments. We hypothesize that these advantages allow ERM-adopting firms to produce greater risk reduction per dollar spent. Our hypothesis further predicts that, after implementing ERM, firms experience profit maximizing incentives to lower risk. Consistent with this hypothesis, we find that firms adopting ERM experience a reduction in stock return volatility. We also find that the reduction in return volatility for ERM-adopting firms becomes stronger over time. Further, we find that operating profits per unit of risk (ROA/return volatility) increase post ERM adoption.

1. Introduction

Managing risk is important for corporations. The theory of corporate risk management argues that firms with smooth cash flows have lower expected tax liabilities, financial distress costs and contracting costs, suggesting that managing risk adds value (Mayers and Smith, 1982; Smith and Stulz, 1985; Froot et al., 1993). Consistent with this theory, 92% of the world's 500 largest companies in 2003 report using derivatives (Smithson and Simkins, 2005). Empirical evidence also shows that risk management enhances shareholder value (Allayannis and Weston, 2001; Carter et al., 2006; Hoyt and Liebenberg, 2011). To the extent that risk management reduces earnings and cash flow volatilities, it also facilitates investors and regulators to evaluate and monitor firm performance and solvency risk. The 2008 financial crisis highlights that risk management is not only important to corporations but also to regulators and the global economy as a whole.

In recent years, a growing number of firms have adopted enterprise risk management (ERM) to improve risk management. Some risk management professionals argue that the 2008 financial crisis resulted from a system-wide failure to embrace ERM and that adopting ERM may prevent the history from repeating itself.[1] According to Nocco and Stulz (2006), ERM is a process that identifies, assesses and manages individual risks (e.g., currency risk, interest rate risk, reputational risk, legal risk, etc.) within a coordinated and strategic framework. Therefore, ERM represents a radical paradigm shift from the traditional method of managing risks individually to managing risk holistically. In other words, ERM emphasizes managing risks as a portfolio (risk-portfolio) as opposed to managing individual risk separately. It is this aspect of ERM that forms the premise of this paper.

We hypothesize that ERM adoption lowers the marginal cost (MC) of reducing risk, which creates incentives for profit-maximizing firms to reduce total risk while increasing firm value. By combining the firm's risks into a risk-portfolio, an ERM-adopting firm is able to better recognize the benefits of natural hedging, prioritize hedging activities towards the risks that contribute most to the

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[1] *Risk management*, April, 1 2009, "The New DNA: Examining the Building Blocks of Risk."

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total risk of the firm, and optimize the evaluation and selection of available hedging instruments.[2] By so doing, the ERM-adopting firm realizes a greater reduction of risk per dollar spent. This reduction in MC of managing risk incentivizes profit-maximizing firms to further reduce risk until the marginal cost of risk management equals the marginal benefits. Consistent with this hypothesis, we find that firms adopting ERM experience a reduction in stock return volatility. Due to the costs and complexity of ERM implementation, we also find that the reduction in return volatility for ERM-adopting firms becomes stronger over time. Further, we find that operating profits per unit of risk (ROA/return volatility) increase post ERM adoption.

This paper makes an important contribution to the literature. We are the first to examine and empirically test the impact of ERM adoption on firms' risk taking behavior. Hoyt and Liebenberg (2011) find a large valuation premium (as measured by Tobin's Q) for ERM adopters, whereas Beasley et al. (2008) find insignificant, negative announcement returns for ERM adoption. We find that, after adopting ERM, firm risk decreases and accounting performance increases for a given unit of risk. Therefore, our results complement the findings in Hoyt and Liebenberg (2011), which are based on market valuation of firm performance. Our analysis also has policy implications, as our results lend support for the recent pressure from regulators, rating agencies and institutional investors on firms to adopt ERM as part of their analysis.[3]

The remainder of the paper is organized as follows: Section 2 reviews related literature, Section 3 develops hypotheses, Section 4 describes the research design, Section 5 summarizes the sample selection process and describes the sample, Section 6 presents empirical findings and Section 7 concludes.

2. Literature review

The theory of corporate risk management is well established and empirical studies analyzing corporate risk management policy are vast. In contrast, the literature on ERM is still in its infancy and much of the existing evidence comes from survey and case studies. In this section, we first summarize the literature on corporate risk management and then review the research on ERM. Given the purpose of this study, we perform a much more exhaustive review of the latter, paying attention to only the more representative papers of the former that are relevant to this paper.

2.1. The literature on corporate risk management

The theory of corporate risk management is developed as an extension of corporate financing policy. Under the Modigliani–Miller (1958) paradigm, with fixed investment policy and with no contracting costs and taxes, corporate financing policy is irrelevant. Following this line of reasoning, the theory of corporate risk management uses taxes, contracting costs, and the impact of risk management on corporate investment policies to explain the firm's risk management decision (Mayers and Smith, 1982; Smith and Stulz, 1985; Froot et al., 1993).

Empirical research on corporate risk management generally addresses two questions: why does a firm manage risk and more important for the current study, what is the impact of risk management on firm value?

Four rationales are generally given for the management of firm risk: (1) managerial self-interest, (2) the non-linearity of taxes, (3) the costs of financial distress, and (4) the existence of capital market imperfections (Allen and Santomero, 1998). For example, Tufano (1996) finds evidence consistent with the theory of managerial risk aversion proposed in Stulz (1984) and Smith and Stulz (1985). Mian (1996), however, finds evidence that is inconsistent with the argument of financial distress cost, evidence that is mixed with respect to the argument of taxes, contracting cost, imperfect capital markets, but strongly supports the argument of economies of scale (i.e., that larger firms hedge more). Graham and Rogers (2002) find that firms hedge to increase debt capacity, not in response to tax convexity. Gay and Nam (1998) find empirical evidence supporting the underinvestment explanation for corporation risk management policy. Haushalter (2000) finds support for the argument that financing costs influence firms' hedging decisions. Harper and Wingender (2000) find strong evidence for Wall's (1989) hypothesis of agency cost reduction by interest rate swaps.

In contrast to the richness of studies examining the determinants of corporate risk management policy, studies analyzing the valuation impact of risk management are relatively few. Allayannis and Weston (2001) find a positive relation between firm value and the use of foreign currency derivatives, with an average hedging premium of 4.87%. Carter et al. (2006) find that the hedging premium could be as large as 10%, and further find that the positive relation between hedging and firm value increases in capital investment, and most of the hedging premium is attributable to the interaction of hedging with investment, suggesting that the hedging benefit comes from a reduction of underinvestment costs.

2.2. The literature on ERM

The theory of enterprise risk management is based on the theory of corporate risk management and is best summarized in Nocco and Stulz (2006). Nocco and Stulz (2006) define ERM as an approach under which "all risks (are) viewed together within a coordinated and strategic framework." They argue that ERM creates value, because it strengthens the firm's ability to carry out its strategic plan, by minimizing costs like underinvestment.

Empirical work on ERM is limited and can be classified along three main lines of research – describing the ERM practice, analyzing the determinants of ERM adoption, and assessing the valuation effect of ERM. In view of the purpose of this study, we focus on the latter two lines of literature.[4]

Liebenberg and Hoyt (2003) compare firm characteristics between 26 ERM adopters and their control firms. They fail to find much difference except that the former is smaller and more levered. Using survey data from Canadian firms, Kleffner et al. (2003) find that forces driving firms to adopt ERM include the influence of risk managers, encouragement from the board of directors, and compliance with Toronto Stock Exchange guidelines, while the main deterrence to ERM adoption is organizational iner-

[2] Note that this risk reduction can be done in any manner. We do not suggest a mechanism (e.g., altering product mix, reinsurance, etc.) by which firms reduce risk.

[3] A.M Best began to implement its Enterprise Risk Model for US insurers in late 2001 (A.M. Best Special Report - A.M. Best's Enterprise Risk Model, A Holistic Approach to Measuring Capital Adequacy, July, 2001). Standard and Poor's introduced ERM analysis into its global corporate credit rating process for financial and insurance companies starting in 2005 and for non-financial companies starting in 2008 (Analysis of Enterprise Risk Management in S&P Ratings of Non-Financial Corporations, Standard and Poor's Presentation to the International Developments Subcommittee of American Bar Association, 18 November 2008). Kleffner et al. (2003) report that many countries, including Canada, the United States, the United Kingdom, Australia, and New Zealand, are pressing firms to adopt more integrated and comprehensive risk management systems, propelling more firms to adopt ERM. Indeed, 37% of their surveyed Canadian firms cite compliance with Toronto Stock Exchange guidelines as their reason to adopt ERM.

[4] To read about the various development stages of ERM, see e.g., Colquitt et al. (1999), Aabo et al. (2005), Gates (2006), and Calandro et al. (2008). For a detailed account of the development of ERM and summary of academic research on this subject, see *Enterprise Risk Management: Today's Leading Research and Best Practices for Tomorrow's Executives*, 2010, Wiley Publishing, Editors: John Fraser and Betty J. Simkins. See Hunter and Smith (2002) for a review of developments in risk management at both the firm level and the macro-economy.

tia. Using survey data from US firms, Beasley et al. (2005) find that forces facilitating ERM implementation include top management support, corporate resources and industry influence.

Using publicly-traded insurers, Hoyt and Liebenberg (2011) find that ERM adoption is associated with higher firm value, indicated by a Tobin's Q premium of roughly 20%. In contrast, Beasley et al. (2008) study the market reactions when firms announce the appointment of a Chief Risk Officer (a proxy for ERM adoption). Unlike Hoyt and Liebenberg (2011), Beasley et al. (2008) find an insignificant market reaction.

