Partial Adjustment toward Target Reinsurance Levels: An Analysis of U.S Property-Liability Insurance Industry

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Abstract

This article analyzes the reinsurance demand adjustment decision and its interaction with organizational form and leverage for U.S. property-liability insurers. This article implements the asymmetric partial adjustment model to analyze (1) Whether insures adjust their reinsurance towards the target level over time? (2) Whether the asymmetric partial adjustment of reinsurance exists? (3) How the reinsurance adjustment interacts with organizational form and leverage? The evidence indicates that the trade-off type adjustment exists and the adjustment speed is about 75% per year. Additionally, the empirical results demonstrate that the asymmetric partial adjustment of reinsurance demand exists. Finally, the evidence significantly shows that organization form and capital structure do influence insurer's reinsurance adjustment behavior distinctly.

Keywords: Demand for reinsurance, asymmetric partial adjustment, organizational form, leverage.

I. Introduction

Why reinsurance is critical for primary insurers? Literature has provided many solid reasons to answer the question, such as to overcome the non-diversifiable risks and catastrophic risks, to limit the insurers' underwriting risks and increase underwriting capacity, to reduce the probability and expected costs of potential bankruptcy, to reduce the cash flow volatility, to limit the expected costs of financial distress, to stabilize sources of funding, to decrease expected taxes, to gain comparative advantages in real services production, to substitute for capital, and so on (Mayers and Smith, 1982; Mayers and Smith, 1990; Hoerger, Sloan, and Hassan, 1990; Adiel, 1996; Jean-Baptiste and Santomero, 2000; Garven and Lamm-Tennant, 2003; Carneiro and Sherris, 2005; Cole and McCullough, 2006; Powell and Sommer, 2007; Adams, Hardwick and Zoo, 2008; Wang et al., 2008; Kader and Adams 2008; Cummins, et. al, 2008; Shiu, 2011; Chang 2014; Chang and Jeng, 2015; Yanase, 2015).

Most of theoretical studies suggest that insurers tend to seek an optimal reinsurance level in terms of maximizing the shareholders' expected utility and/or minimizing firm's non-diversifiable risks as well as risk measures, such as tail risk measures, generalized risk measures, VaR, CTE (Conditional Tail Expectation), and so on (Borch, 1962, 1969; Kaluszka, 2004; Gajek and Zagrodny, 2004; Krvavych and Sherris, 2006; Cai and Tan, 2007; Guerra and Centeno, 2008; Centeno and Guerra, 2008; Cai, Tan, and Zhang, 2008; Bernard and Tian, 2009; Balbá, Balbá, and Heras, 2009; Zhao, Zhu, and Chen, 2010). Since literature concludes that insures tend to maintain an optimal reinsurance level, it implies that over and/or under optimal reinsurance level would generate additional costs for insurers. Insurers with over (under) reinsurance tend to be safe (risky), but tend to disadvantage (advantage) from high (low) costs of reinsurance. Consequently, the trade-off type behavior orient towards an optimal reinsurance is emerged for insurers. Based on the argument of prior literature (i.e. the optimal reinsurance demand analysis), this article presumes that insurers tend to have an optimal (target) reinsurance level so that they would like to adjust their reinsurance level to the target over time.

Insurers with over reinsurance demand possess both costs and benefits. With over reinsurance contracts, insurers could reduce the probability of bankruptcy, the expected cost of financial distress, the loss volatility, the liability on specific risk, as well as increase the protection ability against catastrophic risks. Nevertheless, transferring risk to reinsurers is expensive. Insurers with over reinsurance tend to pay several times the actuarial price of the risk transferred (Froot, 2001; Commins, et. al, 2008). Cmmins and Weiss (2000b) point out that the agency cost problems, e.g., the incentive conflict and the lack of transparency, increase reinsurance costs as well as reinsurance prices. Additionally, Shiu (2004) proposes that the marginal reinsurance earnings and business profits will decrease while insurers with over reinsurance. For the case of insurers with under reinsurance, all above arguments should be inverted.

To balance the underwriting, solvency, and tax management objectives, Kader, Adams, and Mouratidis (2010) indicate that insures tend to behave a trade-off type while deciding to purchase reinsurance. They found that the underwriting, solvency, and tax management play a critical role of reinsurance purchase. Niehaus and Mann (1992) argue that insurer entails two types of costs when adjusting their reinsurance contract: (1) the costs of negotiating and monitoring reinsurance agreements, and (2) the time delay associated with arranging reinsurance. These facts lead insurers to adjust their reinsurance towards the target over time. To my best knowledge, few studies systematically discuss the reinsurance adjustment empirically. Thus, the purpose of this article is to fill this research gap in the literature.

This article is to analyze the reinsurance adjustment decision and its interaction with organizational form and leverage for U.S. property-liability insurers. An unbalanced panel dataset of the NAIC (National Association of Insurance Commissioners) from 2006 to 2010 is used. This article implements the asymmetric partial adjustment model to analyze (1) Whether insures adjust their reinsurance towards the target level over time? (2) Whether the asymmetric partial adjustment of reinsurance exists? (3) How the reinsurance adjustment interacts with organizational form and leverage? The evidence indicates that the trade-off type reinsurance adjustment exists and the adjustment speed is about 75% per year. Additionally, the empirical results demonstrate that the asymmetric partial adjustment of reinsurance exists. Finally, the evidence significantly shows that organization form and capital structure do distinctly influence insurer's reinsurance adjustment behavior. Furthermore, the main empirical results are robust for the checks of an alternative reinsurance measurement as well as the exclusion of extreme values.

The contributions of this article are summarized as follows. First, to my best knowledge, this article is the first study to discuss the reinsurance adjustment for property-liability insurers in terms of the asymmetric partial adjustment model.

