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Organizational structure, risk-based capital requirements, and the sales of downgraded bonds

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ABSTRACT

Using bond downgrades as external shocks to life insurers' asset risk, we document several findings of the impact of organizational structure and risk factors on investment risk taking. First, we find that mutual insurers and widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers. Second, we find evidence that insurers are less likely to sell downgraded bonds that remain in the same rating class than bonds downgraded to a lower rating class. The result implies that insurers sell downgraded bonds mainly because of additional capital charge is imposed, not because of downgrade itself. In other words, risk factors in risk-based capital regulation do matter on life insurers' investment risk taking. Finally, we find that life insurers might be reluctant to sell downgraded bonds at fire-sale prices during the 2008–2009 financial crisis.

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1. Introduction

This paper investigates the impact of organizational structure and risk factors in risk-based capital (RBC) requirements on selling downgraded bonds by life insurers. Bond downgrades provide a good opportunity to examine how life insurers react to an external shock to their asset risk. Selling a downgraded bond and holding the proceeds in cash or buying another bond with a better credit rating than the downgraded bond is a type of risk reduction.

The first purpose of this study is to analyze the relation between organizational structure and life insurers' investment risk taking on downgraded bonds. While the relation between organizational structure and underwriting risk taking in the property-liability insurance industry has been examined (e.g., Lamm-Tennant and Starks (1993); Kleffner and Doherty (1996); Mayers and Smith (2002); Ho et al. (2013)), to our best knowledge, there is no study on the relation between organizational structure and investment risk taking (e.g., bond investing) in the life insurance industry.[1]

We argue that mutual insurers are more likely to sell downgraded bonds than are stock insurers. When a bond held by an insurer gets downgraded, the insurer's asset risk increases because the default risk of the bond issuer increases. Mutual insurers are more likely to sell downgraded bonds to reduce risk and move back to the target risk level for two reasons. First, the expected bankruptcy costs of being away from the optimal risk level is higher for mutual insurers than stock insurers because mutual insurers cannot raise capital in the capital markets. The bankruptcy probability is higher when risk is higher and capital is not adjusted accordingly. Second, the agency cost for managers of mutual insurers related to the decision of keeping downgraded bonds is higher than the agency cost of stock insurers because managers of stock insurers in general have stocks and stock options which can mitigate the agency costs. Therefore, when facing a new exogenous

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[1] The influence of organizational structure on firms' decisions continues to draw attention from the academic study. Some recent works in the general industry are: Mergers and acquisitions (Maksimovic and Phillips, 2013), CEO compensation (Cronqvist and Fahlenbrach, 2013; Edgerton, 2012), cash policy (Gao et al., 2013), and innovation (Bernstein, 2015). Topics in the banking industry include: Asset risk and default risk (Barry et al., 2011), performance and efficiency (Kontolaimou and Tsekouras, 2010; Servin et al., 2012), lending behavior (Ferri et al., 2014), and income smoothing (Bouvatier et al., 2014).

shock of downgraded bonds, mutual insurers are more likely to sell downgraded bonds to go back to optimal risk level than stock insurers.

The comparison between widely-held and closely-held stock insurers is similar to the analysis between mutual and stock insurers. We propose that widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers. From expected bankruptcy cost perspective, there may be no significant difference between widely-held and closely-held stock insurers because both types of insurers can raise capital through issuing stocks. From agency cost perspective, however, agency costs between managers and owners are higher for widely-held stock insurers than agency costs for closely-held stock insurers. Closely-held stockholders have more incentive to monitor their managers to mitigate agency costs than widely-held stockholders because closely-held stockholders have relatively higher percentage wealth invested in their companies than widely-held stockholders. Therefore, when facing a new exogenous shock of downgraded bonds, widely-held stock insurers are more likely to sell downgraded bonds to go back to optimal risk level than closed-held stock insurers. We investigate whether mutual insurers are more likely to sell downgraded bonds than are stock insurers and whether widely-held stock insurers are more likely to sell than are closely-held stock insurers.

The second purpose of this paper is to analyze the impact of risk factors in RBC regulation on investment risk taking. In addition, unlike the existing literature we investigate not only fallen-angel bonds but also non-fallen-angel bonds.[2] Ambrose et al. (2008) and Ellul et al. (2011) analyze bonds downgraded from investment-grade to speculative-grade (so called "fallen angels"). Ellul et al. (2011) also show how life insurers' investment risk taking is affected by the RBC regulation.[3] Ellul et al. (2011) use National Association of Insurance Commissioners (NAIC)' RBC ratio and Street.com's Risk-adjusted capital ratio 1 (RACR1) to measure an insurer's financial soundness and find that for the period from 2001 to 2005 insurers that are relatively more financially-constrained by regulation are more likely to sell fallen-angel bonds. However, Ambrose et al. (2008) and Ellul et al. (2011) do not specifically examine the impact of risk factors. RBC reflects overall company risk which includes not only investment risk but also underwriting risk and other risks. But underwriting risk and other risks are not directly related to whether or not to sell downgraded bonds. We therefore use NAIC risk factors as a proxy to directly examine whether or not additional capital requirements from NAIC affect the sales of downgraded bonds.[4]

While the relation between risk taking and RBC ratio (capital level) is under debate, insurers definitely do not like a greater capital charge if a bond is downgraded to a lower class because holding capital is costly.[5] The required capital of holding a corporate bond is computed as the product of the holding amount and the respective NAIC risk factor. The riskier the bond is, the higher the NAIC risk factor is imposed. For example, regulators currently impose the same 7.4% of book value of a B+-rated bond for capital requirement purposes after that bond is downgraded from B+ to B-, but impose a 17.0% capital requirement after the bond is downgraded to CCC+. In this case, insurers have weaker incentive to sell such a bond downgraded from B+ to B- than a bond downgraded from B+ to CCC+.[6]

The final purpose of this study is to investigate risk taking during the financial crises. When a bond owned by an insurer is downgraded during the period of financial crisis, the insurer may not want to sell the downgraded bond at fire-sale price. The spread contribution from illiquidity increases dramatically with the onset of the recent subprime crisis (Dick-Nielsen et al., 2012). In addition, institutional investors with short horizons may need to sell their holdings in the short run and amplify the price drops (Cella et al., 2013). Life insurers, who are long-horizon investors, may wait to sell a downgraded bond until the price reverses back to normal levels.

The sample observations are comprised of life insurers' detailed corporate bond holdings and matched with the downgrade records in the Mergent's Fixed Investment Securities Database (FISD). The final sample consists of 161,997 observations over an 11-year period from 1999 to 2009. We summarize the results that are important to the literature below. First, we find mutual insurers and widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers. Second, we find a statistically significantly negative relation between the probability of selling downgraded bonds and insurers' RBC ratios. But the economic significance is marginal. A 10-percent better capitalized insurer is 1.03% less likely to sell a downgraded bond. Third, we find that a life insurer is more likely to sell a speculative-grade bond if a downgrade falls into a lower rating class.[7] Finally, life insurers, as a whole, sold fewer downgraded bonds during the 2008–2009 financial crisis.

Our study complements the literature in several ways. First, we are the first to examine the impact of organizational structure on investment risk-taking behavior in the U.S. life insurance industry. Second, we are the first to provide evidence that life insurers are more likely to sell their holdings on speculative-grade bonds if a rating agency downgrades these bonds into a lower rating class. Prior studies investigate only investment-grade bonds downgraded to speculative-grade. Finally, our study is the first to find that life insurers sold fewer downgraded bonds during the 2008–2009 financial crisis. From the perspective of the regulators, it is important to know whether insurers behave differently between investment-grade and speculative-grade bonds, as well as between normal time and crisis time.

The remainder of the paper proceeds as follows. Section 2 presents our hypotheses. Section 3 briefly describes our data. Section 4 provides our empirical models and the results. Section 5 offers conclusions.

2. Hypotheses development

2.1. The organizational structure of a life insurer and the sale of a downgraded bond

Mutuals differ from stocks in both the agency problems faced and the ability to deal with agency problems (Fama and Jensen, 1983a; 1983b; Mayers and Smith, 1981). While agency costs of fixed claims (policyholders' claims) are controlled by forming a mutual organization, the result is offset by less effective control over the owner-manager conflict. Since the cost of controlling

[2] Fallen-angel bonds are bonds downgraded from investment-grade to speculative-grade. Non-fallen-angel bonds are bonds remain as investment-grade or remain non-investment-grade in spite of downgrade.

[3] Two recent papers are associated with RBC regulation but not risk taking. Ellul et al. (2015) document that fair value accounting motivates higher rates of selling of asset-backed securities among property & casualty insurers, whereas historical cost accounting for life insurers motivates them to hold downgraded asset-backed securities, selling corporate bonds instead. Merrill et al. (2012) show that insurers that became more capital-constrained because of operating losses and also recognized fair value losses sold comparable residential mortgage-backed securities at much lower prices than other insurers during the recent financial crisis.

[4] RBC ratio is calculated based on the risk factors.

[5] Please refer to Section 2.2 for the literature review on the relation between risk and capital.

[6] Please see Table 1 for the details of credit ratings and the NAIC risk factors.

[7] After a speculative-grade bond is downgraded, it is still in speculative grade. Prior literature investigates investment-grade bonds downgraded to speculative-grade.

management of mutuals is higher compared to stocks, Fama and Jensen posit that mutuals should be more prevalent in activities in which the costs of expanding and contracting assets are lower and in which the costs of valuing those assets are lower. They also predict that mutual companies should be associated with less uncertainty regarding future cash flows than stock companies.

The managerial discretion hypothesis proposed by Mayers and Smith (1981; 1988) yields a similar prediction if we assume that the uncertainty (riskiness) of future cash flows is positively related to managerial discretion. Mayers and Smith argue that because managerial discretion provides more opportunities for managers to pursue their self-interests at the expense of other stakeholders (owners and/or policyholders) in the firm, organizational forms where owner-manager or policyholder-manager conflicts are strong will be more successful in activities that require relatively low degrees of managerial discretion. Mayers and Smith (1988), Lamm-Tennant and Starks (1993), and Kleffner and Doherty (1996) provide similar evidence that mutual insurers, where owners (policyholders) have little control over management, are more successful in less risky lines of insurance than stock insurers.

The capital-constraint argument (e.g., Cummins and Doherty (2002); Harrington and Niehaus (2002); Mayers and Smith (2002)) helps explain why mutuals take lower risk. The capitalization for stock form and mutual form is very different. Stock insurers can issue stocks when they need new capital. On the other hand, mutual insurers cannot issue stocks to raise new capital. Mutual insurers engage in less risky underwriting to protect against erosion of capital if bad outcomes occur because they have limited ability to raise external capital.

While both underwriting and investments are important to insurers, little research has been done on investment risk taking.[8] Lee et al. (1997) investigate the asset adjustments that occurred around the time that state guaranty-fund laws were enacted and find that mutual insurers did not shift to riskier assets while stock insurers did increase their asset risk.[9] When a bond held by an insurer gets downgraded, the insurer's asset risk increases because the default risk of the bond issuer increases. Suppose that an insurer's value and risk have an inverse-U relationship as shown in Fig. 1. If mutual and stock insurers are at the optimal risk level before bond downgrading then an exogenous bond downgrade would push both types of insurers to a risk level that is higher than their respective target level.[10] It would seem that both types of insurers would respond by selling the downgraded bonds and reducing risk to move back to their target level.

When a bond is downgraded, there are costs and benefits associated with holding the bond. The potential costs could include a higher risk-based capital charge, greater expected losses on the bond, and greater uncertainty associated with the ultimate payoff on the bond. We classify major costs of holding downgraded bonds into two categories. The first type is expected bankruptcy costs.[11] Specifically, the expected bankruptcy costs of being away from the optimal risk level is higher for mutual insurers than stock insurers because mutual insurers cannot raise capital in the capital markets. Other things being equal, the bankruptcy probability is higher when risk is higher and capital is not adjusted accordingly. Thus, mutual insurers are more likely to sell downgraded bonds to reduce bankruptcy probability (expected bankruptcy costs) and go back to the target risk level than are stock insurers.

