Empirical Study of Adverse Selection and Moral Hazard in the Reinsurance Market

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Abstract

This study empirically tests the asymmetric information problem in the property and liability reinsurance market by separating adverse selection from moral hazard. Using the panel data from NAIC and A.M. Best Company, adverse selection is shown to exist between affiliated insurers and non-affiliated reinsurers, while there are mixed evidences on the presence of moral hazard for non-affiliated insurers. When affiliated insurers mostly use inside reinsurance within the group, the adverse selection problem still exists. For non-affiliated insurers, adverse selection instead of moral hazard arises from asymmetric information. Overall, our results, consistent with Garven and Grace (2007), provide supportive evidence on the presence of adverse selection, but mixed evidence on moral hazard in the reinsurance market.

1. Introduction

Reinsurance plays a significant role in the insurance market in which primary insurers can shift risk to reinsurers. However, like any other insurance, reinsurance is also subject to major asymmetric information problems such as adverse selection and moral hazard. In the case of reinsurance, the fact that high-risk primary insurers get better terms may indicate the presence of adverse selection. On the other hand, moral hazard exists when primary insurers loosen underwriting criteria, leading to higher losses than expected. In both cases, less informed reinsurers tend to suffer higher losses than expected as a result.

Compared to the individual insured, the incentive for an insurer to purchase reinsurance is more complicated because it involves risk management, operation capacity, or tax incentive issues. Based on its own characteristics, the insurer usually has a unique demand for reinsurance. As Mayer and Smith (1990) point out, ownership structure, firm size, geographic concentration and business lines concentration have significant effects on the demand for reinsurance.

Meanwhile, the complicated risk structure of an insurer may be reflected in multiple dimensions such as underwriting, operation, financing, or management. As a result, it is costly for a reinsurer to collect the complete information revealing the true risk of the insurer before signing an insurance transaction. In addition, adverse selection, which characterizes that high-risk firms tend to get better terms from reinsurers due to the hidden information, arises in this case. Therefore, both long-term contract and

retrospective rating that adjusts premiums based on the losses incurred during the current policy period are widely applied in the reinsurance industry to solve the asymmetric information problem. Jean-Baptiste and Santomero (2000) show that the new information included in the pricing of both future and past reinsurance coverages for long-term reinsurance contracts can enhance the allocation efficiency between primary insurers and reinsurers.

Later, Doherty and Smetters (2005) test the potential moral hazard problem between primary insurers and reinsurers. They find that loss-sensitive pricing is mainly used to control moral hazard between non-affiliated reinsurers and insurers. Garven and Grace (2007) further explore the adverse selection problem based on the theoretical predictions by Jean-Baptiste and Santomero (2000). Their results show that the adverse selection problem can be mitigated through long-term contracts.

While the aforementioned findings are consistent with theoretical predictions, they tend to focus only on one aspect of information asymmetry, either moral hazard or adverse selection, but not both at the same time. It is, therefore, of intellectual interest to distinguish adverse selection from moral hazard in the reinsurance market. Since both adverse selection and moral hazard problems can exist simultaneously in reinsurance contracts, examining and measuring their separated features are important to further detect adverse selection and moral hazard.

The common method to test asymmetric information in the insurance literature is based on the data from observable characteristics of the insured that are correlated with

outcomes. However, as Chiappori and Salanie (2000) point out, this method could lead to a reverse causality between adverse selection and moral hazard, which could make it more difficult to distinguish their separate effects. Several recent studies have used alternative methodologies to separate moral hazard from adverse selection. For example, Abbring et al. (2003) argue that using dynamic insurance data allows testing both moral hazard and adverse selection. Bajari, Hang, and Khwaja (2006) propose a structure model of consumer demand for health insurance and medical utilization and they find significant evidence of moral hazard and adverse selection in health insurance markets.

The purpose of our study is to extend the extant literature by examining the two well-known effects of asymmetric information in the reinsurance market. Specifically, our main contribution lies in separating adverse selection from moral hazard using a panel data collected from the National Association of Insurance Commissioners (NAIC) and A.M. Best Company.

The remaining of the paper proceeds as follows. Section 2 discusses the panel data and test methodology. Section 3 presents empirical test results and the summary is presented in Section 4.

2. Data and Methodology

2.1. Data

We use a panel data from the property and liability reinsurance market in the United States from 1990 to 2006. The data are collected from the National Association of

Insurance Commissioners (NAIC) Property and Liability Database. For each primary insurer, we collect reinsurance premium, direct loss, financial strength rating and other firm characteristics. We use the A.M. Best ratings as an indicator of each insurer's financial strength. The higher the Best rating, the stronger the financial strength of the insurer.

The whole sample includes 338 insurers, which is further grouped into 151 affiliated insurers and 187 non-affiliated insurers because risk management differs between affiliated and non-affiliated companies due to their unique financial structures.

2.2 Testable Hypotheses

The A.M. Best ratings are used as a proxy for insurers' financial strength. In the context of adverse selection, insurers with lower ratings tend to demand for more reinsurance because of either insufficient financial capability or loss experience. This leads to our first hypothesis with respect to adverse selection as follows:

- **Hypothesis 1**: Other things equal, the Best rating on primary insurers is negatively associated with reinsurance purchases.

Secondly, because the percentage of recovered loss from the last period is used to measure the moral hazard problem in practice, our second hypothesis with respect to moral hazard is specified below:

- **Hypothesis 2**: Other things equal, the percentage of recovered loss in the previous period is positively associated with reinsurance purchases.