Second, the evidence shows that adjustment speed does exist, which indicate insurers adjust their reinsurance demand towards the optimal (target) level over time, and the result is consistent to the trade-off type argument. As well, it indicates that insurers cannot adjust their reinsurance toward the target level immediately as a whole. Third, the asymmetric partial adjustment of reinsurance exists and various hypotheses are supported respectively while insurers deviate from their target reinsurance demand level. Specifically, the speeds of reinsurance adjustment of stocks differ from mutuals as well as of highly levered insurers differ from lowly levered insurers.

The rest of this article is structured as follows. Section II describes the model specifications and discusses the hypotheses. Section III briefly discusses the variables and database. Section IV presents the empirical results of target reinsurance estimations, partial adjustment models, and some robustness checks, and Section V concludes.

II. Model Specifications and Hypotheses

Based on the arguments of prior literature, insurers tend to seek an optimal reinsurance purchasing because of trade-off type behavior between costs and benefits. As a result, this article presumes that insurers have an optimal (target) reinsurance demand level so that they intend to adjust their reinsurance level to the target over time.

Formally, the (asymmetric) partial adjustment analysis is well discussed on the financial literature (Flannery and Rangan, 2006; Byoun, 2008, Lemmon, Roberts, and Zender, 2008, Faulkender, et. al., 2012; Dang, Garrett, and Nguyen, 2011), which is used to analyze the speed of adjustment and adjustment behavior. In accordance with the previous financial literature, this article inherits the standard partial adjustment model to analyze the insurer’s reinsurance adjustment behavior and the model is set as follows,

$$R_{it} - R_{it-1} = \pi(R_{it}^{*} - R_{it-1}) + \omega_{it} \quad (1)$$

where R_{it} and R_{it-1} are the reinsurance ratios for insurer i at time t and t-1, respectively. π is the proportion of the gap between its actual and target reinsurance levels, and is referred to “adjustment speed”. ω_{it} is the well-behaved error term. R_{it}^{*} is the insurer i’s unobserved target reinsurance level and is defined as follows[1],

$$R_{it}^{*} = X_{it-1}\alpha \quad (2)$$

[1] To mitigate the endogenous problems, this article uses lagged explanatory variables in the target reinsurance estimation (Shiu, 2011; Chang and Jeng, 2015).

Similar to the previous studies, this article regresses actual reinsurance level on the lagged firm-specific characteristics (e.g., leverage, liquidity, Herfindahl indices, size, organizational form, and so on) to estimate the insurer's target reinsurance, and the estimation model is set as follows,

$$R_{it} = X_{it-1}\alpha + \delta_{it} \quad (3)$$

where the X_{it-1} represents the vector of lagged firm-specific characteristics and other control variables. α is the vector of the estimated coefficient. δ_{it} is the well-behaved error term. This article provides four distinct targeted estimation models to generate the fitted value for reinsurance which includes (1) pooled estimation without control fixed and random effects, (2) controlled year and firm fixed effects, (3) controlled year and firm random effects, and (4) Mixed Effect Models (MEM) with restricted maximum likelihood (REML) which allowing cross-sectional herteroskedastic and time-wise autoregressive covariance (Byoun, 2008). Finally, we use the fitted value to represent the insurer's target reinsurance, and the fitted equation is constructed as follows,

$$\widehat{R}^*_{it} = \widehat{X}_{it-1}\alpha \quad (4)$$

1. Partial adjustment model with deviations from the target reinsurance

In accordance with model specification of Byoun (2008) and Dang, Garrett, and Nguyen (2011), the equation (1) can be rewritten as follows,

$$\Delta R_{it} = \gamma_0 + \gamma_1 TDE_{it} + \varepsilon_{it} \quad (5)$$

where $\Delta R_{it} = R_{it} - R_{it-1}$, and $TDE_{it} = R^*_{it} - R_{it-1}$. γ_0 is constant term and γ_1 is the estimated coefficient of adjustment speed. ε_{it} is the well-behaved error term. Equation (5) is regarded as a symmetric partial adjustment model.

Additionally, the asymmetric partial adjustment model can be represented as the Equation (6). Define that R^a_{it}=1 if TDE_{it} is less than zero, representing that reinsurance is above the target, and zero otherwise for insurer i at time t. On the other hand, define that R^b_{it}=1 if TDE_{it} is greater than or equal to zero, representing the reinsurance is below the target, and zero otherwise for insurer i at time t.

$$\Delta R_{it} = \gamma_2 + \gamma_3 TDE_{it}R^a_{it} + \gamma_4 TDE_{it}R^b_{it} + \epsilon_{it} \quad (6)$$

where γ_2 is constant term, and γ_3 and γ_4 are estimated coefficients of adjustment speeds. ϵ_{it} is the well-behaved error term.

Literature proposes that if markets are perfect and complete, insurers would completely and rapidly adjust their reinsurance to the target level every year. In the case, γ_1, γ_3, and γ_4 will equal to one and γ_0 and γ_2 will equal to zero. In fact, frictionless markets are untouchable in the real world. Thus, the predictions of γ_1, γ_3, and γ_4 are ranging from 0 to 1.

From Equation (5) and based on the trade-off type argument, this article postulates that the speed of adjustment for reinsurance does exist. The hypothesis ***H1a*** is generated as follow.

H1a: Speed of adjustment exists, i.e. $\boldsymbol{\gamma_1} > 0$.

According to the arguments of costs and benefits of reinsurance purchasing, insurers with over reinsurance would possess two opposite powers inducing them to adjust their reinsurance to the target level. One is that insurers with over reinsurance tend to confront the higher reinsurance costs (Froot, 2001; Cummins, et. al., 2008). To mitigate the high reinsurance cost issue, insurers intend to reduce reinsurance level rapidly. In contrast, insurers with over reinsurance also tend to be safer as well as lower expected cost of financial pressure than insurers with under reinsurance. Thus, the consideration of conservative attitude forces insurers to reduce their reinsurance level slowly. Based on these two contradict arguments, this article then proposes two hypotheses, ***H1b*** and ***H1c***, as follows.