The other type of costs that are relevant to the decision of selling downgraded bonds are agency costs. The agency cost for managers of stock insurers related to the decision of keeping downgraded bonds is lower than the agency cost of mutual insurers because managers of stock insurers in general have stocks and stock options which can mitigate the agency costs. Bond downgrading results in greater uncertainty associated with the ultimate payoff on the bond. The uncertainty includes the possibility that the bond will increase in value (upside risk) and the possibility that the bond will decrease in value (downside risk). Managers of mutual companies are less likely to share in the upside risk than managers of stock companies given that the mutual managers cannot hold stock or stock options. Consequently, mutual managers will have less incentive to hold the bond than managers of stock companies. [12]

Based on the above discussions, the following hypothesis is proposed:

Hypothesis 1. Ceteris paribus, mutual insurers are more likely to sell downgraded bonds than are stock insurers.

Within the category of stock insurers, owner-manager conflicts are expected to be smallest in closely-held stock insurers and largest in widely-held stock insurers because shareholders' incentives to monitor managers decrease as the degree of separation of ownership from management increases (Berle and Means, 1932; Jensen and Meckling, 1976). Thus, the interests between owners and managers are better aligned and riskier strategies are adopted in closely-held stock insurers.[13] Cummins and Sommer (1996) provide evidence that closely-held stock insurers have lower capital and higher portfolio risk than publicly-traded (widely-held) stock insurers. We assume a life insurer which is publicly-traded or belongs to a publicly-traded parent company is widely-held.

The comparison between widely-held and closely-held stock insurers are similar to the analysis between mutual and stock insurers. If widely-held and closely-held stock insurers are at the optimal risk level then an exogenous bond downgrade would push both types of insurers to a risk level that is higher than their respective target level. When insurers deviate from their optimal risk level, their value would be lower. Insurers would try to go back to their respective target risk level. We discuss whether widely-held or closely-held stock insurers are more likely to sell downgraded bonds to reduce their risks. From expected bankruptcy cost perspective, there may be no significant difference between widely-

[8] Some recent papers also show that mutual insurers differ from stock insurers in other important aspects. Berry-Stölzle et al. (2012) document mutual insurers engage in significantly less unrelated diversification than do stock insurers because relatively high levels of managerial discretion are required with unrelated diversification and mutual insurers are less efficient in activities that require relatively high degrees of managerial discretion. Yanase and Limpaphayom (2015) find Japanese mutual insurers purchase more reinsurance than stock insurers. With reinsurance contracts, owners of mutual insurers are able to focus on specific risks in which the firm has expertise. He and Sommer (2010) show mutual insurers, which represent greater separation of ownership and control than stock insurers, are associated with greater use of outside directors than stock insurers. He and Sommer (2011) indicate that while CEO turnover for stock insurers is negatively related to prior performance, no such relationship is found for mutual insurers. Cheng et al. (2015) show the probability of nonroutine CEO turnover is lower for mutual insurers than for publicly-traded and closely-held nonfamily stock insurers.

[9] Ho et al. (2013) argue that insurers consider their total risk which includes underwriting risk, investment risk and leverage risk and find that mutual insurers take lower investment risk.

[10] From earlier discussions, mutual insurers have a lower risk target level than stock insurers.

[11] This is similar to the capital constraint hypothesis at the equilibrium.

[12] We suggest the slopes of marginal cost are steeper for mutual insurers than those of stock insurers. The reason is the marginal costs include both expected bankruptcy costs and agency costs which are higher for mutual insurers than those of stock insurers.

[13] This suggests that widely-held stock insurers have a lower risk target level than closely-held stock insurers.

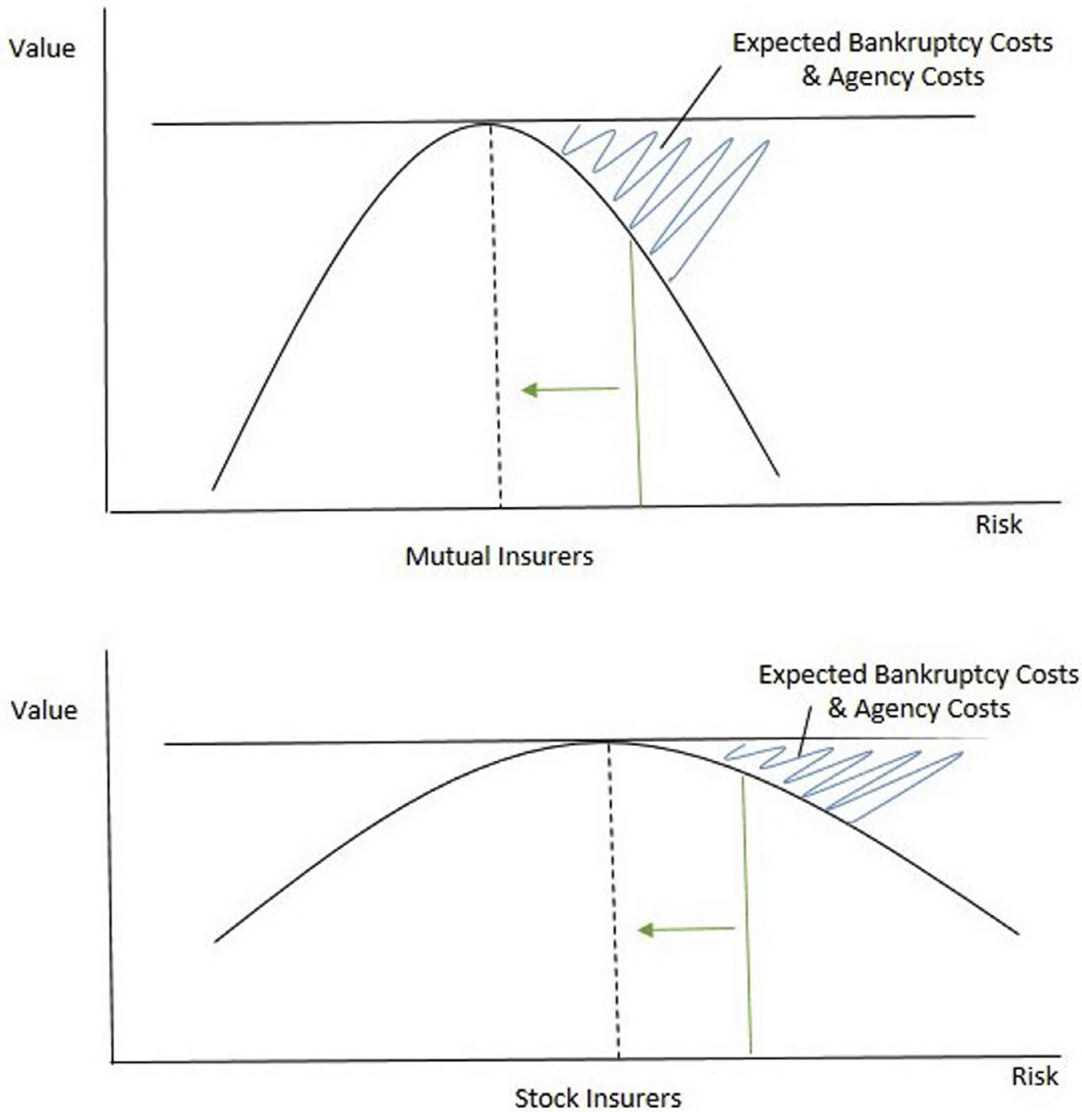

Fig. 1. Optimal risk level and costs of not selling downgraded bonds.

held and closely-held stock insurers because both types of insurers can raise capital through issuing stocks.

From agency cost perspective, we suggest that agency costs between managers and owners are higher for widely-held stock insurers than agency costs for closely-held stock insurers. Closely-held stockholders have more incentive to monitor their managers to mitigate agency costs than widely-held stockholders because closely-held stockholders have relatively higher percentage wealth invested in their companies than widely-held stockholders. Therefore, when facing a new exogenous shock of downgraded bonds, widely-held stock insurers are more likely to sell downgraded bonds to go back to optimal risk level than closed-held stock insurers because agency costs of not selling is higher for widely-held stock insurers than closely-held stock insurers.

Based on the above arguments, we propose the following hypothesis:

Hypothesis 2. Ceteris paribus, widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers.

2.2. The risk-based capital ratio and the sale of a downgraded bond

Life insurers have been required by the National Association of Insurance Commissioners (NAIC) to meet the minimum risk-based capital (RBC) standards since 1993. Insurers with higher RBC ratios are viewed better capitalized than those with lower ones even though both types of insurers meet the minimum required ratio of 200%. Prior literature documents that financial institutions hold a capital to asset ratio well above the required minimum for various reasons (e.g., reputation, or avoidance of regulatory intervention, see Allen et al. (2011); Furfine (2001); Lindquist (2004)). Although both insurers with higher RBC ratios and insurers with lower RBC ratios would like to keep their RBC ratios in excess of required minimum, their reactions to shocks might differ. Ellul et al. (2011) find that insurers that are relatively more capital-constrained are more likely to sell downgraded bonds. Merrill et al. (2012) show that insurers that became more capital-constrained because of operating losses and also recognized fair value losses sold comparable residential mortgage-backed securities at much

Table 1
Credit ratings and the NAIC risk factors.

Explanation	Moody's (modifiers)	S&P/Fitch/DCR (modifiers)	Cardinal scale	NAIC rating category	NAIC risk factor
Investment grade					
Highest grade	Aaa	AAA	1	1	0.3%
High grade	Aa(1,2,3)	AA(+,none,-)	2,3,4	1	0.3%
Upper medium grade	A(1,2,3)	A(+,none,-)	5,6,7	1	0.3%
Medium grade	Baa(1,2,3)	BBB(+,none,-)	8,9,10	2	1.0%
Speculative grade					
Lower medium grade	Ba(1,2,3)	BB(+,none,-)	11,12,13	3	3.4%
Speculative	B(1,2,3)	B(+,none,-)	14,15,16	4	7.4%
Poor standing	Caa(1,2,3)	CCC(+,none,-)	17,18,19	5	17.0%
Highly speculative	Ca	CC	20	5	17.0%
Lowest quality, no interest	C	C	21	5	17.0%
In default		DDD(only Fitch)		6	22.1%
		DD(only DCR and Fitch)		6	22.1%
		D(only S&P and Fitch)		6	22.1%

lower prices than other insurers during the 2008-2009 financial crisis.

Insurers with lower RBC ratios are more likely to sell a downgraded bond than are insurers with higher RBC ratios because holding such a bond might further deteriorate their low RBC ratios.[14] Insurers with higher RBC ratios have greater buffers for the possible deterioration of their RBC ratios. By selling a downgraded bond and holding the proceeds in cash or buying another bond with a better credit rating, an insurer with a lower RBC ratio might achieve a higher RBC ratio even though the sale realizes capital losses.[15] Therefore, we propose the following hypothesis:

Hypothesis 3. Ceteris paribus, life insurers with lower RBC ratios are more likely to sell downgraded bonds than are life insurers with higher RBC ratios.

2.3. The risk factor in the risk-based capital requirements and the sale of a downgraded bond

Previous studies like Ambrose et al. (2008) and Ellul et al. (2011) analyze the selling pressure on bonds downgraded from investment-grade (NAIC-1 and NAIC-2) to speculative-grade (NAIC-3 to NAIC-6). They argue that regulations impose large capital requirements on the holdings of speculative-grade bonds, thus, the selling pressure around the downgrade of bonds that remain investment-grade is lower than that of bonds downgraded from investment-grade to speculative-grade. They, however, do not consider downgraded bonds that remain at either investment-grade or speculative-grade.