2.3 Estimated Equations

To test the above hypotheses, we employee the following regression equation:

$$REINS_{i,t} = \alpha_{10} + \beta_{11} RAT_{i,t} + \beta_{12} LV_{i,t} + \beta_{13} \frac{L^R_{i,t-1}}{L^D_{i,t-1}} + \beta_{14} \frac{P^R_{i,t-1}}{L^R_{i,t-1}} + \beta_{15} LR_{i,t} + \sum_{j=1}^{K_1} \gamma_j X_{i,j,t} + u_{i,t}$$

(1)

where

$REINS_{i,t}$ = Reinsurance purchase for primary insurer i in year t;

$RAT_{i,t}$ = A.M. Best's rating for primary insurer i in year t;

$LV_{i,t}$ = Loss volatility of primary insurer i in year t;

$\frac{L^R_{i,t-1}}{L^D_{i,t-1}}$ = Percentage of recovered loss out of total direct loss for primary insurer i in year $t-1$;

$\frac{P^R_{i,t-1}}{L^R_{i,t-1}}$ = Proxy for the reinsurance price in which $P^R_{i,t-1}$ is the ceded reinsurance premium and $L^R_{i,t-1}$ is the recovered loss for primary insurer i in year $t-1$;

$LR_{i,t}$ = Direct loss normalized by direct written premium, equal to direct loss, $L^D_{i,t}$, divided by direct written premium, $DPW_{i,t}$, for primary insurer i in year t;

$X_{i,t}$ = A set of control variables, including company size, organization type, liquidity, leverage, return on equity, product Herfindahl index, geographic Herfindahl index, percent of business lines with long tail liabilities[1], reinsurance sustainability index,

[1] We follow the definition of long tail lines by Phillips, Cummins, and Allen (1998), which was later adopted by Garven and Grace (2007). Long tail lines include Farmowners Multiple Peril, Homeowners Multiple Peril, Commercial Multiple Peril, Ocean Marine, Medical Malpractice, International, Reinsurance,

effective tax rate, percentage of homeowner written premium in coastal states, and measure of internal reinsurance for primary insurer i in year t.

2.4 Variable Specifications

Reinsurance Purchase ($REINS_{i,t}$). Previous studies define reinsurance purchase differently. For example, Mayers and Smith (1990), Garven and Lanmm-Tenant (2003), and Cole and McCullough (2006) define *REINS* as follows:

$$REINS = \frac{Internal\ \&\ External\ ceded\ reinsurance\ premium}{Direct\ premium\ written + (\text{int}\, ernal + external\ assumed\ reinsurance\ premium)}$$

where "internal ceded reinsurance" refers to the intercompany reinsurance within the affiliates.

Alternatively, Garven and Grace (2007) define *REINS* below:

$$REINS = \frac{External\ ceded\ reinsurance\ premium - external\ assumed\ reinsurance\ premium}{Direct\ premium\ written + (\text{int}\, ernal + external\ assumed\ reinsurance\ premium)}$$ Be

cause they test adverse selection using non-affiliated insurance companies, the numerator of their ratio is the net ceded reinsurance premium, which creates a continuous variable ranging from -1 to +1.

However, as suggested by Doherty and Smetters (2005) that affiliates and non-affiliates use different mechanisms to control moral hazard, when an insurer and its reinsurer are affiliates, monitoring will control moral hazard since monitoring incurs a lower cost for affiliates. In contrast, for non-affiliates where monitoring is not feasible

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Workers' Compensation, Other Liability, Products Liability, Aircraft, Boiler and Machinery and Automobile Liability.

economically, reinsurance will control moral hazard with loss-sensitive premiums.

While Garven and Grace (2007) specifically test adverse selection for non-affiliates in the reinsurance market and obtain evidence supporting their theoretical predictions, it is still of interest to explore how their results will change if we include both affiliates and non-affiliates when testing adverse selection and moral hazard simultaneously using separate definitions for *REINS*. For affiliated insurers, reinsurance purchase is defined as:

$$REINS = \frac{Internal\ \ ceded\ reinsurance\ \text{Pr}emium}{Direct\ premium\ written + total\ assumed\ reinsurance}$$

For non-affiliated insurers, reinsurance purchase is defined as:

$$REINS = \frac{External\ \ ceded\ reinsurance\ \text{Pr}emium}{Direct\ premium\ written + total\ assumed\ reinsurance}$$

A.M. Best's Rating ($RAT_{i,t}$). We follow Mayer and Smith's (1990) method by converting Best's letter scales to numerical scales. Because Best's rating ranges form A++ to F, we assign numerical values from 6 to 0 accordingly[2].

Loss Volatility ($LV_{i,t}$). Loss volatility is used to reveal the true risk type of an insurer, and together with the Best rating, they further signify the adverse selection problem of the primary insurer. We will test two loss volatility measures on the demand for reinsurance. The first measure, proposed by Lei and Schmit (2008), defines loss volatility as the difference between current loss and previous year's loss divided by current written premium. To account for volatility over a longer period of time, the

[2] A value of 6 is assigned for companies with a Best's rating of A++ or A+, 5 for A or A-, 4 for B++ or B+, 3 for B or B-, 2 for C++ or C+, 1 for C or C-, and 0 for D, E, or F.

second measure is calculated as the difference between current loss and the average loss over the last three years normalized by total direct written premium.

Percentage of Recovered Loss in the Prior Period ($L^R_{i,t-1} / L^D_{i,t-1}$). This variable signals moral hazard and is defined as the percentage of recovered loss from reinsurance out of total loss from the previous year.

Normalized Direct Gross Loss ($LR_{i,t}$). Because reinsurance purchase is related to direct gross loss, $L^D_{i,t}$, we normalize it by the direct premium written, $DPW_{i,t,}$ to be consistent with the magnitude of reinsurance purchase, i.e., $LR_{i,t} = \left(\frac{L^D_{i,t}}{DPW_{i,t}} \right)$.

Proxy for Reinsurance Price in the Prior Period ($P^R_{i,t-1} / L^R_{i,t-1}$). This variable is computed as reinsurance premium divided by recovered loss. The higher the reinsurance premium, the lower the amount of reinsurance demanded.

