The Effect of Government Guarantees on Market Discipline in the Property-Casualty Insurance Industry

Abstract

We introduce a novel approach to identifying the effect of public guarantees on market discipline by exploiting variation in U.S. state guarantees of property-casualty insurer obligations. We find that premium growth in the uncovered business (i.e., contracts that are not covered by a state guaranty fund) of a downgraded insurer falls in relation to growth in its covered business, with the estimate of the difference being as high as 17% in some cases. Insurance prices, however, are not affected by insurer downgrades, suggesting policyholders react to downgrades by purchasing less insurance or switching insurers. We also find that market discipline increases after the financial crisis.

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1. Introduction

Public guarantees of financial institution solvency are widely believed to reduce market discipline by customers. Identifying the effect, however, is difficult. Studies from the banking industry have taken a variety of approaches---but most suffer from the drawback that guarantees are applied on a national basis, which makes it difficult to disentangle the effect of the guarantee from other confounding influences. This paper studies the impact of government guarantees on market discipline by exploiting the unique institutional structure of the U.S. property-casualty industry, which provides unusually rich cross-sectional and time-series variation in the level of guarantees.

U.S. property-casualty insurers are licensed and regulated on a state by state basis. Each state has its own guaranty fund, which protects the policyholders of the licensed insurance companies that fail. The types of insurance that receive guaranty fund protection differ across states and time. The amount paid for claims also differs across states and time, as states set different maximum claim amounts and net worth provisions. In addition, certain types of insurance (e.g., surplus lines insurance) typically do not receive guarantee fund coverage.[1] This study exploits cross-sectional and time-series heterogeneity in the breadth and depth of state insurance guaranty fund coverage to identify the influence of public guarantees on market discipline.

We examine whether state insurance guaranty funds dull customer sensitivity to risk by investigating the relationship between firm premium growth and changes in A.M. Best Company financial strength ratings. Since policyholders covered by guaranty funds have less to lose from the failure of their insurance firm than do policyholders not covered, we hypothesize premium

[1] Surplus lines insurers are unlicensed insurers that provide coverage on risks that were not accepted by the licensed insurers in the state. An insurer can be licensed in one state, yet provide insurance on a surplus lines (unlicensed) basis in another state.

growth in lines and states protected by guaranty funds will be less sensitive to rating changes. The alternative hypothesis is guaranty funds have no effect on market discipline when there is a change in insurer risk.

We investigate the question at two levels. The first level of analysis is at the firm-line-year level and uses the proportion of uncovered premiums as the measure of the extent of guaranty fund protection. We use control group tests and fixed effect regressions to measure the difference between covered and uncovered growth in the aftermath of a risk change. The second level of analysis, which pushes beyond the level used in previous studies, is the firm-state-line-year level. Our data allows the decomposition of each firm's yearly premiums by line of business and state of origin, so we are able to classify each state-line combination according to whether it is covered by a state guaranty fund or not. We first use firm-line-year fixed effects and state fixed effects to exploit variation in guaranty fund coverage within a state. The primary source of variation is surplus lines insurers, i.e., insurance firms that are not licensed in some states and therefore not covered by guaranty funds. A secondary source of variation are the lines of insurance that do not receive guaranty fund coverage in the state. We also use firm-state-year fixed effects and line fixed effects to exploit variation across the states in the lines of insurance that do not receive guaranty fund coverage. The analyses are performed separately for downgraded and upgraded firms.

Our analysis shows that guaranty funds decrease market discipline significantly, but the effects are asymmetric. The presence of guaranty funds mitigates market discipline consistently and significantly for the downgrades of A- or low-rated insurers, whereas the effects for upgrades are very weak. The evidence is generally consistent with the existing literature, e.g. Grace et al., (2014) which shows that guaranty funds mitigate the effectiveness of market discipline in life insurance; Epermanis and Harrington (2006), which shows that more risk sensitivity of demand

for commercial insurance lines than insurance lines because of guaranty fund protections; and Halek and Eckles (2010), which finds that stock price responses to rating changes are asymmetric.

We further investigate the mechanism by which market discipline works. Policyholders can discipline higher risk insurers by buying less insurance coverage, shifting their insurance contract to a lower risk insurer, or by demanding lower prices. Since premiums are revenue (price times quantity), the prior analysis is unable to disentangle these effects. Accordingly, we investigate the relationship between insurance prices and changes in financial strength ratings. We also interact the intensity of guaranty fund protection with rating changes to test whether guaranty fund protection influences market discipline through price changes. We do find that prices do not decrease after insurer downgrades, which combined with the evidence on premiums suggests that policyholders respond to increases in insurer risk by reducing the quantity of coverage they buy from the insurer or by shifting their contracts to a lower risk firm. We do, however, find some evidence that guaranty funds blunts market discipline through price channel in the sense that prices are less sensitive to ratings changes in the presence of guaranty fund protection.

We also explore the impact of guaranty fund protection on market discipline in the period surrounding the financial crisis of 2008. The financial crisis provides a natural experiment to study market discipline. First, the financial strength of insurance firms weakened during the crisis. Second, the well-publicized troubles at AIG may have heightened the awareness of policyholders to the financial risk of their insurers and the incomplete protection offered by safety nets. We find evidence consistent with this view: market discipline becomes stronger after the financial crisis, especially for insurance lines not protected by guaranty funds. The financial crisis raises the sensitivity of insurance price and premium growth rates to changes in insurer risk.

This paper contributes to at least four lines of literature. First, there is a growing literature on how market discipline works in insurance sectors (e.g. Eling and Kiesenbauer, 2012; Halek and Eckles, 2010; Sommer, 1996; Epermanis and Harrington, 2006; Eling and Schmit, 2012). The study most closely related to ours is Epermanis and Harrington (2006). Like us, they examine the impact of discrete risk changes (i.e., ratings downgrades) on the premium growth rate of insurers. They identify the impact of guaranty fund protection by examining whether there is a differential impact between commercial insurance, which generally has less complete guaranty fund protection, and personal insurance. They find premium declines for downgrades are larger for commercial insurance than personal insurance. We extend Epermanis and Harrington (2006) by explicitly incorporating the heterogeneity in guaranty fund protection across lines and states. We also explore whether market discipline has a bigger effect on price or quantity.

Second, the paper provides evidence on how market discipline works surrounding a financial crisis, an issue that has received considerable attention amongst regulators (Eling, 2012). Third, our findings provide additional evidence on the adverse incentives created by guaranty funds (Cummins, 1988; Lee, Mayers, and Smith 1997; Lee and Smith, 1999).

Fourth, our analysis of market discipline in the insurance is related to studies examining deposit insurance and market discipline (e.g., Billett, Garfinkel and O'Neal, 1998; Park and Peristiani, 1998; Martinez Peria and Schmuckler, 2001; Demirguc-Kunt and Huizinga, 2004; and Forssbaeck, 2011). Insurance guaranty funds are similar to deposit insurance in banking in that both protect small depositors/policyholders against financial institution insolvency, and are designed to stabilize the financial institutions. However, insurance guaranty funds differ from deposit insurance in two important dimensions. First, guaranty fund protection is less well known to the public. Banks advertise FDIC protection, while regulations forbid insurance sellers to

advertise the presence of guaranty fund protection. Second, guaranty funds are state statutes, while the deposit insurance is national.

The study is also important from a public policy perspective. Policymakers are increasingly aware of the role of market discipline in the regulation of financial firms and modern regulatory policy tries to encourage market discipline (e.g. Solvency Modernization Initiative, Basel II and Solvency II). In fact, both Basel and Solvency II include market discipline as a fundamental pillar and attempt to enhance it through public disclosure of risk-related information by banks and insurance companies. The benefit of stronger market discipline is believed to reduce the need for government intervention. Our study finds that consumer protection schemes, even ones that consumers are less aware of, impair market discipline, as such regulators must take these programs into consideration in the design of solvency regulatory policy.

The rest of the paper is organized as follows. Section 2 discusses the background of guaranty funds and related literature. Section 3 reports data sources and the procedures of sample selection and section 4 describe variable measurements. Section 5 presents the empirical methodology and addresses identification issues. Section 6 reports the main empirical results. Section 7 explores the possible underlying mechanism of market discipline and the influence of the financial crisis. Section 8 concludes.

2. Property-Casualty Insurance Guaranty Funds

State property-casualty insurance guaranty funds, enacted between 1969 and 1981, cover policyholder losses associated with insurer insolvencies. The funds are administered by nonprofit associations that consist of all licensed insurers in the state that write insurance in lines covered by the guaranty funds. All states, with the exception of New York,[2] finance these funds by levying

[2] New York uses a pre-funding model instead of an ex-post funding model.

post-insolvency assessments on solvent insurers. Assessments, based on the net direct premiums written in the state during the past year, are subject to a statutory ceiling (typically 2%). The assessment is independent of an insurer's risk. Assessed insurers can recoup these fees through rate increases or/and tax offsets at a rate of 20% per year based on various state statutes.

Property-liability insurance guaranty fund protection is not complete in several respects. First, guaranty funds do not cover all lines of insurance. The lines most commonly excluded are: accident and health, credit, fidelity, mortgage guaranty, financial guaranty, ocean marine, surety, title, and warranty. However, there is significant variation across the states.[3] Second, guaranty funds do not pay claims beyond maximum amounts. The maximum claim amount ranges from $100,000-$5,000,000. Table 1 shows that a majority of states have a maximum amount in the $300,000-$500,000 range. In most states, the caps do not apply to workers compensation insurance, and some states establish separate guaranty funds for workers compensation. Third, some states apply net worth provisions, in which claims are not paid for firms or individuals that have a net worth that exceeds specified levels. The typical net worth provision is $25,000,000, the net worth cap ranges from $5,000,000 to $50,000,000 (see Table 1). Fourth, the policyholders of insurers not licensed in the state (surplus lines insurers) are not covered by guaranty funds. Surplus lines insurers underwrite risks that do not meet the underwriting guidelines of licensed insurers or require specialized coverage, pricing or underwriting. Surplus lines insurers have flexibility both

[3] Accident and health insurance is excluded in all states except: MI, MT, WA, WV, WI , and WY. Credit is excluded in all states except: MD and MI. Fidelity is excluded in all states except: AL, AZ, AR, KS, KY, ME, MD, MI, MN, MT, NM, NY, OK, OR, VT, WA WV, and WY. Financial guaranty is excluded by all states except: AL, AZ, KS, MD, MI, MT, NJ, OR, VT, WA, WV, and WY. Mortgage guaranty is excluded by all states except: MI. Ocean Marine is excluded in all states except: AK, KS, ME, MD, MI, and NY. Surety is excluded in all states except: AR, KS, KY, ME, MD, MI, MN, and NY. Title is excluded in all states except: AL, AK, CO, MD, MI, NH, NY, and ND. Warranty is excluded in all states except: AL, CA, CO, CT, KS, MD, MI, MT, NE, NH, NJ, NM, NY, OK, OR, VT, WA,WV, and WY.

in contract language and pricing that allow them to underwrite a variety of risks---including ones that are unusual and/or substandard---that do not conform to typical insurer appetites.

Guaranty funds can be viewed as providing a put option on the value of the insurer's assets with a strike price equal to the value of the insurance policies (e.g. Cummins, 1988). The flat rate premiums in New York and the post-assessment scheme of the other states do not reflect insurer risk. Lee, et al. (1997) and Downs and Sommer (1999) find that stock insurers increased their asset risk with the enactment of guaranty-fund laws.

3. Data and Sample

We use data from the National Association of Insurance Commissioners (NAIC) annual statement database for the period 1990-2011. The database contains underwriting and financial information for all U.S property-casualty insurers. Our analysis is based on affiliated and unaffiliated single insurers. The exhibit of premiums written in the annual statement documents the states in which the insurer is licensed and the amount of business an insurer (licensed or unlicensed) writes in each state and line of business. We also collect other firm level information including total assets, leverage, business diversification, and firm demographics such as organizational form, distribution channel, and whether the insurers is affiliated with a group of insurers. The other firm data are obtained on a calendar-year basis.

From A.M. Best's *Best's Insurance Reports, Property-Casualty Edition and Best's Key Rating Guide*, we obtain insurer financial strength ratings from 1989 to 2011. Similar to Epermanis and Harrington (2006), we use rating changes to proxy for discrete changes in insurer default risk. The financial strength ratings are on a scale from A++ (the highest) to F (the lowest). Bohn and Hall (1997) find that insurers approaching insolvency have unusually high premium growth two years prior to failure. As a result, we exclude the small number of insurers with financial strength

ratings below C (less than 0.2% of total observations).[4] Firms that are not assigned a rating by Best's – for reasons such as insufficient size, company request, or failure to submit an NAIC annual statement – are excluded from our analysis. A.M Best updates ratings throughout the year with most changes occurring before July. To allow comparability with other studies (e.g., Epermanis and Harrington, 2006), we treat any rating change from August of last year through July of this year as a rating change in this year, and any rating change after August of this year as a rating change in the next year. Table 2 shows A.M. Best ratings and how we categorize the ratings into high (above A-), A-, and low (below A-) ratings.