It is possible that insurers may have lower selling pressure when the capital requirement stays the same after bonds are downgraded. Thus, we expect that life insurers have weaker incentive to sell bonds that are downgraded but remain in the same NAIC rating category than bonds downgraded from a higher NAIC rating category to a lower NAIC rating category. For example, Table 1 shows that regulators currently impose the same 7.4% of book value of a B+-rated bond for capital requirement purposes after that bond is downgraded from B+ to B−, but impose a 17.0% capital requirement after the bond is downgraded to CCC+. In this case, insurers have weaker incentive to sell such a bond downgraded from B+ to B− than a bond downgraded from B+ to CCC+. Therefore, the following hypothesis is proposed:

Hypothesis 4. Ceteris paribus, life insurers are less likely to sell bonds downgraded but remaining in the same NAIC rating category than bonds downgraded from a higher NAIC rating category to a lower NAIC rating category.

2.4. The financial crisis and the sale of a downgraded bond

The spread contribution from illiquidity increases dramatically with the onset of the recent subprime crisis (Dick-Nielsen et al., 2012). In addition, institutional investors with short horizons may need to sell their holdings in the short run and amplify the price drops (Cella et al., 2013). When a bond owned by an insurer is downgraded during the period of financial crisis, the insurer may not want to sell the downgraded bond at fire-sale price as long as it has no liquidity needs or regulatory concerns.[16] Therefore, we argue that life insurers, as institutional investors with long investment horizons, are less likely to sell downgraded bonds in the period of financial crisis. The following hypothesis is stated:

Hypothesis 5. Ceteris paribus, insurers are less likely to sell downgraded bonds during financial crisis than are at usual times.

3. Data

3.1. Sample construction

We use several databases in this study. First, the insurers' transaction and year-end position data are from NAIC Schedule D. Second, the credit rating, offering date, offering amount and maturity of each bond are from the Mergent Fixed Income Securities Database (FISD). Third, each insurer's organization structure, RBC ratio, as well as capital and surplus level are obtained from the NAIC InfoPro database.[17] Finally, the information on each bond issuer's common equity (listing) is from the Center for Research in Security Price (CRSP).

We begin with all long-term U.S. corporate bond holdings on all life insurers' balance sheets from December 31, 1997 to December 31, 2009. The data are drawn from Part 1 and Part 5 of the NAIC

[14] If insurers hold a bond downgraded to a lower rating class, the required capital (in the denominator of the formula of the RBC ratio) are higher, leading to a lower RBC ratio.

[15] If insurers sell a downgraded bond with capital losses and buy another higher-grade bond, both the actual capital (in the numerator of the formula of the RBC ratio) and the required capital (in the denominator of the formula of the RBC ratio) are lower, leading to a higher or lower RBC ratio. Selling a downgraded bond with capital gains and buying another higher-grade bond will increase insurers' RBC ratios.

[16] The major liquidity need for an insurer comes from insurance claims, which are not like mutual-fund redemptions driven by investors.

[17] The organization structure, "stock" or "mutual," is identified through the NAIC InfoPro database. Whether a stock insurer is closely-held or widely-held is determined manually through *Best's Insurance Reports* and the SEC's EDGAR database.

Schedule D.[18] In this data period, we have eleven announcement years (1999–2009). We investigate whether the bondholder (i.e., the life insurer) sells the bond around the downgrade announcement date. For example, if a bond issued by XYZ Company was on life insurer ABC's balance sheet as of December 31, 1997, we investigate whether the XYZ bond was downgraded during 1999. If it was downgraded on March 31, 1999, we search whether it was sold during the period from April 1, 1998 to June 30, 1999. XYZ bond is included in our sample once per insurer whoever owns it and there must be no downgrade on it before January 1, 1999.[19]

After we exclude bonds downgraded before January 1, 1999, we identify a bond as firstly-downgraded when there is a most-early record of downgrade within the period from January 1, 1999 to December 31, 2009 in Mergent's FISD, which contains S&P, Moody's, Fitch, and DCR historical rating records.[20] The downgraded bond is defined as the bond sold before (after) the first announcement date if we find the record of selling in Part 4 or Part 5 of the NAIC Schedule D and the selling date is within 1-day to 360-day before (0–90-day after) the event date.[21] We classify the bond as not sold if it is sold more than 90 days after the first downgrade announcement date. Finally, we merge each observation with insurer characteristics and bond characteristics and arrive at a sample of 161,997 insurer/downgraded bond issue/year observations. The screening process of the sample and an overview of the distribution of observations by the bond issues, bond issuers, and insurers can be found in Appendix A.

3.2. Descriptive statistics

Table 2 provides descriptive information regarding the life insurers in the United States. Panel A shows the number of life insurers has declined over time. Mutual insurers are approximately six percent of the industry in terms of the number of the insurers. Panel B shows that the mean value of the RBC ratio is extremely high and elevated by some outliers. The median value of the RBC ratio is higher than eight, which means the median insurer in the industry holds more than four times the capital required.[22] Panel C provides the rating distribution of the insurers' long-term corporate bond holdings. Around sixty percent of the corporate bond are rated at NAIC-1, thirty percent are rated at NAIC-2 and very few are at lower rating categories. Panel D shows the disposal rates of corporate bonds with respect to various portfolio sizes. Larger insurers have slightly-lower disposal rates and the dispersion of the disposal rates among smaller insurers is more than that among larger insurers.

Table 3 reports summary statistics for the sale decisions on downgraded bonds. Panel A shows that eighty-three percent of our sample were bonds with an investment-grade (NAIC-1 or NAIC-2) rating before downgrade.[23] The lower the rating category the bond belongs to (except the default category, NAIC-6), the higher the probability that the bond is sold before the first downgrade announcement date by life insurers. For downgraded bonds that remain in NAIC-1 or NAIC-2 rating category, insurers are more likely to keep their holdings. Panel B shows similar patterns as in Panel A in terms of par values of the downgraded bonds.

3.3. Control variables

We control for bond trading probability in our analysis, using both insurer information and bond-issuer information. The control variables related to an insurer's characteristics include the size of the insurer and its portion of holding a specific bond issue. Larger insurers usually have more detailed investment policies than do smaller insurers. Thus, they are more likely to follow their investment policies and sell a downgraded bond. Insurers who hold a larger portion of a bond issue may be more reluctant to dump the bond when a bond downgrade occurs because they may get a worse bid price in order to dispose a larger amount of the bond. In addition, they have more incentive to gather the issuer's information and stay with the issuer.

The bond-issuer control variables include initial bond offering amount, bond age, time to maturity, the post-downgrade rating, the frequency of a series of downgrades, publicly-traded equity of the bond issuer, and the level of the long-term risk-free rate at the time of bond downgrade. Large issues may have lower information costs and thus higher liquidities because more investors own them or have analyzed their features (Crabbe and Turner, 1995). As a bond gets more seasoned, an increasing percentage of its issued amount is absorbed in investors' inactive portfolios (Alexander et al., 2000; Warga, 1992). Alexander et al. (2000); Cai et al. (2007) and Goldstein et al. (2007)) find that the age and the liquidity of a bond are negatively related. Harris and Raviv (1993) and Kandel and Pearson (1995) suggest that differences in investors' forecasts should lead to speculative trading using the issues with highest risk. Thus, other things being equal, a downgraded bond with longer time to maturity is more likely to be sold.

Insurers are more likely to sell downgraded bonds with lower ratings (higher rating numbers) because holding those bonds is more likely to violate investment restrictions.[24] In addition, as a bond receives several consecutive downgrades, the higher is the probability that some investment rules are triggered and insurers have to sell the bond to comply with internal or regulatory policies. Thus, we expect a positive relation between the rating number as well as the frequency of downgrades and the probability of selling downgraded bonds. The degree of liquidity of a publicly-traded firm's debt is under debate. The conventional wisdom stands on the side of information availability, while Alexander et al. (2000) find that debt issues of private firms are traded more actively and explain that for private firms, equity is not traded and only debt is traded. Finally, insurers have less loss on the market value of the downgraded bond in a high-interest-rate environment than they do in a low-interest-rate environment with the same degree of downgrade on the same bond due to the positive convexity of bond pricing. Therefore, we expect that insurers are more likely to sell a downgraded bond and realize less loss in a high-interest-rate environment, compared to the same condition but in a low-interest-rate environment.[25]

[18] Part 1 of the NAIC Schedule D shows all long-term bonds owned by insurers at the end of the year. We investigate issuer obligations only (line number from 3,900,001 to 3,999,996), a subset of unaffiliated industrial and miscellaneous bonds; Part 5 of the NAIC Schedule D shows all long-term bonds and stocks acquired during the year and fully disposed of during the same year. We investigate unaffiliated industrial and miscellaneous bonds only (line number from 4,500,001 to 4,599,996). Our data cover only corporate bonds, and other fixed income securities such as mortgage-backed securities and asset-backed securities (line number from 4,000,001 to 4,499,996 in Schedule D Part 1), or preferred stocks are not included.

[19] If life insurer ABC sold XYZ bond and later bought it again, we count only once for ABC's XYZ bond.

[20] For the same bond, various holders may have different first downgrade announcement dates because of different purchase dates.

[21] Part 4 of the NAIC Schedule D shows all long-term bonds and stocks sold, redeemed or otherwise disposed of during the year. Bonds with words such as "called", "exchanged", "matured", "converted", "tendered", "redeemed", "transfered", "principal", "sink", "paydown" and "repayment" in the PURCHASER column are not sold for the consideration of credit risk and we do not consider such bonds as "sold."

[22] The minimum required RBC ratio is 200%.

[23] Eighty-three percent is the sum of the first four rows.

[24] For example, the aggregate amount of lower grade investments is limited to 10% of admitted assets (NAIC).

[25] Please refer to Houweling et al. (2005) for a thorough review on bond characteristics related to bond liquidity.

Table 2
Descriptive information for life insurers.
This table provides descriptive information regarding life insurers in the United States. Panel A shows the number of firms for each type of organizational structure. Panel B provides the percentiles of life insurers' risk-based capital ratios. Panel C provides rating distribution of life insurers' long-term corporate bond holdings. Panel D shows the disposal rates of corporate bonds with respect to size of the corporate bond portfolio. Disposal rate is defined as the total par value of bonds sold in a year divided by the total par value of bond holdings as of the end of previous year.