Aebi et al. (2012) investigate whether risk management-related corporate governance mechanisms at the end of the year 2006 are associated with better bank performance during the financial crisis of 2007–2008. Using a sample of banks in North America, they find that banks whose Chief Risk Officer reports directly to the board of directors perform better in the crisis, but those whose Chief Risk Officer reports to the CEO perform worse than other banks.

Ultimately, the literature on ERM is still young and the evidence on the valuation effect of ERM adoption is mixed, reflecting the newness of ERM in practice.

3. Hypothesis development

Traditionally firms have managed risk by segmenting and delegating risks to various departments with specific expertise in managing their assigned risks: Employee risks are managed by the human resources department; hazard risks are managed by the insurance department; financial risks are managed by the finance department; operational risks are managed by their respective profit centers, etc. Recognizing the importance of managing the total risk of the firm and seeking both greater effectiveness and efficiency in risk management, some firms have adopted an enterprise-wide approach to risk management (ERM). Part of the rationale for adopting ERM and/or appointing a Chief Risk Officer (CRO) is to break down the departmental budgetary and political barriers in the identification, evaluation and management of risk, allowing the firm to consolidate its "non-core" risks into a risk-portfolio and hedge the risk-portfolio in a coordinated manner. Thus, central to the implementation of an ERM process is the notion that risks should be combined and managed together as a 'risk-portfolio.'

Modern Portfolio Theory predicts that combining assets (e.g., risks) into a portfolio will reduce the risk of the portfolio so long as some of the assets are less than perfectly, positively correlated (Markowitz, 1952). Thus, the total risk of the portfolio is less than the sum of the individual risks. A firm using the traditional 'siloed' approach to risk management would not be cognizant of all the correlations and interdependencies amongst its risks and thus, the Pre-ERM firm would not be in a position to reap the full benefits of natural hedges. In addition, Meulbroek (2002, p. 19) notes, that "by focusing narrowly on one specific risk, the (Pre-ERM) manager may create or exacerbate other types of risk for the company. Such interactions between risks are not always obvious, especially when they occur among unrelated businesses within the firm."[5] In contrast, once a firm adopts ERM, the Post-ERM firm becomes 'aware' of its portfolio and is able to recognize the full potential of natural hedges within its risk-portfolio and achieve cost savings in reaching its desired level of risk by eliminating the purchase of hedging contracts that erode (or even offset) the natural hedging occurring within the risk-portfolio. So when a firm chooses to adopt an ERM program and combines its individual risks into a risk-portfolio, we expect that the ERM-adopting firm will experience savings in the cost of managing its risks. This clear, straightforward application of the Modern Portfolio Theory should lead to greater firm value so long as the savings exceed the ERM implementation costs and is supported by the empirical findings of Hoyt and Liebenberg (2011).

Yet this result leads us to consider an additional question: How does ERM adoption impact the firm's incentives to manage risk?

This question lead us to consider more closely how firms manage risks within a portfolio. Doherty (2000, p.548) notes that we are able to draw upon the analytical techniques used to manage asset portfolios, and argues "we can use similar techniques to choose an 'efficient portfolio' of hedging instruments for a firm." In addition, managing a combination of risks allows us to consider contracts that hedge combinations of risks and more efficiently reduce risk. Doherty (2000, p.531) illustrates this point through an example using integrated insurance products and shows that for "the same cost, the firm was able to transfer more risk with the combined hedge than with the separate hedges." The above arguments, taken in combination with the fact that ERM adopting firms consolidate their risks into a portfolio and manage those risks in a coordinated manner, suggest that ERM adopting firms should be able to lower their MC of reducing risk. We will expand upon this point, and provide a short theoretical model to motivate our hypotheses.

For the model, we will compare the risk management decisions of a firm using the traditional 'siloed' approach to risk management (we will refer to this as a Pre-ERM firm) to a firm using enterprise risk management (Post-ERM). We assume that the firm can buy an unlimited number of hedges at an actuarially fair price. We constrain both the Pre-ERM and Post-ERM firm to using the same budget for reducing risk. These restrictions preclude a firm with ERM from taking advantage of differences in hedging prices, correlations between hedging instruments, and different levels of hedging. In addition, we preclude the Post-ERM firm from exploiting natural hedges to reduce risk. Relaxing these constraints only provides a firm using an integrated risk management function with further opportunities to reduce the marginal cost of risk reduction.

Consider a firm with two distinct segments, where one segment is arbitrarily set to have a higher risk profile than the other. The segments face the following simple loss distributions:

Segment A		Segment B	
Loss	Probability	Loss	Probability
L_1	π_1	L_1	π_1
L_2	$1-\pi_1$	L_3	π_3
		L_4	$1-\pi_1-\pi_3$

where $L_2(1-\pi_1) = L_3\pi_3 = L_4(1-\pi_1-\pi_3)$ and $L_2 < L_3 < L_4$.[6] With no loss of generality, we will consider L_1 to be the no-loss state (i.e., $L_1 = 0$). The mean loss for Segments A and B are $\mu_A = L_2(1-\pi_1)$ and $\mu_B = L_3\pi_3 + L_4(1-\pi_1-\pi_3)$, respectively.

Consider the Pre-ERM firm that utilizes a siloed approach to risk management. Each segment of the firm is given a hedging budget of $L_2(1-\pi_1)$ to manage their own risk. At actuarially fair prices, Segment A can hedge L_2 and Segment B can hedge L_4. The hedged loss distributions are now:

[5] For an interesting case study, see The Economist (1996, p. 16) for a story on Lufthansa hedging away a risk that was already naturally hedged from their business operations.

[6] We can consider Segment A to be legal risk (e.g., the risk of the insurer being sued for bad-faith claims) managed by the legal department and Segment B to be a pool of product liability policies managed by underwriting.

Segment A		Segment B	
Loss	Probability	Loss	Probability
L_1	π_1	L_1	π_1
(hedged: $L_2 = 0$)	$1-\pi_1$	L_3	π_3
		(hedged: $L_4 = 0$)	$1-\pi_1-\pi_3$

The mean and variance of the hedged Segment A are now zero. The mean of the hedged Segment B is now $\mu_{B,h} = L_3\pi_3$, which by assumption equals to the mean of an un-hedged Segment A (μ_A). The variance of the Pre-ERM firm utilizing a siloed risk management strategy is:

$$\sigma^2_{firm,silo} = \sigma^2_{A,silo} + \sigma^2_{B,silo} + 2\rho_{A,B,silo}\sigma_{A,silo}\sigma_{B,silo}$$

where, for a firm utilizing 'siloed' risk management, $\sigma^2_{i,silo}$ represents the hedged variance of Segment i ($i \in [A, B]$) and $\rho_{A,B,silo}$ represents the correlation between the hedged segments. Again noting that the hedged mean of Segment B is equal to the un-hedged mean of Segment A and that the variance of the hedged Segment A is zero, the variance of the firm using a siloed approach to risk management can be shown to be:

$$\sigma^2_{firm,silo} = \pi_3(L_3 - \mu_A)^2 + (1-\pi_3)(0-\mu_A)^2 \quad (1)$$

Now let us assume the firm utilizes an enterprise risk management process. Through their enterprise-level analysis of risk, the Post-ERM firm can now triage the segments' risks, prioritizing the risks to hedge by their contribution to total firm risk.[7] The post-ERM firm is able to recognize that a more effective allocation of their risk management budget exists. Using the same total hedging budget, $2L_2(1-\pi_1)$, the firm using enterprise risk management would now optimally hedge L_4 and L_3. The loss distributions for each segment of the firm are now:

Segment A		Segment B	
Loss	Probability	Loss	Probability
L_1	π_1	L_1	π_1
L_2	$1-\pi_1$	(hedged: $L_3 = 0$)	π_3
		(hedged: $L_4 = 0$)	$1-\pi_1-\pi_3$

The mean and variance of Segment A are the same as the un-hedged Segment A and the mean and variance of Segment B are now both zero. The variance of the firm with enterprise risk management is therefore:

$$\sigma^2_{firm,ERM} = \sigma^2_A + \sigma^2_{B,ERM} + 2\rho_{A,B,ERM}\sigma_A\sigma_{B,ERM}$$

where σ^2_A is the original variance of Segment A and for a firm utilizing enterprise risk management, $\sigma^2_{B,ERM}$ represents the hedged variance of Segment B and $\rho_{A,B,ERM}$ represents the correlation between the hedged segments. Substituting for the variance of Segment A and again noting the variance of Segment B is now zero, the variance of the firm utilizing enterprise risk management is given as:

$$\sigma^2_{firm,ERM} = (1-\pi_1)(L_2 - \mu_A)^2 + (\pi_1)(0-\mu_A)^2 \quad (2)$$

The Post-ERM firm is able to achieve lower total firm risk using the same risk management budget. Specifically, the risk of the firm using enterprise risk management is less than the firm using a siloed approach (i.e., Eq. (2) can be shown to be less than Eq. (1)) if $L_3 > L_2$ (this relationship is true by assumption). This model highlights that segments within a firm using a siloed approach to risk management are myopic and will, subject to the segment's hedging budget, reduce the risk within their own segment (if the reduction is optimal for the segment), regardless of the effects on the organization's risk. The real advantage, then, is that the firm using enterprise risk management is able to consider the relative size and probability of risks in the context of the entire organization. Hence, a firm that shifts from a siloed approach to enterprise risk management is better able to prioritize hedging the risks that contribute most to the total risk of the *firm*, generating a greater reduction of firm risk per dollar spent (i.e., a lower marginal cost of reducing firm risk).