H1b: Insurers with over reinsurance tend to adjust faster than with under reinsurance, i.e. $\boldsymbol{\gamma_3} > \boldsymbol{\gamma_4}$ ***if costs of reinsurance are larger than benefits of reinsurance.***

H1c: Insurers with over reinsurance tend to adjust slower than with under reinsurance, i.e. $\boldsymbol{\gamma_3} < \boldsymbol{\gamma_4}$ ***if costs of reinsurance are smaller than benefits of reinsurance.***

2. Adjustment behavior interacts with organizational form

Mayers and Smith (1990) suggest that the organizational form of insurers could influence their risk-taking behavior and alter the demand for reinsurance. Thus, it is predicted that the demand for reinsurance for these firms with distinct organizational form is different. This article further tries to examine whether stock insurers adjust reinsurance towards their target faster than mutual insurers, given the cases of above- or below-target reinsurance (deviate from the target reinsurance level). The interacting model between reinsurance deviation and organizational form can be represented as follows.

$$\Delta R_{it} = \theta_0 + (\theta_1 \mathrm{Stock}_{it} + \theta_2 \mathrm{Mutual}_{it}) \mathrm{TDE}_{it} R^a_{it}$$

$$+(\theta_3 \text{Stock}_{it} + \theta_4 \text{Mutual}_{it})\text{TDE}_{it}\text{R}_{it}^{b} + \varphi_{it} \quad (7)$$

where Stock_{it}=1 if the insurer is a stock, and zero otherwise for insurer i at time t. On the other hand, Mutual_{it}=1 if the insurer is a mutual, and zero otherwise for insurer i at time t. θ_0 is constant term. θ_1, θ_2, θ_3, and θ_4 are estimated coefficients of adjustment speeds for different organizational forms with above-target and below-target reinsurance levels. φ_{it} is the well-behaved error term. Likewise, if markets are frictionless, it is expected that θ_0 equal zero and θ_1, θ_2, θ_3, and θ_4 equal to one.

Mutual insurers likely have greater difficulty accessing sources of new capital in the event of a large loss. In other words, stock insurers can benefit from a lower cost of raising external capital (*the raising capital hypothesis*). In addition, stock insurers also tend to benefit from the risk diversification mechanism (*the risk diversification hypothesis*). Summing up, stock insurers tend to demand less reinsurance than mutual insurers. Nevertheless, several subsequent empirical studies find evidence that leads them to conclude that stock insurers demand more reinsurance than mutual insurers (Garven and Lamm-Tennant, 2003; Cole and McCullough, 2006; Adams 1996; Shiu 2011; Chang 2014; Chang and Jeng, 2015). Literature suggests that managers and shareholders of stock insurers have incentive to under-invest so that the purchase of reinsurance could mitigate the disadvantages of underinvestment among residual claimants (*the agency cost hypothesis*).

According to the arguments above, the impacts of organizational form on reinsurance also present two contradictory powers in terms of these hypotheses. Consequently, testing hypotheses could be generated as follows. First, given insurers with over reinsurance, the hypothesis of ***H2a*** indicates that benefits of *the raising capital hypothesis* and *the risk diversification hypothesis* are greater than of *the agency cost hypothesis*. Thus, stock insures tend to demand less reinsurance and reduce their reinsurance faster than mutual insurers as a whole. In contrast, if the condition reverses, the hypothesis of ***H2b*** is supported.

H2a: Given insurers with over reinsurance, stock insurers tend to adjust faster than mutual insurers, i.e. $\theta_1 > \theta_2$ if the benefits of the raising capital hypothesis and the risk diversification hypothesis dominate the benefits of the agency cost hypothesis.

H2b: Given insurers with over reinsurance, stock insurers tend to adjust slower

than mutual insurers, i.e.* $\boldsymbol{\theta_1} < \boldsymbol{\theta_2}$ *if the benefits of the agency cost hypothesis dominate the benefits of the raising capital hypothesis and the risk diversification hypothesis.

Second, given the cases of insurers with under reinsurance, the hypothesis of ***H2c*** indicates that the benefits of *the agency cost hypothesis* is greater than of *the raising capital hypothesis* and *the risk diversification hypothesis*. Stock insures tend to demand more reinsurance to alleviate the underinvestment problem. Therefore, they increase their reinsurance faster than mutual insurers as a whole. Likewise, opposing argument indicates that the hypothesis of ***H2d*** is supported.

H2c: Given insurers with under reinsurance, stock insurers tend to adjust faster than mutual insurers, i.e.* $\boldsymbol{\theta_3} > \boldsymbol{\theta_4}$ *if the benefits of the agency cost hypothesis dominate the benefits of the raising capital hypothesis and the risk diversification hypothesis.

H2d: Given insurers with under reinsurance, stock insurers tend to adjust slower than mutual insurers, i.e.* $\boldsymbol{\theta_3} < \boldsymbol{\theta_4}$ *if the benefits of the raising capital hypothesis and the risk diversification hypothesis dominate the benefits of the agency cost hypothesis.

Third, given insurers are stocks, the hypothesis of ***H2e*** proposes that stock insurers with over reinsurance tend to adjust faster than with under reinsurance. The argument of over and/or under reinsurance purchasing is the same to the arguments of ***H1b*** and ***H1c***. The reason is that the costs of insurers with over reinsurance are larger than benefits so that they intend to reduce reinsurance level rapidly (Froot, 2001; Cummins, et. al., 2008). On the other hand, given insurers are mutuals, the same arguments indicate that the hypothesis of ***H2f*** is supported.