Panel A: organizational structure

	1999	2002	2006	2009
Type	Number of firms	Number of firms	Number of firms	Number of firms
Mutual	91	71	59	50
Widely-Held Stock	512	487	386	342
Closely Held Stock	736	603	521	460
Total	1339	1161	966	852

Panel B: RBC ratio

	1999				2002				2006				2009			
RBC	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct
ratio	2113.06	3.75	8.45	93.63	552.14	3.77	8.93	113.00	1113.56	4.64	10.08	110.85	3,106.37	4.09	9.76	89.22

Panel C: corporate bond holdings

	1999				2002				2006				2009			
Rating	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct
NAIC-1	0.65	0.33	0.64	1.00	0.58	0.30	0.57	1.00	0.67	0.41	0.67	1.00	0.62	0.35	0.59	1.00
NAIC-2	0.28	0.00	0.29	0.54	0.32	0.00	0.33	0.54	0.25	0.00	0.25	0.49	0.31	0.00	0.33	0.55
NAIC-3	0.04	0.00	0.02	0.09	0.05	0.00	0.03	0.11	0.04	0.00	0.02	0.08	0.04	0.00	0.02	0.09
NAIC-4	0.02	0.00	0.00	0.06	0.02	0.00	0.00	0.04	0.03	0.00	0.00	0.06	0.01	0.00	0.00	0.03
NAIC-5	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.03	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.02
NAIC-6	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.03

Panel D: corporate bond trading

	1999				2002				2006				2009			
Holding	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct	Mean	10th Pct	50th Pct	90th Pct
> 500M	0.16	0.04	0.12	0.29	0.19	0.05	0.16	0.37	0.13	0.03	0.12	0.26	0.12	0.03	0.11	0.24
<= 500M	0.16	0.01	0.11	0.33	0.22	0.02	0.18	0.49	0.13	0.00	0.08	0.29	0.17	0.04	0.12	0.37
<= 100M	0.16	0.00	0.09	0.44	0.24	0.01	0.19	0.51	0.13	0.00	0.07	0.30	0.16	0.00	0.10	0.40
<= 10M	0.18	0.00	0.06	0.50	0.20	0.00	0.13	0.49	0.14	0.00	0.04	0.40	0.21	0.00	0.13	0.52
<= 2M	0.10	0.00	0.00	0.50	0.16	0.00	0.00	0.62	0.14	0.00	0.00	0.52	0.16	0.00	0.00	0.57

Table 3
Sale decisions on downgraded bonds.
This table reports the sale decisions made by life insurers on bonds downgraded between Jan. 1, 1999 and Dec. 31, 2009. "NAIC1" means the bond is downgraded but remains in the NAIC first rating category. "Below NAIC1" means the bond is downgraded from NAIC first rating category to a lower NAIC rating category (NAIC-2–NAIC-6). Definitions for other rating categories apply the same logic. "SAME" is a dummy variable equal to one if the bond is downgraded but remains in the same NAIC rating category as before the downgrade and zero if the bond is downgraded to a lower NAIC rating category. "Sell before (after)" means the bond is sold within one year prior to (90 days after) the first downgrade announcement date. "Not sell" means the bond is sold more than 90 days after the first downgrade announcement date or not sold at all. Panel A reports the sale decisions in terms of the number of observations and panel B reports in terms of total par values as of the end of previous year. The summation of three weights for sale timing is not necessarily equal to one in panel B because partial sale is possible.

Panel A

Post-downgrade rating	Observations	%	Sell before	%	Sell after	%	Not sell	%
NAIC1	68,171	41.27	12,766	18.73	3,030	4.44	52,375	76.83
Below NAIC1	22,113	13.39	4,311	19.50	1,193	5.40	16,609	75.11
NAIC2	36,964	22.38	7,733	20.92	2,411	6.52	26,820	72.56
Below NAIC2	10,564	6.40	3,368	31.88	1,288	12.19	5,908	55.93
NAIC3	7,109	4.30	2,280	32.07	844	11.87	3,985	56.06
Below NAIC3	5,784	3.50	2,161	37.36	864	14.94	2,759	47.70
NAIC4	8,178	4.95	3,643	44.55	1,015	12.41	3,520	43.04
Below NAIC4	4,957	3.00	2,303	46.46	780	15.74	1,874	37.81
NAIC5	1,262	0.76	594	47.07	195	15.45	473	37.48
Below NAIC5	76	0.05	15	19.74	24	31.58	37	48.68
SAME = 1	121,684	73.67	27,016	22.20	7,495	6.16	87,173	71.64
SAME = 0	43,494	26.33	12,158	27.95	4,149	9.54	27,187	62.51
TOTAL	165,178	100.00	39,174	23.72	11,644	7.05	114,360	69.23

Panel B

Post-downgrade rating	Par values	%	Sell before	%	Sell after	%	Not sell	%
NAIC1	3.08E + 11	46.74	3.26E + 10	10.57	7.94E + 09	2.58	2.49E + 11	80.91
Below NAIC1	9.73E + 10	14.77	1.00E + 10	10.31	3.08E + 09	3.17	7.89E + 10	81.12
NAIC2	1.70E + 11	25.85	1.75E + 10	10.30	6.90E + 09	4.05	1.35E + 11	79.24
Below NAIC2	3.86E + 10	5.86	6.85E + 09	17.74	3.15E + 09	8.16	2.44E + 10	63.10
NAIC3	1.33E + 10	2.02	2.01E + 09	15.07	9.34E + 08	7.01	8.61E + 09	64.63
Below NAIC3	9.21E + 09	1.40	1.54E + 09	16.74	8.29E + 08	9.00	5.42E + 09	58.88
NAIC4	1.24E + 10	1.88	2.16E + 09	17.47	8.32E + 08	6.73	7.70E + 09	62.22
Below NAIC4	7.49E + 09	1.14	1.54E + 09	20.57	8.17E + 08	10.91	4.21E + 09	56.21
NAIC5	1.45E + 09	0.22	2.37E + 08	16.32	1.24E + 08	8.53	9.71E + 08	66.97
Below NAIC5	8.24E + 08	0.12	2.10E + 08	25.49	4.39E + 07	5.33	4.12E + 08	49.96
SAME = 1	5.06E + 11	76.71	5.45E + 10	10.78	1.67E + 10	3.31	4.02E + 11	79.42
SAME = 0	1.53E + 11	23.29	2.02E + 10	13.15	7.92E + 09	5.16	1.13E + 11	73.87
TOTAL	6.59E + 11	100.00	7.47E + 10	11.33	2.47E + 10	3.74	5.15E + 11	78.13

4. Methodology and results

4.1. Empirical models

We use a Logit model to test hypothesis one to four. The model is:

$$\begin{aligned} P_r(SELL=1) = F_L\big(&\alpha_0 + \alpha_1 MUTUAL + \alpha_2 WHSTK + \alpha_3 lnRBC \\ &+ \alpha_4 SAME + \alpha_5 lnCAPSURP + \alpha_6 lnHoldPCT + \alpha_7 lnAMT \\ &+ \alpha_8 lnAGE + \alpha_9 lnTTM + \alpha_{10} lnRating + \alpha_{11} lnTimes \\ &+ \alpha_{12} LIST + \alpha_{13} T10YIELD\big), \end{aligned} \tag{1}$$

where $P_r(\cdot)$ is a probability measure; $F_L(\cdot)$ is the logistic cumulative distribution function; *SELL* is a dummy variable equal to one if the downgraded bond is sold by the insurer within the period from one year before to 90 days after the first downgrade announcement date, and zero, otherwise; *MUTUAL* is a dummy variable equal to one if the insurer is a mutual insurer and zero if the insurer is a stock insurer; *WHSTK* is a dummy variable equal to one if the insurer is a publicly-traded stock insurer or owned by a publicly-traded company, and zero, otherwise;[26] *lnRBC* is the natural logarithm of the insurer's RBC ratio; and *SAME* is a dummy variable equal to one if the bond is downgraded but remains in the same NAIC rating category as before the downgrade and zero if the bond is downgraded to a lower NAIC rating category. The detailed definitions of variables are provided in the Appendix B. The summary statistics for key variables are reported in Table 4. The correlation matrices among variables are not reported but are available upon request.

To account for the dependence amongst the multiple sell decisions made by the same insurer (firm) for different bonds, the dependence amongst the multiple sell decisions for the same bond issuer made by different insurers, and the cross-sectional correlational clustering of sell decisions for the same bond issuer and also for the same insurer, we make triple-cluster (time-firm-issuer) adjustments suggested by Peterson (2009) and Thompson (2011) on the estimated standard errors. The adjusted variance estimates by triple-cluster on time, firm, and issuer for the coefficient estimator in equation (1) are presented in equations (2)–(4):

$$\hat{Var}(\hat{\beta})_{tfi} = \hat{V}_{tf} + \hat{V}_{ti} - \hat{V}_{tfi}, \tag{2}$$

$$\hat{Var}(\hat{\beta})_{fti} = \hat{V}_{tf} + \hat{V}_{fi} - \hat{V}_{tfi}, \tag{3}$$

$$\hat{Var}(\hat{\beta})_{itf} = \hat{V}_{ti} + \hat{V}_{fi} - \hat{V}_{tfi}, \tag{4}$$

where $\hat{V}_{tf}$, $\hat{V}_{ti}$, $\hat{V}_{fi}$, and $\hat{V}_{tfi}$ are the estimated variances that cluster by time and firm, time and issuer, firm and issuer, and time and firm and issuer, respectively.[27]

[26] It is common that a publicly-traded insurance or financial holding company has several insurance subsidiaries. We define a company as publicly-traded if it is listed on a United States, Canadian, or European stock exchange.

[27] We do not use the usual heteroskedasticity-robust (white-robust) variance matrix as the subtracted variance in equations (2)–(4) because we may have multiple

Table 4
Summary statistics for key variables.

Variable	N	Mean	Std Dev	Minimum	1st Quarter	Median	3rd Quarter	Maximum
SELL	165,178	0.31	0.46	0.00	0.00	0.00	1.00	1.00
MUTUAL	165,178	0.09	0.29	0.00	0.00	0.00	0.00	1.00
WHSTK	165,178	0.63	0.48	0.00	0.00	1.00	1.00	1.00
lnRBC	163,918	2.03	0.58	−2.33	1.72	1.96	2.22	12.72
FA	137,812	0.08	0.27	0.00	0.00	0.00	0.00	1.00
SAME	165,178	0.73	0.44	0.00	0.00	1.00	1.00	1.00
CRISIS1	165,178	0.26	0.44	0.00	0.00	0.00	1.00	1.00
CRISIS2	165,178	0.24	0.43	0.00	0.00	0.00	0.00	1.00
lnCAPSURP	164,895	19.74	1.92	11.34	18.47	19.87	21.17	23.78
lnHoldPCT	165,138	−0.88	1.92	−16.81	−2.08	−0.69	0.47	4.61
lnAMT	165,166	12.92	1.02	0	12.32	12.90	13.53	17.99
lnAGE	165,095	0.80	1.11	−5.89	0.10	0.96	1.62	3.65
lnTTM	165,035	1.91	0.89	−5.89	1.46	1.96	2.27	4.59
lnRating	165,178	2.08	0.43	0.69	1.79	2.08	2.30	3.22
lnTimes	165,178	0.06	0.23	0.00	0.00	0.00	0.00	1.95
LIST	165,178	0.47	0.50	0.00	0.00	0.00	1.00	1.00
T10YIELD	163,545	4.39	0.93	2.08	3.87	4.37	4.96	6.79

4.2. Interpretation of interactions in Logit models

To explore whether the probability of selling a downgraded bond is more sensitive to the main explanatory variables (the level of capitalization and the degree of downgrade) for mutual insurers (or widely held stock insurers) than closely held stock insurers, we specify interaction terms between the dummy variables of organizational structure and the RBC ratio and the post-downgrade rating status. For example, after including interaction terms, equation (1) becomes:

$$\begin{aligned} P_r(SELL=1) = F_L\big(&\delta_1 MUTUAL + \delta_2 WHSTK + \delta_3 lnRBC + \delta_4 SAME \\ &+ \delta_{13} MUTUAL \times lnRBC + \delta_{23} WHSTK \times lnRBC \\ &+ \delta_{14} MUTUAL \times SAME + \delta_{24} WHSTK \times SAME + \gamma_0 X_0\big), \end{aligned} \tag{5}$$

where $P_r(\cdot)$ is a probability measure; $F_L(\cdot)$ is the logistic cumulative distribution function; and X_0 is a set of other explanatory variables, including the constant term.