We match the insurer data with guaranty fund data in the property-casualty insurance industry. The guaranty fund data has been hand collected from the following sources: the National Conference of Insurance Guaranty Funds, state insurance divisions, and filings by state legislatures. We aggregate direct written premiums to the firm-line-year level to obtain total direct premiums, direct premiums not covered by guaranty funds (called uncovered premiums) and direct premiums covered by guaranty funds (called covered premiums).[5]

To be included in the sample, firms must have positive direct and net premiums written and write business in the three years around a rating change (i.e. year t-1, t, t+1).[6] Insurer that specialize in reinsurance or international business are excluded. The sample originally has 4,615,898 firm-line-state level observations and is aggregated to 245,934 firm-line-year level observations. The sample screens described above reduce the sample to 114,022 firm-line-year level observations. The inclusion of lagged rating variables in our regressions further reduce the

[4] The inclusion of these very low-rated firms in our analysis does not change any of the results.
[5] For example, suppose Insurance ABC writes direct business in Other Liability insurance in three states in 2009: $1,000,000 in Michigan, $1,500,000 in Wisconsin, and $200,000 in Illinois. Insurance ABC, however, is not licensed in Illinois, so it writes business as a surplus lines insurer. The total direct premiums are $1,000,000 + $1,500,000 + $200,000 = $2,700,000. The uncovered premiums are $200,000 and the covered premiums are $2,500,000.
[6] Since our analysis unit is at firm-line-year level, as long as a firm writes the same line of business in any of the 50 states in three years surrounding rating change, it is included in our sample.

sample size to 107,147. In our analysis of the impact of market discipline on prices, we exclude all observations with negative implicit insurance price and winsorize all variables at the upper and bottom 1% of their distribution to mitigate the effect of outliers. This step further reduces the price sample to 73,314 observations at the firm-line-year level in the price regression.

4 Variables Measurement

To study market discipline we investigate the impact of rating changes on premium growth. Since net premiums written (premium net of reinsurance) is not available at the state level, we measure premium growth using direct premiums written. Growth in direct premiums written ($\Delta Log\ Premium$) is measured as the first difference of the log of direct premium written by insurer i at time t and the log of direct premium written by insurer i at time $t-1$. We truncate growth at -1.0 and 1.0.

To disentangle quantity and price changes, we calculate insurance price growth ($\Delta Log\ Price$). Since explicit contract prices are not available (i.e., we do not have information on prices at the contract level), we follow the literature and use an implicit measure of price (e.g. Cummins and Danzon, 1997; Cummins et al., 2005). We measure price at the firm-line-year level. Specifically, *Price* for firm i, line j, in year t, is defined as follows:[7]

$$Price_{ijt} = \frac{NPW_{ijt} - DIV_{ijt} - EXP_{ijt}}{(NLI_{ijt} + LAE_{ijt}) \times PVF_{jt}} \qquad (1)$$

Where *NPW* is net premiums written, *DIV* is dividends to policyholders, *EXP* is underwriting expenses, *NLI* is net losses incurred, *LAE* is loss adjustment expenses incurred, and *PVF* is the present value factor for line j, in year t.[8] Since premiums reflect the discounting of loss in a competitive market, losses incurred and loss adjustment expenses are discounted using a present

[7] We use direct premiums written and direct losses incurred to calculate price at the firm-line-state level.
[8] We also measure price using direct premium written as robustness check and to proxy the implicit price at the firm-line-state-year level.

value factor that accounts for differences in the payout pattern across insurance lines (e.g. long-tail lines vs. short tail lines). To calculate present value factors (*PVF*) we use information about how losses developed in the past to estimate how losses develop in the future. Specifically, we estimate payout proportions for each insurance line by applying the Taylor separation method (Taylor, 2002) to loss reserve data from the Schedule P of the regulatory annual statements.[9] We discount these estimated future payments using US Treasury yields obtained from the Federal Reserve Bank of St Louis. The estimation of payout tail proportions is akin to the method prescribed by the Internal Revenue Service (IRS) for computing loss present values for tax purposes (Cummins 1990).

Our identification strategy is to exploit the features of guaranty funds that vary across the states. Insurance lines with a higher proportion of premiums not covered by guaranty funds are hypothesized to be more risk sensitive and affected by rating changes. To measure this effect, we calculate *Prop. Uncover*, the proportion of uncovered premiums by guaranty funds to total direct premiums at the firm-line-year level.

It is possible that insurers and markets anticipate the rating changes of some firms and thus react less to the rating changes. To control for this possibility, we use a continuous measure of insurer risk. Specifically, we calculate an insurer's default-value-to-liability ratio (*Risk*) (Myers and Read, 2001):

$$d = f\left(s,\sigma\right) = N\left\{z\right\} - \left(1+s\right)N\left\{z-\sigma\right\} \qquad (2)$$

[9] Schedule P of the NAIC regulatory annual statement aggregates each insurer's lines of business into 12 categories: homeowner/farmers, auto liability, commercial multiple peril, workers' compensation, medical malpractice, special liability (ocean marine, aircraft and boiler & machinery), other liability, special property (fire, allied lines, inland marine, earthquake, burglary and theft), auto physical damages, fidelity/surety, other, and warranty.

where $N\{\cdot\}$ is the cumulative probability function for the standard normal variable, s is the surplus to liability ratio, $z = \frac{-\log(1+s) + \sigma^2/2}{\sigma}$, and σ is the volatility of the asset to liability ratio. The overall firm's volatility of the asset to liability ratio is calculated as $\sigma = \sqrt{\sigma_V^2 + \sigma_L^2 - 2\sigma_{VL}}$, where σ_V is the volatility of insurer's assets, σ_L is the volatility of insurer's liabilities, and σ_{VL} is the covariance of the natural logarithms of liabilities and assets. The respective volatilities are calculated by the following functions:

$$\sigma_V^2 = \sum_i^M \sum_j^M x_i x_j \rho_{V_i V_j} \sigma_{V_i} \sigma_{V_j} \tag{3}$$

$$\sigma_L^2 = \sum_i^N \sum_j^N y_i y_j \rho_{L_i L_j} \sigma_{L_i} \sigma_{L_j} \tag{4}$$

$$\sigma_{VL}^2 = \sum_i^M \sum_j^N x_i y_j \rho_{V_i L_j} \sigma_{V_i} \sigma_{L_j} \tag{5}$$

where x_i is the proportion of asset from asset type i to total asset, y_i is the proportion of liabilities from line i to the loss liability, $\rho_{V_i V_j}$ is the correlation coefficient of the logarithms of asset classes i and j with M number of asset classes[10], $\rho_{L_i L_j}$ is the correlation coefficient of the logarithms of liability line i and j with N number of lines of insurance business[11], and $\rho_{V_i L_j}$ is the correlation coefficient of the logarithms of liability line i and asset j. The volatilities and correlation matrix

[10] Assets are divided into six classes: stocks, bonds, real estate, mortgages, cash and other invested, and other assets.
[11] Lines of insurance business are divided into 12 classes based on Schedule P.

of insurers' assets are calculated using industry wide quarterly time series of return for each asset[12] and liability class[13].

Various features of state guaranty funds might affect market discipline and our model attempts to control for these effects. Guaranty funds have a maximum claim payment, which may dampen the cost of undercutting market discipline. If there is a significant proportion of private loss in excess of the caps in the case of an insurer's insolvency, policyholders might have additional incentive to monitor insurers. We construct a continuous variable *Max%* to represent the percentage of the insurer's direct premium written in a state with maximum claim paid of guaranty fund exceeding $300,000.[14,15] Another feature of state guaranty funds is net worth provisions. Given these provisions, wealthier policyholders have a greater incentive to monitor their insurers. We apply a continuous variable *Prov%* to represent the percentage of the insurer's direct premium written in states with state guaranty funds that have the net worth provision above $25,000,000.[16] More stringent rate regulation may dampen the impact of market discipline on prices, if the regulated rate is not a function of insurer risk. To account for rate regulation, we use *Reg%* (Grace and Leverty, 2010): it represents the percentage of the insurer's direct premium written in states with strict rate regulation laws (with prior approval or state made rate regulation)

[12] The quarterly estimates of the asset returns on the first five categories are obtained from the standard rate of return series: the total return on the Standard & Poor's 500 stock index for the stock returns, Moody's corporate bond total return for the bond, the National Association of Real Estate Investment Trusts total return for the real estate, the Merrill Lynch mortgage backed securities total return for the mortgages, and 30 day US Treasury bill rate for the cash/other invested assets. The non-invested assets are calculated by the natural logarithm of the gross quarterly percentage change in the total value of asset of the insurance industry net of the value of the first five asset categories.

[13] The quarterly liability return series are defined as the natural logarithm of the present value of incurred losses divided by the earned premium for each quarter.

[14] $Max\% = \frac{\sum_{i,j,s,t} Premium\ Written_{ijst} \times Indicators\ of\ guaranty\ fund\ exceeding\ \$300{,}000}{\sum_{i,j,s,t} Premium\ Written_{ijst}}$

[15] Workers compensation is treated as other lines covered by guaranty funds, although most states have infinite coverage for it. The reason is in many cases workers compensations are sold in insurance packages with other insurance contracts. Our results are very similar if we exclude workers compensation from our sample.

[16] $Prov\% = \frac{\sum_{i,j,s,t} Premium\ Written_{ijst} \times Indicators\ of\ net\ worth\ provision\ above\ \$25{,}000{,}000}{\sum_{i,j,s,t} Premium\ Written_{ijst}}$

for regulated lines such as medical malpractice, auto insurance, homeowner insurance and workers compensation at the firm-line-year level.[17]

We also use a number of firm level control covariates that have been shown in previous research to affect the change of insurance premiums and prices. Although regulations forbid insurers to advertise guaranty funds in selling insurance policies, insurance agents and brokers are aware of guaranty funds and of insurer financial strength ratings. Accordingly, we control for insurer distribution channel by using *Directw,* which is an indicator variable that equals one if an insurer is a direct writer and zero otherwise. To account for firm business diversification we use product line Herfindahl index (*Busherf*) and geographic Herfindahl index (*Geoherf*), which are calculated by the sum of the squares of the percentages of direct premium written across all lines of business (all states for geographic Herfindahl index) for the insurer. Other firm characteristic control variables are *Size,* the natural logarithm of total assets; *Leverage,* the ratio of total liability to total asset; *Mutual,* a dummy variable set equal to one if the insurer is a mutual organization; and *Group,* an indicator if the firm belongs to some affiliated group.

Table 3 presents the summary statistics for the variables used in the analysis. Panel A shows the summary statistics at the firm-line-year level. Average direct premium growth is 4.3%. The average price is 1.419 and mean price growth is -0.017. The average proportion of direct premiums that are uncovered by guaranty funds is 0.132.

Panel B shows the summary statistics at the firm-line-year level. The average value for *default-value-to-liability ratio* (*Risk*) is 0.1%. Nineteen percent of the observations are direct writers of insurance, 18% are mutuals, and 80.2% are affiliated with a group. The average observation has a product line Herfindahl of 0.323 and geographical Herfindhal of 0.441. On

[17] $\text{Reg\%} = \frac{\sum_{i,j,s,t} \text{Premium Written}_{ijst} \times \text{Indicators of stringent reg law}}{\sum_{i,j,s,t} \text{Premium Written}_{ijst}}$

average, 25.5% of direct premiums written are in business lines and states subject to stringent rate regulation; 87.2% are in states with a guaranty fund maximum claim amount of $300,000 or more; and 42.2% are in states with net provisions beyond $25,000,000.

Tables 4 and 5 show the number and distribution of firms by rating category and by upgrades and downgrades[18]. Table 4 provides this information for samples uncovered by guaranty funds, while Table 5 shows it for covered samples. Comparing Tables 4 and 5, the uncovered samples have a slightly lower percentage of downgraded insurers. Meanwhile, there is a higher percentage for uncovered samples' upgrades, especially for observations with ratings below B. Tables 6 and 7 show that the patterns of rating changes by year are similar for covered- and uncovered- samples.

5. Methodology and Results

5.1 Control Group Tests for Premium Growth

For abnormal growth in premiums, we use time, line, and size adjusted mean (median) abnormal premium growth in each rating category (high, A-, or low). For each year and line of business, we rank all insurers by total direct premiums and calculate mean (median) premium growth for insurers in each premium decile. The time, line, and size adjusted premium growth for each insurer equals its growth in line *j* and year *t* minus the mean (median) growth for insurers in its premium decile in line *j* and year *t*. The estimated mean (median) abnormal premium growth for downgraded (upgraded) firms in each rating category equals the difference between the mean (median) adjusted growth for downgraded (upgraded) insurers and for insurers in that rating category with no rating change.

[18] We make Table 4 to 7 by aggregating premiums at firm-line-year level based on whether premiums are covered by guaranty funds. The results are similar if we employ uncovered- and covered-group using 25% threshold as shown in Figure 1.

To categorize firms into uncovered and covered groups we look at the proportion of premiums written that are not covered by guaranty funds. Figure 1 shows the quantile plot of the proportion of uncovered premiums to total direct premiums. More than 80% of the firm-line-year observations are fully covered by guaranty funds (the proportion of uncovered premiums equals 0). Beyond this 80th percentile threshold, the proportion of uncovered premiums increases sharply from 0% uncovered to above 50%. Amongst the firm-year observations that write uncovered insurance, less than 3% have less than 25% in uncovered premiums. We categorize firms into "covered" and "uncovered" groups using a threshold of 25% of business written in uncovered premiums.[19]

The results are shown in Table 8 -- Panel A for insurer downgrades and Panel B for upgrades. The mean abnormal premium growth for downgrades is negative and statistically significant in year *t* and *t+1* for both the covered and uncovered groups. However, for firms rated A- and below, the mean and median abnormal premium growth for the covered and uncovered group are significantly different. Specifically, in the A- rating category mean abnormal premium growth is -26.25% in year *t* and -32.28% in year *t*+1 for the uncovered-group. It is -11.83% in year *t* and -17.76% in year *t*+1 for the covered-group. The difference between the uncovered and covered-groups is 14.42% and 14.52% in year *t* and *t*+1, respectively. For low rated firms, mean abnormal premium growth is -18.05% in year *t* and -23.46% in year *t*+1 for the uncovered-group and -11.79% and -15.31% for the covered-group. The difference is 6.26% in year *t* and 8.33% in year *t*+1. Mean and median abnormal premium growth in year t-1 is not statistically significant for downgrades, suggesting that there is no decline in premiums prior to the downgrade. The results

[19] The results are robust to using different thresholds: 0%, 10%, 30%, 50% and 75%.

indicate that the uncovered-group experiences more negative mean abnormal premium growth with ratings downgrades compared to the covered-group.