The above model shows a firm reducing the marginal cost of reducing firm risk while not taking any additional (potentially risky) positions (the firm does take on two hedging contracts, but was also prepared to do so under its pre-ERM strategy). It is not too difficult to imagine how a firm in a similar position may lower its marginal cost of risk reduction while taking on additional positions after ERM implementation. Imagine the firm above would indeed like to hedge both Segments A and B, but individually the hedging instruments available do not meet the standard set by the firm with respect to some standard risk management tool such as value-at-risk (VaR). The pre-ERM firm would, therefore, not hedge the risks. A post-ERM firm, however, would consider the *joint* effects of adding the two hedging instruments.[8] Assuming they are not perfectly correlated, together, the hedging instruments could well meet the firm's VaR decision rule.[9,10]

The model presented above is very simplistic. We have not allowed for several options that could further reduce the marginal cost of risk reduction for a firm utilizing enterprise risk management. To the extent that the firm's risks are less than perfectly correlated across segments, the myopia of the siloed approach will cause the Pre-ERM firm to remain ignorant of the natural hedges. Thus, natural hedges between segments enhance the Post-ERM firm's advantage in analyzing each risk's contribution to total firm risk and generate even greater risk reduction per dollar spent. Similar to the model extension discussed above, managing risk at the enterprise, rather than segment, level of the firm gives the Post-ERM firm advantages in optimizing the set of hedging instruments used to reduce total firm risk. Specifically, the Post-ERM firm can analyze how much each hedging contract reduces total firm risk per dollar spent. In summary, an ERM-adopting firm is better able to prioritize hedging activities towards the risks that contribute most to the total risk of the firm, recognize the benefits of natural hedging, and optimize the evaluation and selection of available hedging instruments. These advantages lower the marginal cost of reducing risk for ERM-adopting firms.

Therefore, the above argument leads us to put forth our first hypothesis that the adoption of ERM reduces the marginal cost of risk reduction. This change in MC will create incentives for profit maximizing firms to further reduce risk until the marginal costs

[7] Note that this change is not merely a change in budget allocation process. Rather, there must be an enterprise-level decision maker (CRO, VP of Risk Management, etc.) who is prioritizing the risks by the degree that each is contributing to the firm's risk profile. If the risks are not considered jointly (i.e., without enterprise risk management), it does not matter if budgets are allocated in a centralized or de-centralized manner.

[8] This extension is motivated by an instrument used to hedge existing risks, but could well apply to a firm's overall investment decision.

[9] We assume that the hedging instruments are appropriately valued, and their risks appropriately quantified. Regardless of the risk management strategy in place, inaccurately quantifying either of these measures can lead to dire consequences to firms, as seen in the recent financial crisis.

[10] We thank Achim Wambach for this addition to our model.

once again equal the marginal benefits, lowering the optimal risk level of an ERM-adopting firm.[11] Hence we predict that, all else equal, ERM adoption will lead to a reduction in firm risk.

H1. All else equal, firms adopting ERM will exhibit a reduction in risk.

To clarify, if we control for firm size, business mix, and other factors that impact firm volatility, we predict that an ERM-adopting firm will exhibit less risk than an identical, but non-ERM-adopting firm. However, we make no prediction on an ERM-adopting firm's business strategy and its appetite for risk. We expect that an ERM-adopting firm will continue to invest resources in value enhancing projects which will alter the company's size, business mix, and risk level. Thus, we acknowledge that the total risk level of an ERM-adopting firm may increase as the firm evolves over time. That said, we predict that the ERM-adopting firm will have profit-maximizing incentives to reduce risk to a greater extent than it would in the absence of an ERM program.

We also make no prediction on the form or the extent of hedging (i.e., type of hedging contracts purchased or total dollars spent on reducing risk) by the ERM-adopting firm. As discussed above, an ERM-adopting firm may be able to achieve risk reduction by hedging more efficiently. Thus, it is not apparent that the Post-ERM firm must increase hedging volume, increase expenditures to achieve a lower risk level, or alter business mix.

Due to the complexity and costs associated with ERM implementation (e.g., acquiring the understanding of a firm's risks and their correlations) as well as the fact that significant time may be required to optimally adjust a firm's hedges, the effect of ERM on firm risk may take time prior to reaching its full effect.[12] Therefore, we offer a corollary to our first hypothesis:

H1a. Risk reductions post ERM adoption will be lagged (and/or become stronger over time).

Thus far, we have argued that ERM adoption lowers the MC of risk reduction and that this reduction of MC creates economic incentives for profit-maximizing firms to further reduce risk. This same logic also predicts that ERM-adopting firms will simultaneously increase profits while lowering risk. Hence, finding evidence of lower firm risk post ERM-adoption is necessary, but not sufficient support for our argument. To illustrate, one could argue that a reduction in firm risk post-ERM adoption may simply result from agency costs associated with political pressure within the firm to demonstrate that the ERM implementation was successful. For example, a CRO might deploy excess corporate resources to reduce risk in order to justify his/her position or higher pay, even when the costs of reducing risk exceed the benefits of reducing risk. The ultimate purpose of ERM should be creating firm value through better management of risk. Thus, to properly test whether ERM adoption leads to an impact on MC, we need to examine both firm risk and profits post-ERM adoption.

To test the simultaneous impact of ERM implementation on firm risk and profits, we relate ERM adoption to operating profits scaled by firm risk. This approach utilizes a well-understood concept, namely the reward-to-risk ratio, to test whether the risk reduction post ERM-adoption is associated with greater risk-adjusted profits; henceforth our second main hypothesis is formally stated as:

H2. Risk reduction post ERM-adoption is associated with increasing risk-adjusted profits as evidenced by an increase in the ratio of ROA to firm risk post-ERM adoption.

A likely question that may be raised when any profit-maximizing managerial innovation is adopted is, "Why has ERM [or another strategy] been implemented only recently?" Given the nature of H2, it is instructive to consider some of the driving forces behind ERM. As pointed out by Liebenberg and Hoyt (2003, p. 40), the "trend toward the adoption of ERM programs is usually attributed to a combination of external and internal factors." Some commentators have argued that the nature of risks facing financial firms has changed due to consolidation and the growing complexity of financial institutions and the products they offer. Others suggest that increased regulatory stringency and oversight has been a major contributing factor in the adoption of ERM. A third driving force that is often cited is the increasing availability of technology that is available to effectively manage and analyze the significant amounts of data that are necessary for firms to successfully adopt ERM strategies (see Liebenberg and Hoyt (2003) for a complete discussion of these driving trends).

4. Research design

To test our first hypothesis (H1), we specify a model with firms' risk as the dependent variable and ERM adoption and other controls that potentially influence firms' risk as the independent variables:

$$firm\_risk = intercept + \gamma^{*} ERM\_adoption + \beta^{*} controls \quad (3)$$

A finding of $\gamma < 0$ will provide support of H1. One potential concern in estimating Eq. (3) is endogenous decision by a firm to adopt ERM. To mitigate this form of omitted-variable bias, we employ the Heckman two-step procedure to estimate the impact of ERM adoption on firm risk. Specifically, we first use a *Probit* model to estimate the probability of a firm adopting ERM to get the predicted probability for each firm (*prob(ERM)*). We then use this predicted probability (*prob(ERM)*) to compute the Inverse Mills ratio (*IML*), which is the probability density function of *prob(ERM)* over the cumulative probability density function of *prob(ERM)*. We then estimate Eq. (3) including the inverse Mill ratio in addition to other control variables.

To predict the probability of ERM adoption, we control for firm size and operation complexity by using the log of total assets (*size*), the log of the number of business segments (*BUSSEG*), and a dummy variable that takes the value of one if a firm generates revenue from international operations (*INTL*). We argue that the more complex and the more myriad risks that a firm faces, the greater benefit a firm can realize by taking a portfolio approach to manage risk. Further, existing literature (see, e.g., Mian, 1996) finds that corporate hedging activities are a function of economies of scale and operation complexity. Towers Perrin's 2008 ERM survey also

[11] The marginal benefits of risk reduction are based upon the theory presented by Mayers and Smith (1982), Smith and Stulz (1985) and Froot et al. (1993). These theoretical benefits of risk reduction (e.g., lower corporate taxes, lower cost of capital and lower contracting costs) are exogenous to the firm's decision to implement an ERM program. Thus, we do not expect the adoption of ERM to impact the functions of the marginal benefits of risk reduction. Therefore, lowering the marginal cost of risk reduction, but maintaining the same level of marginal benefit of risk reduction induces a profit maximizing firm to increase "production" of risk reducing "output," i.e., the firm reduces risk.

[12] As an example, Aabo et al. (2005) analyze the implementation of ERM over a five-year period at Hydro One, a large electricity delivery company in North America and a pioneer of ERM practice. Management first attempted to implement ERM at Hydro One by using external consultants. When no lasting benefits resulted from this initiative, Hydro One created a new position of Chief Risk Officer and a Corporate Risk Management Group. The board of directors approved the blueprint for ERM in 2000 after a pilot study had been successfully conducted. This case study highlights that ERM adoption is a gradual, learning process.

finds that larger firms are significantly more advanced in ERM implementation.[13] We use the percent of institutional ownership (*Instit_own*) to capture the potential pressure from institutional investors to adopt ERM (Hoyt and Liebenberg, 2011). We include a lagged measure of firm risk, the log of annualized standard deviation of daily stock returns over the previous three years (*volt*), to control for the potential relation that riskier firms have greater incentive to hedge (see, e.g., Smith and Stulz, 1985). Following Hoyt and Liebenberg (2011), we use a dummy for life insurers (*Life*) to control for the potential heterogeneity in ERM adoption across different lines of business.