Reinsurance Purchase in the Prior Period ($REINS_{i,t-1}$). In practice, reinsurance usually takes a long-term contract to allow for the arrival of new information in order to monitor the primary insurance company. The reinsurance purchase in the previous term is a useful reference mark for the next purchase. In the presence of moral hazard, purchasing more reinsurance in the previous period may reduce managerial incentives, thus increasing the loss possibility in the following year.

Size. The natural logarithm of total assets is included to control for company size.

Organization Type. To control for organization type on the demand for reinsurance,

a dummy variable is adopted. If an insurer is a public company, the dummy is equal to 1; otherwise, it is equal to 0. Different organization types affect risk diversification of the insurance companies. For a public insurer, it is capable of spreading operating risks to its stockholders, while a private insurer has limited resources to deal with risks. This suggests private insurers demand more reinsurance than public insurers.

Liquidity. It is defined as net working capital, which measures an insurer's capability to settle claims in a timely manner. Lower liquidity means more demand for reinsurance to relieve tight financial constraints for claim settlements.

Leverage. It is measured as debt ratio.

Return on Equity. It measures how much return a primary insurance company earns on its equity.

Reinsurance Sustainability Index. It measures the percentage of premiums ceded over a three-year period to external reinsurers that are present in all three years. The higher percentage, the more important the longer term contracting relationship.

Product Herfindahl Index ($\sum_{l=1}^{n}(\frac{DPW_l}{TDPW})^2$). This variable captures the product diversity of an insurer, where DPW_l denotes direct premium written from business line l and $TDPW$ is total direct premium written for an insurer. The smaller the index, the more diversified business lines of the company.

Geographic Herfindahl Index ($\sum_{s=1}^{50}(\frac{DPW_s}{TDPW})^2$). This variable captures the

geographic diversification in operations of an insurer, where DPW_s is direct premium written in state s and $TDPW$ is total direct premium written for an insurer. The smaller the index, the more diversified geographically.

Percentage of Long-Tail Business Lines. The previous literature (for example, Garven and Grace, 2007) shows that long-tail business lines increase a primary insurer's reinsurance demand. We use it as a control variable to predict the reinsurance demand.

Measure of Internal Reinsurance. Following Garven and Grace (2007), we use "Internal" as another control variable, where $Internal = \frac{\text{int}\,ernal\ ceded\ reinsurance - \text{int}\,ernal\ assumed\ reinsurance}{external\ ceded\ reinsurance - external\ assumed\ reinsurance}$. The higher the ratio, the less expected demand for external reinsurance. Internal reinsurance is not available for non-affiliated insurers.

2.5 Some Econometric issues

Endogeneity. Since direct loss may be related to previous period's reinsurance purchase in the presence of moral hazard, the explanatory variable $LR_{i,t}$ in Equation (1) can be endogenous. To correct for endogeneity, we apply the instrumental variable approach adopted by Wooldridge (2002).

Intuitively, because direct loss is positively related to insurance premium, we choose lagged direct written premium (in logarithm) as an instrumental variable. We also choose lagged direct loss ($LR_{i,t-1}$) and two lagged reinsurance purchases ($REIN_{i,t-1}$ and $REIN_{i,t-2}$) as additional instrumental variables. The inclusion of the latter can be used to test their respective effect on the concurrent loss incurred, which may arise due to the presence of

moral hazard with the reinsurance coverage. The reduced form of direct loss can thus be estimated by using all control variables ($X_{i,t}$) in Equation (1) and the above four instrumental variables as independent variables below:

$$LR_{i,t} = \alpha_{20} + \beta_{21} REINS_{i,t-1} + \beta_{22} REINS_{i,t-2} + \beta_{23} LR_{i,t-1} + \beta_{24} \ln(DPW)_{i,t-1} + \sum_{j=1}^{K_2} \gamma_j X_{i,j,t} + \varepsilon_{i,t}$$

(2)

Equation (1) is then rerun with the obtained residuals from Equation (2).

Heteroskedasticity. We also apply the White test to detect the potential heteroskedasticity problem. The corresponding White statistic is 2261.24 with a p-value of 0.00, which indicates that the model's residuals exhibit relatively a high level of heteroskedasticity. Therefore, the robust standard errors are used instead to improve the estimator efficiency in the presence of heteroskedasticity.

Individual Effect versus Pooled OLS: We use Breusch and Pagan's (1979) Lagrange Multiplier (LM) test to detect the presence of the individual effect that may be associated with the error term in Equation (1). The LM test statistic is 5217.6, indicating that the pooled OLS estimation is not appropriate for this model in the presence of the individual effect.

Fixed Effects versus Random Effects. Both fixed-effects and random-effects models can control the individual effect. A fixed-effects model assumes that the individual effect is correlated with the independent variables in the model, while a random-effects model assumes that there is no correlation. The Hausman test result shows that a fixed-effects

model is appropriate for our sample.

3 Empirical Results

Empirical analysis is undertaken at two levels. First, the demands for total reinsurance purchase for affiliated and non-affiliated insurers are tested, respectively. Two loss volatility measures are used to test the robustness of the model. Second, the reinsurance demand of affiliated insurers is examined in detail and the reinsurance purchases from affiliated reinsurers and non-affiliated reinsurers are analyzed separately to see if there is any different information asymmetry problem. Further, depending on whether reinsurance was bought from affiliated or non-affiliated reinsurers, the data associated with affiliated insurers are divided into two subgroups and tested.