H2e: Stock insurers with over reinsurance adjust faster than with under reinsurance, i.e.* $\boldsymbol{\theta_1} > \boldsymbol{\theta_3}$ *if the costs of reinsurance purchasing are larger than the benefits of reinsurance purchasing.

H2f: Mutual insurers with over reinsurance adjust faster than with under reinsurance, i.e.* $\boldsymbol{\theta_2} > \boldsymbol{\theta_4}$ *if the costs of reinsurance purchasing are smaller than the benefits of reinsurance purchasing.

3. Adjustment behavior interacts with leverage

The literature suggests that insurers with highly levered tend to purchase more reinsurance (Hoerger, Sloan, and Hassan, 1990; Adams, 1996; Garven and

Lamm-Tennant, 2003; Shortridge and Avila, 2004; Cole and McCullough, 2006; Powell and Sommer, 2007; Adams, Hardwick, and Zou, 2008; Shiu, 2011, Chang, 2014; Chang and Jeng, 2015). Also, this article further tries to examine whether highly levered insurers adjust reinsurance demand towards their target faster than lowly levered insurers, given the case of above-target or of below-target reinsurance. The interacting effects between reinsurance and leverage can be represented as follows,

$$\Delta R_{it} = \beta_0 + (\beta_1 LLev_{it} + \beta_2 HLev_{it}) TDE_{it} R^a_{it} + (\beta_3 LLev_{it} + \beta_4 HLev_{it}) TDE_{it} R^b_{it} + \tau_{it} \quad (8)$$

where $LLev_{it}$=1 if the insurer's leverage is less than and equal to the median value of industry, and zero otherwise for insurer i at time t. On the other hand, $HLev_{it}$=1 if the insurer's leverage is greater than the median value of industry, and zero otherwise for insurer i at time t. β_0 is constant term. β_1, β_2, β_3, and β_4 are estimated coefficients of adjustment speeds for different levered insurers with above-target and below-target reinsurance. τ_{it} is the well-behaved error term. Likewise, if markets are frictionless, it is expected that β_0 equal zero and β_1, β_2, β_3, and β_4 equal to one.

Shiu (2011) indicates that several aspects, e.g., *the bankruptcy cost*, *the agency cost*, *the risk bearing*, and *the renting capital hypotheses*, are significantly supported, which indicates that demand for reinsurance are positively related to leverage. Based on this argument, insurers with highly levered tend to purchase more reinsurance. Thus, given insurers with over reinsurance, highly levered insurers tend to reduce their reinsurance level slower than lowly levered because insurers with highly levered essentially need more reinsurance. Thus, the hypothesis of ***H3a*** is generated as follows.

H3a: Given insurers with over reinsurance, insurers with lowly levered tend to adjust faster than insurers with highly levered, i.e. $\boldsymbol{\beta_1 > \beta_2}$.

Insurers with under reinsurance tend to have higher probability of insolvency so that they intend to demand more reinsurance. In addition, insurers with highly levered indicate that they encounter higher expected costs of financial pressure. As a result, given insures with under reinsurance, highly levered insurers intend to increase their reinsurance as faster as possible in order to satisfy the solvency requirement. Thus, the hypothesis of ***H3b*** is generated as follows.

H3b: Given insurers with under reinsurance, insurers with highly levered tend to

adjust faster than insurers with lowly levered, i.e. $\boldsymbol{\beta_3} < \boldsymbol{\beta_4}$.

Given insurers are lowly levered insurers, the hypothesis of ***H3c*** proposes that insurers with over reinsurance tend to adjust faster than with under reinsurance. The reason is that the costs of insurers with over reinsurance are larger than the benefits so that they intend to reduce reinsurance level rapidly (Froot, 2001; Cummins, et. al., 2008). Another plausible reason is that lowly levered insurers confront less expected cost of financial pressure. Thus, they need less reinsurance as a whole.

H3c: Lowly levered insurers with over reinsurance adjust faster than lowly levered insurers with under reinsurance, i.e. $\boldsymbol{\beta_1} > \boldsymbol{\beta_3}$.

Finally, it is predicted that highly levered insurers with over reinsurance adjust slower than highly levered insurers with under reinsurance. The reason is that highly levered insurance with under reinsurance tend to encounter both higher expected cost of financial pressure (highly levered) and higher probability of insolvency (under reinsurance) simultaneously. Therefore, they have to adjust their reinsurance to the target as faster as possible. As a whole, highly levered insurers with under reinsurance adjust faster than highly levered insurers with over reinsurance are expected. Thus, the hypothesis of ***H3d*** is generated as follows.

H3d: Highly levered insurers with over reinsurance adjust slower than highly levered insurers with under reinsurance, i.e. $\boldsymbol{\beta_2} < \boldsymbol{\beta_4}$.

III. Numerical Variables and Data

1. Variables Descriptions

The explanatory variables used for the target reinsurance estimation are referred from the existing literature on reinsurance researches (e.g., Mayers and Smith, 1990; Garven and Lamm-Tennant, 2003; Cole and McCullough, 2006; Wang et al., 2008; Yanase, 2010; Shiu, 2011; Chang, 2014; Chang and Jeng, 2015). Literature also suggests that the variation effects in the different lines of business may influence firms' reinsurance decision. As a result, this article also uses premiums written in each line of business[2] to control the impact of variations in lines of business on the reinsurance demand (Mayers and Smith, 1990; Cole and McCullough, 2006; Wang et. al., 2008; Chang, 2014; Chang and Jeng, 2015). Table 1 provides the definitions and