The results in Panel B show that with ratings upgrades low rated firms in the uncovered-group experience significantly greater mean abnormal premium growth than the covered-group. In particular, mean abnormal premium growth is 9.45% in year *t* and 8.03% in year *t*+1 for the uncovered group, while it is 2.33% and 4.99% for the covered group. The difference is 7.12% in year *t* and 3.04% in year *t*+1. Overall, the results are consistent with the hypothesis that the presence of guaranty fund protection reduces the sensitivity of premium growth to changes in insurer's financial strength ratings.

5.2 Regressions tests for insurer risk and market discipline

5.2.1 Firm-line-year level analysis

A potential concern with the regression analysis is that premium changes that are associated with changes in firm financial strength ratings may be endogenous. First, unfavorable changes in the insurance market (e.g. large catastrophes, like Hurricane Katrina) could deplete insurer capital and lead to changes in premium growth and financial strength ratings. Second, unobservable firm and line of business heterogeneity could be correlated with both premium growth and rating changes. Third, premium growth could result from an anticipated change in an insurer's rating. For example, an insurer that anticipates weak financial conditions in the future may respond by reducing the amount of business they write, while firms that anticipate strong future financial conditions may expand.

To establish causality, we use three identification strategies. First, to address unfavorable changes in the environment for writing insurance we include indicator variables for one-year leaded, contemporaneous, and one-year lagged rating changes. We also interact these indicators

with guaranty fund coverage. This framework, which is also employed by Epermanis and Harrington (2006), is similar to an event study with a short yearly window (-1 year, 0, and +1 year). The one year lagged rating change is used to account for the fact that rating information is available to the public with a delay. The coefficients of leaded variables provide insight into whether market discipline occurs in the year t-1. The differences among the coefficients of the lead rating change variables, contemporaneous variables, and lagged variables provide information on whether market discipline occurs before, during, or after the year of the rating change. Second, to address potential unobservable heterogeneity we include a variety of covariates, firm fixed effects, insurance line fixed effects, and year fixed effects. Third, to control for the possibility that the insurers and markets anticipate rating changes we include a non-ratings based measure of firm risk. In particular, we include the variable, *Anticipation*, which is the average value of default-value-to-liability ratio (*Risk)* for the year's t-1 and t-2.

The flexible event study framework is estimated using the following regression:

$$\begin{aligned}\Delta P_{ijt} = {} & E\left(\Delta P_{ijt} | no\, rating\, change\right) + \delta_1^{'} RC + \delta_2 Prop\_Uncover_{ijt} \\ & + \delta_3^{'} RC \times Prop\_Uncover_{ijt} + \varepsilon_{ijt}\end{aligned} \tag{6}$$

where ΔP_{ijt} is market discipline representing by premium growth for firm *i*, line *j* and year *t*; *RC* is a vector of rating downgrade and upgrade indicators for each rating category in t-1, t, and t+1; *Prop_Uncov* is the proportion of premiums not covered by guaranty funds to total premiums; and ε_{ijt} is the error term. Since the proportion of uncovered premiums varies through time, we also include the interaction of a linear time trend with the proportion of uncovered premiums in the regressions.

The expected premium growth conditional on no rating change is:

$$E\left(\Delta P_{ijt} | no\, rating\, change\right) = \beta_0 + \beta_1 P_{ijt-1} + \beta_2{}' X_{ij} + \beta_3^{'} Rating + \gamma_i + \tau_t + \lambda_j + \varepsilon_{ijt} \tag{7}$$

where P_{ijt-1} is lagged log premiums; X_{ij} is a vector of covariates; *Rating* is the rating categories (A- or LOW); γ_i is firm fixed effects; τ_t is year fixed effects; and λ_j is insurance lines of business fixed effects. We adjust standard errors for clustering at the firm-line level.[20]

Consistent with market discipline, we predict negative signs on the A- and LOW rating dummies, but we make no prediction for the sign of the vector of covariates. A negative estimate of $\delta_1{}'$ for the lagged or contemporaneous downgrade (a positive estimate of α' for upgrade) indicators is interpreted as evidence of market discipline. A significant positive (negative) estimate of δ_2 would indicate that the higher the proportion of uncovered premiums the higher (lower) the premium growth. The interaction terms of the proportion of uncovered premiums variable with the vector of rating changes estimates whether guaranty funds reduce or enhance market discipline. Specifically, a significant and negative (positive) coefficient for δ_3 on the contemporaneous and lagged downgrade (upgrade) variables would suggest that the presence of guaranty fund protection reduces market discipline, i.e., guaranty funds dull the risk sensitivity of demand.

Table 9 reports the least squares and fixed effects estimates of the model described by Equations (6) and (7) for direct premium growth. Model (1) reports the OLS results, Model (2) shows the results with firm, line, and year fixed effects, Model (3) adds "Anticipation" and firm and guaranty fund controls, and Model (4) is the 2SLS regression.

The implications of the regressions are broadly consistent with those of the control group tests, but the magnitude of the coefficients on the rating change variables estimated are smaller in the fixed effects regressions. A Hausman test rejects the null hypothesis that differences in coefficients of OLS and fixed effects are not systematic, suggesting fixed effects model are consistent. The results are robust to inclusion of the firm and guaranty funds controls and to

[20] The results are robust if we adjust standard errors for clustering at the firm level.

allowing for the interaction of linear year trend with the proportion of uncovered premiums. The results support the hypothesis that the guaranty fund protections reduce the risk sensitivity of policyholders. The variable of *Anticipation* is insignificant, indicating that market anticipation of the insurer risk change is weak. The coefficients for the lead rating change variables (i.e. rating changes from t to t+1) provide little evidence that decreases in premium growth are continuous declines from the year prior to rating change. The coefficient on these variables for A- insurer downgrade (-0.182 in year t and -0.062 in year t+1) is significantly negative, indicating that firm-lines with relatively higher proportion of uncovered premiums experience more negative premium reactions to downgrades, ceteris paribus.

Economically, the coefficient in year t for A- insurer downgrade implies that a 10% increase in the proportion of uncovered premiums is associated with 1.8% decrease in premium growth to a downgrade action. Given that the difference between the average proportion of uncovered premiums for covered- and uncovered-group is approximately 86% (see the table attached to Figure 1) and statistically significant, A- rated uncovered-group would on average be associated with a less 15.6% premium growth for downgrades in year t (and a less 5.3% premium growth in year t+1). The coefficient on these variables for low rated insurer downgrade is -0.171, which means the low rated uncovered-group would on average experience a less 14.7% premium growth for downgrades in year t. These results imply that guaranty funds dramatically dull risk sensitivity of demand for insurer downgrades. Similarly, the coefficient on the interaction variable for low rated insurer upgrade is 0.04, suggesting that on average low rated uncovered-group would have a more 3.5% premium growth for upgrades in year t+1.

While the features of guaranty funds in each state (i.e. which lines are covered, the maximum claim amount, and the net worth provisions) are exogenous for individual insurers, it is

possible that the proportion of uncovered premiums is endogenous, as insurers that experience downgrades may rely more on covered business, and vice versa[21]. To deal with this potential, we use an instrumental variables (2SLS) procedure. The first stage regression instruments the proportion of uncovered premiums with its value lagged by three years, *Mutual*, *Group, Busberf, and Geoherf.* The R^2 of the first regression (not reported here) is around 0.90. The predicted value of the first-stage regression is then used in the second stage regression instead of the actual value. The results, shown in Table 9 model (4), are robust to using the 2SLS regression. We find that the coefficients of interest are in the similar magnitudes and same signs that the results only show marginally increases the sensitivity of market discipline to rating changes.

We also use an event study framework with longer window (-7 years to 7 years surrounding the rating change) to nonparametrically estimate the pattern of premium growth for both uncovered- and covered-groups for downgrades and upgrades. The model is:

$$\Delta P_{ijt} = \sum_{x=-T}^{T} \theta_x W_{ijx} + \gamma_i + \tau_t + \lambda_j + \varepsilon_{ijt} \qquad (8)$$

where ΔP_{ijt} is premium growth for firm *i*, line *j*, and year *t*; γ_i is firm fixed effects; τ_t is year fixed effects; and λ_j is insurance line of business fixed effects. The independent variables of interest are the event time indicator variables, W_{ijx}. These variables track the year of a rating change and the years preceding and following a rating change. The indicator variable W_{ij0} equals 1 if a firm-line has a rating change in that calendar year. The indicator variable W_{ijx} equals 1 if the firm-line has rating change in $-x$ years. Many firm-lines have more than one rating change during the sample

[21] A significant proportion of insurance that is not covered by guaranty funds belongs to insurers with stable business or some particular firm organization, e.g. risk retention groups. It is important to note that a number of insurance entities that do not receive guarantee fund coverage (e.g., risk retention groups) are establsihed to provide stable and dependable coverage to their policyholders.

period. For these firm-lines, each rating change is coded with its own set of indicator variables.[22] To make the results comparable with the flexible event study framework, the event time indicator variable $W_{ij,-2}$ is normalized to zero. In practice, this is done by excluding $W_{ij,-2}$ from the regression. We also create $W_{ij,head}$ = 1 if $x \in [-20, -7]$, and $W_{ij,tail}$ = 1 if $x \in [7, 20]$. Equation (8) is then estimated with these two bin indicators. The estimated coefficients are interpreted as the percent change in the premium growth in firm *i*, line *j* relative to the year before a rating change.

Figure 2 Panel A-Panel C plot the event time indicator coefficients, θ_x, from the estimation of equation (8) on the 1990–2010 panel for downgrades regardless of pre-rating categories, A- and low-rated insurers and high-rated insurers, respectively. Event time is plotted on the x-axis. Year 0 corresponds to the year an insurer experiences a rating change, while years −1,…, −7 and 1,…, 7 are the years before and after the rating change, respectively. The results are normalized to two years before the rating change, i.e., year t-2 is omitted from our regressions. The plotted event time coefficients can be interpreted as the percent change in the premium growth relative to two years prior to the rating change. The bands represent the 95 percent confidence interval and show whether each point estimate is statistically different from 0. Premium growth is lowest in the year of a downgrade for both groups. In the year of a downgrade, there is a 12 percent decrease in the premium growth relative to two years before a downgrade for the uncovered group, while there is a 6 percent decrease in premium growth for covered-group.

As shown in the figure, there is no discernable trend in premium growth in the years before a rating change. After a downgrade premium growth remains negative and statistically significant for five years. After five years, premium growth is not statistically different from zero. We do not

[22] For example, firm A has a downgrade in 2005 and 2009. Thus, in year 2007, W_{ij2} = 1, since it has been 2 years since the 2005 rating change and $W_{ij,-2}$= 1, since it is 2 years before the 2009 rating change. W_{ij20} = 1 only if there is a rating change in 1990 and $W_{ij,-20}$ = 1 only if there is a rating change in 2010.

find any significant evidence that there are different effects of guaranty fund protections on market discipline for insurer upgrades in Figure 3. The patterns shown in Figure 2 are in line with results of Table 9---we find the differences of premium growth decreases are much larger for A- and low-rated insurers in the year of and the year after downgrades.

Interestingly, the differences of impulse responses between two groups disappear after two years. The pattern of premium growth is very similar three years after downgrades regardless of the presence of guaranty funds. There is no statistically significant difference between any of the pairs of post-downgrades coefficients after three years. The same decline pattern in insurance premium growth repeats if an insurer has multiple downgrades during the period. The pattern suggests that the process of market discipline is most consistent with a Bayesian learning model that allows for forgetting or incomplete information about past downgrades.

5.2.2 Firm-line-state-year level analysis

To further analyze the impact of guaranty funds on market discipline, we switch to regressions at the firm-state-line-year level. To be included in these regressions, a firm-line-state-year observation is required to be downgraded in that year. We run the regressions two ways. The first regression includes firm-line-year fixed effects and state fixed effects. The regression test for variation in guaranty fund coverage within a state. The primary source of identification is driven by surplus lines insurers, i.e., insurance firms that are not licensed in some states and therefore not covered by guaranty funds. A secondary source of identification is the lines of insurance that do not receive guaranty fund coverage in the state (see footnote 6). The second regression includes firm-state-year fixed effects and line fixed effects. The regression tests for variation within a line of business. The source of identification is the variation across the states in the lines of insurance that do not receive guaranty fund coverage. Specifically, we estimate the following models:

State variations:

$$\Delta P_{ijst} = \alpha_{ijt} + \psi_s + \gamma P_{ijst-1} + \theta' RC \times Uncover + \varepsilon_{ijst} \quad (9)$$

Insurance line of business variations:

$$\Delta P_{ijst} = \alpha_{ist} + \varphi_j + \gamma P_{ijst-1} + \theta' RC \times Uncover + \varepsilon_{ijst} \quad (10)$$

where ΔP_{ijst} is premium growth for firm *i*, insurance line *j*, state *s*, and year *t*; P_{ijst-1} is the natural logarithm of lagged premiums, *RC* is the pre-change rating category (i.e. A- or Low), and Uncover is an indicator variable that equals 1 if the insurance line *j* is not covered by the guaranty fund in state *s*, and 0 otherwise; α_{ijt} is the firm-line-year fixed effect; ψ_s is the state fixed effect; α_{ist} is the firm-state-year fixed effect; and φ_j is the line fixed effect. The standard errors are clustered at the firm-line-year in (9) and at the firm-state-year in (10).

Table 10 Column 1 shows the regression results for Equation (9) for all lines. The coefficients on the interaction terms of ratings level and the indicator for lack of guaranty fund protection are negative and statistically significant for downgrades. A downgrade yields a 2.8% drop in premiums for high rated firms in lines of insurance not protected by guaranty funds. The drop is 16.8% for A- rated firms and 12.1% for low rated firms.