Towards the end of 2001, A. M. Best began to implement its new Enterprise Risk Model.[14] In 2002, Congress enacted the Sarbanes–Oxley Act (SOX), which represents the most significant securities legislation since the Great Depression. Although ERM is not a stated objective of SOX, the Act has served as a catalyst for ERM adoption by providing the necessary infrastructure. According to a study conducted by the Conference Board, SOX's mandates on corporate responsibility and financial reporting have forced firms to conduct the internal control process at the enterprise level and in a coordinated framework. Therefore, as a result of the mandated effort to comply with SOX, companies have a platform on which to build their ERM infrastructure. To capture these external shocks to a firm's decision to implement ERM, we use a dummy variable (*BestSOX_dummy*) that takes the value of one if 2002 and zero otherwise.[15]

Starting in 2005, Standard & Poor's began incorporating ERM analysis into their credit-rating process for insurance companies. According to the 2006 Towers Perrin Tillinghast survey of executives at 70 North American life insurance companies, a majority of respondents indicate that their firms have planned to set up an ERM infrastructure or decided to improve their current ERM program based on comments received from major rating agencies such as S&P and Moody's. Thus, we also include a dummy variable (*S&P_dummy*) that takes the value of one for year 2005 and zero otherwise to control for this external push for ERM adoption.[16]

The dependent variable in this *Probit* model is a dummy variable (*ERM*) that takes the value of one if a firm practices ERM in that year.[17] Therefore, we have the following equation for the first-stage regression of the two-step Heckman procedure.

$$\begin{aligned} Pr(ERM_{i,t} = 1) &= intercept + \beta_1 size_{i,t} + \beta_2 Instit\_own_{i,t} \\ &\quad + \beta_3 BUSSEG_{i,t} + \beta_4 INTL_{i,t} + \beta_5 volt_{i,[t-3,t-1]} \\ &\quad + \beta_6 Life_{1,0} + \beta_7 BestSOX\_dummy \\ &\quad + \beta_8 S\&P\_dummy + \varepsilon_{i,t} \end{aligned} \tag{4.1}$$

For the second stage, we estimate an *OLS* model of the following specification to investigate the impact of ERM adoption on firm risk.

$$\begin{aligned} volt_{i,t} &= intercept + \beta_1 ERM\_firm_{1,0} + \beta_2 ERM\_firm_{1,0} \\ &\quad * ERM\_implem\_dummy_{i,t} + \beta_3 IMR_{i,t} + \beta_4 size_{i,t} \\ &\quad + \beta_5 firm\_age_{i,t} + \beta_6 MTB_{i,t} + \beta_7 debt_{i,t} \\ &\quad + \beta_8 Instit\_own_{i,t} + \beta_9 BUSSEG_{i,t} + \beta_{10} INTL_{i,t} \\ &\quad + \beta_{11} Life_{1,0} + \beta_{12} S\&P\_volt_t + \beta_{13} Mean\_Ind\_ROA \\ &\quad + \varepsilon_{i,t} \end{aligned} \tag{4.2}$$

The dependent variable (*volt*) is the log of the annualized standard deviation of daily stock returns. We choose stock return volatility as our proxy for firm risk, because it is a well-establish measure for a firm's total risk. Mayers and Smith (1982) and Smith and Stulz (1985) show that, when capital markets are imperfect, firms care about total risk (as opposed to systematic or idiosyncratic risk). Stock return volatility is also preferred to other alternative measures of firm risk such as earnings or cash flow volatility, because stock price data are available on a daily basis whereas earnings and cash flow data are only reported quarterly.

Our variable of interest is the interaction term between a dummy that takes the value of one if a firm has ever adopted ERM during our sample period (*ERM_firm*) and a dummy variable that is set to one for all years after and including the year of first evidence of ERM implementation (*ERM_implem_dummy*). Based on H1, we expect $\beta_2 < 0$. The dummy *ERM_firm* controls for any potential group fixed effects between firms that ever adopted ERM and firms that never adopted ERM during our sample period. An example for this potential group effect is corporate culture. ERM firms may have a more flexible corporate culture than non-ERM firms, which allows them to more quickly learn and implement new technology. Supporting this argument, Kleffner et al. (2003) find that organizational inertia is a major deterrence preventing firms from adopting ERM. By including both *ERM_firm* and *ERM_firm** *ERM_implem_dummy* in the regression, we can then isolate the incremental impact of ERM adoption on firm risk. Adopting ERM is an endogenous decision made by a firm. Our estimation could be biased if ERM adoption coincides with a change in underlying firm characteristics that drive firm risk. We explicitly control for this potential omitted-variable bias by including the Inverse Mills ratio (*IMR*) that we compute from Eq. (4.1).

We also include in Eq. (4.2) other variables that the existing literature predicts influence firm risk, such as firm size (the log of total assets, *size*), firm age (the log of the number of years that a firm has stock price data in the CRSP database, *firm_age*), growth opportunities (the log of the market-to-book ratio of assets, *MTB*), firm leverage (long-term debt over total assets, *debt*), institutional ownership (*Instit_own*), and the extent of firm diversification (*BUSSEG*; *INTL*). Larger firms and firms with a long trading history provide the market with more information (Barry and Brown, 1985). Thus, we expect those firms to be less volatile. Supporting this argument are the findings by Bartram et al. (2013), who find that firms' total risk decreases in firm age and size. Debt acts as a lever, magnifying profits and losses, and thus, contributes to higher firm risk (e.g., Lev, 1974). Prior literature (e.g., Del Guercio, 1996; Falkenstein, 1996) find that institutional investors prefer stocks with low volatility. Other than the common wisdom that diversification is associated with lower firm risk due to imperfect correlation between different lines of business, Amihud and Lev (1981) also argue that self-serving managers pursue diversification through mergers and acquisitions to reduce their employment risk. Including *BUSSEG* and *INTL* in the second-stage regressions also control for the possibility that firms decide to change business mix or other activities in response to a change in firm risk due to ERM adoption. We include a dummy for life insurers to control for systematic variation in risk across different lines of business. We include mean industry ROA to control for factors that would

[13] *Embedding ERM – A Tough Nut to Crack* (2008), a Towers Perrin global survey of the insurance industry on the topic of ERM.

[14] A.M. Best Special Report – A.M. Best's Enterprise Risk Model, A Holistic Approach to Measuring Capital Adequacy (July, 2001).

[15] "Emerging Governance Practices in Enterprise Risk Management," Research Report (R-1398-07-WG) by the Conference Board, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=963221.

[16] Jack Gibson and Hubert Muller, *Life Insurance CFO Survey #13: Enterprise Risk Management*, Towers Perrin Tillinghast, May 2006, p. 2. Respondents primarily included CFOs from large and mid-size North American life insurance companies; 52% had assets of $5 billion or more and 21% were multinationals.

[17] For example, if a firm has data from 1992 to 2005 and it adopted ERM in 2002, then the dependent variable in Eq. (4.1) takes the value of one for 2002–2005 and zero for 1992–2001.

impact insurance industry profitability. We also include the log of annualized standard deviation of daily S&P 500 equally-weighted index returns to filter out changes in firm risk due to changes in market-wide volatility.[18]

To test the corollary to our first hypothesis (H1a), we modify Eq. (4.2) by adding time lags of ERM implementation (*X* denotes the vector of the control variables):

$$volt_{i,t} = intercept + \kappa ERM\_firm_{1,0} * \sum_{t=1}^{n} ERM\_implem\_lag_{i,t} + \lambda X + \varepsilon_{i,t} \quad (5)$$

To test our second hypothesis (H2), we follow similar framework as Eqs. (4.1) and (4.2), but we replace *volt* with *ROA/volt* in the second-stage of equation. Additionally, we run a median regression instead of an OLS to mitigate extreme outliers.[19] Specifically, we estimate:

$$\begin{aligned} Pr(ERM_{i,t} = 1) &= intercept + \beta_1 size_{i,t} + \beta_2 Instit\_own_{i,t} \\ &\quad + \beta_3 BUSSEG_{i,t} + \beta_4 INTL_{i,t} + \beta_5\, volt_{i,[t-3,t-1]} \\ &\quad + \beta_6 Life_{1,0} + \beta_7 BestSOX\_dummy \\ &\quad + \beta_8 S\&P\_dummy + \varepsilon_{i,t} \end{aligned} \quad (6.1)$$

$$\begin{aligned} \frac{ROA_{i,t}}{volt_{i,t}} &= intercept + \beta_1 ERM\_firm_{1,0} + \beta_2 ERM\_firm_{1,0} \\ &\quad * ERM\_implem\_dummy_{i,t} + \beta_3 IMR_{i,t} + \beta_4 size_{i,t} \\ &\quad + \beta_5 firm\_age_{i,t} + \beta_6 MTB_{i,t} + \beta_7 debt_{i,t} \\ &\quad + \beta_8 Instit\_own_{i,t} + \beta_9 BUSSEG_{i,t} + \beta_{10} INTL_{i,t} \\ &\quad + \beta_{11} Life_{1,0} + \beta_{12} Mean\_Ind\_ROA + \varepsilon_{i,t} \end{aligned} \quad (6.2)$$

For all our regressions, except for the median regression, we control for firm-level clustering.