3.1 Empirical Results for Affiliated Insurers

A. Test of Adverse Selection

First, we examine whether adverse selection exists. Table 1 and Table 2 report the regression results with two alternative loss volatility measures, respectively, for affiliated insurers. As shown in both Table 1 and Table 2, the coefficient of the Best rating is negative and statistically significant at the 1% level, thus supporting Hypothesis 1. Furthermore, the coefficients of the lagged recovered loss ratio reported in Table 1 and Table 2 are significantly positive, implying that insurers with higher recovered loss in the previous period tend to purchase more reinsurance. These findings suggest that adverse selection exists in reinsurance transactions from affiliated insurers, which contradicts the

common notion that affiliated insurers are supposed to suffer less asymmetrical information problem because they can buy reinsurance from the same insurance group. We argue that adverse selection may disappear between affiliated insurers and reinsurers with more information available, so we further divide our sample into two groups, depending on whether reinsurance was purchased from affiliated reinsurers or non-affiliated reinsurers.

Table 3 presents the regression results regarding affiliated insurers' reinsurance demand from affiliated, non-affiliated, and all reinsurers, respectively. Several findings are worthy noting. First, the coefficient of the Best rating is significantly and negatively related to the reinsurance demand when insurers and reinsurers are not affiliated, but that is not the case for when insurers and reinsurers are affiliated. These findings suggest that insurers with lower Best rating tend to seek more reinsurance from reinsurers outside of their group. Secondly, loss volatility, an alternative indicator for adverse selection, presents opposite effects for affiliated and non-affiliated reinsurers. When both insurers and reinsurers are affiliated in one group, loss volatility is significantly and negatively associated with reinsurance purchase, implying that more stable insurers tend to buy less reinsurance internally. However, when insurers and reinsurers are not affiliated, loss volatility is significantly and positively related to reinsurance purchase. Therefore, the adverse selection problem exists only between affiliated insurers and non-affiliated reinsurers, but not between affiliated insurers and reinsurers.

In practice, some affiliated insurers may transfer risks to their affiliated reinsurers

within the group, but other affiliated insurers may cede premiums to non-affiliated reinsurers. Consequently, the asymmetric information problem may prevail in different facets for those affiliated insurers. Thus, we further analyze the effect of reinsurance purchase based on the percentage of ceded premium paid to affiliated reinsurers. Tables 4 and 5 show the regression results for affiliated insurers with more than 75 percent and less than 25 percent ceded premium paid to affiliated reinsurers, respectively. As shown in Table 4, the coefficient of the Best rating is significantly negative and the coefficient of loss volatility is significantly positive, which indicate the existence of adverse selection problem for affiliated insurers that transfer most of their risks to affiliated members. However, in Table 5, we do not find evidence of adverse selection for affiliated insurers that mostly buy reinsurance from non-affiliated companies. This comparison indicates that information asymmetry still exits even within the same group, especially when affiliated insurers mostly cede premiums to their affiliated reinsurers.

B. Test of Moral Hazard

Next, we exam the presence of moral hazard. The percentage of recovered loss from the prior period in Equation 1 signals the presence of moral hazard, which is found significantly positive in Table 1. However, when using an alternative loss volatility measure in Table 2, no statistical significance in the coefficient of the percentage of recovered loss from the prior period is detected. Overall, based on these mixed results, we do not find convincing evidence on the moral hazard problem for affiliated insurers.

Tables 3, 4, and 5 present the regression results regarding the reinsurance demand of

affiliated insurers on various reinsurer groups. As shown, the estimated coefficients of the lagged recovered loss ratio are positive but not statistically significant, thus rejecting the hypothesis of the existence of moral hazard for affiliated insurers.

Furthermore, we test the effects of various reinsurance-specific factors, such as the reinsurance sustainability index, the lagged reinsurance price, and the internal reinsurance percentage. We find that the internal reinsurance percentage is significantly and negatively related to the demand for external reinsurance. Affiliated insurers will likely decrease their demand for external reinsurance when they participate in an insurance risk management pool or other similar arrangements. Surprisingly, the estimated coefficients of the lagged reinsurance price are significantly positive. One plausible explanation is that affiliated insurers retain the so-called "good" risks by themselves, and purposely cede the "bad' risks to external reinsurers with less consideration of price. However, the reinsurance sustainability index has no significant effect on the demand for reinsurance, which could be attributed to the dependence on internal reinsurance arrangements within the group.

Our results also show that firm-specific factors also affect affiliated insurers' demand for reinsurance. The estimated coefficients of the direct gross loss ratio and leverage in Table 1 and 2 are significantly positive. Higher direct loss ratio and higher leverage tend to encourage insurers to buy more reinsurance in order to diversify risks and improve business performance. In addition, both the log of total assets and the geographic Herfindahl index are negatively related to the demand for reinsurance, meaning that

larger and more geographically-diversified companies can better strengthen their capability to control risks, thus reducing their demand for external reinsurance coverage. Interestingly, the estimated coefficients of the percentage of homeowner written premium in coastal states such as Alabama, Louisiana, North Carolina, South Carolina, and Mississippi are significantly negative, but the estimated coefficients for Florida and Texas are not significant. Further investigation is needed to explain these conflicting results.

3.2 Regression Results for Non-Affiliated Property and Liability Insurers

As shown in Tables 1 and 2, the regression results of Equation (1) do not support the hypotheses of adverse selection and/or moral hazard for non-affiliated insurers. Specifically, the estimated coefficient of the Best rating is significantly positive, which implies that better rated insurers purchase more reinsurance. The estimated coefficient of loss volatility is significantly negative. This evidence shows that better rated and more stable non-affiliated insurers generally demand for more reinsurance. Furthermore, the estimated coefficient of the signal of moral hazard, the percentage of recovered loss out of total loss incurred, is not statistically significant. Overall, no supportive evidence is found for the existence of adverse selection or moral hazard for non-affiliated insurers in the reinsurance market.