To see whether the state-variation effect is driven by non-traditional lines of insurance, we re-do the analysis using only traditional lines of insurance or only non-traditional lines. We classify non-traditional lines of insurance as credit, surety, fidelity, financial guaranty, mortgage guaranty, ocean marine, warranty, and title insurance. These are the lines of insurance that are most commonly not covered by guaranty funds. Column 2 shows the results using the traditional lines of insurance. Column 3 shows the results for non-traditional lines. For traditional lines, the coefficients on the interaction terms of ratings level and the indicator for lack of guaranty fund protection are negative and statistically significant for downgrades of A- and low rated firms, but

not for high rated firms. A downgrade yields a 21.8% drop in premiums for A- rated firms. The drop is 16.6% for low rated firms. For non-traditional lines, the coefficients on the interaction terms of ratings level and the indicator for lack of guaranty fund protection are negative and statistically significant for downgrades of high and A- rated firms, but not for low rated firms. A downgrade yields a 6.8% drop in premiums for high rated firms and a 10.7% drop for A- rated firms. The results indicate that the effect of guaranty funds is not being driven by non-traditional lines of insurance. In fact, the magnitudes of the declines are greater for traditional lines than non-traditional lines. The results also indicate that customer sensitivity to risk is greater for lower rated insurers in traditional lines, but higher for higher rated insurers in non-traditional lines, suggesting that financial quality is perhaps more important in non-traditional lines.

Columns 4 and 5 test state variation for personal lines and commercial lines.[23] The results imply that guaranty funds mainly influence downgrades of commercial lines, which are in line with Epermanis and Harrington (2006) that market discipline works in commercial lines.

The last two columns of Table 10 examine the effect of differences in the maximum amount of claims paid for covered premiums for personal lines and commercial lines. A dummy variable *uncover* equals one if the premiums in a state are covered by guaranty funds and the maximum amount of claims paid by the guaranty fund is less than $300,000, and zero otherwise. The results suggest that state variation of the maximum amount of claims paid for covered premiums only matters in high-rated insurer downgrades for personal lines.

As shown in Table 11 (line of business variation model described in Equation 10), a downgrade yields a 7.7% drop in premiums for high rated firms in lines of insurance not protected by guaranty funds. The effect is not statistically significant for A- and low rated firms.

[23] Personal lines include farmowners multiple peril, homeowners multiple peril, private passenger auto liability, and private auto physical damage; commercial lines include everything else.

7. Extensions

7.1 Mechanism of market discipline

In this section we explore the mechanism behind market discipline. Policyholders can exert market discipline by buying less coverage, not buying insurance, or demanding a lower price from a downgraded insurer. Insurers may respond to market discipline as well, but not all insurers have the same flexibility. Insurers subject to stringent rate regulation may not be able to adjust prices (Grace and Leverty, 2010). Insurers may increase price as well when the aggregate capital of the industry is low (e.g. liability crises depleted insurers' capital). As a result, risky insurers may not lower their price after downgrades, especially insurers in the low pre-change rating category. So the relationship between downgrades and insurance price growth are unclear.

The presence of guaranty funds may also change insurer operations. In contrast to the risk-free deposit in banks[24], insurers may charge higher insurance prices to offset the higher risk of writing premiums in lines not covered by guaranty funds, e.g. surplus lines. Meanwhile, a lower insurance price with guaranty funds may also result if insurers attempt to decrease price within the range of regulation permitted in order to attract more premiums. Hence, a negative correlation may be observed between the absence of guaranty funds and insurance price. The influence of guaranty funds on price growth for downgraded insurers is also complex. The downgraded insurers may cause policyholders to perceive the insurance business uncovered by guaranty funds to be more risky than those business covered by guaranty funds. Thus policyholders would demand to pay further lower price than business covered by guaranty funds experiencing downgrade. However, since the absence of guaranty fund protection may increase insurance price, it is possible that an increase of insurance price can be observed for premiums uncovered by guaranty funds comparing

[24] The average influence of the presence of deposit insurance on interest rate is unclear (Demirguc-Kunt and Huizinga, 2004).

with those uncovered by guaranty funds for downgraded insurers. An examination of price growth provides a better understanding of these relations and the mechanism of market discipline.

To determine the mechanism, we study insurance price growth. In particular, we use equation (6) and equation (7), but replace the dependent variable, premium growth, with price growth. Since premiums are revenues (price times quantity), the impact of downgrades on prices will yield insight on the price mechanism and because we have already studied the impact on premiums, we can impute the impact on quantity.

The results for fixed effects estimates of price growth using either net business or direct business are reported in Table 12. The significant and negative coefficients for all lead rating change variables of downgrades provide clear evidence that insurers have slower price growth if they are approaching downgrades in the following year. The negative and statistical significant coefficients on *Anticipation* also support the evidence that insurers anticipate future downgrade and adjust price accordingly before the downgrade. Most coefficients of contemporaneous and lagged variables for downgrades are not significant (except for high-rated insurers in year t), suggesting that we should fail to reject the hypothesis that policyholders would not punish insurers by requiring lower price after downgrades. This phenomenon could be explained by regulatory discipline that insurers have limited ability to adjust insurance price after the financial strength deteriorates, especially for high risk insurers. On the contrary, with the exception of contemporaneous upgrades for high-rated insurer, upgrade effects through price channel appear to be significant and around 4.8% for A- insurers and 3.1% for low-rated insurers in year t. We use price calculating by direct business (i.e. replace net premium written with direct premium written, and net loss incurred with direct loss incurred) as robustness check and the results hold.

In addition, we control for price growth in the premium growth regression, since premium growth endogenously depends on price growth. We employ the two-stage least square method (2SLS) to investigate how premium growth changes after controlling price growth change. The predicted price growth is included in the premium growth regression in the second step. Although the regression sample size is reduced by one third because we only keep strict positive calculated price in our analysis, we can still identify market discipline in the form of premium growth. The magnitudes of the coefficients on the rating change variables estimated for premium growth rates are smaller than the previous fixed effects regressions. The signs of these estimated variables in 2SLS are consistent with previous regression. Overall, the results shown in Table 12 confirm the conclusion of Epermanis and Harrington (2006) that market discipline works even after we control for price growth. The results also suggest that price growth depends on the direction of the rating action.

The results of influence of guaranty funds on market discipline through price channel are reported in Table 13. The proportion of uncovered premiums enters all regressions positively in Table 13. We find clear evidence suggesting that on average the guaranty fund scheme causes insurance prices to grow relatively slower (i.e. the coefficients of proportion of uncovered premiums are positive and significant). Our variables of interest in Table 13, the interaction term of upgrades and the proportion of uncovered premiums, generally confirms that the effectiveness of market discipline through the price channel also depends on the extent of the safety net. Specifically, the results show that the absence of guaranty fund protection enhances the sensitivity of price growth to insurer upgrades. For insurers rated below A- (as A-) prior to being upgraded, the coefficients are significantly positive, indicating that firm-lines with a 10% higher proportion of uncovered direct premiums experience 0.9% (1.2%) increase in the estimated price growth to a

upgrade in year t+1. However, we cannot find the consistent results of interaction terms of downgrades and the proportion of uncovered premiums. There are at least two reasons why guaranty funds have mixed influence on insurer downgrades. First, guaranty funds reduce the rate of price growth and it may create incentive for A- and above rated covered insurers to decrease the price faster within the range of rate regulation in order to attract more customers. Alternatively, risky insurers uncovered by guaranty funds can be observed less safe than covered business, thus insurers may decide or be forced to decrease the price further and relatively increasing loss reserve. The inconclusive results of these interaction terms for insurer downgrades may reflect that market discipline works on quantity changes for insurer downgrades, since premiums decrease but prices do not change. The results suggest that when insurers experience financial deterioration, policyholders shift their contracts rather than require lower price.

7.2 The influence of the financial crisis in 2008

The financial crisis in 2008 provides natural experiment to study market discipline and the role of guaranty funds in market discipline. We compare premium growth before and after the financial crisis. To avoid the aftermath influence of the insurance hard market around the year of 2002-2003, the subsample regressions include observations from 2005 to 2010. We select the year of 2008 as the event year since the crisis can be dated from August, 2007 and there is a delay for public reaction to insurers' performance. We first evaluate whether market discipline is affected by the 2008 financial crisis, that is, whether policyholders respond more to insurer risk after the crisis. Our estimation covers the pre-crisis period, 2005 to 2007, and the post-crisis period, 2008 to 2010. The fixed effects regressions are at firm-line-year level and exclude the consideration of rating categories. The model including the financial crisis indicator is:

$$\Delta P_{ijt} = E\left(\Delta P_{ijt} \middle| no\ rating\ change\right) + \theta_1{}' VRC_1 + \theta_2 crisis$$

$$+\theta_3{}'crisis \times VRC_1 + qZ' + \varepsilon_{ijt} \quad (11)$$

And we extend model (6) to study the effects of guaranty funds surrounding financial crisis as:

$$\Delta P_{ijt} = E\left(\Delta P_{ijt} \middle| no\ rating\ change\right) + \omega_1{}'VRC_1 + \omega_2 crisis + \omega_3 Prop.Uncover_{ijt} +$$

$$\omega'_4 crisis \times VRC_1 + \omega'_5 VRC_1 \times Prop.Uncover_{ijt} + \omega_6 crisis \times Prop.Uncover_{ijt} +$$

$$\omega'_7 crisis \times VRC_1 \times Prop.Uncover_{ijt} + qZ' + \varepsilon_{ijt} \quad (12)$$

where in both models crisis is an indicator variable equal to 1 if the observation is after the financial crisis; VRC_1 is a vector of rating downgrade and upgrade indicators without identifying different pre-change ratings; Z' is a vector of firm fixed effects, line fixed effects, year fixed effects, the interaction of linear time trend with the proportion of uncovered premiums and the interaction of the crisis variable with linear time in the regressions.

The interaction terms of the vector of rating changes with the dummy variable crisis enable us to estimate whether the financial crisis reduces or enhances market discipline. If there is no difference of market discipline before and after the financial crisis, premium growth should be uncorrelated with the interaction variable, and $\theta_3{}'$ cannot be rejected to 0. Meanwhile, the interaction terms of the proportion of uncovered premiums with the vector of rating changes and the financial crisis enable us to examine whether the absence of guaranty funds further enhances market discipline after the financial crisis. The positive (negative) of the ω'_7 coefficient for interaction variables of contemporaneous and lagged upgrades (downgrades) suggest that the absence of guaranty funds protection further enhances market discipline after the financial crisis.

Our results in Table 14 shows risk sensitivities of policyholders become more evident and are magnified during the financial crisis. The significant coefficient takes negative sign to the interaction between downgrade (in year t) and the crisis variable in the regressions for premium growth, implying that there is stronger market discipline for downgraded insurers after the

financial crisis. The result shows that, all else equal, the financial crisis lead to a decrease of 6.6% in premium growth in the year of downgrades.

The results in Table 14 second parts show that the financial crisis had a big effect on the sensitivity of premium growth to the changes of insurer's financial strength ratings with respect to the protection of guaranty funds. The coefficients on the three-way interaction among the rating actions, the proportion of uncovered premiums and the financial crisis are economically and statistically significant negative for downgrades (-0.241) in year t and significant positive (0.196) for upgrades in year t+1. Summarizing, the degree of market discipline via premiums growth channel rises substantially relative to pre-crisis period; so does the sensitivity of market discipline regarding guaranty funds.

7. Conclusion

The paper concentrates on the issue largely unexplored by the existing literature on market discipline in financial institutions---How safety-net schemes affect market discipline in the property-casualty insurance industry? The study is the first to thoroughly examine the intensity of guaranty funds protection on market discipline in property-casualty insurance industry. We do so by measuring the proportion of uncovered direct premiums to total direct premiums. The evidences for premium growth are very suggestive and consistent, that is, guaranty funds reduce market discipline significantly. Policyholders are prompted to exercise much more market discipline when there is a lack of guaranty funds protections. Interestingly, the relationships of market discipline and guaranty funds related to financial strength rating changes are asymmetric that policyholders are much more sensitive for punishing less protected insurers' downgrades.

We further explore the underlying mechanism of market discipline by analyzing insurance price growth. The results presented in this paper show that the relation of price growth and firm

risks depends on the level of insurer financial strength and the direction of the finance strength evaluation change. We cannot reject that the regulatory discipline offset market discipline for A- and below insurer downgrades, since there is no clear evidence that policyholders exert market discipline by requiring lower price on the contracts after downgrades. Rather, we observe policyholders are willing to pay higher price for insurers with stronger financial strength. The results of price growth also imply that insurers expect approaching downgrades are more likely to have lower price growth. Such results complement the prior studies finding the negative relationship between insurer risk and price (e.g. Phillips et al., 1998; Sommer, 1996; Cummins and Danzon, 1997). We conclude that policyholders punish insurers for risky behavior by shifting their insurance contract instead of requiring lower price. We also show that market discipline increase after crisis. One explanation is that policyholders become more aware of the insurers' risk after traumatic financial events. The crisis seems to be wake-up calls for insurance market.

Our paper offers novel evidence on a previously under-explored adverse consequence of guaranty funds—it dulls to customer sensitivity to risk. The effects are especially large for A- and low-rated insure downgrades but only last for two years. The same decline pattern in premium growth suggests that the process of market discipline is most consistent with a Bayesian learning model that allows for forgetting or incomplete information about past downgrades. The findings cast doubt on the ability of market to effectively disciple the insurers' behavior within the current regulatory environment. However, we need to interpret our results with important caveats. First, we cannot rule out the role of market discipline in property-casualty insurance. The evidence of market discipline among covered lines suggests that insurance safety-net schemes are not fully credible. The potential rationale is state guaranty funds only provide limited coverage for insurance lines. Hence, it is inappropriate to conclude, if based solely on the evidence provided by our study,

that regulators should not consider market discipline as one essential element in monitoring insurers. Nevertheless, we have demonstrated one particular "dark side" of guaranty funds that they significantly blunt market discipline. This implies the necessity to correct the adverse incentives guaranty funds create in order to better discipline insurers and protects policyholders. Second, although a proper evaluation of the exact upper limits of guaranty funds and maximum coverage of insurance contracts seems necessary, such research design is beyond the scope of this study and calls for more future research.