[2] The variable is defined as the ratios of premiums written in each line of business to premiums written in all 27 lines of business. To avoid a singular matrix in the regression, Mayers and Smith (1990), Cole and McCullough (2006), Wang et. al. (2008), Chang (2014), and Chang and Jeng (2015) suggest the model should exclude the financial guaranty, international, and reinsurance lines.

the predictions of all explanatory variables on the reinsurance analysis.[3]

[Insert Table 1 approximately here]

2. Data

The analysis is implemented by using the data from information that is provided in the annual reports of the NAIC (National Association of Insurance Commissioners) for all U.S. property-liability insurance companies. The sample covers the 5-year period from 2006 to 2010, which originally comprised 2,950 insurers. To be included in the sample, each company must have complete data for each single year and need to meet the following requirements. First, insurers with missing value will be excluded, and 2,623 insurers remain in this stage. Insurers that operated as professional reinsurers and whose reinsurance accounts for more than 75% of their total premium written were also excluded (Cole and McCullough, 2006; Powell and Sommer, 2007; Shiu, 2011; Chang, 2014; Chang and Jeng, 2015) and 2,506 insurers remain in this stage. Third, companies with unreasonable values (or illogical values) for all explanatory variables are also excluded from the empirical analysis.[4] Subsequently, 2,294 insurers remain. Third, because the regression specification includes lagged variables, any insurer with fewer than two consecutive years of data was excluded. Thus, the minimum number of years per insurer is 2, and the maximum number of years is 5. Finally, the exclusions leave this article with complete data for 1,949 insurers and with an unbalanced panel data of 6,959 firm-year observations. To minimize the influence of outliers, all variables are winsorized at the 1st and 99th percentiles, except for the dummy variables.

Summary statistics for all variables of the unbalanced panel data are showed in Table 2.[5] The mean (median) levels of **Reins** is 47.89% (43.53%) and with 34.61% standard deviation. The average (median) **Liq** is 81.48% (86.33%), which reports that the percentages of liquidity assets are about 81% of insurers' total assets for liquidity measurement. Additionally, the mean (median) value of **Leverage** is approximately 2.8771 (1.3077) and with 5.3451 standard deviation. The mean (median) of 2 years loss development (**Two_years_loss**) is $-2.8641*10^{-5}$ ($-9.2343*10^{-6}$), which indicates that insurers tend to over loss reserving. Moreover, 67.61% observations are stock

[3] This article does not provide the arguments of sign expectation. Please refer to Chang (2014) and Chang and Jeng (2015).

[4] For instance, the reinsurance ratio <0 and >1, leverage <0, the geographic and business Herfindahl index >1 and/or <0.

[5] Table 2 does not report the summary statistics of other control variables (*W(i)*) and year dummies.

insurers and 38.65% are single insurers. In sum, the summary statistics present the values of all variables are consistent to prior studies which propose that the variables used in this study are suitable.

[Insert Table 2 approximately here]

IV. Empirical Results

To examine whether insurers exhibit a tendency to adjust their reinsurance to the target level, this study first controls firm specific determinants of optimal (target) level of reinsurance and then examines the partial adjustment behavior. In Table 3, this article provides the regression results on determinants of target reinsurance level in terms of 4 distinct models, named Pooled Model (Column 1), Fixed Effect Model (Column 2), Random Effect Model (Column 3), and Mixed Effect Model (MEM; Column 4) with restricted maximum likelihood (REML), which allowing cross-sectional herteroskedastic and time-wise autoregressive covariance (Byoun, 2008). The results consistently indicate that most of firm-specific characteristics, such as leverage, liquidity, Herfindahl indices, size, organizational form, and single insurers, do influence the determinants of insurer's reinsurance level. Additionally, the sign of coefficients for 4 different models are consistent to the predictions. Furthermore, Hausman fixed effect test[6] (F test) indicates that year and firm fixed effects exist, whereas Hausman random effect test[7] (LM test), BP test, and BP2[8] test reject that the random effect model is appropriate for the target reinsurance estimate. Hence, this article adopts the fitted values of Fixed Effect Model to proxy insurers' target reinsurance level while running the partial adjustment models.

[Insert Table 3 approximately here]

In Table 4, this article reports the results of asymmetric partial adjustment models of Equation (5), (6), (7), and (8) which controlling both year and firm fixed effects. Column (1) presents the benchmark model results of reinsurance adjustment analysis (reinsurance ratio; **Reins**), whereas Column (2) and (3) report the empirical results of robustness checks for an alternative reinsurance measurement, named **Reins_loss reserve based**[9], and for the dataset which excluded the extreme values[10].

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[6] The null hypothesis of fixed effects test is "no fixed effects".

[7] The null hypothesis of Hausman random effect test is "random effect model is appropriate".

[8] Breusch and Pagan (1980).

[9] The definition of **Reins_loss reserve based** is referred from Weiss and Cheng (2012) and Fier, McCullough, and Carson (2012), which is defined as ceded loss reserves to the sum of direct loss reserves and assumed loss reserves.

[10] For the extreme value robustness check, this article also delete the values less than the 1st percentile

Column (1) of Panel A in Table 4 indicates that adjustment speed does exist and the speed is 77.13% per year. The evidence indicates that insurers intend to adjust their reinsurance toward the target level and/or intend to maintain a target reinsurance level so that the hypothesis of ***H1a*** ($\boldsymbol{\gamma_1} > \boldsymbol{0}$) is supported. Furthermore, Column (1) of Panel B in Table 4 also indicates the adjustment speed of above-target reinsurance is faster than of below-target reinsurance, which proposes that the hypothesis of ***H1b*** ($\boldsymbol{\gamma_3} > \boldsymbol{\gamma_4}$) is sustained. Insurers with over reinsurance tend to confront higher reinsurance costs so that they intend to reduce reinsurance level rapidly (Froot, 2001; Cummins, et. al., 2008).