The regression results in Tables 1 and 2 also show that the reinsurance sustainability index, direct loss ratio, leverage, liquidity, and the percentage of homeowner written premium in Florida are positively related to the purchase of reinsurance. Our findings of

a long-term reinsurance relationship that is related to higher reinsurance purchase and a positive coefficient estimation for the reinsurance sustainability index are consistent with the findings of Garven and Grace (2007). Non-affiliated insurers with higher leverage also purchase more reinsurance. Moreover, both the product Herfindahl index and the geographic Herfindahl index are negatively related to the reinsurance demand, which are consistent with Garven and Grace's (2007) findings. The estimated coefficient of the percentage of homeowner written premium in Florida is significantly positive in Table 1, which indicates the fact that the homeowner insurance in Florida faces a high catastrophic hurricane risk, and thus the underwriting of homeowner insurance in Florida increases the demand for reinsurance for non-affiliated insurers.

3.*3 Regression Results for All Property and Liability Insurers*

To test the presence of asymmetric information for the whole reinsurance market, we run the regression on the panel data including both affiliated and non-affiliated property and liability insurers from 1990 to 2006. The regression results, however, fail to support the presence of asymmetric information in either adverse selection or moral hazard in the reinsurance market.

The estimated coefficient of the Best rating is not statistically significant, while loss volatility is shown to be negatively related to reinsurance purchase. The estimated coefficient of the lagged recovered loss ratio is not statistically significant either.

The regression results also show that the direct loss ratio and leverage are positively

related to the demand for reinsurance. The product Herfindahl index, the geographic Herfindahl index, and the percentage of homeowner written premium in Alabama, Louisiana, North Carolina, South Carolina, and Mississippi are negatively related to the reinsurance demand, when all insurers are considered.

4. Conclusion

As an effective risk management tool, reinsurance meets the demand for insurance by diversifying risks, obtaining expertise from the reinsurer, increasing capacity, and lowering taxes. Thus, the reinsurance market becomes an important supplementary to the primary insurance market. However, the asymmetric information problem exists between insurers and reinsurers, and the presence of adverse selection and moral hazard may damage the reinsurance market.

This study empirically tests the asymmetric information problem in the property and liability reinsurance market by separating adverse selection from moral hazard. Using the panel data from NAIC and A.M. Best Company, adverse selection is shown to exist between affiliated insurers and non-affiliated reinsurers, while there is conflicting evidence on the presence of moral hazard for non-affiliated insurers. When affiliated insurers mostly use inside reinsurance within the group, the adverse selection problem still exists. For non-affiliated insurers, adverse selection instead of moral hazard arises from asymmetric information. Overall, our results, consistent with Garven and Grace (2007), provide supportive evidence on the presence of adverse selection, but mixed

evidence on moral hazard in the reinsurance market.

Table 1. Estimated Coefficients on Reinsurance Purchase for the Property and Liability Insurers

Second Stage Regression	**Dependent Variable: Reinsurance Purchase**		
Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
A.M. Best Rating	**-0.013 (0.005)*** **	**0.009 (0.003)*** **	0.004 (0.003)
Loss Volatility Definition One	-0.013 (0.014)	**-0.045 (0.016)*** **	**-0.031 (0.009)*** **
Lagged Recovered Loss Ratio	**0.091 (0.016)*** **	0.0009 (0.0005)	0.0001 (0.002)
Reinsurance Sustainability Index	-0.014 (0.011)	**0.016 (0.010)***	0.003 (0.007)
Direct Gross Loss Ratio	**0.091 (0.016)*** **	**0.173 (0.030)*** **	**0.151 (0.016)*** **
Lag of Reinsurance Price	**0.013 (0.003)*** **	0.001 (0.001)	**0.004 (0.001)*** **
Internal Reinsurance Percentage	**-0.001 (0.003)*** **		**-0.002 (0.0003)*** **
Log of Total Assets	**-0.072 (0.025)** **	**-0.274 (0.230)*** **	**-0.121 (0.018)*** **
Stock Indicator	0.002 (0.030)	-0.011 (0.016)	-0.014 (0.014)
Return on Equity	**0.001 (0.0002)** **	0.0002 (0.0002)	**0.0003 (0.0001)** **
Leverage	**0.011 (0.001)*** **	**0.009 (0.001)*** **	**0.009 (0.001)*** **
Liquidity	-0.003 (0.003)	**0.017 (0.004)*** **	0.003 (0.002)
Effective Tax Rate	-0.015 (0.010)	-0.006 (0.010)	-0.011 (0.007)
Product Herfindahl Index	0.003 (0.028)	**-0.130 (0.032)*** **	**-0.066 (0.021)*** **
Geographic Herfindahl Index	**-0.073 (0.034)*** **	**-0.047 (0.018)** **	**-0.074 (0.014)*** **
Percentage of Homeowner Written Premium in Florida	0.001 (0.001)	**0.010 (0.006)***	0.001 (0.002)
Percentage of Homeowner Written Premium in Texas	-0.006 (0.004)	-0.013 (0.012)	-0.005 (0.004)
Percentage of Homeowner Written Premium in AL, LA, NC, SC and MS	**-0.019 (0.003)*** **	0.008 (0.027)	**-0.014 (0.003)*** **
Percentage of Long Tail Business Lines	0.006 (0.016)	0.001 (0.013)	0.004 (0.010)
Affiliation indicator			-0.013 (0.025)
Square of Log of Total Assets	**0.001 (0.0004)*** **	**0.006 (0.0006)*** **	**0.002 (0.0004)*** **

Continued

First Stage Regression	**Endogeneous Variable: Loss Ratio**		
One Lag of Reinsurance Purchase	**0.205 (0.066)*** **	-0.035 (0.026)	**0.095 (0.031)*** **
Two Lag of Reinsurance Purchase	**0.135 (0.063)** **	**-0.047 (0.025)***	0.030 (0.030)
One Lag of Direct Gross Loss Ratio	**0.823 (0.032)*** **	**0.381 (0.014)*** **	**0.555 (0.016)*** **
One Lag of Log Direct Premium Written	**0.083 (0.016)** **	**0.163 (0.010)*** **	**0.091 (0.009)*** **
Observations	2,236	3,226	5,524
R-squared	0.154	0.101	0.126

1. Fixed effect model on panel data is used for affiliated, non-affiliated and all property and liability insurers based on Hausman test.
2. Regression results of year dummies are not reported in this table.
3. The regression results of other instrumental variables included in the first stage regression are not shown in this table.
4. Regression results are shown as coefficient and standard deviation. The figures on the top are the estimated coefficients and the figures in the parenthesis are standard deviations.
5. * , ** and *** denote significance at 10%, 5% and 1% level respectively.