5. Sample selection, data sources and sample description

5.1. Sample selection and ERM identification

We start our sample selection process with all publicly-traded insurance companies in the US in the merged CRSP/COMPUSTAT database (i.e., firms with Standard Industry Classification Code between 6311 and 6399). We focus on one industry to control for heterogeneity in regulatory and industry effects. We select insurance companies, because, compared to other firms, insurance companies are in the business of managing risk and should be better positioned to recognize the benefits of ERM and successfully implement it. We focus on publicly-traded insurers in this study so that we can utilize stock return data and more easily identify ERM implementation through public filings and media coverage. There are 354 public insurers in the merged CRSP/COMPUSTAT database that have data on total assets, stock prices and institutional ownership from 1990 to 2008.[20]

Firms are not required to disclose information about ERM implementation. Therefore, we follow Hoyt and Liebenberg (2011) to identify ERM adoption for the above-mentioned 354 insurers. Specifically, we search Factiva, LexisNexis, Thomson and Edgar, using key words of "Chief Risk Officer," "Enterprise Risk Management," "Enterprise Risk Officer," "Strategic Risk Management," "Integrated Risk Management," "Holistic Risk Management" and "Consolidated Risk Management." Once we find an article using any of these key words, we then read the article carefully to determine whether it documents an ERM adoption event. We record the date of publication of the document that first provides evidence of ERM adoption as our event date. Our search yields 69 unique firms that adopted ERM between 1995 and 2008. Fig. 1 depicts the unique ERM adoption events that we identify from 1990 to 2008.[21]

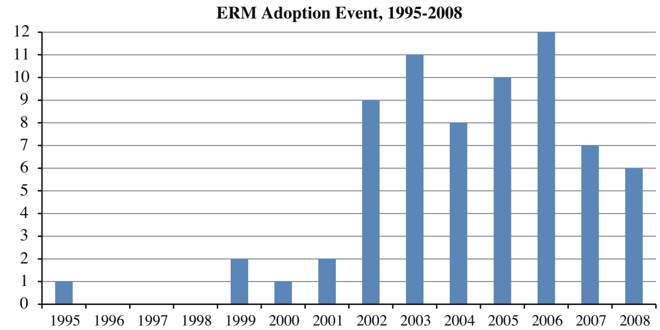

Fig. 1. ERM adoption EVENTS from 1995 to 2008. This graph portrays 69 unique ERM adoption events for US public insurers from 1995 to 2008. We search for ERM adoption events using the sample of publicly-traded insurance companies in the US in the merged CRSP/COMPUSTAT database that have data on total assets, stock prices and institutional ownership from 1990 to 2008. We search Factiva, LexisNexis, Thomson and Edgar, using key words of "Chief Risk Officer," "Enterprise Risk Management," "Enterprise Risk Officer," "Strategic Risk Management," "Integrated Risk Management," "Holistic Risk Management," and "Consolidated Risk Management." Once we find an article using either of these key words, we then read the article carefully to determine whether it documents an ERM adoption event. We record the earliest adoption date as our event date. This search process yields 69 unique firms that adopted ERM between 1995 and 2008.

5.2. Data sources and variable description

We collect financial data from COMPUSTAT, stock price data from CRSP and institutional ownership from Compact Disclosure. Table 1 shows a detailed description of variable construction and related data sources.

5.3. Sample description

Table 2 reports the number of total sample firms and the number of firms that adopt ERM by year for the period 1992–2008. We choose 1992 as the start of our sample period (i.e. three years prior to the first ERM adoption event) to examine the impact of ERM adoption on firm risk over time. As Fig. 1 and Table 2 show, although insurers start to adopt ERM in the mid 1990s, this practice does not become widespread until the 2000s. By 2008, 43% of US publicly-traded insurers had implemented ERM.

Table 3 reports key operating characteristics for the sample firms. For more in-depth illustration, we partition the sample by whether a firm implemented ERM between 1992 and 2008 (hereafter ERM firms) or never adopted ERM within the same period (hereafter non-ERM firms). Panel A reports the descriptive

[18] Our results remain the same using S&P500 value-weighted return.

[19] OLS models the relationship between one or more covariates X and the conditional mean of a response variable Y given X. In contrast, median regression models the relationship between X and the conditional median of Y given X. It is a very useful technique when the data has extreme outliers and is widely used in the literature when examining issues such as CEO compensation (see, e.g., Aggrawal and Samwick, 1999) where the distribution of CEO pay can be extremely, positively skewed.

[20] We choose 1990 as the starting point because according to Beasley et al. (2008) and Hoyt and Liebenberg (2011), insurers start to adopt ERM in the 1990s.

[21] An example of the ERM practice can be found in Allstate's 10-Q statement (3/31/2005): "A principal ERM goal is to further increase our return on equity by reducing our exposure to catastrophe losses, and thereby lessen our earnings volatility and our capital requirements."

Table 1
Variable description.

Variable	Mnemonic	Computation	Data source
Annualized stock return volatility	*Volt*	Annualized standard deviation of daily stock returns	CRSP
Firm age		Number of years that a firm has stock price data in CRSP	CRSP
Long-term debt over total assets	*Debt*		COMPUSTAT
Market-to-book ratio	*MTB*	[Closing stock price at the end of the fiscal year * number of shares outstanding + total assets – book value of common equity]/total assets. When share outstanding is missing, we get the number from the daily stock file in CRSP	COMPUSTAT
Return on assets	*ROA*	Earnings before interest and taxes over total assets	COMPUSTAT
Total assets			COMPUSTAT
Number of business segments	*BUSSEG*	Number of different types of business segments	COMPUSTAT segment
International operation dummy	*INTL*	A dummy that takes the value of one if a firm generates revenue from international operation (i.e. geographic segment type is designated as three in COMPUSTAT)	COMPUSTAT segment
Institutional ownership	*Instit_own*		Compact disclosure

This table lists the key variables used in this study and, when applicable, corresponding mnemonic, construction method and data sources.

statistics partitioned by ERM practice (Panel A. *T*-test displays a two-sample *t*-test comparing the mean differences of the variables). We also partition the sample by whether a firm exhibits stock return volatility greater than the sample median. Panel B reports the descriptive statistics partitioned by firm risk. As Panel A shows, ERM firms are generally less volatile, significantly larger, more diversified and levered, and have higher institutional ownership. Thus, descriptive statistics confirm our prior that ERM firms could be systematically different from non-ERM firms, highlighting the importance of controlling for the group fixed effect in our empirical tests. As Panel B shows, less volatile firms are larger and more diversified, and have longer stock return history and higher institutional ownership. These relations between firm risk and other firm characteristics are consistent with the findings from the existing literature.

6. Empirical results

6.1. The impact of ERM adoption on firm risk

Table 4 reports the regressions results for Eqs. (4.1) and (4.2). We exclude 2008 from the test, for now, to mitigate noise introduced into estimation due to the global financial crisis. The financial crisis, which began with the burst of the subprime mortgage bubble in the US in the mid 2007, developed into a full blown global economic crisis in 2008 and caused unprecedented volatility in that year. (Appendix I, available online, provides more details on the extreme volatilities that our sample firms experienced in 2008. We do run additional robustness checks including 2008 data. We discuss those results in Section 6.1.1)

Table 4 Column (1) reports regression results for Eq. (4.1). Consistent with the argument of economies of scale, larger firms are more likely to adopt ERM (Géczy et al., 1997; Allayannis and Ofek, 2001). We find that less-diversified firms are more likely to adopt ERM, while the dummy for international operations is positive and insignificant. These results are counter intuitive, because we expect firms with more dispersed operations to have more complex risks and benefit more from ERM. It may be that less diversified firms are riskier and hence have greater incentive to adopt ERM. Consistent with this argument, the Pearson correlation between *BUSSEG* and $volt_{[t-3,t-1]}$ is negative with coefficient of 0.088 and 1% significance; the two-sample *t*-test of $volt_{[t-3,\ t-1]}$ between firms with international operations and firms without is also significant at 1%.

Consistent with the clientele argument, institutional ownership is positively and significantly related to the probability of ERM adoption (Hoyt and Liebenberg, 2011). The positive and significant coefficient of past stock return volatility is contrary to earlier univariate statistics showing that ERM firms are less volatile; but the finding is consistent with the argument that riskier firms engage in greater hedging activities to reduce contracting costs (Smith and Stulz, 1985). The external push from credit ratings agencies like A.M. Best and S&P and from the passage of SOX also have a positive effect on a firm's decision to adopt ERM. Pseudo *R*-squared for the *Probit* model is 0.378, suggesting that our empirical specification for the determinants of ERM adoption fit our data reasonably well.

Table 4 Column (2) reports regression results for Eq. (4.2). Consistent with H1, we find that the interaction term (*ERM_firm * ERM_implem_dummy*) is significantly and negatively related to firm risk, indicating that ERM firms reduce risk post ERM-adoption. Since our dependent variable is the log form of firm risk, the negative coefficient of 0.149 on the interaction term implies that, on average, ERM-adopting firms reduce risk by 13.9% ($1 - e^{-0.149} = 13.9\%$). The dummy variable for ERM firms is significant and positively related to firm risk, suggesting that ERM adopters are systematically riskier than non-ERM firms, which is consistent with the results of our first-stage *Probit* model.

Table 2
Timelines of the sample firms.

	Total firms	ERM firms	%ERM firms
1992	120	0	0
1993	195	0	0
1994	202	0	0
1995	192	1	1
1996	191	1	1
1997	181	1	1
1998	171	1	1
1999	155	3	2
2000	145	3	2
2001	142	5	4
2002	136	13	10
2003	139	24	17
2004	141	30	21
2005	147	39	27
2006	150	50	33
2007	144	54	38
2008	129	55	43
#Unique firms	354	69	19
#Firms years	2680	280	10

This table reports the number of sample firms in this study by year from 1992 to 2008. We also report the number of firms that adopt ERM (ERM firms) during our sample period and their percentage relative to the total number of sample firms. To be included in the sample, a firm needs to be a US publicly-traded insurer in the merged CRSP/COMPUSTAT database that has data on total assets, stock prices and institutional ownership.