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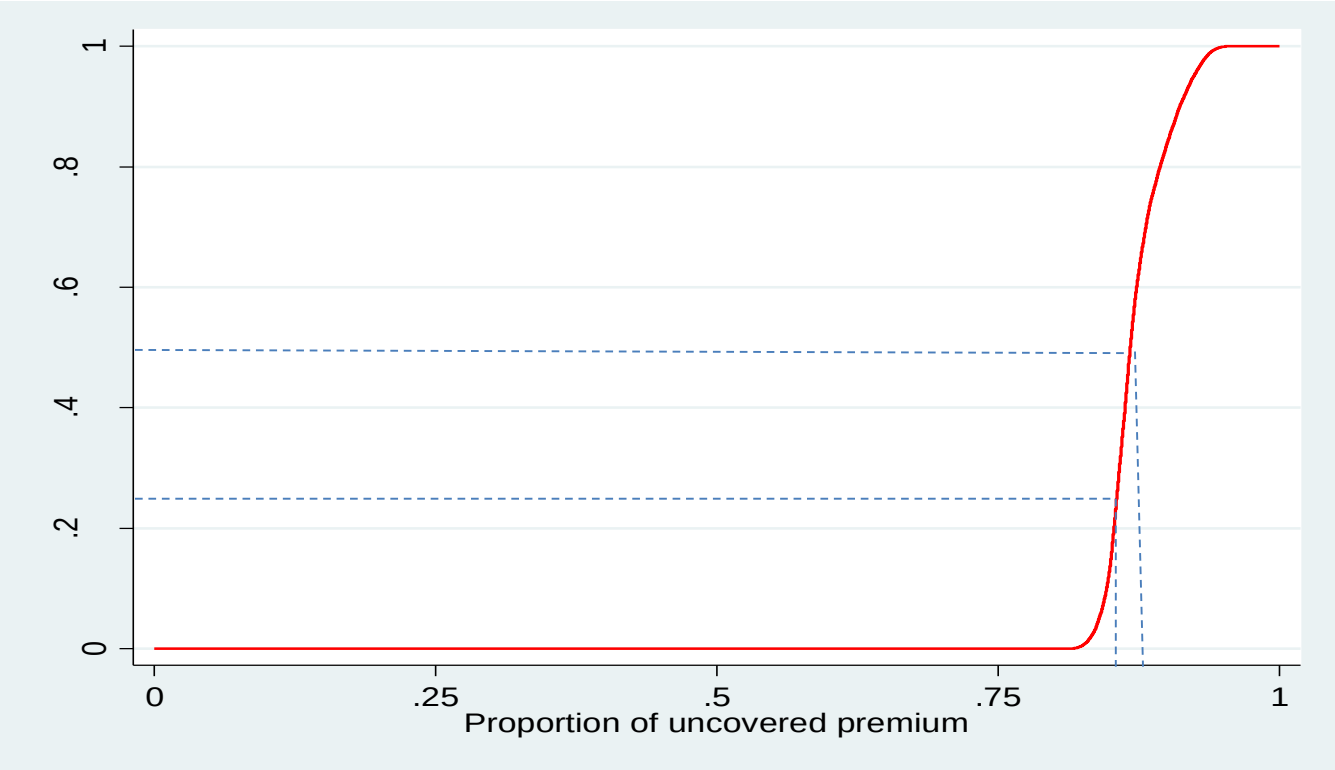
Figure 1: The quantile plot of the proportion of uncovered premiums to total direct premiums



Note: We set the threshold of 25% to categorize our observations into covered- and uncovered groups. The summary statistics of the two groups are as following:

	Mean	Median	STD	Min	Max	N
Uncovered-group	0.861	0.962	0.194	0.250	1.000	16466
Covered-group	0.003	0.000	0.019	0.000	1.000	97556

Figure 2: Panel A Premium growth for insurer downgrades at firm-line-year level, 1990–2010

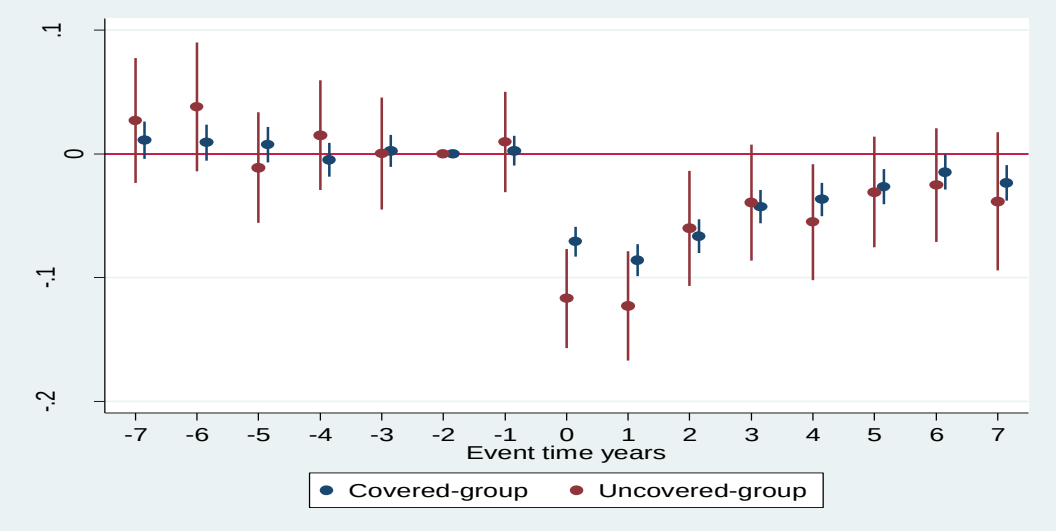


Figure 2: Panel B Premium growth for A- and low-rated insurer downgrades at firm-line-year level, 1990–2010

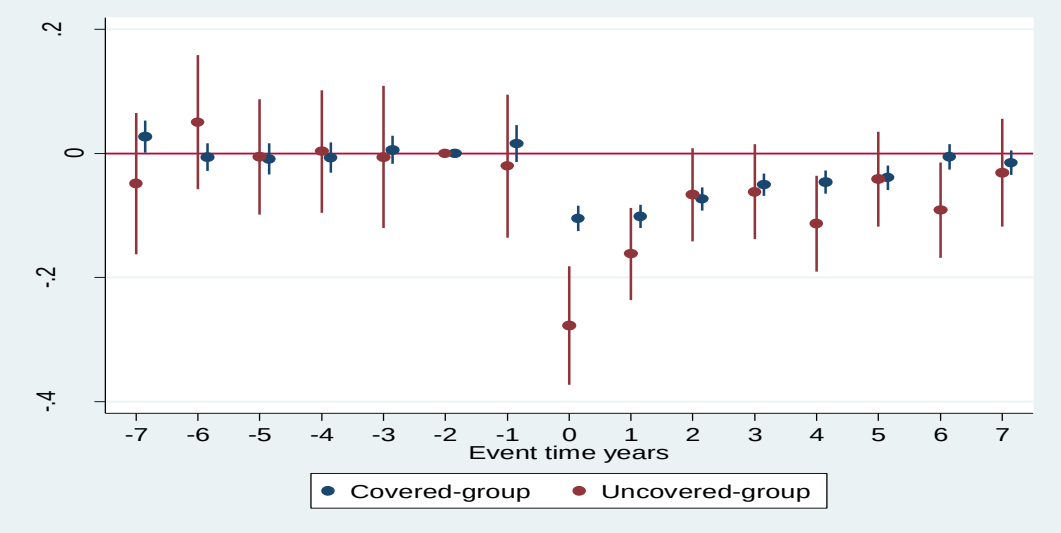


Figure 2: Panel C Premium growth for High-rated insurer downgrades at firm-line-year level, 1990–2010

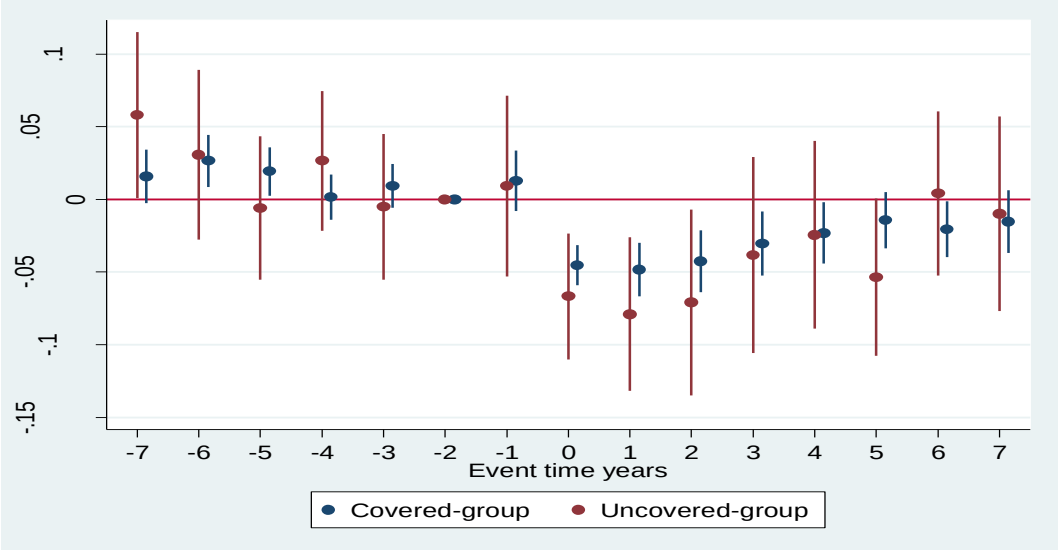


Figure 3: Panel A Premium growth for insurer upgrades at firm-line-year level, 1990–2010

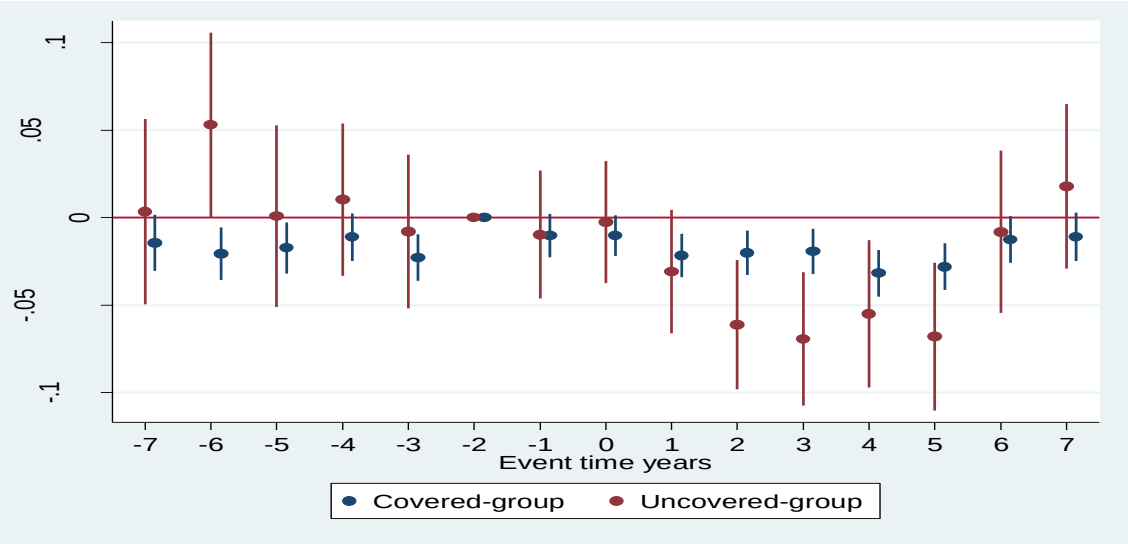


Figure 3: Panel B Premium growth for A- and low-rated insurer upgrades at firm-line-year level, 1990–2010

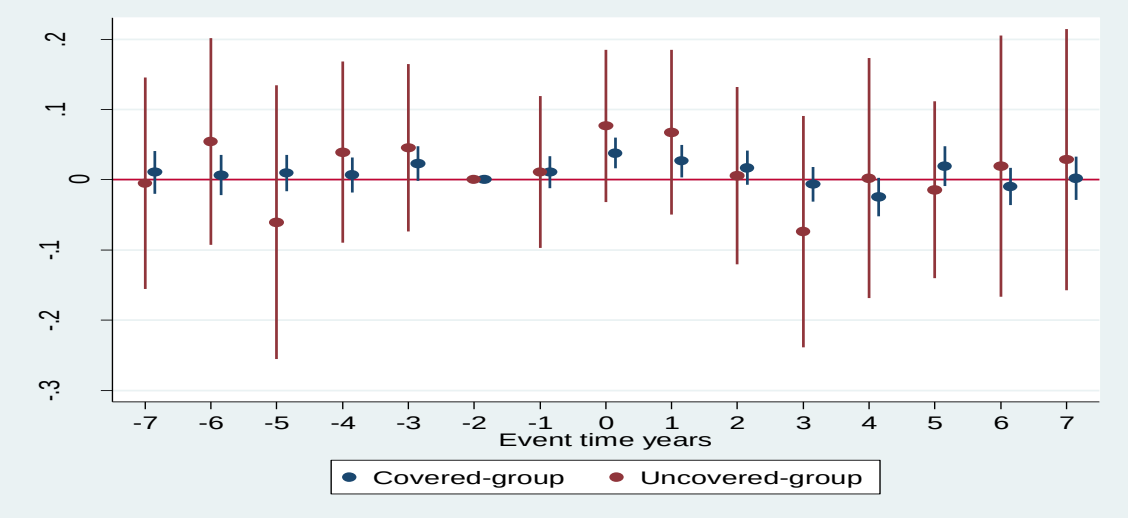
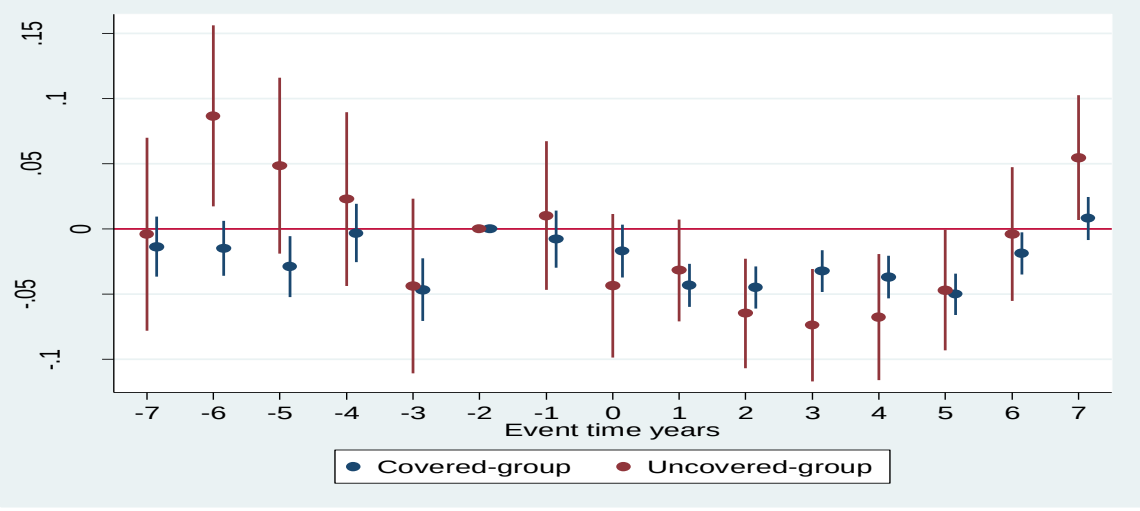