Marginal Effects (Measured at the Means)

Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
Log of Total Assets	**-0.072 (0.025)*** **	**-0.274 (0.030)*** **	**-0.121 (0.018)*** **

Table 2. Estimated Coefficients on Reinsurance Purchase for the Property and Liability Insurers

Second Stage Regression	**Dependent Variable: Reinsurance Purchase**		
Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
A.M. Best Rating	**-0.037 (0.010)*** **	**0.008 (0.004)** **	-0.002 (0.003)
Loss Volatility Definition Two	0.005 (0.022)	**0.038 (0.021)***	**0.032 (0.010)*** **
Lagged Recovered Loss Ratio	-0.0001 (0.0003)	**0.003 (0.001)*** **	0.0001 (0.0001)
Reinsurance Sustainability Index	-0.031 (0.021)	**0.017 (0.010)***	0.0005 (0.008)
Direct Gross Loss Ratio	**0.123 (0.037)*** **	0.015 (0.038)	**0.045 (0.018)** **
Lag of Reinsurance Price	-0.003 (0.002)	0.0005 (0.001)	0.002 (0.001)
Internal Reinsurance Percentage	**0.002 (0.001)*** **		**-0.001 (0.0004)*** **
Log of Total Assets	**-0.199 (0.057)*** **	**-0.328 (0.034)*** **	**-0.188 (0.021)*** **
Stock Indicator	0.035 (0.058)	-0.023 (0.017)	-0.010 (0.015)
Return on Equity	**0.001 (0.0004)*** **	**0.0005 (0.0002)** **	**0.0004 (0.0002)*** **
Leverage	**0.006 (0.003)** **	**0.007 (0.001)*** **	**0.007 (0.001)*** **
Liquidity	**0.055 (0.009)*** **	**0.016 (0.005)*** **	**0.012 (0.003)*** **
Effective Tax Rate	**-0.031 (0.017)***	-0.016 (0.010)	**-0.017 (0.007)** **
Product Herfindahl Index	**-0.136 (0.054)** **	**-0.113 (0.036)*** **	**-0.040 (0.023)***
Geographic Herfindahl Index	**-0.204 (0.067)*** **	**-0.037 (0.019)** **	**-0.062 (0.014)*** **
Percentage of Homeowner Written Premium in Florida	-0.0001 (0.004)	0.006 (0.072)	-0.0005 (0.002)
Percentage of Homeowner Written Premium in Texas	0.008 (0.007)	-0.018 (0.011)	-0.002 (0.004)
Percentage of Homeowner Written Premium in AL, LA, NC, SC and MS	**-0.002 (0.009)*** **	0.033 (0.052)	**-0.003 (0.005)*** **
Percentage of Long Tail Business Lines	-0.067 (0.034)**	-0.004 (0.013)	0.004 (0.010)
Affiliation indicator			-0.023 (0.021)
Square of Log of Total Assets	**0.004 (0.001)*** **	**0.007 (0.0007)*** **	**0.004 (0.0004)*** **

Continued

First Stage Regression	**Endogeneous Variable: Loss Ratio**		
One Lag of Reinsurance Purchase	0.113 (0.103)	**-0.053** **(0.029)***	0.068 (0.072)
Two Lag of Reinsurance Purchase	0.141 (0.125)	-0.007 (0.028)	-0.017 (0.071)
One Lag of Direct Gross Loss Ratio	**0.231** **(0.031)*****	**0.382** **(0.018)*****	**0.267** **(0.018)*****
One Lag of Log Direct Premium Written	-0.067 (0.045)	**0.022** **(0.012)***	0.032 (0.021)
Observations	1,749	2,627	4,381
R-squared	0.121	0.104	0.149

1. Fixed effect model on panel data is used for affiliated, non-affiliated and all property and liability insurers based on Hausman test.
2. Regression results of year dummies are not reported in this table.
3. The regression results of other instrumental variables included in the first stage regression are not shown in this table.
4. Regression results are shown as coefficient and standard deviation. The figures on the top are the estimated coefficients and the figures in the parenthesis are standard deviations.
5. * , ** and *** denote significance at 10%, 5% and 1% level respectively.

Marginal Effects (Measured at the Means)

Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
Log of Total Assets	**-0.199** **(0.057)*****	**-0.328** **(0.034)*****	**-0.121** **(0.018)*****

Table 3. Estimated Coefficients on Reinsurance Purchase for the Affiliated Property and Liability Insurers