Table 3
Descriptive statistics.

	n	Mean	Median	Min	Max
Panel A: Partition the sample by whether a firm has ever implemented ERM between 1992–2007					
ERM firms					
Annualized stock return volatility (%)	680	33.37	28.79	12.55	282.28
Total assets (in millions)	680	82,673	10,517	41	1,916,658
Market value of equity (in millions)	680	11,201	3137	3	228,227
Firm age	680	15.18	11.00	1.00	48.00
#Business segments	680	2.80	3.00	0.00	10.00
Whether a firm has gobal operation (%)	680	0.21	0.00	0.00	1.00
Market-to-book ratio	680	1.09	1.05	0.49	2.15
L/T debt over total assets (%)	680	6.05	3.73	0.00	64.88
ROA (%)	680	3.07	2.54	−25.20	17.26
ROMVE (%)	680	4.85	10.78	−2123.30	91.37
ROBVE (%)	680	11.89	15.56	−474.76	55.50
Stock return (%)	680	13.28	12.79	−80.67	233.33
Institutional ownership (%)	680	53.94	58.06	0.00	100.00
Non-ERM firms					
Annualized stock return volatility (%)	1721	42.54	34.54	9.66	395.98
Total assets (in millions)	1721	9249	1262	8	458,709
Market value of equity (in millions)	1721	1935	358	1	144,150
Firm age	1721	14.17	12.00	1.00	68.00
#Business segments	1721	2.53	2.00	0.00	10.00
Whether a firm has gobal operation (%)	1721	0.13	0.00	0.00	1.00
Market-to-book ratio	1721	1.13	1.04	0.65	8.57
L/T debt over total assets (%)	1721	5.01	3.43	0.00	50.55
ROA (%)	1720	3.22	2.81	−289.36	56.78
ROMVE (%)	1720	−17.87	10.98	−23874.86	155.69
ROBVE (%)	1720	10.40	14.29	−1394.78	627.86
Stock return (%)	1721	13.66	10.38	−97.35	400.00
Institutional ownership (%)	1721	39.23	35.42	0.00	100.00

Panel A.T-test: This table reports a two-sample means test on the descriptive statistics reported in Table A. The data are partitioned by whether a firm has ever implemented ERM between 1992 and 2007 (ERM firms) or otherwise non-ERM firms

	ERM firms		Non-ERM firms		dif
	n	Mean	n	Mean	
Panel A. t-test (1992-2007)					
Annualized stock return volatility (%)	680	33.37	1721	42.54	−9.17[a]
Total assets (in millions)	680	82,673	1721	9249	73,424[a]
Market value of equity (in millions)	680	11,201	1721	1935	9265[a]
Firm age	680	15.18	1721	14.17	1.01[b]
#Business segments	680	2.80	1721	2.53	0.27[a]
Whether a firm has gobal operation (%)	680	0.21	1721	0.13	0.07[a]
Market-to-book ratio	680	1.09	1721	1.13	−0.03[a]
L/T debt over total assets (%)	680	6.05	1721	5.01	1.04[a]
ROA (%)	680	3.07	1720	3.22	−0.15
ROMVE (%)	680	4.85	1720	−17.87	22.71
ROBVE (%)	680	11.89	1720	10.40	1.49
Stock return (%)	680	13.28	1721	13.66	−0.38
Institutional ownership (%)	680	53.94	1721	39.23	14.71[a]

Panel B reports the descriptive statistics partitioned by whether the sample firm exhibits stock return volatility greater than the sample median, which is 32.483%

	n	Mean	Median	Min	Max
Panel B: Partition the sample by median stock return volatility (32.483%)					
Low volatility firms					
Annualized stock return volatility (%)	1200	23.87	24.21	9.66	32.47
Total assets (in millions)	1200	42,604	4824	85	1,916,658
Market value of equity (in millions)	1200	6434	1514	23	207,431
Firm age	1200	16	14	1	68
#Business segments	1200	2.79	3.00	0.00	10.00
Whether a firm has gobal operation (%)	1200	0.18	0.00	0.00	1.00
Market-to-book ratio	1200	1.11	1.06	0.77	4.77
L/T debt over total assets (%)	1200	5.38	3.98	0.00	64.88
ROA (%)	1200	4.00	3.10	−22.44	42.62
ROMVE (%)	1200	11.38	11.63	−47.15	66.64
ROBVE (%)	1200	16.11	16.02	−53.40	258.22
Stock return (%)	1200	17.53	15.96	−47.31	120.41
Institutional ownership (%)	1200	53.87	55.19	0.00	100.00
High volatility firms					
Annualized stock return volatility (%)	1201	55.99	47.89	33.52	395.98
Total assets (in millions)	1201	17,494	766	8	1,179,017
Market value of equity (in millions)	1201	2687	187	1	228,227
Firm age	1201	13	10	1	63
#Business segments	1201	2.42	2.00	0.00	10.00

(*continued on next page*)

Table 3 (*continued*)

	n	Mean	Median	Min	Max
Whether a firm has gobal operation (%)	1201	0.12	0.00	0.00	1.00
Market-to-book ratio	1201	1.12	1.02	0.49	8.57
L/T debt over total assets (%)	1201	5.23	2.92	0.00	50.55
ROA (%)	1200	2.36	2.16	−289.36	56.78
ROMVE (%)	1200	−34.24	9.44	−23874.86	155.69
ROBVE (%)	1200	5.53	12.39	−1394.78	627.86
Stock return (%)	1201	9.58	3.33	−97.35	400.00
Institutional ownership (%)	1201	32.93	26.90	0.00	100.00

This table reports summary statistics of key operating variables for the sample firms for the period of 1992 to 1997. For consistency, we use the same sample to test our baseline model, i.e., the same observations ($n = 2401$) that have non-missing values for variables used in the baseline model (Table 4). Panel A reports the descriptive statistics partitioned by whether a firm has ever implemented ERM between 1992 and 2007 (ERM firms) or otherwise non-ERM firms.

[a] Significance level at 1% level.
[b] Significance level at 5% level.
[c] Significance level at 10% level.

Table 4
Impact of ERM adoption on firm risk.

	(1)		ERM group FE (2)	Firm FE (3)
First-stage regression – Determinants of ERM adoption		*Second-stage regression – Impact of ERM adoption on volatility*		
Dep. Var. = Prob(ERM = 1)		Dep. Var. = Log(stock return volatility [*t*])		
Log(total assets)	0.384[a]	ERM firm	0.089[b]	
	(<0.001)		(0.042)	
%Institutional ownership	0.010[a]	ERM firm ∗ ERM implementation dummy	−0.149[a]	−0.091[b]
	−0.007		(0.001)	(0.047)
Log(#Business segments)	−0.236[c]	Inverse Mills ratio (selection hazard)	−0.191[a]	−0.055[c]
	−0.095		(<0.001)	(0.103)
International dummy	0.096	Log(total assets)	−0.170[a]	−0.109[a]
	−0.664		(<0.001)	(0.001)
Log(stock return volatility [$t-1$, $t-3$])	0.445[b]	Log(firm age)	−0.046[a]	−0.066
	−0.044		(0.004)	(0.142)
Life insurer dummy	−0.486[b]	Log(market-to-book ratio)	−0.163	−0.370[a]
	−0.049		(0.115)	(<0.001)
bestSOX dummy	0.295[b]	L/T debt over total assets	0.007[a]	0.005[c]
	−0.045		(<0.001)	(0.070)
S&P dummy	1.254[a]	Life insurer dummy	0.188[a]	0.204[c]
	(<0.001)		(<0.001)	−0.076
		Log(S&P500 volatility [*t*])	0.388[a]	0.436[a]
#obs	2401		(<0.001)	(<0.001)
Pseudo *R*-squared	0.378	Mean industry ROA	0.011	0.139
Wald chi2	280.09		(0.938)	(0.139)
Prob > chi2	<0.001	%Institutional ownership	−0.007[a]	−0.005[a]
			(<0.001)	(<0.001)
		Log(#Business segments)	0.038	−0.03
			(0.17)	(0.359)
		International dummy	0.007	−0.027
			(0.815)	(0.515)
		#obs	2401	2401
		R-squared	0.429	0.67
		Model *F*-value	41.72	31.46
		Prob > *F*	<0.001	<0.001

This table reports the regression results following a two-stage Heckman procedure. Column (1) reports the regression results from estimating a *Probit* model. We then use the predicted probability from the first stage to compute the Inverse Mills ratio, which is the probability density function of the predicted probability over the cumulative probability function of the predicted probability. Columns (2) and (3) report the estimation results from the second-stage OLS regressions. In parenthesis are *p*-values controlling for heteroskedasticity and firm-level clustering. The sample period is 1992–2007.

[a] Significance level at 1% level.
[b] Significance level at 5% level.
[c] Significance level at 10% level.

The Inverse Mills ratio also enters the regression with significance, suggesting that it is important to control for the endogenous choice to adopt ERM. Results on our other control variables are consistent with the existing literature. For example, we find that larger firms, more mature firms and firms with higher institutional ownership are less volatile.

In Column (2), we include the Inverse Mills ratio and a dummy for ERM adopting firms (*ERM_firm*) to account for latent firm heterogeneities that potentially drive our results. In Column (3), we include firm fixed effects as an additional robustness check to address the omitted-variable concern due to time-invariant firm heterogeneities. The cost of this robustness check is the omission of the *ERM_firm* dummy from the regression. Our main results hold using this alternative specification; the interaction term of *ERM_firm∗ERM_implem_dummy* remains significantly and negatively related to firm risk. Consistent with the idea that firm fixed effects better control for latent firm-level heterogeneities, the significance level of the Inverse Mills ratio decreases to 10% in Column

Table 5
Impact of ERM adoption on firm risk – robustness check: incorporating 2008.