Interpreting interaction effects in terms of probability rather than log-odds is more straight forward. It is conditional on not only the related coefficients but also on all the explanatory variables in a Logit model (Ai and Norton, 2003; Powers, 2005). For instance, the (correct) marginal effect of a change in the interaction variable between the dummy variable *MUTUAL* and the capitalization level (*lnRBC*) for Eq. (5) is:

$$\begin{aligned} \frac{\Delta \frac{\partial F_L(u_1)}{\partial lnRBC}}{\Delta MUTUAL} = &(\delta_3+\delta_{13})\{F_L((\delta_3+\delta_{13})lnRBC+\delta_1 \\ &+(\delta_4+\delta_{14})SAME+\gamma_0X_0)[1-F_L((\delta_3+\delta_{13})lnRBC+\delta_1 \\ &+(\delta_4+\delta_{14})SAME+\gamma_0X_0)]\} - (\delta_3+\delta_{23}WHSTK) \\ &\times\{F_L((\delta_3+\delta_{23}WHSTK)lnRBC+\delta_2 WHSTK \\ &+(\delta_4+\delta_{24}WHSTK)SAME+\gamma_0X_0) \\ &\times[1-F_L((\delta_3+\delta_{23}WHSTK)lnRBC+\delta_2 WHSTK \\ &+(\delta_4+\delta_{24}WHSTK)SAME+\gamma_0X_0)]\}, \end{aligned} \tag{6}$$

where $F_L(u_1)= Pr(SELL=1)$, which is given by Eq. (5) and u_1 denotes the regression specification.

Similarly, the (correct) marginal effect of a change in the interaction variable between the dummy variable *MUTUAL* and the post-downgrade rating status (*SAME*) for Eq. (5) is:

$$\begin{aligned} \frac{\Delta^2 F_L(u_1)}{\Delta SAME\,\Delta MUTUAL} = &\frac{1}{1+e^{-(\delta_1+\delta_4+\delta_{14}+(\delta_3+\delta_{13})lnRBC+\gamma_0X_0)}} \\ &-\frac{1}{1+e^{-(\delta_2 WHSTK+\delta_4+\delta_{24}WHSTK+(\delta_3+\delta_{23}WHSTK)lnRBC+\gamma_0X_0)}} \\ &-\frac{1}{1+e^{-(\delta_1+(\delta_3+\delta_{13})lnRBC+\gamma_0X_0)}} \\ &+\frac{1}{1+e^{-(\delta_2 WHSTK+(\delta_3+\delta_{23}WHSTK)lnRBC+\gamma_0X_0)}}, \end{aligned} \tag{7}$$

where $F_L(u_1)= Pr(SELL=1)$, which is given by Eq. (5) and u_1 denotes the regression specification.

Eqs. (6) and (7) show that the marginal effect of the interaction variable may not be zero even when δ_{13} or δ_{14} is zero. Thus, the standard coefficient on the interaction term may have an incorrect magnitude, standard error, and sign relative to the true interaction effect in terms of probability. To specify our models correctly, we use the methodology developed by Norton et al. (2004) to compute the correct marginal effects. We determine the distribution of interaction effects and the associated z-statistics over the entire range of predicted probabilities.

4.3. Main results

4.3.1. Logit results for the probability of selling downgraded bonds

Table 5 presents the results of probability of selling downgraded bonds. To compare our results on bonds downgraded from investment grade to speculative grade with those of prior literature, Models 1–3 report the estimation for the bonds that have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade. As expected, we find coefficients for *MUTUAL* that are positive and significant in all Models in Table 5, implying mutual insurers are more likely to sell downgraded bonds. The coefficient of *MUTUAL* (0.23) in Model 4 through Model 6 of Panel A indicates that mutual insurers have a 25.86% higher probability than closely-held stock insurers of selling downgraded bonds.

The results of all Models in Table 5 also show that the coefficient for *WHSTK* is positive and significant at the one percent level, suggesting widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers. Specifically, the coefficient of 0.28 in Model 4 through Model 6 of Panel A indicates that a stock insurer has a 32.31% higher probability of selling a downgraded bond if the insurer is publicly-traded or owned by a publicly-traded company.

We perform two additional tests on the organizational-structure variables. One test is to disentangle the agency hypothesis and the capital-constraint hypothesis that mutual insurers are more

observations per cluster. Please see Programming Advice of Dr. Mitchell A. Peterson's homepage for further explanations.

Table 5
Probability of selling a downgraded bond.
This table reports the estimated coefficients for a logit regression relating the probability of selling a downgraded bond to the characteristics of the life insurer and the bond for the bonds downgraded during the period from 1999 to 2009. The dependent variable is a dummy variable equal to one if the downgraded bond is sold by the insurer within the period from one year before to 90 days after the first downgrade announcement date. Models 1–3 report the estimation for the bonds that have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade. Models 4–6 report the estimation for all the downgraded bonds in the sample. MUTUAL is a dummy variable equal to one if the insurer is a mutual insurer and zero if the insurer is a stock insurer. NEGOCF is a dummy variable equal to one if the insurer's operating cash flow is negative, and zero, otherwise. We investigate the interaction effect between MUTUAL and NEGOCF in Panel B using the methodology of Norton et al. (2004). The detailed definitions for other variables are provided in the Appendix B. The median of the interaction effects and the median of the z-statistics in Panel B are provided in the curly brackets and square brackets, respectively. Cluster-robust standard errors for other variables in two Panels are provided in parentheses. The standard errors in Models 1 and 4 are adjusted by using Eq. (2) where the time is the overlap dimension of clustering. The standard errors in Models 2 and 5 are adjusted by using Eq. (3) where the firm (insurer) is the overlap dimension of clustering. The standard errors in Models 3 and 6 are adjusted by using Eq. (4) where the issuer is the overlap dimension of clustering. ***, and ** indicate significance at the 1%, and 5% two-tailed levels, respectively.

Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A						
Intercept	−8.11	−8.11	−8.11	−7.89	−7.89	−7.89
	(0.449)***	(0.285)***	(0.391)***	(0.420)***	(0.274)***	(0.357)***
MUTUAL	0.22	0.22	0.22	0.23	0.23	0.23
	(0.076)***	(0.077)***	(0.027)***	(0.077)***	(0.078)***	(0.024)***
WHSTK	0.32	0.32	0.32	0.28	0.28	0.28
	(0.049)***	(0.048)***	(0.021)***	(0.047)***	(0.046)***	(0.020)***
lnRBC	−0.27	−0.27	−0.27	−0.33	−0.33	−0.33
	(0.038)***	(0.035)***	(0.022)***	(0.038)***	(0.035)***	(0.019)***
FA	0.69	0.69	0.69			
	(0.085)***	(0.031)***	(0.084)***			
SAME				−0.11	−0.11	−0.11
				(0.043)***	(0.015)***	(0.042)***
lnCAPSURP	0.09	0.09	0.09	0.13	0.13	0.13
	(0.013)***	(0.012)***	(0.007)***	(0.012)***	(0.011)***	(0.007)***
lnHoldPCT	−0.06	−0.06	−0.06	−0.15	−0.15	−0.15
	(0.015)***	(0.013)***	(0.009)***	(0.013)***	(0.010)***	(0.009)***
lnAMT	0.35	0.35	0.35	0.22	0.22	0.22
	(0.027)***	(0.016)***	(0.024)***	(0.025)***	(0.014)***	(0.023)***
lnAGE	−0.23	−0.23	−0.23	−0.24	−0.24	−0.24
	(0.020)***	(0.010)***	(0.018)***	(0.018)***	(0.009)***	(0.016)***
lnTTM	−0.20	−0.20	−0.20	−0.20	−0.20	−0.20
	(0.020)***	(0.012)***	(0.018)***	(0.019)***	(0.011)***	(0.017)***
lnRating	0.24	0.24	0.24	0.85	0.85	0.85
	(0.084)***	(0.037)***	(0.080)***	(0.076)***	(0.035)***	(0.071)***
lnTimes	0.78	0.78	0.78	0.80	0.80	0.80
	(0.135)***	(0.037)***	(0.134)***	(0.093)***	(0.029)***	(0.093)***
LIST	0.09	0.09	0.09	0.10	0.10	0.10
	(0.045)**	(0.016)***	(0.045)**	(0.039)***	(0.014)***	(0.039)***
T10YIELD	0.23	0.23	0.23	0.19	0.19	0.19
	(0.026)***	(0.018)***	(0.021)***	(0.026)***	(0.018)***	(0.021)***
Cluster	**T**&F&I	T&**F**&I	T&F&**I**	**T**&F&I	T&**F**&I	T&F&**I**
R^2	12.20%	12.20%	12.20%	15.30%	15.30%	15.30%
N	135,008	135,008	135,008	161,997	161,997	161,997
Panel B						
Intercept	-8.27	-8.27	-8.27	-8.02	-8.02	-8.02
	(0.450)***	(0.283)***	(0.394)***	(0.420)***	(0.273)***	(0.358)***
MUTUAL	0.24	0.24	0.24	0.24	0.24	0.24
	(0.081)***	(0.082)***	(0.029)***	(0.082)***	(0.083)***	(0.025)***
WHSTK	0.29	0.29	0.29	0.25	0.25	0.25
	(0.049)***	(0.048)***	(0.022)***	(0.048)***	(0.046)***	(0.020)***
NEGOCF	0.33	0.33	0.33	0.28	0.28	0.28
	(0.063)***	(0.060)***	(0.028)***	(0.060)***	(0.058)***	(0.024)***
MUTUAL× NEGOCF†	{-0.02}	{-0.02}	{-0.02}	{-0.01}	{-0.01}	{-0.01}
	[-0.48]	[-0.48]	[-1.75]	[-0.17]	[-0.17]	[-0.75]
lnRBC	-0.28	-0.28	-0.28	-0.33	-0.33	-0.33
	(0.038)***	(0.035)***	(0.021)***	(0.038)***	(0.035)***	(0.019)***
FA	0.70	0.70	0.70			
	(0.086)***	(0.031)***	(0.085)***			
SAME				-0.11	-0.11	-0.11
				(0.043)***	(0.015)***	(0.043)***
lnCAPSURP	0.10	0.10	0.10	0.14	0.14	0.14
	(0.013)***	(0.012)***	(0.007)***	(0.013)***	(0.011)***	(0.007)***
lnHoldPCT	-0.07	-0.07	-0.07	-0.15	-0.15	-0.15
	(0.015)***	(0.013)***	(0.009)***	(0.013)***	(0.010)***	(0.009)***
lnAMT	0.34	0.34	0.34	0.21	0.21	0.21
	(0.027)***	(0.016)***	(0.024)***	(0.025)***	(0.014)***	(0.023)***
lnAGE	-0.23	-0.23	-0.23	-0.25	-0.25	-0.25
	(0.020)***	(0.010)***	(0.018)***	(0.018)***	(0.009)***	(0.016)***

(*continued on next page*)

Table 5 (*continued*)

Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
lnTTM	-0.19	-0.19	-0.19	-0.19	-0.19	-0.19
	(0.020)***	(0.012)***	(0.018)***	(0.019)***	(0.011)***	(0.017)***
lnRating	0.25	0.25	0.25	0.85	0.85	0.85
	(0.084)***	(0.036)***	(0.081)***	(0.076)***	(0.035)***	(0.071)***
lnTimes	0.78	0.78	0.78	0.80	0.80	0.80
	(0.136)***	(0.037)***	(0.135)***	(0.094)***	(0.029)***	(0.093)***
LIST	0.09	0.09	0.09	0.10	0.10	0.10
	(0.045)**	(0.016)***	(0.045)**	(0.039)***	(0.014)***	(0.039)***
T10YIELD	0.22	0.22	0.22	0.18	0.18	0.18
	(0.026)***	(0.017)***	(0.021)***	(0.026)***	(0.017)***	(0.021)***
Cluster	**T**&F&I	T&**F**&I	T&F&**I**	**T**&F&I	T&**F**&I	T&F&**I**
R^2	12.60%	12.60%	12.60%	15.60%	15.60%	15.60%
N	135,008	135,008	135,008	161,997	161,997	161,997

†Summary statistics for the interaction term are available upon request.

likely to sell downgraded bonds and the results are presented in Table 5 Panel B.[28] *NEGOCF* is a dummy variable equal to one if an insurer has negative operating cash flows, and zero, otherwise. If the capital-constraint hypothesis holds, a mutual insurer with negative operating cash flows is more likely to sell downgraded bonds than is a stock insurer with negative operating cash flows because mutual insurers have more difficulties to raise external capital and rely on sales of downgraded bonds to generate cash inflows and offset negative operating cash flows. None of the medians of the z-statistics of the interaction variable *MUTUAL* × *NEGOCF* is statistically significant, therefore, mutual insurers are more likely to sell downgraded bonds mainly because they have less incentive to take higher risk.