Second Stage Regression	**Dependent Variable: Reinsurance Purchase**		
Variables	**Affiliated Reinsurers**	**Non-Affiliated Reinsurers**	**All Reinsurers**
A.M. Best Rating	-0.013 (0.011)	**-0.034** **(0.007)***	**-0.037** **(0.010)***
Loss Volatility	**-0.038** **(0.022)***	**0.031** **(0.016)****	0.005 (0.022)
Lagged Recovered Loss Ratio	**-0.003** **(0.001)****	-0.001 (0.001)	-0.0001 (0.0003)
Reinsurance Sustainability Index		-0.013 (0.015)	-0.031 (0.021)
Direct Gross Loss Ratio	0.026 (0.037)	**0.133** **(0.026)***	**0.123** **(0.037)***
Lag of Reinsurance Price	-0.0001 (0.0004)	**0.011** **(0.004)****	-0.003 (0.002)
Internal Reinsurance Percentage		**-0.001** **(0.001)***	**0.002** **(0.001)***
Log of Total Assets	**-0.256** **(0.062)***	**-0.082** **(0.040)****	**-0.199** **(0.057)***
Stock Indicator	0.030 (0.060)	0.056 (0.041)	0.035 (0.058)
Return on Equity	**0.001** **(0.0004)***	**0.001** **(0.0002)***	**0.001** **(0.0004)***
Leverage	-0.005 (0.003)***	**0.008** **(0.002)***	**0.006** **(0.003)****
Liquidity	**0.040** **(0.009)***	**0.018** **(0.007)***	**0.055** **(0.009)***
Effective Tax Rate	-0.022 (0.017)	-0.013 (0.012)	**-0.031** **(0.017)***
Product Herfindahl Index	**-0.162** **(0.058)***	0.017 (0.039)	**-0.136** **(0.054)****
Geographic Herfindahl Index	-0.063 (0.075)	**-0.114** **(0.078)****	**-0.204** **(0.067)***
Percentage of Homeowner Written Premium in Florida	0.0001 (0.004)	0.001 (0.002)	-0.0001 (0.004)
Percentage of Homeowner Written Premium in Texas	0.010 (0.007)	-0.001 (0.005)	0.008 (0.007)
Percentage of Homeowner Written Premium in AL, LA, NC, SC and MS	0.005 (0.011)	-0.006 (0.007)	**-0.002** **(0.009)***
Percentage of Long Tail Business Lines	**-0.071** **(0.034)****	0.038 (0.024)	-0.067 (0.034)**
Square of Log of Total Assets	**0.004** **(0.001)***	**0.002** **(0.0007)****	**0.004** **(0.001)***

Continued

First Stage Regression	**Endogenous Variable: Loss Ratio**		
One Lag of Reinsurance Purchase	0.010 (0.151)	**0.414** **(0.192)****	0.113 (0.103)
Two Lag of Reinsurance Purchase	0.234 (0.167)	-0.190 (0.192)	0.141 (0.125)
One Lag of Direct Gross Loss Ratio	**0.216** **(0.035)*****	**0.233** **(0.030)*****	**0.231** **(0.031)*****
One Lag of Log Direct Premium Written	-0.084 (0.056)	-0.61 (0.045)	-0.067 (0.045)
Observations	1,434	1,749	1,749
R-squared	0.168	0.105	0.121

1. Fixed effect model is used for the affiliated insurers cede to affiliated, non-affiliated and all reinsurers based on Hausman test.
2. Regression results of year dummies are not reported in this table.
3. The regression results of other instrumental variables included in the first stage regression are not shown in this table.
4. Regression results are shown as coefficient and standard deviation. The figures on the top are the estimated coefficients and the figures in the parenthesis are standard deviations.
5. * , ** and *** denote significance at 10%, 5% and 1% level respectively.

Marginal Effects (Measured at the Means)

Variables	**Affiliated Reinsurers**	**Non-Affiliated Reinsurers**	**All Reinsurers**
Log of Total Assets	**-0.256** **(0.060)*****	**-0.082** **(0.040)****	**-0.199** **(0.057)*****

Table 4. Estimated Coefficients on Reinsurance Purchase for the Affiliated Property and Liability Insurers with More than 75% Ceded Premium Paid to Affiliated Reinsurers

Second Stage Regression	**Dependent Variable: Reinsurance Purchase**		
Variables	**Affiliated Reinsurers**	**Non-Affiliated Reinsurers**	**All Reinsurers**
A.M. Best Rating	**-0.057 (0.018)*** **	**-0.012 (0.004)*** **	**-0.054 (0.019)*** **
Loss Volatility	**0.102 (0.056)***	**0.022 (0.012)***	**0.138 (0.058)** **
Lagged Recovered Loss Ratio	**-0.025 (0.002)*** **	0.001 (0.001)	**-0.021 (0.002)**
Reinsurance Sustainability Index		0.006 (0.007)	0.048 (0.033)
Direct Gross Loss Ratio	**0.087 (0.040)** **	**0.015 (0.008)***	**0.099 (0.042)** **
Lag of Reinsurance Price	-0.001 (0.002)	**0.005 (0.003)***	0.001 (0.002)
Internal Reinsurance Percentage		**-0.001 (0.0001)*** **	**0.002 (0.001)*** **
Log of Total Assets	**-0.181 (0.097)***	-0.003 (0.021)	-0.084 (0.100)
Stock Indicator	-0.013 (0.089)	0.006 (0.020)	0.046 (0.093)
Return on Equity	0.0005 (0.0008)	0.0001 (0.0001)	0.001 (0.001)
Leverage	-0.004 (0.006)	**0.007 (0.001)*** **	0.004 (0.006)
Liquidity	**0.050 (0.012)*** **	**0.007 (0.003)*** **	**0.060 (0.013)*** **
Effective Tax Rate	**-0.071 (0.026)*** **	-0.001 (0.006)	**-0.060 (0.027)** **
Product Herfindahl Index	-0.156 (0.107)	**-0.055 (0.024)** **	-0.106 (0.110)
Geographic Herfindahl Index	**0.372 (0.163)** **	**-0.097 (0.035)*** **	**0.279 (0.164)***
Percentage of Homeowner Written Premium in Florida	-0.016 (0.010)	0.002 (0.002)	-0.001 (0.010)
Percentage of Homeowner Written Premium in Texas	0.017 (0.032)	-0.005 (0.007)	0.009 (0.033)
Percentage of Homeowner Written Premium in AL, LA, NC, SC and MS	0.014 (0.016)	-0.003 (0.004)	**0.028 (0.017)***
Percentage of Long Tail Business Lines	**-0.171 (0.059)*** **	**0.021 (0.013)***	**-0.161 (0.061)*** **
Square of Log of Total Assets	0.003 (0.002)	-0.0001 (0.00004)	0.001 (0.002)