	(1) *volt* < 152%	(2) *volt* < 115%		(3) *volt* < 152%	(4) *volt* < 115%
First-stage regression – determinants of ERM adoption			*Second-stage regression – impact of ERM adoption on volatility*		
Dep. Var. = Prob(ERM = 1)			Dep. Var. = Log(stock return volatility [*t*])		
Log(total assets)	0.387[a]	0.391[a]	ERM firm	0.062	0.053
	(<0.001)	(<0.001)		(0.109)	(0.135)
%Institutional ownership	0.009[a]	0.009[a]	ERM firm * ERM implementation dummy	−0.061[c]	−0.061[c]
	(0.013)	(0.009)		(0.088)	(0.077)
Log(#Business segments)	−0.234[c]	−0.237[c]	Inverse Mills ratio (selection hazard)	−0.147[a]	−0.137[a]
	(0.081)	(0.078)		(<0.001)	(<0.001)
International dummy	0.017	0.026	Log(total assets)	−0.148[a]	−0.138[a]
	(0.937)	(0.907)		(<0.001)	(<0.001)
Log(stock return volatility [$t-1$, $t-3$])	0.377[c]	0.372[c]	Log(firm age)	−0.039[a]	−0.040[a]
	−0.091	(0.100)		(0.009)	(0.005)
Life insurer dummy	−0.506[b]	−0.508[b]	Log(market-to-book ratio)	−0.148	−0.1
	(0.038)	(0.039)		(0.136)	(0.297)
BestSOX dummy	0.296[b]	0.307[b]	L/T debt over total assets	0.006[a]	0.006[a]
	(0.045)	(0.039)		(0.001)	(0.001)
S&P dummy	1.294[a]	1.282[a]	Life insurer dummy	0.161[a]	0.162[a]
	(<0.001)	(<0.001)		(<0.001)	(<0.001)
			Log(S&P500 volatility [*t*])	0.472[a]	0.469[a]
#obs	2488	2450		(<0.001)	(<0.001)
Pseudo R^2	0.385	0.383	Mean industry ROA	−0.008	0.004
LR chi2(5)	290.17	286.83		(0.957)	(0.978)
Prob > chi2	<0.001	<0.001	%Institutional ownership	−0.006[a]	−0.005[a]
				(<0.001)	(<0.001)
			Log(#Business segments)	0.025	0.033
				(0.342)	(0.187)
			International dummy	0.017	0.019
				(0.557)	(0.492)
			#obs	2488	2450
			Adj *R*-squared	0.439	0.429
			Model *F*-value	62.31	63.28
			Prob > *F*	<0.001	<0.001

	(1)		(2)
First-stage regression – determinants of ERM adoption		*Second-stage regression – impact of ERM adoption on volatility*	
Dep. Var. = Prob(ERM = 1)		Dep. Var. = Log(stock return volatility [*t*])	
Log(total assets)	0.393[a]	ERM firm	0.068[a]
	(<0.001)		(0.007)
%Institutional ownership	0.009[a]	ERM firm * ERM implementation dummy	−0.079[b]
	(0.013)		(0.036)
Log(#Business segments)	−0.240[c]	Inverse Mills ratio (selection hazard)	−0.115[a]
	(0.073)		(<0.001)
International dummy	0.018	Log(total assets)	−0.142[a]
	(0.935)		(<0.001)
Log(stock return volatility [$t-1$, $t-3$])	0.412[c]	Log(firm age)	−0.041[a]
	(0.06)		(<0.001)
Life insurer dummy	−0.507[b]	Log(market-to-book ratio)	−0.169[a]
	(0.038)		(0.001)
BestSOX dummy	0.289[b]	L/T debt over total assets	0.006[a]
	(0.05)		(<0.001)
S&P dummy	1.318[a]	Life insurer dummy	0.143[a]
	(<0.001)		(<0.001)
		Log(S&P500 volatility [*t*])	0.502[a]
#obs	2528		(<0.001)
Pseudo *R*-squared	0.394	Mean industry ROA	−0.108
LR chi2	296.78		(0.174)
Prob > chi2	<0.001	%Institutional ownership	−0.005[a]
			(<0.001)
		Log(#Business segments)	0.026
			(0.14)
		International dummy	0.024
			(0.367)
		#obs	2528
		Pseudo *R*-squared	0.281

This table reports the regression results following a two-stage Heckman procedure. We use a *Probit* model during the first-stage estimation. We then use the predicted probability from the first stage to compute the Inverse Mills ratio, which is the probability density function of the predicted probability over the cumulative probability function of the predicted probability. We use OLS during the second-stage estimation. In Panel A, we run the regressions using two sample sizes: (1) firm-year observations from 1992 to 2008 that have annualized standard deviation less than 152% (i.e., 1.5% truncation at the top) and (2) firm-year observations from 1992 to 2008 that have annualized standard deviation less than 115% (i.e., 3% truncation at the top). In Panel B, we use the full sample of firms from 1992 to 2008 and use the quantile regression in the second-stage estimation. In parenthesis are *p*-values controlling for heteroskedasticity and firm-level clustering.

[a] Significance level at 1% level.
[b] Significance level at 5% level.
[c] significance level at 10% level.

Table 6
Impact of ERM on firm risk over time.

	(1)	(2)	(3)	(4)
Second-stage regression – impact of ERM adoption on volatility				
Dep. Var. = Log(stock return volatility [*t*])				
ERM firm	0.089[b]	0.089[b]	0.089[b]	0.089[b]
	(0.042)	(0.042)	(0.042)	(0.042)
ERM firm * ERM implementation (year 0)	−0.130[a]	−0.131[a]	−0.131[a]	−0.131[a]
	(0.01)	(0.01)	(0.01)	(0.01)
ERM firm * ERM implemention (year ⩾ 1)	−0.156[a]			
	(0.001)			
ERM firm * ERM implemention (year 1)		−0.117[a]	−0.116[a]	−0.116[a]
		(0.01)	(0.01)	(0.01)
ERM firm * ERM implemention (year ⩾ 2)		−0.173[a]		
		(0.001)		
ERM firm * ERM implemention (year 2)			−0.192[a]	−0.192[a]
			(0.001)	(0.001)
ERM firm * ERM implemention (year ⩾ 3)			−0.162[a]	
			(0.009)	
ERM firm * ERM implemention (year 3)				−0.176[a]
				(0.011)
ERM firm * ERM implemention (year ⩾ 4)				−0.153[b]
				(0.037)
Inverse Mills ratio (selection hazard)	−0.192[a]	−0.192[a]	−0.192[a]	−0.192[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Log(total assets)	−0.170[a]	−0.170[a]	−0.170[a]	−0.170[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Log(firm age)	−0.046[a]	−0.046[a]	−0.046[a]	−0.046[a]
	(0.004)	(0.004)	(0.004)	(0.004)
Log(market-to-book ratio)	−0.164	−0.164	−0.163	−0.163
	(0.115)	(0.115)	(0.115)	(0.116)
L/T debt over total assets	0.007[a]	0.007[a]	0.007[a]	0.007[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Life insurer dummy	0.188[a]	0.188[a]	0.188[a]	0.188[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Log(S&P500 volatility [*t*])	0.387[a]	0.387[a]	0.387[a]	0.387[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Mean industry ROA	−0.011	−0.011	−0.011	−0.011
	(0.938)	(0.938)	(0.938)	(0.938)
%Institutional ownership	−0.007[a]	−0.007[a]	−0.007[a]	−0.007[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
#Business segments	0.038	0.038	0.038	0.038
	(0.171)	(0.17)	(0.171)	(0.172)
International dummy	0.007	0.007	0.007	0.007
	(0.817)	(0.826)	(0.823)	(0.827)
#obs	2401	2401	2401	2401
Adj *R*-squared	0.429	0.43	0.43	0.43
Model *F*-value	39.86	37.55	35.17	33.16
Prob > *F*	<0.001	<0.001	<0.001	<0.001

This table reports the regression results from the second stage Heckman procedure. We do not report the results from the first-stage estimation to conserve space. (The first-stage regression results can be found in Table 4.) In parenthesis are *p*-values controlling for heteroskedasticity and firm-level clustering. The sample period is 1992–2007.
[c] Significance level at 10% level.
[a] Significance level at 1% level.
[b] Significance level at 5% level.

(3) as opposed to 1% when we control for the ERM_firm dummy in Column (2). As expected, adjusted *R*-squared also increases substantially to 0.669 in Column (3) compared to 0.429 in Column (2).

6.1.1. Robustness check: incorporating 2008

Due to the global financial crisis, the entire equity market experienced record volatility in 2008. The annualized standard deviation of equally-weighted S&P500 indices nearly tripled in 2008 compared to the year before. Our sample firms exhibit similar trends. From 1992 to 2007, only 25% of our sample firms have annualized standard deviation exceeding 45.50%.[22] In 2008, 75% of sample firms have annualized standard deviation greater than 58.04%. Therefore, including 2008 likely introduces substantial noise into our estimation. On the other hand, we also notice increased ERM adoption in the latter part of our sample period. To test our H1a, we require time series post ERM adoption. Therefore, to balance between maximizing time series and minimizing estimation noise, we conduct two robustness checks using firm-year observations from 1992 to 2008.

In the first robustness check, we restrict the sample to those observations with annualized standard deviation less than 152% and 115% (i.e., truncating the sample by 1.5% and 3% at the top). (Our results hold if we try alternative cutoff points such as 5%.) An advantage of this approach is that it applies equally to all firm years (i.e., there is no systematic discrimination against one particular year). By doing so, we likely also exclude firms experiencing extreme situations (e.g., firms near bankruptcy, delisting or being acquired). As Table 5 Panel A shows, all our results hold. Particularly, the interaction term (*ERM_firm * ERM_implem_dummy*) is significantly, negatively related to firm risk, albeit of lower magnitude. The smaller coefficient is consistent with our conjecture that

[22] See Appendix I online for details.

Table 7
Impact of ERM adoption on ROA scaled by return volatility.