Column (1) of Panel C in Table 4 reports the adjustment behavior of interaction impacts between reinsurance and organizational form. Given insurers with over reinsurance, the empirical results support the hypothesis of ***H2a*** ($\boldsymbol{\theta_1} > \boldsymbol{\theta_2}$). Stock insurers tend to adjust faster than mutual insurers which indicate that the benefits of *the raising capital hypothesis* and *the risk diversification hypothesis* is greater than the costs of *the agency cost hypothesis*. In contrast, given insurers with under reinsurance, the oppositely empirical results show that mutual insurers adjust their reinsurance faster than stock insurers which also supports that the benefits of *the raising capital hypothesis* and *the risk diversification hypothesis* is greater than the costs of *the agency cost hypothesis* (***H2d:*** $\boldsymbol{\theta_3} < \boldsymbol{\theta_4}$). It overall concludes that *the raising capital hypothesis* and *the risk diversification hypothesis* dominate insurers' reinsurance adjustment decision. Additionally, this article finds that both stock and mutual insurers with over reinsurance adjust faster than with under reinsurance (the hypotheses of ***H2e:*** $\boldsymbol{\theta_1} > \boldsymbol{\theta_3}$ and ***H2f:*** $\boldsymbol{\theta_2} > \boldsymbol{\theta_4}$ are supported) which is also consistent to the main argument of ***H1a*** hypothesis. Both stock and mutual insurers with over reinsurance tend to confront the higher reinsurance costs rather than insolvency protection benefits from over reinsurance, so they reduce reinsurance purchasing faster than with under reinsurance (Froot, 2001; Cummins, et. al., 2008).

Column (1) of Panel D in Table 4 shows the interaction influence of leverage decision to reinsurance adjustment. Given insurers with over reinsurance, the empirical results contradict to the hypothesis of ***H3a*** ($\boldsymbol{\beta_1} > \boldsymbol{\beta_2}$), which propose that insurers with highly levered tend to adjust faster than insurers with lowly levered. This study conjectures that insurers with over reinsurance tend to encounter higher

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and greater than the 99^{th} percentile from the data, which comprise 4,740 firm-year observations.

reinsurance costs (Froot 2001; Shiu 2009) so that highly levered with over reinsurance insurers reduce reinsurance faster than lowly levered ones. Additionally, insurers with highly levered tend to encounter a higher cash flow constraints as a result managers might reduce insurance premium expenditures (reinsurance premium) to fulfill the obligations of debt contracts (Zou et. al., 2003). Furthermore, Rochet and Villeneuve (2011) indicate that financial distress firms always purchase less insurance because they cannot afford the insurance costs.   On the other hand, given insurers with under reinsurance, insurers with lowly levered tend to adjust faster than insurers with highly levered. Also, the hypothesis of ***H3b*** ***($\boldsymbol{\beta_3} < \boldsymbol{\beta_4}$)*** is opposite. The plausible explanation is that lowly levered insures tend to have lower cash flow (John, 1993) as a result they have incentives to preserve higher reinsurance level to prevent liquidity risk and insolvency risk simultaneously. Therefore, lowly levered insurers with under reinsurance intend to increase reinsurance level fast.

Moreover, this study finds that lowly levered insurers with over reinsurance adjust faster than lowly levered insurers with under reinsurance (***H3c:*** $\boldsymbol{\beta_1} > \boldsymbol{\beta_3}$) which is also consistent to the argument of hypothesis ***H1a***. However, the empirical results show that highly levered insurers with over reinsurance adjust faster than highly levered insurers with under reinsurance which indicates the hypothesis of ***H3d*** ($\boldsymbol{\beta_2} < \boldsymbol{\beta_4}$) is not sustained These results indicate that the arguments of *the bankruptcy cost*, *the agency cost*, *the risk bearing*, and *the renting capital hypotheses* seem not sustain for those highly levered insurers. Similar to the prior arguments, insurers with over reinsurance tend to confront the higher reinsurance cost is upheld again. As a whole, highly levered insurers with over reinsurance adjust faster than highly levered insurers with under reinsurance.

[Insert Table 4 approximately here]

This study implements some robustness checks to complement the main findings in this article. Column (2) in Table 4 reports the empirical results of reinsurance adjustment for an alternative reinsurance measurement (loss reserve based measurement; Weiss and Cheng, 2012; Fier, McCullough, and Carson, 2012). Overall, most of empirical results of Panel A to Panel D are consistent to the benchmark analysis (Panel A to Panel D of Column (1)).   Nevertheless, there still exist some inconsistent results, for instance, given insurer with over reinsurance, Panel C shows that the hypothesis of ***H2a*** ($\boldsymbol{\theta_1} > \boldsymbol{\theta_2}$) is not supported again. As well, given mutual insurers, the hypothesis $\boldsymbol{H2f}$ ($\boldsymbol{\theta_2} > \boldsymbol{\theta_4}$) does not hold again. In addition, in Panel D, given insurers with lowly levered, $\boldsymbol{H3c}$ ($\boldsymbol{\beta_1} > \boldsymbol{\beta_3}$) does not uphold again. However, it should be noted that the coefficients equality tests of these contradict results are non-rejected which propose that these inconsistent results might be weakly. In other words, it concludes that insurers' reinsurance adjustment behaviors of an alternative reinsurance measurement are overall consistent to the benchmark analysis. For the robustness check of extreme values analysis, the empirical results are showed in Column (3) of Table 4. Overall, the results from Panel A to Panel D are consistent to the main findings in Column (1) which propose our main findings are robust to the extreme values test.