Figure 3: Panel C Premium growth for High-rated insurer upgrades at firm-line-year level, 1990–2010



The figure plots event time premium growth coefficients from estimation of equation (8) on the 1990–2010 panel. There are 114,022 observations in the event study at firm-line-year level. All estimated coefficients can be interpreted as the percent change in premium growth for a downgrade relative to the last second year before a downgrade (−2 on the *x*-axis is omitted). The end points on the graph are binned so that −7 (+7) is a bin for years −7 to −20 (+20 to +7). The vertical axis measures ΔLog Premium. The uncovered-group is defined as firm-lines with proportions of uncovered premiums larger or equal than 25% for downgraded insurers. The covered-group is defined as firm-lines with proportions of uncovered premiums less than 25% for downgraded insurers. The coefficient for the last second year before a downgrade is normalized to zero. The bars show the 95% confidence interval. Standard errors are clustered by firm-line level.

Table 1 Summary of property-casualty guaranty funds, by state

State	Effective Date	Max Per Claim (not WC)	Net Worth Provision	State	Effective Date	Max Per Claim (not WC)	Net Worth Provision
AL	1981	$150,000	$25,000,000	MT	1971	$300,000	$50,000,000
AK	1970	$300,000 before 1990; $500,000	NO	NE	1971	$300,000	NO
AZ	1977	$100,000 before 2007; $300,000	NO	NV	1971	$300,000	$25,000,000
AR	1977	$300,000	$50,000,000	NH	2004	$300,000	$25,000,000
CA	1969	$500,000	NO	NJ	1974	$300,000	$25,000,000
CO	1971	$300,000	$25,000,000	NM	1973	$100,000	NO
CT	1971	$300,000 before 2007; $400,000	NO	NY	1969	$1,000,000	NO
DE	1970	$300,000	$10,000,000	NC	1971	$300,000	$50,000,000
FL	1970	$300,000	NO	ND	1971	$300,000	$10,000,000
GA	1970	$100,000 before 2005; $300,000	$10,000,000	OH	1970	$300,000	$50,000,000
HI	1971	$300,000	$25,000,000	OK	1980	$150,000	$50,000,000
ID	1970	$300,000	NO	OR	1971	$300,000	$25,000,000
IL	1971	$300,000*	$25,000,000	PA	1994	$300,000	$50,000,000
IN	1972	$50,000 before 1988; $100,000	$5,000,000	RI	1970	$500,000	$50,000,000
IA	1970	$300,000 before 2010; $500,000	NO	SC	1971	$300,000	$10,000,000
KS	1970	$300,000	NO	SD	2000	$300,000	$50,000,000
KY	1972	$100,000 before 1998; $300,000	$25,000,000	TN	1971	$100,000	$10,000,000
LA	1970	$150,000 before 2008; $500,000	$25,000,000	TX	2007	$300,000	$50,000,000
ME	1970	$300,000	$25,000,000	UT	1971	$300,000	$25,000,000
MD	1971	$300,000	$50,000,000	VT	1970	$500,000	NO
MA	1971	$300,000	$25,000,000	VA	1970	$300,000	$50,000,000
MI	1969	$5,000,000	$25,000,000	WA	1971	$300,000	NO
MN	1971	$300,000	$25,000,000	WV	1970	$300,000	NO
MS	1971	$300,000	NO	WI	1969	$300,000	$25,000,000
MO	1971	$300,000	$25,000,000	WY	1971	$150,000	No

Notes: The detailed information of excluded lines is described in the footnote.

Table 2 Rating categories of A.M Best rating

A.M. Best Rating	Numerical value
High categories ↓	
A++	1
A+	2
A	3
A-	4
Low categories ↓	
B++	5
B+	6
B	7
B-	8
C++	9
C+	10
C	11
C-	12
D	13
E	14
F	15
No categories ↓	
NR (NR 1, NR 2, NR 3, NR 4, NR5)	16
None rating (rating is blank)	17

Table 3 Summary statistics of sample firm-line-years

Variable	Mean	Median	SD	Min	Max
Full sample (N=114022)					
Log Direct Premium	15.321	15.628	2.586	9.210	23.525
Δ Log Direct Premium	0.043	0.035	0.352	-1.000	1.000
Prop. of Uncover.	0.127	0.000	0.311	0.000	1.000
Regression sample (N=107141)					
Δ Log Direct Premium	0.041	0.035	0.352	-1.000	1.000
High	0.610	1.000	0.488	0.000	1.000
A-	0.233	0.000	0.422	0.000	1.000
Low	0.157	0.000	0.364	0.000	1.000
High×Down	0.048	0.000	0.364	0.000	1.000
A-×Down	0.012	0.000	0.214	0.000	1.000
Low×Down	0.011	0.000	0.107	0.000	1.000
High×Up	0.021	0.000	0.142	0.000	1.000
A-× Up	0.020	0.000	0.140	0.000	1.000
Low× Up	0.034	0.000	0.180	0.000	1.000
Prop. of Uncover.	0.131	0.000	0.317	0.000	1.000
Portfolio_Risk (sigma)	0.142	0.117	0.070	0.011	0.485
Default-value-to-liability ratio (Risk)	0.001	0.000	0.005	0.000	0.117
Anticipation	0.005	0.000	0.013	0.000	0.117
Size	19.020	18.918	1.822	13.636	25.451
Leverage	0.601	0.633	0.152	0.110	0.840
Directw	0.132	0.000	0.338	0.000	1.000
Mutual	0.180	0.000	0.384	0.000	1.000
Group	0.802	1.000	0.399	0.000	1.000
Busherf	0.323	0.260	0.216	0.068	1.000
Geoherf	0.441	0.312	0.366	0.030	1.000
Reg%	0.255	0.000	0.370	0.000	1.000
Max%	0.876	0.961	0.218	0.000	1.000
Prov%	0.414	0.356	0.347	0.000	1.000

Notes: The full sample includes firm-line-years during 1990-2010. The regression sample includes firm-years for 1991-2010. *High (A-, Low)* indicates rating of A or above (A-, B+ + or below). *Down* equals 1 if rating downgrade during year, 0 otherwise. *Up* equals 1 if rating upgrade during year, 0 otherwise. *Prop. of Uncover* is the proportion of uncovered direct premiums to the total direct premiums. *Portfolio_Risk (sigma)* and *default-value-to-liability ratio* (*risk*) are calculated as in Myers and Read (2001). Anticipaton is the average value of *default-value-to-liability ratio* for the year's t-1 and t-2. *Size* is logarithm of total asset. *Leverage* is the ratio of total liability to total asset. *Directw* equals 1 if direct writer, 0 otherwise. *Mutual* equals 1 if mutual company, 0 otherwise. *Group* equals 1 if an insurer is affiliated to a group, 0 otherwise. *Busherf* is calculated by the sum of the squares of the percentages of direct premium written across all lines of business. *Geoherf is* calculated by the sum of the squares of the percentages of direct premium written across all states. *Reg%* is the percentage of the insurer's direct premium written in states with prior approval or state made rate regulation. *Max%* is the percentage of the insurer's direct premium written in states with guaranty fund exceeding $300,000. *Prov%* is the percentage of the insurer's direct premium written in states with net worth provision above $25,000,000.

Table 4 Number and percentage of sample firm-line-years uncovered by state guaranty funds, by rating categories

	Rating	No. of firms at t-1	%Total	No change at t	% No change	Upgrade at t	%Upgrade	Downgrade at t	%Downgrade
High	**A++**	2392	8.67%	2158	90.22%	0	0.00%	234	9.78%
	A+	7869	28.52%	7027	89.30%	262	3.33%	580	7.37%
	A	8839	32.03%	7798	88.22%	471	5.33%	570	6.45%
	Total	19100	69.22%	16983	88.92%	733	3.84%	1384	7.25%
	A-	6168	22.35%	5259	85.26%	635	10.30%	274	4.44%
Low	**B++**	967	3.50%	649	67.11%	234	24.20%	84	8.69%
	B+	931	3.37%	583	62.62%	299	32.12%	49	5.26%
	B	296	1.07%	200	67.57%	83	28.04%	13	4.39%
	B-	87	0.32%	45	51.72%	35	40.23%	7	8.05%
	C++	12	0.04%	3	25.00%	9	75.00%	0	0.00%
	C+	20	0.07%	10	50.00%	9	45.00%	1	5.00%
	C	13	0.05%	7	53.85%	6	46.15%	0	0.00%
	Total	2326	8.43%	1497	64.36%	675	29.02%	154	6.62%
Total		27594	100.00%	23739	86.03%	2043	7.40%	1812	6.57%
Before crisis (2005-2007)		3637	13.18%	3330	91.56%	193	5.31%	114	3.13%
During crisis (2008-2010)		4056	14.70%	3693	91.05%	188	4.64%	175	4.31%

Table 5 Number and percentage of sample firm-line-years covered by state guaranty funds, by rating categories

	Rating	No. of firms at t-1	%Total	No change at t	% No change	Upgrade at t	%Upgrade	Downgrade at t	%Downgrade
High	**A++**	6377	5.99%	5676	89.01%	0	0.00%	701	10.99%
	A+	26437	24.82%	23545	89.06%	733	2.77%	2159	8.17%
	A	32063	30.10%	28224	88.03%	1427	4.45%	2412	7.52%
	Total	64877	60.91%	57445	88.54%	2160	3.33%	5272	8.13%
A-		24534	23.04%	21112	86.05%	2091	8.52%	1331	5.43%
Low	**B++**	6355	5.97%	4736	74.52%	1109	17.45%	510	8.03%
	B+	6303	5.92%	4395	69.73%	1429	22.67%	479	7.60%
	B	2789	2.62%	1983	71.10%	599	21.48%	207	7.42%
	B-	978	0.92%	592	60.53%	298	30.47%	88	9.00%
	C++	276	0.26%	146	52.90%	109	39.49%	21	7.61%
	C+	238	0.22%	115	48.32%	101	42.44%	22	9.24%
	C	156	0.15%	85	54.49%	63	40.38%	8	5.13%
	Total	17095	16.05%	12052	70.50%	3708	21.69%	1335	7.81%
Total		106506	100.00%	90609	85.07%	7959	7.47%	7938	7.45%
Before crisis (2005-2007)		15075	14.15%	13708	90.93%	915	6.07%	452	3.00%
During crisis (2008-2010)		15592	14.64%	14161	90.82%	727	4.66%	704	4.52%

Table 6 Number and percentage of rated sample firm-line-years uncovered by state guaranty funds

Year t	Number of firms at t-1	no change at t	%no change	Downgrade at t	% Downgrade	Upgrade at t	% Upgrade
1990	1375	1224	89.02%	65	4.73%	86	6.25%
1991	1400	1213	86.64%	86	6.14%	101	7.21%
1992	1547	1032	66.71%	191	12.35%	324	20.94%
1993	1618	1399	86.46%	50	3.09%	169	10.44%
1994	1648	1329	80.64%	81	4.92%	238	14.44%
1995	1674	1468	87.69%	119	7.11%	87	5.20%
1996	1320	1163	88.11%	86	6.52%	71	5.38%
1997	1062	924	87.01%	62	5.84%	76	7.16%
1998	1236	1116	90.29%	74	5.99%	46	3.72%
1999	1159	960	82.83%	51	4.40%	148	12.77%
2000	1165	947	81.29%	70	6.01%	148	12.70%
2001	1032	836	81.01%	134	12.98%	62	6.01%
2002	1053	885	84.05%	138	13.11%	30	2.85%
2003	1289	1053	81.69%	206	15.98%	30	2.33%
2004	1323	1167	88.21%	110	8.31%	46	3.48%
2005	1246	1100	88.28%	63	5.06%	83	6.66%
2006	1153	1062	92.11%	38	3.30%	53	4.60%
2007	1238	1168	94.35%	13	1.05%	57	4.60%
2008	1350	1229	91.04%	32	2.37%	89	6.59%
2009	1403	1230	87.67%	117	8.34%	56	3.99%
2010	1303	1234	94.70%	26	2.00%	43	3.30%