(1)		(2)	
First-stage regression – determinants of ERM implementation		*Second-stage regression – impact of ERM implementation on ROA/volt*	
Dep. Var. = Prob(ERM = 1)		Dep. Var. = ROA/Stock return volatility	
Log(total assets)	0.384[a]	ERM firm	−0.006
	(<0.001)		(0.191)
%Institutional ownership	0.010[a]	ERM firm * ERM implementation dummy	0.020[a]
	(0.007)		(0.006)
Log(#Business segments)	−0.236[c]	Inverse Mills ratio (selection hazard)	0.014[a]
	(0.095)		(0.002)
International dummy	0.096	Log(total assets)	0.001
	(0.664)		(0.717)
Log(stock return volatility [$t-1$, $t-3$])	0.445[b]	Log(firm age)	0.009[a]
	(0.044)		(<0.001)
Life insurer dummy	−0.486[b]	Log(market-to-book ratio)	0.383[a]
	(0.049)		(<0.001)
BestSOX dummy	0.295[b]	L/T debt over total assets	0.000
	(0.045)		(0.661)
S&P dummy	1.254[a]	Life insurer dummy	−0.032[a]
	(<0.001)		(<0.001)
		Mean industry ROA	0.351[a]
#obs	2401		(<0.001)
Pseudo R^2	0.378	%Institutional ownership	0.001[a]
Wald chi2(8)	280.09		(<0.001)
Prob > chi2	<0.001	#Business segments	−0.015[a]
			(<0.001)
		International dummy	0.007
			(0.185)
		#obs	2400
		Adj R-squared	0.198

This table reports the regression results from estimating Eq. (4), which is a two-stage Heckman procedure. Column (1) reports the regression results from estimating a *Probit* model. We then use the predicted probability from the first stage to compute the Inverse Mills ratio, which is the probability density function of the predicted probability over the cumulative probability function of the predicted probability. Column (2) reports the estimation results from the second-stage median regression. In parenthesis are *p*-values. The sample period is 1992–2007.
[a] Significance level at 1% level.
[b] Significance level at 5% level.
[c] Significance level at 10% level.

including 2008 introduces estimation noise. In the second robustness check, we estimate quantile regression using the full sample.[23] As Table 5 Panel B shows, our results remain qualitatively the same.

6.1.2. The impact of ERM on firm risk over time

Table 6 reports the regression results from estimation Eq. (5). To test the corollary to our first hypothesis (H1a), we estimate four model specifications using different time lags post ERM adoption. Consistent with H1a, we find that the risk reduction post ERM-adoption grows stronger over time. Specifically, based on Table 6 Column 3, firms realize 12.3% ($1 - e^{-0.131}$) risk reduction during the year ERM is implemented (year = 0). The risk reduction increases to 17.5% ($1 - e^{-0.192}$) two years after the firm adopts ERM. Therefore, our results are consistent with the argument and anecdotal evidence that implementing ERM is a complicated process and that the full benefits from ERM adoption are realized over time. In untabulated analysis, we add firm fixed effects to the regressions and find qualitatively similar results, namely risk reduction post ERM adoption becomes stronger over time.

6.2. The impact of ERM adoption on profits per unit of risk

Table 7 reports regression results that test our H2. Our variable of interest is the interaction term (*ERM_firm * ERM_implem_dummy*). Consistent with our hypothesis, the estimated coefficient of this interaction is positive and statistically significant at 1% level. The magnitude of 0.020 suggests that adopting ERM increases the ratio of ROA over annualized standard deviation of stock returns by 2.00%, which is a non-trivial increase when considering firms as an on-going concern (i.e., generating perpetual cash flows). Therefore, our results are consistent with Hoyt and Liebenberg (2011), who find a valuation premium of roughly 20% (as measured by Tobin's Q) for US public insurers that adopt ERM from 1998 to 2005.

Interestingly, the dummy for ERM firms is no longer significant in the second-stage regression, suggesting that ERM adopting firms (prior to ERM-adoption) are not systematically more profitable per unit of risk than non-ERM firms. Coefficient estimates of our other controls are consistent with the conventional knowledge. For example, we find that older firms, firms with greater growth opportunities, and firms with high institutional ownership are more profitable relative to their risk.[24]

In Section 6.1.2, we find that ERM has a lagged effect on risk reduction, consistent with the argument that ERM implementation is a complex process and its effects may take time to manifest. This argument could also apply to the effect of ERM adoption on profits scaled by risk. To investigate this lagged effect, we estimate a similar set of regressions as in Table 6. In this case, we use profit per unit of risk as the dependent variable and examine the impact of ERM adoption over various time lags. Results are reported in Table 8. We find some evidence in support of a lagged effect. Specifically, based on Table 8 Column 3, firms realize 2.1% ($e^{0.021} - 1$) increase in ROA over stock return volatility during the year ERM is

[23] We thank an anonymous referee for suggesting this model.

[24] We also use alternative definitions of profits, including return on book value of common equity and return on market value of common equity, and in both cases, the interaction term between ERM firm and ERM implementation dummy (*ERM_firm * ERM_implem_dummy*) is positive and significant at 1% level. These results are reported online in Appendix II.

Table 8
Impact of ERM adoption on ROA scaled by return volatility over time.

	(1)	(2)	(3)	(4)
Second-stage regression – Impact of ERM adoption on firm profit/firm risk				
Dep. Var. = ROA/Volt				
ERM firm	−0.006	−0.006	−0.006	−0.006
	(0.197)	(0.206)	(0.228)	(0.198)
ERM firm * ERM implementation (year 0)	0.018	0.021[c]	0.021[c]	0.021[c]
	(0.148)	(0.074)	(0.096)	(0.063)
ERM firm * ERM implemention (year ⩾ 1)	0.019[b]			
	(0.022)			
ERM firm * ERM implemention (year 1)		0.010	0.010	0.014
		(0.39)	(0.423)	(0.243)
ERM firm * ERM implemention (year ⩾ 2)		0.025[a]		
		(0.004)		
ERM firm * ERM implemention (year 2)			0.017	0.012
			(0.238)	(0.345)
ERM firm * ERM implemention (year ⩾ 3)			0.027[a]	
			(0.013)	
ERM firm * ERM implemention (year 3)				0.024[c]
				(0.099)
ERM firm * ERM implemention (year ⩾ 4)				0.029[b]
				(0.020)
Inverse-mill ratio (selection hazard)	0.013[a]	0.015[a]	0.015[a]	0.015[a]
	(0.007)	(0.001)	(0.002)	(0.001)
Log(total assets)	0.000	0.001	0.001	0.001
	(0.898)	(0.649)	(0.672)	(0.619)
Log(firm age)	0.009[a]	0.009[a]	0.009[a]	0.009[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Log(market-to-book ratio)	0.383[a]	0.384[a]	0.384[a]	0.384[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
L/T debt over total assets	0.000	0.000	0.000	0.000
	(0.694)	(0.742)	(0.742)	(0.709)
Life insurer dummy	−0.032[a]	−0.031[a]	−0.032[a]	−0.031[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
Mean industry ROA	0.352[a]	0.348[a]	0.349[a]	0.348[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
%Institutional ownership	0.001[a]	0.001[a]	0.001[a]	0.001[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
#Business segments	−0.015[a]	−0.015[a]	−0.015[a]	−0.015[a]
	(<0.001)	(<0.001)	(<0.001)	(<0.001)
International dummy	0.007	0.006	0.006	0.006
	(0.189)	(0.225)	(0.26)	(0.227)
#obs	2400	2400	2400	2400
Adj R-squared	0.198	0.198	0.198	0.198

This table reports the regression results from the second stage Heckman procedure. We do not report the results from the first-stage estimation to conserve space. Columns (1) through (4) report the estimation results from the second-stage median regression. In parenthesis are p-values. The sample period is 1992–2007.
[a] Significance level at 1% level.
[b] Significance level at 5% level.
[c] Significance level at 10% level.

implemented (year = 0). This ratio increases to 2.7% ($e^{0.027} - 1$) three years after the firm adopts ERM.

6.3. Robustness check: using the sub-period of 2000–2007

We also conduct all the tests using the sub-sample period of 2000–2007, as opposed to the full sample period of 1992–2007, since more than 95% of our ERM adoptions occur after 2000. Our results remain qualitatively unchanged. Adopting ERM significantly reduces firm risk as measured by the annualized standard deviation of daily stock returns. Further, the risk reduction appears to be lagged, consistent with the notion that implementing ERM is a complex process. Lastly, adopting ERM significantly increases the ratio of firm profits over firm risk, regardless of whether we use ROA or ROE as the proxy for firm profit.

While still statistically significant, the results using the sub-sample period of 2000–2007 are generally weaker than if using the full sample period of 1992–2007. For example, the effect of adopting of ERM using the sub-sample has a p-value of 5.6% compared to less than 1% when using the full sample. The reduced statistical significance probably arises from a smaller sample and a shorter time series. The sub-sample consists of 1083 observations, compared to 2401 observations in the full sample, a 55% reduction in sample size.

7. Conclusion

In this paper, we test the hypothesis that the impact of ERM adoption on the MC of reducing risk. This hypothesis is based on the premise that firms adopting ERM are better able to recognize the benefits of natural hedging, prioritize hedging activities towards the risks that contribute most to the total risk of the firm, and optimize the evaluation and selection of available hedging instruments. Therefore, ERM-adopting firms are able to produce a greater reduction of risk per dollar spent. The resulting lower marginal cost of risk reduction provides economic incentive for profit-maximizing firms to further reduce risk until the marginal cost of risk reduction equals the marginal benefits. Consequently, after implementing ERM, firms experience lower risk and higher profits, simultaneously. Consistent with our hypotheses, we find that firms adopting ERM experience a reduction in stock return volatility. Due to the costs and complexity of ERM implementation, the reduction in return volatility for ERM-adopting firms is gradual and becomes stronger over time. Lastly, we find that returns per unit of risk (ROA/return volatility) increase post ERM adoption.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jbankfin.2014.02.007.

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