Continued

First Stage Regression	**Endogenous Variable: Loss Ratio**		
One Lag of Reinsurance Purchase	-0.172 (0.127)	0.575 (0.396)	-0.111 (0.117)
Two Lag of Reinsurance Purchase	0.143 (0.132)	**-1.115** **(0.337)***	0.018 (0.138)
One Lag of Direct Gross Loss Ratio	**-0.507** **(0.056)***	**-0.486** **(0.056)***	**-0.520** **(0.056)***
One Lag of Log Direct Premium Written	**0.178** **(0.069)***	**0.154** **(0.065)****	**0.161** **(0.068)****
Observations	502	513	513
R-squared	0.585	0.293	0.549

1. Fixed effect model is used for the affiliated insurers cede to affiliated, non-affiliated and all reinsurers based on Hausman test.
2. Regression results of year dummies are not reported in this table.
3. The regression results of other instrumental variables included in the first stage regression are not shown in this table.
4. Regression results are shown as coefficient and standard deviation. The figures on the top are the estimated coefficients and the figures in the parenthesis are standard deviations.
5. * , ** and *** denote significance at 10%, 5% and 1% level respectively.

Marginal Effects (Measured at the Means)

Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
Log of Total Assets	**-0.181** **(0.097)***	-0.003 (0.021)	-0.084 (0.100)

Table 5. Estimated Coefficients on Reinsurance Purchase for the Affiliated Property and Liability Insurers with Less than 25% Ceded Premium Paid to Affiliated Reinsurers

Second Stage Regression	**Dependent Variable: Reinsurance Purchase**		
Variables	**Affiliated Reinsurers**	**Non-Affiliated Reinsurers**	**All Reinsurers**
A.M.Best Ratings	-0.005 (0.004)	**-0.024** **(0.010)****	**-0.029** **(0.010)*****
Loss Volatility	-0.004 (0.006)	0.011 (0.021)	-0.014 (0.022)
Lag of Ratio of Recovered Losses	**0.004** **(0.002)****	0.0001 (0.0002)	0.0001 (0.00001)
Reinsurance Sustainability Index		-0.013 (0.019)	-0.014 (0.019)
Direct Gross Loss Ratio	0.001 (0.007)	**0.039** **(0.018)****	**0.042** **(0.182)****
Lag of Reinsurance Price	0.0001 (0.0002)	0.002 (0.005)	0.002 (0.005)
Internal Reinsurance Percentage		**0.005** **(0.002)*****	**0.005** **(0.002)*****
Log of Total Assets	**-0.042** **(0.021)****	-0.099 (0.062)	-0.102 (0.064)
Stock Indicator	-0.004 (0.023)	0.070 (0.054)	0.072 (0.056)
Return on Equity	0.00001 (0.0001)	**0.001** **(0.0004)*****	**0.001** **(0.0004)*****
Leverage	**0.004** **(0.001)*****	**0.008** **(0.003)*****	**0.010** **(0.003)*****
Liquidity	0.007 (0.007)	**0.028** **(0.012)****	**0.035** **(0.013)*****
Effective Tax Rate	-0.004 (0.006)	-0.020 (0.017)	**-0.018** **(0.018)****
Product Herfindahl Index	**-0.046** **(0.019)****	0.004 (0.051)	-0.035 (0.052)
Geographic Herfindahl Index	-0.040 (0.030)	**-0.136** **(0.058)****	**-0.149** **(0.060)****
Percentage of Homeowner Written Premium in Florida	-0.003 (0.003)	-0.004 (0.005)	-0.006 (0.005)
Percentage of Homeowner Written Premium in Texas	**-0.005** **(0.002)*****	0.003 (0.006)	0.001 (0.006)
Percentage of Homeowner Written Premium in AL, LA, NC, SC and MS	0.005 (0.004)	-0.006 (0.007)	-0.005 (0.007)
Percentage of Long Tail Business Lines	-0.006 (0.009)	0.045 (0.030)	-0.042 (0.030)
Square of Log of Total Assets	**0.001** **(0.0004)***	0.002 (0.001)	0.002 (0.001)

Continued

First Stage Regression	**Endogenous Variable: Loss Ratio**		
One Lag of Reinsurance Purchase	-0.135 (0.963)	0.162 (0.237)	0.064 (0.228)
Two Lag of Reinsurance Purchase	0.421 (0.766)	0.025 (0.229)	0.183 (0.191)
One Lag of Direct Gross Loss Ratio	**0.398** **(0.066)*** **	**0.466** **(0.043)*** **	**0.466** **(0.043)*** **
One Lag of Log Direct Premium Written	0.067 (0.118)	-0.002 (0.067)	0.003 (0.067)
Observations	431	731	731
R-squared	0.141	0.155	0.154

1. Fixed effect model is used for the affiliated insurers cede to affiliated, non-affiliated and all reinsurers based on Hausman test.
2. Regression results of year dummies are not reported in this table.
3. The regression results of other instrumental variables included in the first stage regression are not shown in this table.
4. Regression results are shown as coefficient and standard deviation. The figures on the top are the estimated coefficients and the figures in the parenthesis are standard deviations.
5. * , ** and *** denote significance at 10%, 5% and 1% level respectively.

Marginal Effects (Measured at the Means)

Variables	**Affiliated Insurers**	**Non-Affiliated Insurers**	**All Insurers**
Log of Total Assets	**-0.042** **(0.021)** **	-0.099 (0.062)	-0.102 (0.064)

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