The other test is the Wald test on the equality of the coefficients for *MUTUAL* and the coefficients for *WHSTK* in Table 5. We find that *WHSTK* has a significantly larger impact on the probability of selling a downgraded bond than *MUTUAL* in Model 1 through Model 3 of Panel A in Table 5. We do not find a significant difference between *MUTUAL* and *WHSTK* in Model 4 through Model 6 of Panel A and all six Models of Panel B in Table 5. We could not conclude that widely-held stock insurers take lower risk than do mutual insurers. Mutual insurers in our sample take lower risk than only one specific type of the stock insurer–closely-held stock insurers.

We next discuss the results related to RBC ratios and risk factors. The results in all six Models in Panel A of Table 5 show that the coefficient for *lnRBC* is negative and significant at the one percent level, suggesting that the probability of selling a downgraded bond is negatively related to the level of the life insurer's risk-based capital ratio while controlling for bond characteristics. Specifically, the coefficient, -0.33, for *lnRBC* in Model 4 indicates that as the RBC ratio increases 271.83% (100.00%), the odds of selling a downgraded bond decreases 28.11% (10.34%).[29] A 10-percent-better capitalized insurer is 1.03% more likely to keep the downgraded bonds. This evidence is consistent with Ellul et al. (2011).

The coefficients of the variables that indicate the post-downgrade rating status in Table 5 have expected signs and are significant at the one percent level. The coefficient of 0.69 for "fallen angels" (*FA*) in Panel A suggests the probability is 99.37% higher for selling "fallen angels" than downgraded bonds remaining at investment-grade. This result is consistent with Ambrose et al. (2008) and Ellul et al. (2011), who document insurers have higher regulatory pressure to sell "fallen angels."

We extend the analyses of Ambrose et al. (2008) and Ellul et al. (2011) to bonds that are not "fallen angels." The coefficient of −0.11 for *SAME* in Panel A illustrates life insurers have a 10.42% lower probability of selling downgraded bonds remaining in the same NAIC rating category than bonds downgraded to a lower NAIC rating category. In unreported models where we drop fallen-angel bonds, we still find coefficients for *SAME* are negative and statistically significant at one percent level. Therefore, insurers sell downgraded bonds mainly because of additional capital charge is imposed, not because of downgrade itself.

Other interesting results are summarized below. We find that a bond from a large bond issue, a bond issued more recently, or a bond with lower rating is more likely sold. These results are in line with suggestions from Crabbe and Turner (1995), Alexander et al. (2000), Goldstein et al. (2007)), and Cai et al. (2007). The life insurers in our sample tend to sell shorter-term bonds and bonds issued by publicly-traded companies. These results contradict those of Alexander et al. (2000).[30]

4.3.2. Logit results with interaction terms

To explore whether the association between the probability of selling a downgraded bond and the main explanatory variables (level of capitalization and degree of downgrade) is related to the insurer's organizational structure, we include interaction terms between the dummy variables of organizational structure and the RBC ratio and the post-downgrade rating status. The results are reported in Table 6. Also knowing that the interaction effect is conditional on the explanatory variables and therefore both the magnitude and statistical significance of the interaction term can vary across observations, we chart the distributions of interaction effects and the associated z-statistics over the entire range of predicted probabilities.[31] Panel A of Fig. 2 plots the interaction effects and corresponding z-statistics of the interaction variable between an organizational-structure dummy and the natural logarithm of the RBC ratio (*lnRBC*). Panel B of Fig. 2 depicts the interaction effects and corresponding z-statistics of the interaction variable between an organizational-structure dummy and the post-downgrade rating status of *SAME*.

First, we interact organizational structure and RBC ratio. The first graph in Panel A of Fig. 2 shows that for mutual insurers,

[28] We thank one anonymous referee for suggesting us disentangle the two hypotheses.

[29] The odds ratio is $\frac{p}{1-p}$, where p is the probability of selling a downgraded bond.

[30] Our approach is different to that of Alexander et al. (2000) in several aspects and may cause different results. First, we investigate selling-initiated transactions while Alexander et al. (2000) might include both selling-initiated and buying-initiated transactions. Second, Alexander et al. (2000) study high-yield bonds while the majority of our sample is investment-grade bonds. Finally, we analyze life insurers' responses to a bond downgrade while the transactions studied in Alexander et al. (2000) could be made by any type of investor for any type of reason.

[31] We present the results for Model 4 of Table 6 in Fig. 2 only to save space. Charts for other Models of Table 6 are available upon request.

Table 6
Probability of selling a downgraded bond with interaction terms.
This table reports the estimated coefficients for a logit regression relating the probability of selling a downgraded bond to the characteristics of the life insurer and the bond for the bonds downgraded during the period from 1999 to 2009. The interaction effect is defined as the change in the predicted probability of selling a downgraded bond for a change in both the organizational structure and the main explanatory variable using the methodology of Norton et al. (2004). Models 1–3 report the estimation for the bonds that have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade. Models 4–6 report the estimation for all the downgraded bonds in the sample. Variable definitions are provided in the Appendix B. The median of the interaction effects and the median of the z-statistics are provided in the curly brackets and square brackets, respectively. Cluster-robust standard errors for other variables are provided in parentheses. The standard errors in Models 1 and 4 are adjusted by using Eq. (2) where the time is the overlap dimension of clustering. The standard errors in Models 2 and 5 are adjusted by using Eq. (3) where the firm (insurer) is the overlap dimension of clustering. The standard errors in Models 3 and 6 are adjusted by using Eq. (4) where the issuer is the overlap dimension of clustering. ***, and ** indicate significance at the 1%, and 5% two-tailed levels, respectively.

Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	−8.45	−8.45	−8.45	−8.26	−8.26	−8.26
	(0.451)***	(0.291)***	(0.391)***	(0.425)***	(0.285)***	(0.357)***
MUTUAL	1.45	1.45	1.45	1.62	1.62	1.62
	(0.377)***	(0.380)***	(0.132)***	(0.405)***	(0.405)***	(0.125)***
WHSTK	0.79	0.79	0.79	0.82	0.82	0.82
	(0.174)***	(0.169)***	(0.080)***	(0.167)***	(0.162)***	(0.075)***
lnRBC	−0.12	−0.12	−0.12	−0.14	−0.14	−0.14
	(0.054)**	(0.053)**	(0.027)***	(0.054)***	(0.053)***	(0.023)***
FA	0.79	0.79	0.79			
	(0.094)***	(0.059)***	(0.090)***			
SAME				−0.13	−0.13	−0.13
				(0.056)**	(0.034)***	(0.052)**
MUTUAL× lnRBC†	{-0.08}	{-0.08}	{-0.08}	{-0.09}	{-0.09}	{-0.09}
	[−2.11]**	[−2.09]**	[−5.74]***	[−2.19]**	[−2.18]**	[−6.88]***
WHSTK× lnRBC†	{-0.04}	{-0.04}	{-0.04}	{-0.06}	{-0.06}	{-0.06}
	[−3.36]***	[−3.49]***	[−6.87]***	[−3.97]***	[−4.10]***	[−8.93]***
MUTUAL× FA†	{0.03}	{0.03}	{0.03}			
	[1.28]	[1.28]	[1.42]			
WHSTK× FA†	{-0.01}	{-0.01}	{-0.01}			
	[−0.86]	[−0.98]	[−0.95]			
MUTUAL× SAME†				{-0.01}	{-0.01}	{-0.01}
				[−0.67]	[−0.67]	[−0.83]
WHSTK× SAME†				{0.00}	{0.00}	{0.00}
				[0.31]	[0.38]	[0.36]
lnCAPSURP	0.09	0.09	0.09	0.13	0.13	0.13
	(0.013)***	(0.012)***	(0.007)***	(0.012)***	(0.011)***	(0.007)***
lnHoldPCT	−0.06	−0.06	−0.06	−0.15	−0.15	−0.15
	(0.015)***	(0.013)***	(0.009)***	(0.013)***	(0.010)***	(0.009)***
lnAMT	0.34	0.34	0.34	0.21	0.21	0.21
	(0.027)***	(0.016)***	(0.024)***	(0.025)***	(0.014)***	(0.023)***
lnAGE	-0.23	-0.23	-0.23	-0.24	-0.24	-0.24
	(0.020)***	(0.010)***	(0.018)***	(0.018)***	(0.009)***	(0.016)***
lnTTM	-0.20	-0.20	-0.20	-0.20	-0.20	-0.20
	(0.020)***	(0.012)***	(0.018)***	(0.019)***	(0.011)***	(0.017)***
lnRating	0.25	0.25	0.25	0.85	0.85	0.85
	(0.084)	(0.037)***	(0.080)	(0.076)***	(0.035)***	(0.071)***
lnTimes	0.78	0.78	0.78	0.80	0.80	0.80
	(0.135)***	(0.037)***	(0.134)***	(0.093)***	(0.029)***	(0.093)***
LIST	0.10	0.10	0.10	0.10	0.10	0.10
	(0.045)**	(0.016)***	(0.044)**	(0.039)***	(0.014)***	(0.039)***
T10YIELD	0.22	0.22	0.22	0.18	0.18	0.18
	(0.026)***	(0.018)***	(0.021)***	(0.026)***	(0.017)***	(0.021)***
Cluster	**T**&F&I	T&**F**&I	T&F&**I**	**T**&F&I	T&**F**&I	T&F&**I**
R^2	12.40%	12.40%	12.40%	15.40%	15.40%	15.40%
N	135,008	135,008	135,008	161,997	161,997	161,997

†Summary statistics for interaction terms are available upon request.

the correct interaction effects are overwhelmingly negative across the predicted probabilities, while the second graph in Panel A of Fig. 2 shows that these interaction effects are also significant (z value lower than −1.96) for most probabilities. We summarize the correct interaction effect and its significance in the respective positions of Table 6 by reporting the medians of interaction effect and its significance (−0.09, z-statistic = −2.19 for Model 4 in Table 6). In terms of economic significance compared to a closely-held stock insurer, the probability of selling a downgraded bond by a mutual insurer increases by 9.00% (3.31%) when the RBC ratio decreases 271.83% (100%). Although the interaction effect is statistically significant, the economic magnitude is small given the average probability of selling downgraded bonds is 0.31.[32] This result corresponds with the insignificance of *MUTUAL* × *NEGOCF* documented in the prior section and further confirms that capital constraint is not the primary reason for the higher probability of selling downgraded bonds by mutual insurers.

For widely-held stock insurers, we find patterns different to mutual insurers. The correct interaction effects, presented in the third graph in Panel A of Fig. 2 and summarized in the respective positions of Table 6, are sometimes positive and sometimes negative. Compared to a closely-held stock insurer, the probability of selling a downgraded bond by a median widely-held stock insurer

[32] 0.31 is taken from the first row of Table 4. 0.31 × 3.31% = 0.0103 = 1.03%.