Year t	Number of firms at t-1	no change at t	%no change	Downgrade at t	% Downgrade	Upgrade at t	% Upgrade
1990	5199	4610	88.67%	293	5.64%	296	5.69%
1991	5150	4406	85.55%	449	8.72%	295	5.73%
1992	5291	3695	69.84%	781	14.76%	815	15.40%
1993	5755	5042	87.61%	236	4.10%	477	8.29%
1994	5950	4815	80.92%	496	8.34%	639	10.74%
1995	6058	4962	81.91%	745	12.30%	351	5.79%
1996	5051	4335	85.82%	394	7.80%	322	6.37%
1997	4252	3572	84.01%	309	7.27%	371	8.73%
1998	4529	3865	85.34%	331	7.31%	333	7.35%
1999	4462	3613	80.97%	163	3.65%	686	15.37%
2000	4403	3456	78.49%	269	6.11%	678	15.40%
2001	4153	3226	77.68%	561	13.51%	366	8.81%
2002	4610	3898	84.56%	457	9.91%	255	5.53%
2003	5403	4400	81.44%	812	15.03%	191	3.54%
2004	5573	4845	86.94%	486	8.72%	242	4.34%
2005	5052	4526	89.59%	205	4.06%	321	6.35%
2006	4841	4409	91.08%	128	2.64%	304	6.28%
2007	5182	4773	92.11%	119	2.30%	290	5.60%
2008	5258	4798	91.25%	163	3.10%	297	5.65%
2009	5159	4657	90.27%	376	7.29%	126	2.44%

2010	5175	4706	90.94%	165	3.19%	304	5.87%

Table 7 Number and percentage of rated sample firm-line-years covered by state guaranty funds

Table 8 Mean and Median abnormal premium growth for downgraded insurers for uncovered- and covered-group at firm-line-year level, 1990-2010

Panel A shows the adjusted mean (median) abnormal premium growth rate for downgrades. Panel B shows it for upgrades. The uncovered-group is defined as lines with a proportion of uncovered premiums greater than or equal to 25%. The covered-group is defined as lines with a proportion of uncovered premiums less than 25%. Time, line, and size adjusted mean [median] abnormal premium growth in year t equals the firm-line's time, line, and size adjusted premium growth in year t minus the mean [median] time, line, and size adjusted premium growth in year t for firm-lines in the same rating category with no rating change in year t. Medians are reported in square parentheses. Significance of tests of differences in means are based on a two-tailed t-test and the difference in medians are based on a two-sided nonparametric Wilcoxon rank sum test. The one-tailed t-test standard error are reported in parentheses. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1, 5, and 10 percent levels, respectively.

A. Downgrades	**High**			**A-**			**Low**		
	t-1	t	t+1	t-1	t	t+1	t-1	t	t+1
Uncovered group	-1.16% (0.02) [-0.15%]	**-6.30%***** **(0.02)** **[-3.45%]**	**-9.08%***** **(0.02)** **[-3.14%]**	-3.86% (0.05) [-3.80%]	**-26.25%***** **(0.04)** **[-16.61%]**	**-32.28%***** **(0.05)** **[-31.41%]**	0.96% (0.06) [-2.82%]	**-18.05%***** **(0.06)** **[-7.85%]**	**-23.64%***** **(0.07)** **[-19.63%]**
	10241 no change; 827 downgrades			3051 no change; 162 downgrades			879 no change; 98 downgrades		
Covered group	-1.25% (0.01) [-0.66%]	**-4.62%***** **(0.01)** [-0.22%]	**-6.54%***** **(0.01)** **[-3.95%]**	0.70% (0.01) [-0.03%]	**-11.83%***** **(0.01)** **[-5.25%]**	**-17.76%***** **(0.01)** **[-8.84%]**	-1.99% (0.01) [-1.94%]	**-11.79%***** **(0.01)** **[-6.46%]**	**-15.31%***** **(0.01)** **[-8.80%]**
	51869 no change; 4822 downgrades			19380 no change; 1224 downgrades			11655 no change; 1287 downgrades		
Mean difference	0.09%	-1.68%	-2.54%	-4.56%	**-14.42%****	**-14.52%*****	2.92%	**-6.26%***	**-8.33%****
Median difference	0.51%	-3.23%	0.81%	-3.77%	**-11.36%*****	**-22.57%*****	-0.88%	-1.39%	**-10.83%****

B. Upgrades	**High**			**A-**			**Low**		
	t-1	t	t+1	t-1	t	t+1	t-1	t	t+1
Uncovered group	-3.31% (0.03) **[-4.90%]**	-2.96% (0.03) [0.25%]	0.39% (0.03) [0.49%]	-2.11% (0.03) [-1.97%]	-1.32% (0.03) [-3.22%]	-0.72% (0.03) [0.84%]	-2.71% (0.03) [-1.91%]	**9.45%***** **(0.03)** **[7.32%]**	**8.03%***** **(0.03)** **[4.55%]**
	10241 no change; 422 upgrades			3051 no change; 372 upgrades			879 no change; 414 upgrades		
Covered group	-0.01% (0.01) [0.01%]	-0.26% (0.01) [0.30%]	-1.16% (0.01) [-0.24%]	**1.80%**** **(0.01)** [0.18%]	-0.06% (0.01) [-0.88%]	0.59% (0.01) [1.84%]	-1.86%*** (0.01) [-1.10%]	**2.33%***** **(0.01)** **[1.13%]**	**4.99%***** **(0.01)** **[3.10%]**
	51869 no change; 1939 upgrades			19380 no change; 1886 upgrades			11655 no change; 3494 upgrades		
Mean difference	-3.30%	-2.70%	1.55%	-3.91%	-1.26%	-1.31%	-0.85%	**7.12%*****	**3.04%***
Median difference	**-4.91%****	-0.05%	0.73%	-2.15%	-2.34%	-1.00%	-0.81%	**6.19%*****	1.45%

Table 9 Guaranty funds and market discipline on premium growth

The dependent variable is ΔLog Premium$_t$. The sample consists of 107,141 firm-line-years. Premium growth is truncated at -1 and 1. Anticipation is the average value of default-value-to-liability ratio (*Risk*) calculated as in Myers and Read (2001) for the year's t-1 and t-2. The *Firm Control* variables include *Size, Leverage, Group, Mutual, Geoherf, Busherf, Reg%, Max%, Prov%* and *Directw* (these variables are defined in Table 3). The *Vector of Rating & Prop Uncover* include the proportion of uncovered premiums, the interaction of the proportion of uncovered premiums with rating categories, and all the variables of rating upgrades and downgrade and rating categories as shown in Table 3. The last column shows the results of Two-Stage Least Square estimates of ΔLog Premium $_t$. The proportion of uncovered premiums is instrumented by its value lagged of three years, *Size, Geoherf, Busherf, Mutual* and *Group* in the first stage of regression and the predicted value is used in the second stage. The interaction of the proportion of uncovered premiums with a linear trend is included in 2SLS. The sample for 2SLS regression includes 101,867 as the data of 1991 is deleted. Standard errors are adjusted for firm-line-level clustering. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	OLS		**F.E. (1)**		**F.E. (2)**		**2SLS**	
Regressor	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**
Log premium $_{t-1}$	-0.025***	0.001	-0.039***	0.001	-0.040***	0.001	-0.039***	0.001
Prop. of Uncovered Premiums	-0.031***	0.007	0.041***	0.015	0.041***	0.015	0.003	0.020
Prop. Uncover×High$_{t-2}$×Down $_{t-1}$	0.010	0.023	0.007	0.023	0.008	0.026	0.013	0.025
Prop. Uncover×High $_{t-1}$ ×Down $_t$	-0.005	0.022	-0.012	0.022	-0.012	0.028	-0.013	0.023
Prop. Uncover ×High $_t$ ×Down $_{t+1}$	-0.010	0.015	-0.007	0.015	-0.007	0.017	-0.007	0.017
Prop. Uncover × A- $_{t-2}$×Down $_{t-1}$	-0.047	0.070	-0.000	0.074	0.008	0.075	0.035	0.081
Prop. Uncover ×A- $_{t-1}$×Down $_t$	-0.220***	0.055	-0.175***	0.058	-0.182***	0.057	-0.179***	0.062
Prop. Uncover ×A- $_t$ ×Down $_{t+1}$	-0.075**	0.032	-0.063**	0.032	-0.062**	0.031	-0.059*	0.032
Prop. Uncover × Low $_{t-2}$× Down $_{t-1}$	-0.072	0.103	-0.060	0.095	-0.035	0.099	-0.050	0.109
Prop. Uncover × Low $_{t-1}$× Down $_t$	-0.097	0.072	-0.171**	0.081	-0.171**	0.080	-0.193**	0.088
Prop. Uncover × Low $_t$× Down $_{t+1}$	0.019	0.042	-0.011	0.041	-0.007	0.046	-0.017	0.048
Prop. Uncover × High $_{t-2}$× Up $_{t-1}$	0.051*	0.028	0.047*	0.027	0.047	0.031	0.050*	0.028
Prop. Uncover × High $_{t-1}$× Up $_t$	-0.045	0.029	-0.042	0.029	-0.042	0.035	-0.043	0.036
Prop. Uncover × High $_t$× Up $_{t+1}$	-0.042	0.030	-0.040	0.030	-0.039	0.032	-0.090**	0.036
Prop. Uncover × A- $_{t-2}$× Up $_{t-1}$	0.038	0.028	0.023	0.029	0.025	0.034	0.043	0.038
Prop. Uncover × A- $_{t-1}$× Up $_t$	-0.009	0.032	-0.017	0.034	-0.021	0.036	-0.000	0.038
Prop. Uncover × A- $_t$ × Up $_{t+1}$	-0.053*	0.032	-0.071**	0.033	-0.080**	0.032	-0.014	0.047
Prop. Uncover × Low $_{t-2}$ × Up $_{t-1}$	0.031***	0.015	0.036**	0.015	0.040***	0.015	0.046***	0.016
Prop. Uncover × Low $_{t-1}$ × Up $_t$	0.038	0.034	0.039	0.034	0.041	0.040	0.016	0.041
Prop. Uncover × Low $_t$ × Up $_{t+1}$	0.001	0.035	0.015	0.040	0.010	0.041	0.015	0.046
Anticipation	—	—	—	—	0.075	0.272	0.592	0.441
Vector of Rating & Prop. Uncover	YES		YES		YES		YES	
Firm Fixed Effects	NO		YES		YES		YES	
Line Fixed Effects	NO		YES		YES		YES	
Year Fixed Effects	NO		YES		YES		YES	
Firm & Guaranty funds Controls	NO		NO		YES		YES	
Prop. Uncover ×Trend	NO		NO		NO		YES	
R^2	0.033		0.126		0.130		0.133	
Observations	107,141		107,141		107,141		101,867	

Table 10 Regression for market discipline and guaranty fund at firm-line-state-year level, state variation

The dependent variable is premium growth. The sample is at firm-line-state-year level and the period is 1990-2010. Regressions include only firms with a ratings downgrade. *Uncover* equals 1 if the premiums in a state are uncovered by guaranty funds, 0 otherwise. Traditional lines exclude ocean marine, fidelity, surety, credit, title, financial guaranty, mortgage guaranty and warranty. Only covered insurers are included in the sample for the last two columns. *Uncover* equals 1 if the maximum amount of claims paid is less than $300,000, 0 otherwise. The control variables include the logarithm of lagged premium, firm-line-year and state fixed effects. Standard errors are adjusted for state clustering, and are reported in column. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	State Variation						
Downgrades	**All lines**	**Traditional Lines**	**Nontraditional lines**	**Personal lines**	**Commercial lines**	**Personal lines (Max claim paid)**	**Commercial lines (Max claim paid)**
Log Premium $_{t-1}$	-0.092***	-0.091***	-0.099***	-0.031***	-0.096***	-0.033***	-0.117***
	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)
Uncover × High	-0.028**	0.041	-0.068***	0.121	-0.029**	-0.033*	0.016
	(0.011)	(0.025)	(0.015)	(0.099)	(0.011)	(0.019)	(0.012)
Uncover × A-	-0.168***	-0.218***	-0.107***	0.027	-0.175***	-0.037	0.008
	(0.031)	(0.042)	(0.038)	(0.132)	(0.031)	(0.034)	(0.017)
Uncover × Low	-0.121***	-0.166***	-0.062	-0.157	-0.124***	-0.023	0.059**
	(0.034)	(0.041)	(0.061)	(0.457)	(0.034)	(0.038)	(0.023)
Firm –Line –Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES
State Fixed Effects	YES	YES	YES	YES	YES	YES	YES
R^2	0.422	0.424	0.407	0.440	0.423	0.449	0.458
Observations	201,071	182,444	18,627	9921	191150	26,375	97,399

Table 11 Regression for market discipline and guaranty fund at firm-line-state-year level, line of business variation

The dependent variable is premium growth. The sample is at firm-line-state-year level and the period is 1990-2010. Regressions include only firms with a ratings downgrade. *Uncover* equals 1 if the premiums in a state are uncovered by guaranty funds, 0 otherwise. Traditional lines exclude ocean marine, fidelity, surety, credit, title, financial guaranty, mortgage guaranty and warranty. The set of control variables include logarithm of lagged premium, firm-state-year and insurance line of business fixed effects. Standard errors are adjusted for line of business cluster, and are reported in column. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	All lines	**Traditional Lines**	**Nontraditional lines**
Log Premium $_{t-1}$	-0.063***	-0.066***	-0.038***
	(0.005)	(0.005)	(0.009)
Uncover × High	-0.077***	-0.070*	-0.052
	(0.019)	(0.035)	(0.036)
Uncover × A-	-0.043	0.004	-0.038
	(0.054)	(0.090)	(0.063)
Uncover × Low	-0.070	0.204	-0.555**
	(0.084)	(0.167)	(0.207)
Firm –State –Year Fixed Effects	YES	YES	YES
Line Fixed Effects	YES	YES	YES
R^2	0.430	0.449	0.769
Observations	201,071	182,444	18,627