V. Conclusion

Most of theoretical studies suggest that insurers tend to seek an optimal (target) reinsurance level. It implies that insurers with an over and/or under optimal reinsurance level would generate additional costs if they intend to adjust their reinsurance level to the target. Insurers with over (under) reinsurance tend to be safe (risky), but tend to disadvantage (advantage) from high (low) reinsurance costs. Consequently, trade-off type behavior orient toward an optimal reinsurance level is emerged. This article evidences that insurers tend to have the optimal (target) reinsurance level so that they intend to adjust their reinsurance level to the target over time.

This article analyzes the insurers' reinsurance adjustment decision and its interaction with organizational form and leverage for U.S. property-liability insurance insurers. Overall, the empirical results indicate that adjustment speed does exist, which present insurers adjust their reinsurance level towards the target over time, and the result is consistent to the trade-off type behavior. Also, the evidence shows that the speed of reinsurance adjustment of above-target reinsurance is faster than of below-target reinsurance, which supports the hypotheses that this article proposed. Finally, the evidence also indicates that the speeds of reinsurance adjustment are distinct between stock and mutual insurers as well as highly and lowly levered insurers in terms of various incentives.

The evidence further sustains that the transferring risk to reinsurers is expensive (Froot, 2001; Commins, et. al, 2008). Insurers with over reinsurance will pay several times the actuarial price of the risk transferred. Additionally, the evidence also enhances the argument of Niehaus and Mann (1992). Insurers confront the costs of negotiating and monitoring reinsurance agreements and of time delay associated with arranging reinsurance when adjusting their reinsurance contract. Thus, it takes times to adjust their reinsurance towards the target over time but not immediately.

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Table 1 Summaries of the definitions and the predictions for all explanatory variables

Variables	Prediction	Definition
Dependent Variables		
Reins		(Affiliated reinsurance ceded + nonaffiliated reinsurance ceded) / (direct business written plus reinsurance assumed).
Independent Variables (-1)		
Liq	-	The sum of cash plus invested assets to total assets.
Leverage	+	Direct business written to surplus.
Tax_ex	+	Tax-exempt investment income relative to total investment income.
ROA	-	Net income plus tax and interest expense divided by admitted assets.
Bus_H	+/-	Sum of the squares of the ratio of the dollar amount of direct business written in a particular line of insurance to the dollar amount of direct business across all 27 lines of insurance.
Geo_H	+/-	Sum of the squares of the ratio of the dollar amount of direct business in state j to the total amount of direct business across all states.
Two_year_loss	+	Development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by the policyholders' surplus.
Size	-	Natural logarithm of admitted assets.
Stock	+/-	Equal to 1 for a stock insurer and 0 for a mutual insurer.
Single	-	Equal to 1 if for a non-affiliated insurer and 0 for an affiliated insurer.
W(i)		The ratios of the premiums written in each line of business to the premiums written in all 26 lines of business.

Table 2 Summary Statistics of Numerical Variables

The dependent variables for the target reinsurance estimation is **Reins**, which is defined as (affiliated reinsurance ceded + nonaffiliated reinsurance ceded) / (net premium written plus reinsurance assumed), (affiliated reinsurance ceded) / (net premium written plus reinsurance assumed). The **Liq** is defined as sum of cash plus invested assets to admitted assets. The **Leverage** is defined as the net premium written/surplus. The variable of **Tax_ex** is defined as tax-exempt investment income relative to total investment income. And **ROA** is defined as net investment gain divided by assets. The **Geo_H** variable is geographic Herfindahl index for insures, which is defined as the sum of the squares of the ratio of the dollar amount of direct business in state j to the total amount of direct business across all states. On the other hand, the **Bus_H** variable is line of business Herfindahl index for insurers, which is defined as sum of the squares of the ratio of the dollar amount of direct business written in a particular line of insurance to the dollar amount of direct business across all 27 lines of insurance. The variable of **Two_year_loss** is two-year loss development, this variable equals the development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by policyholders' surplus. The proxy of **Size** is the natural logarithm of total assets. The organizational form dummy is **Stock**, which equals 1 if the insurer is a stock and 0 if it is a mutual. Finally, the group dummy is **Single**, which is to indicate an affiliated or non-affiliated insure. It equals 1 if the insurer is non-affiliated and 0 if it is affiliated. The sample consists of 6,959 firm-year observations and is winsorized at 1st and 99th percentiles.

Variables	Mean	Median	Std Dev	25th	75th
Dependent Variables					
Reins	0.4789	0.4353	0.3461	0.1594	0.8119
Independent Variables (-1)					
Liq	0.8148	0.8633	0.1735	0.7685	0.9283
Leverage	2.8771	1.3077	5.3451	0.6985	2.5920
Tax_ex	0.2644	0.1911	0.2666	0.0204	0.4282
ROA	0.0417	0.0404	0.0592	0.0156	0.0682
Bus_H	0.5843	0.5157	0.2976	0.3186	0.9646
Geo_H	0.5975	0.6194	0.3863	0.1921	1.0000
Two_year_loss	0.0000	0.0000	0.0001	-0.0001	0.0000
Size	17.8906	17.8077	1.8914	16.5011	19.2158
Stock	0.6761	1.0000	0.4680	0.0000	1.0000
Single	0.3865	0.0000	0.4870	0.0000	1.0000
Firm-year observations	6,959				

Note a: The mean value of **Two_year_loss** equals to $-2.8641*10^{-5}$ rather than 0.
Note b: The median value of **Two_year_loss** equals to $-9.234277*10^{-6}$ rather than 0.

Table3 Parameter Estimates on Determinants of Target Reinsurance

The dependent variable is reinsurance ratio, named **Reins**. Independent variables are those lagged variables presented in Table 2. This study provides 4 distinct targeted estimation models to generate the fitted value for reinsurance which includes (1) pooled estimation without control fixed and random effects, (2) year and firm fixed effects, (3) year and firm random effects, and (4) Mixed Effect Models (MEM) with restricted maximum likelihood (REML) which allowing cross-sectional herteroskedastic and time-wise autoregressive covariance. The sample consists of 5,959 firm-year observations and winsorized at the 1st and 99th percentiles.