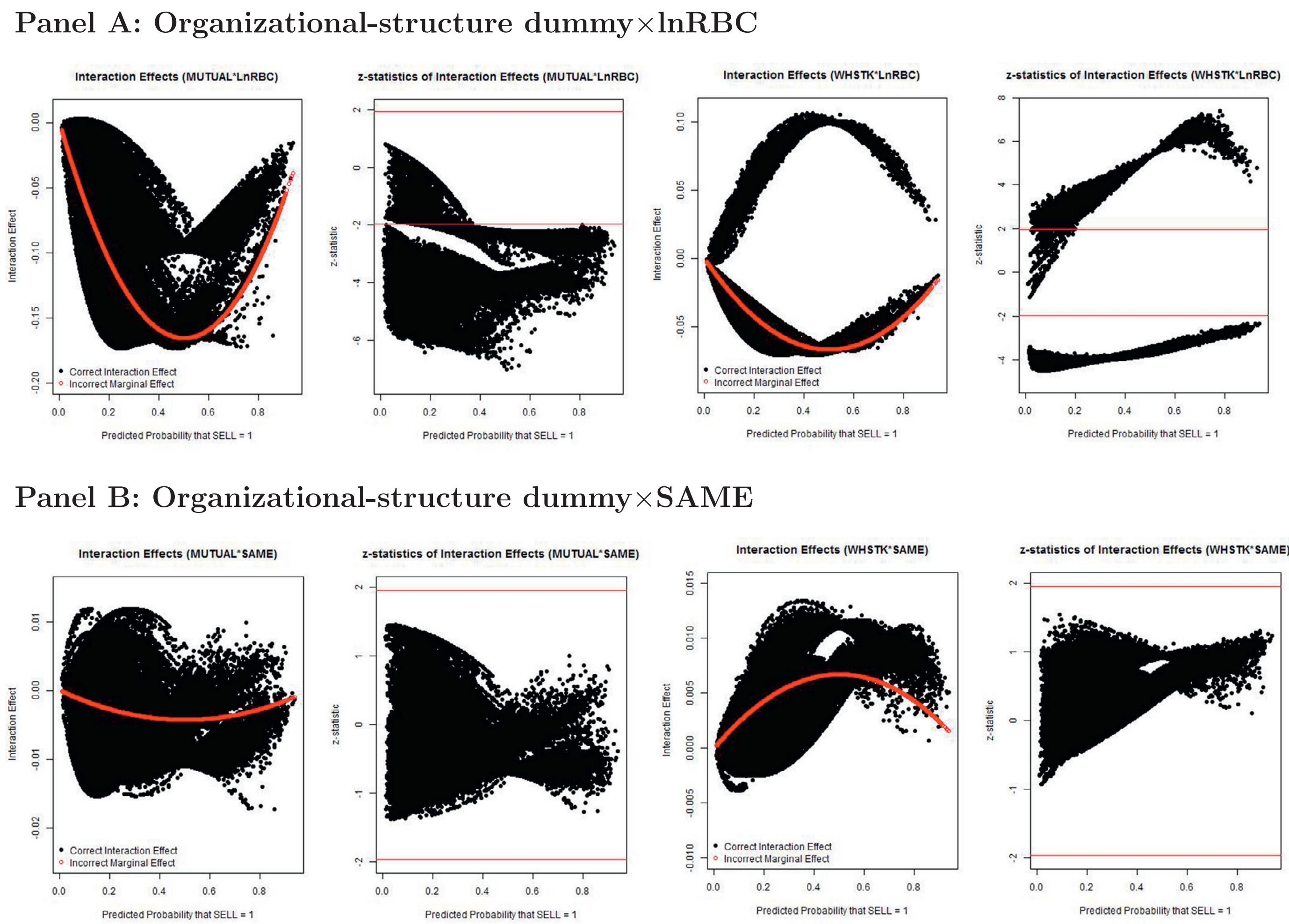

Fig. 2. The economic significance of the impact of organizational structure on the relation between the probability of selling a downgraded bond and a main explanatory variable. The graphs display the interaction effects and corresponding z-statistics of the interaction variable between a respective organizational-structure dummy and a main explanatory variable using the methodology of Norton et al. (2004). The interaction effect is defined as the change in the predicted probability of selling a downgraded bond for a change in both a main explanatory variable and a respective organizational-structure dummy. Panel A plots the interaction effects and corresponding z-statistics of the interaction variable between the organizational-structure dummy and the natural logarithm of RBC ratio reported in the Model 4 of Table 6. Panel B depicts the interaction effects and corresponding z-statistics of the interaction variable between the organizational-structure dummy and the post-downgrade rating status (SAME) reported in the Model 4 of Table 6. The sample includes all the bonds downgraded during the period from 1999 to 2009. The lines above and below 0 on the second and the fourth figures in each Panel represent the 5% significance levels (± 1.96).

increases by 6.00% (2.21%) when the RBC ratio decreases 271.83% (100%) (The median of the interaction effects is −0.06 and the median of z-statistics is −3.97 for Model 4 in Table 6).[33] The economic magnitude of the median interaction effect between *WHSTK* and *lnRBC* is also small.

Second, we interact organizational structure and post-downgrade rating status. The summarized results of all Models in Table 6 show that there is no significant relation between the probability of selling a downgraded bond and the interaction between the organizational structure and the post-downgrade rating status of the bond. Again, we chart the distribution of interaction effects and the associated z-statistics over the entire range of predicted probabilities for Model 4 in Table 6. The second graph and the fourth graph in Panel B of Fig. 2 further confirm that the majority of interaction effects are insignificant across the range of predicted probabilities. This result indicates that life insurers are exposed to the same NAIC regulation on risk factors regardless of their organizational structures.

In summary, the association between the probability of selling a downgraded bond and the RBC ratio is related to the insurer's organizational structure. Mutual insurers and median widely-held stock insurers take significantly lower risk than closely-held stock insurers when they have a low level of capitalization. We find the association between the probability of selling a downgraded bond and the post-downgrade rating status has no relation with the insurer's organizational structure in all cases.

4.3.3. The probability of selling downgraded bonds during the financial crises

To explore whether insurers behave differently in the financial crises and test the fifth hypothesis, we introduce two dummy variables– *CRISIS*1 and *CRISIS*2 in our models. We define *CRISIS*1 (*CRISIS*2) as one if the observation is regarding to a first downgrade during the period from January 1, 2001 to December 31, 2002 (from January 1, 2008 to December 31, 2009) and zero, otherwise. In Table 7, Panel A reports the estimation for the bonds that

[33] The interaction effects between *WHSTK* and *lnRBC* go two opposite extremes as shown in the third and the fourth graphs of Fig. 2 Panel A. In other words, widely-held stock insurers sometimes significantly sell more downgraded bonds than closely-held stock insurers and sometimes significantly sell fewer when their RBC ratios decrease.

Table 7
Probability of selling a downgraded bond during the financial crises.
This table reports the estimated coefficients for a logit regression relating the probability of selling a downgraded bond to the characteristics of the life insurer and the bond for the bonds downgraded during the period from 1999 to 2009. CRISIS1 (CRISIS2) is a dummy variable equal to one if the bond is downgraded during the period from January 1, 2001 to December 31, 2002 (from January 1, 2008 to December 31, 2009), and zero, otherwise. Panel A reports the estimation for the bonds that have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade. Panel B reports the estimation for all the downgraded bonds in the sample. Models 4–6 in each panel report the estimation for CRISIS1 and CRISIS2 interacting with main explanatory variables using the methodology of Norton et al. (2004). Variable definitions are provided in the Appendix B. The median of the interaction effects and the median of the z-statistics are provided in the curly brackets and square brackets, respectively. Cluster-robust standard errors for other variables are provided in parentheses. The standard errors in Models 1 and 4 are adjusted by using Eq. (2) where the time is the overlap dimension of clustering. The standard errors in Models 2 and 5 are adjusted by using Eq. (3) where the firm (insurer) is the overlap dimension of clustering. The standard errors in Models 3 and 6 are adjusted by using Eq. (4) where the issuer is the overlap dimension of clustering. ***, and ** indicate significance at the 1%, and 5% two-tailed levels, respectively. To save the space, the results for the control variables are not reported.

Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A						
Intercept	−7.18	−7.18	−7.18	−7.00	−7.00	−7.00
	(0.447)***	(0.288)***	(0.388)***	(0.461)***	(0.303)***	(0.395)***
MUTUAL	0.21	0.21	0.21	0.20	0.20	0.20
	(0.076)***	(0.077)***	(0.027)***	(0.098)**	(0.098)**	(0.037)***
WHSTK	0.29	0.29	0.29	0.23	0.23	0.23
	(0.049)***	(0.048)***	(0.021)***	(0.062)***	(0.060)***	(0.030)***
lnRBC	−0.27	−0.27	−0.27	−0.33	−0.33	−0.33
	(0.038)***	(0.035)***	(0.021)***	(0.049)***	(0.045)***	(0.029)***
FA	0.69	0.69	0.69	0.77	0.77	0.77
	(0.082)***	(0.031)***	(0.081)***	(0.104)***	(0.037)***	(0.103)***
CRISIS1	0.10	0.10	0.10	0.15	0.15	0.15
	(0.065)	(0.043)**	(0.051)**	(0.216)	(0.206)	(0.105)
CRISIS2	−0.52	−0.52	−0.52	−1.34	−1.34	−1.34
	(0.089)***	(0.062)***	(0.069)***	(0.239)***	(0.217)***	(0.136)***
CRISIS1× MUTUAL†				{0.02}	{0.02}	{0.02}
				[0.39]	[0.39]	[1.17]
CRISIS1× WHSTK†				{0.00}	{0.00}	{0.00}
				[0.08]	[0.09]	[0.19]
CRISIS2× MUTUAL†				{-0.04}	{-0.04}	{-0.04}
				[−1.63]	[−1.63]	[−4.28]***
CRISIS2× WHSTK†				{0.03}	{0.03}	{0.03}
				[1.67]	[1.75]	[3.48]***
CRISIS1× lnRBC†				{-0.01}	{-0.01}	{-0.01}
				[−0.51]	[−0.53]	[−1.03]
CRISIS2× lnRBC†				{0.06}	{0.06}	{0.06}
				[3.97]***	[4.29]***	[7.25]***
CRISIS1× FA†				{-0.03}	{-0.03}	{-0.03}
				[−0.98]	[−2.44]***	[−1.00]
CRISIS2× FA†				{-0.07}	{-0.07}	{-0.07}
				[−1.95]	[−3.34]***	[−2.01]**
Cluster	**T**&F&I	T&**F**&I	T&F&**I**	**T**&F&I	T&**F**&I	T&F&**I**
R^2	12.90%	12.90%	12.90%	13.10%	13.10%	13.10%
N	135,008	135,008	135,008	135,008	135,008	135,008
Panel B						
Intercept	-7.07	-7.07	-7.07	-6.80	-6.80	-6.80
	(0.414)***	(0.278)***	(0.347)***	(0.426)***	(0.291)***	(0.353)***
MUTUAL	0.21	0.21	0.21	0.19	0.19	0.19
	(0.076)***	(0.077)***	(0.024)***	(0.100)	(0.101)	(0.032)***
WHSTK	0.25	0.25	0.25	0.17	0.17	0.17
	(0.047)***	(0.046)***	(0.020)***	(0.060)***	(0.058)***	(0.026)***
lnRBC	-0.32	-0.32	-0.32	-0.39	-0.39	-0.39
	(0.037)***	(0.035)***	(0.019)***	(0.048)***	(0.045)***	(0.026)***
SAME	-0.11	-0.11	-0.11	-0.17	-0.17	-0.17
	(0.041)***	(0.015)***	(0.040)***	(0.055)***	(0.021)***	(0.054)***
CRISIS1	0.12	0.12	0.12	0.01	0.01	0.01
	(0.056)**	(0.040)***	(0.042)***	(0.211)	(0.197)	(0.108)
CRISIS2	-0.52	-0.52	-0.52	-1.54	-1.54	-1.54
	(0.079)***	(0.057)***	(0.059)***	(0.253)***	(0.225)***	(0.147)***
CRISIS1× MUTUAL†				{0.02}	{0.02}	{0.02}
				[0.49]	[0.50]	[1.66]
CRISIS1× WHSTK†				{0.01}	{0.01}	{0.01}
				[0.37]	[0.38]	[0.88]
CRISIS2× MUTUAL†				{-0.05}	{-0.05}	{-0.05}
				[-1.68]	[-1.68]	[-5.20]***
CRISIS2× WHSTK†				{0.04}	{0.04}	{0.04}
				[1.93]	[2.03]**	[4.09]***
CRISIS1× lnRBC†				{-0.00}	{-0.00}	{-0.00}
				[-0.17]	[-0.18]	[-0.37]
CRISIS2× lnRBC†				{0.07}	{0.07}	{0.07}
				[4.08]***	[4.37]***	[8.11]***

(*continued on next page*)

Table 7 (*continued*)

Explanatory variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
CRISIS1× SAME†				{0.01}	{0.01}	{0.01}
				[0.82]	[2.13]**	[0.84]
CRISIS2× SAME†				{0.04}	{0.04}	{0.04}
				[2.18]**	[4.85]***	[2.24]**
Cluster	**T**&F&I	T&**F**&I	T&F&**I**	**T**&F&I	T&**F**&I	T&F&**I**
R^2	16.00%	16.00%	16.00%	16.20%	16.20%	16.20%
N	161,997	161,997	161,997	161,997	161,997	161,997

†Summary statistics for interaction terms are available upon request.