Table 12 Market discipline on insurance price growth at firm-line-years

The dependent variables are ΔLog $Price_t$ for first three regressions. The dependent variable of the last regression (2SLS) is ΔLog $Premium_t$. The sample includes 73,314 firm-line-years with calculating insurance price as in Cummins and Danzon (1997) during 1990-2010 for the first three regressions. The third regression uses calculating insurance price by direct business written instead of business net of reinsurance. The 2SLS (ΔLog Premium t) regression uses predicted price growth, which is instrumented by lagged log price, rating vectors and firm and guaranty funds control variables. Firm and guaranty funds control variables include *Size, Leverage, Group, Mutual, Geoherf, Busherf, Reg%, Max%, Prov%* and *Direct writer*. Firm fixed effects, year fixed effects and insurance line of business fixed effects are included in all fixed effects regressions. Standard errors are adjusted for firm-line-level clustering, and are reported in column. ∗∗∗, ∗∗, and ∗ denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	OLS		**F.E.**		**F.E. (Direct Business)**		**2SLS (ΔLog Premium t)**	
	Coeff.	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**
Log price $_{t-1}$	-0.364***	0.006	-0.428***	0.007	-0.467***	0.007	—	—
Predicted ΔLog Price $_t$	—	—	—	—	—	—	-0.003	0.005
A-	-0.003	0.007	0.002	0.012	-0.017	0.013	-0.007	0.004
Low	0.001	0.010	0.041***	0.016	-0.034	0.022	-0.018***	0.006
High$_{t-2}$×Down $_{t-1}$	0.009	0.013	-0.012	0.013	0.002	0.015	-0.016**	0.007
High $_{t-1}$ ×Down $_t$	-0.010	0.012	-0.024*	0.012	0.029**	0.014	-0.046***	0.007
High $_t$ ×Down $_{t+1}$	-0.038***	0.009	-0.019**	0.010	-0.048***	0.011	-0.003	0.005
A- $_{t-2}$×Down $_{t-1}$	0.014	0.036	-0.014	0.036	-0.013	0.033	-0.049***	0.015
A- $_{t-1}$×Down $_t$	-0.012	0.031	0.001	0.031	-0.080**	0.031	-0.106***	0.016
A- $_t$ ×Down $_{t+1}$	-0.070***	0.019	-0.047**	0.019	-0.045**	0.018	-0.001	0.010
Low $_{t-2}$× Down $_{t-1}$	0.036	0.033	0.022	0.035	-0.002	0.032	-0.039**	0.016
Low $_{t-1}$× Down $_t$	-0.035	0.028	-0.043	0.029	-0.040	0.026	-0.092***	0.015
Low $_t$× Down $_{t+1}$	-0.085***	0.017	-0.056***	0.018	-0.042**	0.018	-0.002	0.009
High $_{t-2}$× Up $_{t-1}$	-0.004	0.017	-0.015	0.017	-0.002	0.021	-0.019*	0.011
High $_{t-1}$× Up $_t$	-0.046**	0.020	-0.037*	0.020	-0.001	0.022	-0.010	0.010
High $_t$× Up $_{t+1}$	-0.040*	0.021	-0.026	0.021	0.001	0.026	0.006	0.011
A- $_{t-2}$× Up $_{t-1}$	0.024	0.020	0.035*	0.020	0.001	0.020	-0.018	0.012
A- $_{t-1}$× Up $_t$	0.048**	0.020	0.048**	0.020	0.037*	0.022	-0.013	0.012
A- $_t$ × Up $_{t+1}$	-0.011	0.022	-0.003	0.022	0.021	(0.023	0.004	0.011
Low $_{t-2}$ × Up $_{t-1}$	-0.001	0.008	0.003	0.009	0.006	0.009	0.021***	0.005
Low $_{t-1}$ × Up $_t$	0.050***	0.016	0.031*	0.017	0.007	0.018	0.023***	0.008
Low $_t$ × Up $_{t+1}$	-0.006	0.017	-0.017	0.017	0.015	0.018	-0.015*	0.008
Anticipation	—	—	-1.224***	0.427	-0.763	0.471	-0.052	0.264
Firm & Guaranty Funds Controls	NO		YES		YES		YES	
Firm Fixed Effects	NO		YES		YES		YES	
Line Fixed Effects	NO		YES		YES		YES	
Year Fixed Effects	NO		YES		YES		YES	
R^2	0.208		0.267		0.250		0.212	
Observations	73,314		73,314		83,844		73,314	

Table 13 Guaranty fund and market discipline on insurance price growth

The dependent variable is ΔLog Price $_t$. for first three regressions. The dependent variable of the last regression (2SLS) is ΔLog Premium$_t$. The sample period is 1990-2010. The sample consists of 73,314 firm-line-years with positive calculated insurance price. Firm and guaranty funds controls include Size, Anticipation, Group, Mutual, Geoherf, Busherf, Reg%, Max%, Prov%, and Direct writer. Vector of Rating & Prop Uncover include the proportion of uncovered premiums, the interaction of the proportion of uncovered premiums with rating categories, and all the variables of rating upgrade, rating downgrade, rating categories as shown in table 18. Firm controls are included in the second fixed effect regression. The last column shows the results of Two-Stage Least Square estimates of ΔLog Price $_t$. The last two regressions use 2SLS. The proportion of uncovered premiums is instrumented by its value lagged of three years, *Size*, *Geoherf*, *Busherf*, *Mutual* and *Group* in the first stage of 2SLS (price growth) regression. The 2SLS (ΔLog Premium$_t$) regression uses predicted price growth, which is instrumented by lagged log price, rating vectors and firm and guaranty funds control variables in the first stage. The interaction of the proportion of uncovered premiums with a linear trend is included in 2SLS. The sample for 2SLS regression includes 69480 since the data of 1991 is deleted. Standard errors are adjusted for firm-line-level clustering. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	OLS		**F.E.**		**2SLS (price growth)**		**2SLS (ΔLog Premium $_t$)**	
	Coeff.	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**
Log price $_{t-1}$	-0.392***	0.006	-0.459***	0.007	-0.463***	0.007	—	—
Predicted ΔLog Price $_t$	—	—	—	—	—	—	-0.003	0.005
Prop. Uncovered Direct Premium	0.060***	0.017	0.094***	0.034	0.127***	0.044	0.031***	0.016
Prop. Uncover×High$_{t-2}$×Down $_{t-1}$	-0.013	0.061	-0.026	0.064	-0.090	0.068	-0.002	0.027
Prop. Uncover×High $_{t-1}$ ×Down $_t$	0.040	0.049	0.006	0.051	0.031	0.054	-0.001	0.027
Prop. Uncover ×High $_t$ ×Down $_{t+1}$	-0.056	0.036	-0.037	0.037	-0.048	0.040	0.005	0.018
Prop. Uncover × A- $_{t-2}$×Down $_{t-1}$	-0.389**	0.169	-0.269	0.170	-0.380**	0.191	-0.176**	0.080
Prop. Uncover ×A- $_{t-1}$×Down $_t$	0.201	0.155	0.218*	0.129	0.213	0.158	-0.135**	0.064
Prop. Uncover ×A- $_t$ ×Down $_{t+1}$	-0.039	0.080	-0.033	0.077	-0.110	0.077	-0.044	0.038
Prop. Uncover × Low $_{t-2}$× Down $_{t-1}$	0.465*	0.270	0.461	0.280	0.464	0.322	0.223	0.141
Prop. Uncover × Low $_{t-1}$× Down $_t$	0.085	0.152	0.175	0.183	0.159	0.224	-0.086	0.073
Prop. Uncover × Low $_t$× Down $_{t+1}$	0.193*	0.107	0.224**	0.110	0.087	0.119	0.077	0.052
Prop. Uncover × High $_{t-2}$× Up $_{t-1}$	-0.076	0.065	-0.080	0.064	-0.102	0.070	0.035	0.031
Prop. Uncover × High $_{t-1}$× Up $_t$	0.112*	0.066	0.120*	0.067	0.122*	0.068	-0.038	0.032
Prop. Uncover × High $_t$× Up $_{t+1}$	0.010	0.094	0.006	0.089	0.032	0.109	-0.037	0.028
Prop. Uncover × A- $_{t-2}$× Up $_{t-1}$	-0.057	0.076	-0.094	0.079	-0.085	0.084	0.065**	0.031
Prop. Uncover × A- $_{t-1}$× Up $_t$	-0.081	0.078	-0.089	0.080	-0.116	0.083	-0.015	0.033
Prop. Uncover × A- $_t$ × Up $_{t+1}$	-0.103	0.075	-0.095	0.078	-0.058	0.090	-0.058	0.038
Prop. Uncover × Low $_{t-2}$ × Up $_{t-1}$	0.068*	0.036	0.091**	0.037	0.118***	0.038	0.009	0.017
Prop. Uncover × Low $_{t-1}$ × Up $_t$	-0.083	0.094	-0.103	0.095	-0.063	0.102	-0.028	0.035
Prop. Uncover × Low $_t$ × Up $_{t+1}$	-0.100	0.092	-0.095	0.099	-0.157	0.108	-0.094**	0.042
Anticipation	—	—	-0.996**	0.403	-1.267	0.787	0.065	0.362
Vector of Rating & Prop. Uncover	YES		YES		YES		YES	
Firm, Line, & Year Fixed Effects	NO		YES		YES		YES	
Firm & Guaranty funds Controls	NO		YES		YES		YES	
Prop. Uncover ×Trend	NO		NO		YES		YES	
R^2	0.209		0.268		0.271		0.213	
Observations	73314		73314		69480		73,314	

Table 14 Market discipline and guaranty fund surrounding financial crisis

The dependent variable is premium growth. The sample period is 2005-2010. Crisis is an indicator variable equal to 1 for the year in or after 2008, and 0 otherwise. Growth control is Log Premium $_{t-1}$. Firm control variables include Anticipation, Size, Leverage, Group, Mutual, Geoherf, Busherf, Reg%, Max%, Prov%, and Direct writer. The set of other control variables include year fixed effects, insurance line fixed effects and the interaction of the proportion of uncovered premiums with a linear trend. The 2SLS regressions use predicted price growth, which is instrumented by lagged log price, rating vectors and firm and guaranty funds control variables. Standard errors are adjusted for firm-line-level clustering. ***, **, and * denote statistical significance at the 1, 5, and 10 percent levels, respectively.

	ΔLog Premium $_t$ (1)		**ΔLog Premium $_t$ ---2SLS (1)**		**ΔLog Premium $_t$ (2)**		**ΔLog Premium $_t$ ---2SLS (2)**	
Regressor	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**	**Coeff.**	**Robust Err.**
Crisis	-0.028***	0.006	-0.104***	0.036	-0.019***	0.006	0.020***	0.006
Down $_{t-1}$	-0.013	0.014	-0.022*	0.012	-0.026*	0.014	-0.026**	0.011
Down $_{t-}$	0.008	0.017	0.013	0.015)	0.003	0.016	-0.002	0.014
Down $_{t+1}$	-0.011	0.012	-0.011	0.010	-0.002	0.012	-0.008	0.009
Up $_{t-1}$	-0.032***	0.012	-0.016	0.010	0.054***	0.011	0.033***	0.009
Up $_t$	0.049***	0.010	0.032***	0.009	-0.033***	0.013	-0.014	0.011
Up $_{t+1}$	-0.038***	0.012	-0.014	0.010	-0.039***	0.012	-0.009	0.010
Crisis ×Down $_{t-1}$	-0.007	0.022	-0.007	0.020	0.097*	0.053	0.034	0.056
Crisis ×Down $_t$	-0.066***	0.022	-0.071***	0.021	0.041	0.067	0.132**	0.062
Crisis ×Down $_{t+1}$	0.003	0.015	0.013	0.014	-0.069	0.045	-0.037	0.043
Crisis ×Up $_{t-1}$	-0.012	0.015	-0.046***	0.013	-0.035	0.040	-0.015	0.034
Crisis ×Up $_t$	0.038**	0.017	0.015	0.015	0.005	0.046	-0.023	0.038
Crisis ×Up $_{t+1}$	0.017	0.018	0.006	0.019	0.017	0.052	-0.053	0.058
Prop. Uncovered premiums					0.025	0.024	0.008	0.021
Prop. Uncover × Crisis					-0.032	0.027	0.026	0.036
Prop. Uncover × Down $_{t-1}$					-0.004	0.023	-0.009	0.020
Prop. Uncover × Down $_t$					-0.032	0.022	-0.036*	0.021
Prop. Uncover × Down $_{t+1}$					-0.006	0.016	0.003	0.014
Prop. Uncover × Up $_{t-1}$					-0.042***	0.015	-0.054***	0.013
Prop. Uncover × Up $_t$					0.041**	0.017	0.018	0.016
Prop. Uncover × Up $_{t+1}$					0.014	0.019	0.007	0.020
Prop. Uncover × Crisis ×Down $_{t-1}$					-0.027	0.086	0.006	0.082
Prop. Uncover × Crisis ×Down $_t$					-0.241***	0.083	-0.294***	0.087
Prop. Uncover × Crisis ×Down $_{t+1}$					0.074	0.055	0.078	0.060
Prop. Uncover × Crisis ×Up $_{t-1}$					0.196***	0.055	0.070	0.059
Prop. Uncover × Crisis ×Up $_t$					-0.024	0.067	-0.037	0.062
Prop. Uncover × Crisis ×Up $_{t+1}$					0.033	0.079	-0.007	0.081
Year & Line Fixed Effects	YES		YES		YES		YES	
Firm, Growth & Guaranty funds	YES		YES		YES		YES	
Prop. Uncover ×Trend	YES		YES		YES		YES	
R^2	0.039		0.290		0.042		0.290	
Firm-line-years observations	33,100		22,754		33,100		22,754	