Variables	(1)Pooled		(2)Fixtwo		(3)Rantwo		(4)Mixed	
Intercept	2.0482	***	1.3268	***	1.6164	***	1.6734	***
Liq	-0.3551	***	-0.1086	***	-0.1588	***	-0.1740	***
Leverage	0.0100	***	0.0021	***	0.0052	***	0.0058	***
Tax_ex	-0.0155		-0.0036		-0.0059		-0.0066	
ROA	-0.0645		0.0416		0.0560	**	0.0525	
Bus_H	-0.1056	***	-0.0046		-0.0688	***	-0.0756	***
Geo_H	-0.1084	***	-0.0864	***	-0.0912	***	-0.0940	***
Two_year_loss	82.3376	***	-19.3121		-9.9129		-9.0686	
Size	-0.0491	***	-0.0278	***	-0.0380	***	-0.0395	***
Stock	0.0785	***	0.0065		0.0607	***	0.0633	***
Single	-0.2236	***	-0.0941	***	-0.1564	***	-0.1671	***
Hausman Fixed Effect F Test[a]			25.95	***				
Hausman Random Effect LM Test					285.39	***		
BP Random Effect Test (one way)[b]					6311.18	***		
BP2 Random Effect Test (two way)					51217.2	***		

Note a: The null hypothesis of fixed effects test is “no fixed effects”.

Note b: Breusch and Pagan (1980). The null hypothesis of Hausman random effect test is “random effect model is appropriate”.

Table 4 Estimation of Asymmetric Partial Adjustment Models: Main analysis

This table shows the estimation results of reinsurance partial adjustment models by controlling year and firm fixed effects. The samples consist of 5,959 firm-year observations and are winsorized at the 1st and 99th percentiles. Column (1) is the benchmark model of insurers' reinsurance adjustment. Column (2) presents the adjustment results for alternative reinsurance measurement. Column (3) shows the empirical results for the dataset which excluded the extreme values (4,740 firm-year observations). This study also provides χ_2 values of likelihood ratio test which are provided to examine whether or not the coefficient estimates are equal.

$\Delta R_{it} = \gamma_0 + \gamma_1 TDE_{it} + \varepsilon_{it}$,

$\Delta R_{it} = \gamma_2 + \gamma_3 TDE_{it} R^a_{it} + \gamma_4 TDE_{it} R^b_{it} + \epsilon_{it}$,

$\Delta R_{it} = \theta_0 + (\theta_1 stock + \theta_2 mutual) TDE_{it} R^a_{it} + (\theta_3 stock + \theta_4 mutual) TDE_{it} R^b_{it} + \varphi_{it}$.

$\Delta R_{it} = \beta_0 + (\beta_1 LLev + \beta_2 HLev) TDE_{it} R^a_{it} + (\beta_3 LLev + \beta_4 HLev) TDE_{it} R^b_{it} + \tau_{it}$.

	(1)Reins	(2)Reins_loss reserve based	(3)Excluded extreme values
Panel A Symmetric Partial Adjustment Model			
Intercept(γ_0)	0.0167	0.0037	0.0126
TDE(γ_1)	0.7713 ***	0.7373 ***	0.7841 ***
Panel B Asymmetric Partial Adjustment Model			
Intercept(γ_2)	-0.0078	-0.0070 ***	-0.0148
TDE*R^a(γ_3)	0.8826 ***	0.8003 ***	0.9369 ***
TDE*R^b(γ_4)	0.6164 ***	0.6688 ***	0.5676 ***
Panel C Asymmetric Partial Adjustment Model with deviations from target reinsurance and Organizational Form			
Intercept(θ_0)	-0.0215	-0.0186	-0.0225
TDE*R^a*Stock(θ_1)	0.9191 ***	0.8020 ***	0.9677 ***
TDE*R^a*Mutual(θ_2)	0.7270 ***	0.8430 ***	0.8332 ***
TDE*R^b*Stock(θ_3)	0.4888 ***	0.5261 ***	0.4949 ***
TDE*R^b*Mutual(θ_4)	0.6974 ***	0.9989 ***	0.5756 ***
Panel D Asymmetric Partial Adjustment Model with deviations from target reinsurance and leverage			
Intercept(β_0)	-0.0289	-0.0228	-0.0215
TDE*R^a*LLev(β_1)	0.8297 ***	0.7482 ***	0.9348 ***
TDE*R^a*HLev(β_2)	0.9580 ***	0.8523 ***	0.9445 ***
TDE*R^b*LLev(β_3)	0.7482 ***	0.8136 ***	0.6760 ***
TDE*R^b*HLev(β_4)	0.4562 ***	0.5352 ***	0.4540 ***
$\gamma_3 = \gamma_4$ Test	33.05 ***	7.74 ***	46.92 ***
$\theta_1 = \theta_2$ Test	4.88 **	0.33	2.12
$\theta_3 = \theta_4$ Test	4.57 **	42.69 ***	0.57
$\theta_1 = \theta_3$ Test	62.96 ***	25.74 ***	55.23 ***
$\theta_2 = \theta_4$ Test	0.04	1.73	2.54
$\beta_1 = \beta_2$ Test	12.94 ***	6.39 **	0.05
$\beta_3 = \beta_4$ Test	36.70 ***	38.42 ***	14.98 ***
$\beta_1 = \beta_3$ Test	2.26	1.27	14.77 ***
$\beta_2 = \beta_4$ Test	72.22 ***	29.36 ***	54.43 ***
Firm-year obs.	6,965	6,965	4,740

Note: ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.