Fig. 3. The daily average credit spread and the daily average price of U.S. investment-grade corporate bonds from 1998 to 2010. Source: Barclays Capital Live.

have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade; and Panel B reports the estimation for all the downgraded bonds in the sample.

Models 1–3 in Panels A through B of Table 7 show that insurers are less likely to sell downgraded bonds during the 2008–2009 financial crisis as the coefficients for *CRISIS*2 are significantly negative at the one percent level. The coefficients for *CRISIS*1 are positive and only significant at 1% level in Models 2 and 3 of Panel B. We interpret the results of *CRISIS*1 that the 2001–2002 financial crisis concentrates on the equity price falling of technology companies. The life insurers on average hold only 1% of technology-company bonds in their corporate bond portfolios and the average spread of investment-grade corporate bonds over Treasury never exceeds 300 basis points during the 2001–2002 period (Please see Fig. 3.).[34] Insurers might have difficulties to sell downgraded, technology-company bonds, but they are able to sell other downgraded bonds without losing too much liquidity in the 2001–2002 period. The credit spread of investment-grade corporate bonds skyrocketed to a historical high (650 basis points) during the 2008–2009 financial crisis, and insurers might be reluctant to dump their bonds at such a temporary fire-sale price. We find the probability of selling downgraded bonds that have an investment-grade rating (equivalent to NAIC-1 or NAIC-2) before the downgrade decreases by 40.55% during the 2008–2009 financial crisis (Models 1–3 in Panel A of Table 7). This effect is economically significant as insurers reduced their trading during the 2008–2009 financial crisis by more than forty percent. In retrospect, insurers were correct not to sell because the price has stabilized gradually after the 2008–2009 financial crisis.

We interact the crisis dummies with the organizational structure, the RBC ratio, and the post-downgrade rating status and report the results in Models 4–6 of Table 7. The interaction effect between *CRISIS*2 and *WHSTK* is positive and significant at 1% level in Model 6 of both Panels of Table 7, indicating that widely-held stock insurers are much more likely to sell downgraded bonds than are closely-held stock insurers during the 2008–2009 financial crisis. The relation between the probability of selling downgraded bonds and the RBC ratio weakened during the 2008–2009 financial crisis as we find significantly-positive interaction effects between *CRISIS*2 and *lnRBC* in Models 4–6 of both Panels. The relation between the

[34] 1% is calculated as the face amount of technology-company (first-two digit of SIC code: 73 (Emory et al., 2000)) bonds divided by total face amount of corporate bonds as of December 31, 2000.

probability of selling downgraded bonds and the post-downgrade rating status of *SAME* also weakened during the 2008–2009 financial crisis as we find significantly-positive interaction effects between *CRISIS*2 and *SAME* in Models 4–6 of Table 7 Panel B.[35]

In summary, the relation between the probability of selling a downgraded bond and the RBC ratio and the post-downgrade rating status weakened during the 2008–2009 financial crisis. These results are probably driven by the incentive to avoid fire-sale prices and consistent with our hypothesis.

4.4. Robustness analysis

We conduct two types of robustness analysis for the paper. First, we perform the analyses for various event windows. The main results for the event windows $[-360, +1]$ and $[0, +90]$ are similar to those for our base window $[-360, +90]$ and are consistent with Ellul et al. (2011).[36] To account for the possibility that insurers might postpone the sales of downgraded bonds, we extend the base window to 180 days after the announcement date. Our main results still hold for the event windows $[-360, +180]$ and $[-180, +180]$.[37]

Next, we substitute variables to see whether our results change with them. We use *LOWRBC*, a dummy variable equal to one if the insurer's RBC ratio is lower than 300%, and zero, otherwise, to proxy for the financial distress of an insurer. We find positive coefficients for *LOWRBC*, indicating that financially-distressed insurers are more likely to sell downgraded bonds than are financially-sound insurers. However, only two models out of six are statistically significant.[38] For the control variable of firm size, we use "Net Admitted Assets" instead of "Capital and Surplus" to proxy for the size of the insurer. Our main results do not change.

[35] The significantly-negative interaction effect between *CRISIS*2 and *FA* in Models 5 and 6 of Table 7 Panel A also indicates a weaker relation between the probability of selling downgraded bonds and the post-downgrade rating status.

[36] Ellul et al. (2011) estimate for the effects of regulatory constraints on the probability that an insurer will sell the bonds downgraded from investment-grade to speculative-grade during event weeks -10 to 0 and event weeks 0 to +5. They find more constrained insurers are more likely to sell in the period leading up to the downgrade.

[37] It is also possible that an insurer postpones the sales of bonds downgraded in the first quarter until the end of the year of reporting RBC ratios. Therefore, we also extend the window to the end of the reporting period. The result is not statistically significant. Combining the significant results of $[-360, +180]$ and $[-180, +180]$ and the insignificant results of $[-360,$ end of the reporting period$]$ and $[-180,$ end of the reporting period$]$, it seems managers of insurers are more likely to sell downgraded bonds, but do not necessarily wait until the end of the reporting period to sell downgraded bonds when the bonds are downgraded to a different category. We thank one anonymous referee for addressing this concern.

[38] The interaction effect between *MUTUAL* and *LOWRBC* is also statistically significant in only two models out of six. In addition, the economic magnitude of the interaction is small as that of *MUTUAL* $\times$ *lnRBC*. These results also confirm that capital constraint is not the primary reason for the higher probability of selling downgraded bonds by mutual insurers.

5. Conclusion

We investigate the impact of organizational structure and risk-based capital requirements on selling downgraded bonds by life insurers. Consistent with the agency hypothesis, we find mutual insurers and widely-held stock insurers are more likely to sell downgraded bonds than are closely-held stock insurers. We, however, do not find mutual insurers take lower risk than do widely-held stock insurers.

Our results show that the probability of selling a downgraded bond is negatively related to the level of a life insurer's risk-based capital (RBC) ratio even after controlling for bond characteristics. Specifically, we find life insurers that are 10-percent better capitalized (in terms of RBC ratio) are at least 1.03% more likely to keep the downgraded bonds. This evidence is consistent with Ellul et al. (2011).

Our results also suggest a selling decision strongly relies on whether the downgraded bond remains in the same rating category. Consistent with Ambrose et al. (2008) and Ellul et al. (2011), we find life insurers sell more "fallen angels" than downgraded bonds remaining at investment-grade. More important, we provide evidence on non-fallen-angel bonds, which remain investment-grade or speculative-grade in spite of downgrade. Our results show insurers are 10.42% less likely to sell downgraded bonds remaining in the same NAIC rating category than bonds downgraded from a higher NAIC rating category to a lower NAIC rating category. Combining the results from RBC ratios and RBC risk factors, we conclude that there are minor differences on the probability of selling a downgraded bond if insurers have similar RBC ratios because the economic impact of RBC ratios is low, but differences among risk factors do matter on the decision to sell a downgraded bond even if the bond remains at investment grade.[39]

Life insurers, as a whole, sold fewer downgraded bonds during the 2008–2009 financial crisis. We find some evidence that widely-held stock insurers are much more likely to sell downgraded bonds than are closely-held stock insurers during the crisis. Finally, the relation between the probability of selling a downgraded bond and the RBC ratio and the post-downgrade rating status also weakened during the crisis period.

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[39] Life insurers are more likely to sell bonds downgraded from AA to BBB than bonds downgraded from AA to A. The risk factor increases from 0.3% to 1.0% in the former case.

Appendix A. Sample construction

See Table A1.

Table A1
Data screening process.

	Observations	Bond issues	Bond issuers	Life insurers
Raw sample (1999–2009)	199,499	15,725	4,571	1,116
Deduct: Bonds that are not debentures or medium-term notes	(18,244)	(2,993)	(848)	(17)
Deduct: Non-mutual and non-stock insurers	(16,077)	(20)	(1)	(7)
Deduct: Missing values and two-side 1% winsorization	(3,181)	(0)	(0)	(14)
Final sample	161,997	12,712	3,722	1,078

Appendix B. Definitions of variables

See Table B1.

Table B1

Variable	Definition
SELL	Dummy variable equal to one if the downgraded bond is sold by the insurer within the period from one year before to 90 days after the first downgrade announcement date, and zero, otherwise.
MUTUAL	Dummy variable equal to one if the insurer is a mutual insurer and zero if the insurer is a stock insurer.
WHSTK	Dummy variable equal to one if the insurer is a publicly-traded stock insurer or owned by a publicly-traded company, and zero, otherwise. We define a company as publicly-traded if it is listed on a United States, Canadian, or European stock exchange.
NEGOCF	Dummy variable equal to one if the insurer's operating cash flow is negative, and zero, otherwise.
lnRBC	The natural logarithm of the insurer' risk-based capital (RBC) ratio (winsorized at the 1st and 99th percentile).
FA	Dummy variable equal to one if the bond is downgraded from investment-grade (NAIC-1 and NAIC-2) to speculative-grade (NAIC-3 to NAIC-6) and zero if the bond is downgraded but remains at investment-grade.
SAME	Dummy variable equal to one if the bond is downgraded but remains in the same NAIC rating category as before the downgrade and zero if the bond is downgraded to a lower NAIC rating category.
CRISIS1	Dummy variable equal to one if the bond is downgraded during the period from January 1, 2001 to December 31, 2002, and zero, otherwise.
CRISIS2	Dummy variable equal to one if the bond is downgraded during the period from January 1, 2008 to December 31, 2009, and zero, otherwise.
lnCAPSURP	The natural logarithm of the capital and surplus of the insurer. All dollar amounts are expressed in constant 2006 units (winsorized at the 1st and 99th percentile).
lnHoldPCT	The natural logarithm of the percentage of the insurer's holding amount to the offering amount of the downgraded bond (winsorized at the 1st and 99th percentile).
lnAMT	The natural logarithm of the offering amount (in thousands) of the downgraded bond (winsorized at the 1st and 99th percentile).
lnAGE	The natural logarithm of the number of years since offering date until the first downgrade announcement date of the bond (winsorized at the 1st and 99th percentile).
lnTTM	The natural logarithm of the time to maturity (in years) at the first downgrade announcement date of the downgraded bond (winsorized at the 1st and 99th percentile).
lnRating	The natural logarithm of the cardinal scale of post-downgrade credit rating (see Table 1) of a downgraded bond.
lnTimes	The natural logarithm of the frequency that the bond is consecutively downgraded within three months.
LIST	Dummy variable equal to one if the issuer of the bond has publicly-traded equity, and zero, otherwise.
T10YIELD	The spot rate (in percentage) of the 10-year constant-maturity U.S. Treasury at the first downgrade announcement date.

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