Determinants of the Demand for Reinsurance for the U.S. Property-Liability Insurance Industry: Quantile Regression Analysis

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(Received Feb 19, 2013; First Revision Dec 11, 2013; Second Revision Apr 9, 2014; Third Revision Jun 6, 2014; Accepted Aug 7, 2014)

1. Introduction

Reinsurance is an important risk management device for primary insurers, especially when that risk leads to catastrophes such as the 921 earthquake in Taiwan, Hurricane Katrina in the U.S., and the earthquake in Sichuan province, in China. Insurers always treat reinsurance as a hedge mechanism to overcome non-diversifiable risks. In addition, reinsurance can be used to limit the insurer’s underwriting risks and reduce the probability and expected costs of potential bankruptcy. Thus, reinsurance is often regarded as an indispensable and effective risk management mechanism for primary insurers.

It is critical for property-liability insurers to purchase sufficient reinsurance contracts. The short-term contract characteristic forces managers to pay more attention to a firm’s liquidity. Because reinsurance can be treated as a substitute for firm liquidity, as well as for firm capital, property-liability insurers actually rely on reinsurance to reduce short-term financial pressures and liquidity risks. Furthermore, short-term insurance policies may generate insufficient cash reserves, encouraging managers to demand further reinsurance to mitigate the impact of catastrophic risk on the near-event horizon.

The current literature provides insightful evidence of factors for determining insurers’ demand for reinsurance (Carneiro and Sherris 2005; Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Kader and Adams 2007; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008; Yanase 2015). However, most of analyses adopt the ordinary least squares regression (OLS), or the two-stage least squares regression (2SLS) methods, which model the relationship between the covariates of firm-specific characteristics and the conditional mean of demand for reinsurance, by examining issues related to demand for reinsurance. To the best of my knowledge, relatively few papers have studied the determinants of an insurer’s demand for reinsurance using a quantile regression (QR) approach or a two-stage quantile regression approach (2SQR), even though QR could provide an alternative dimension to the study of demand analysis and contribute to the analysis of heavy-tailed data. Thus, this study aims to fill an important void in the literature.

It is predicted that insurers with higher levels of reinsurance tend to be safer and experience less financial pressure and liquidity risk than insurers with lower reinsurance levels. Thus, one can predict that the insurer’s behavior, for instance, including risk behavior and financial and operating strategies, should present a significant difference in the lower and higher reinsurance quantiles. Thus, the QR approach naturally provides useful functions for examining the determinants of insurer’s demand for reinsurance across various quantiles, especially for insurers within the lower quantiles.

Prior studies suggest that insurer leverage and liquidity maintenance may represent endogenous influences on demand for reinsurance (Chang and Jeng 2015; Shiu 2011). Therefore, in this study, the 2SQR paradigm is implemented to correct for endogeneity bias (Amemiya 1982; Chen and Portnoy 1996; Kim and Muller 2004; Powell 1983). Instead of focusing on the average effects of covariates on the demand for reinsurance, this study applies the 2SQR approach to explore the potentially differential effects across the demand distribution. Using pooled, time-series, and

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1Koenker and Bassett (1978) introduce the QR approach. Koenker and Hallock (2001) further propose that there are several advantages to this approach. For example, the QR approach seizes the critical features of the database used and offers a complete picture of the covariate effect when a set of percentiles is modeled (Chang and Tsai 2014).

2I sincerely thank the anonymous referee who proposed that this study should provide the endogeneity test among demand for reinsurance, leverage, and liquidity. In this study, the Hausman’s specification test indicates that the endogeneity influences of insurer’s leverage and liquidity on demand for reinsurance do exist. This study details the endogeneity test in the methodology section.

3The QR estimation bias due to endogenous variables is as a result of ignoring the dependence between the explanatory variable and the unobserved error term. Since the error term of reduced-form of the endogenous variable is correlated with the structural error term of the dependent variable, it can be regarded as an omitted control variable in the traditional QR model. The QR estimation has large MSE (mean square errors) as the degree of endogeneity is higher. Thus, this study uses 2SQR to correct for the endogeneity bias from endogenous variables.
cross-sectional data for U.S. property-liability insurers from 2006 to 2010, the 2SQR results show that the influence of some firm-specific characteristics, for instance liquidity and loss development, are not constant across quantiles, which contradicts the findings of prior studies (Chang and Jeng 2015; Cole and McCullough 2006; Hau 2006; Wang et al. 2008). The evidence presented here indicates that 2SQR analysis could provide a richer and more insightful explanation for the lower and higher quantiles of the reinsurance distribution than by just using the 2SLS approach. In addition, the evidence indicates that other firm-specific characteristics (e.g., leverage, profitability, organizational form, and concentrations) exert an impact on the consistency of results with the 2SLS approach. However, the magnitude of these influences on demand for reinsurance differs significantly across various reinsurance quantiles. These findings again enhance the main argument proposed in this study.

The contributions of this study are as follows. First, this study is the first article to analyze the determinants of the insurer’s demand for reinsurance within a particular quantile of the overall demand distribution, and it provides more meaningful information than the traditional 2SLS approach, while also compensating for the inherently biased estimations of the latter model. Thus, the present study fills an important analytic gap in the literature by applying the 2SQR analysis. Second, the 2SQR approach can analyze the influence of covariates at a specific point in the reinsurance distribution, which provides more insightful evidence for the lower and higher quantiles of the demand distribution than the 2SLS approach. Specifically, this study finds that liquidity and the loss of development are not constant across various quantiles, which contradicts the findings reported in previous studies (Chang and Jeng 2015; Cole and McCullough 2006; Hau 2006; Wang et al. 2008). In addition, the magnitude of the impacts for other firm-specific characteristics on demand for reinsurance varies significantly across the quantile range, even if the signs of empirical results are consistent with the previous literature. The evidence further concurs with the main hypotheses, which are developed and presented below. Third, the insightful information obtained using the 2SQR approach provides an incentive for policyholders, policy makers, and/or regulators to assess the insurer’s demand for reinsurance through these firm-specific characteristics, especially in the case of insurers in the lower reinsurance quantiles.

The rest of this paper is structured as follows. Section II describes the primary hypotheses and variables used in this study. Section III briefly discusses the 2SQR approach. Section IV interprets the data, presents model fitness checks, and reports the empirical results. Section V concludes the article.

2. Hypotheses Development and Variables Description

2.1 Hypotheses Development

Note that the expectations of all exogenous variables for the traditional 2SLS approach may be distinct from the 2SQR approach. For instance, the hypotheses of bankruptcy cost, agency cost, risk bearing, and renting capital all propose that a higher-leverage insurer tends to increase their demand for reinsurance (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Shiu 2011; Wang et al. 2008). However, the impact of leverage on demand for reinsurance may differ between insurers in lower and higher quantiles. Since the negative marginal effect of reinsurance on underwriting risk is likely to diminish in the higher reinsurance quantiles, the effect of leverage on reinsurance is likely to increase as the level of reinsurance increases. For each additional unit of leverage, an insurer with a high level of reinsurance will need “more” reinsurance to satisfy its target level of underwriting risk, because the negative marginal effect of reinsurance on underwriting risk is likely to increase for the lower reinsurance quantiles.

Furthermore, the substitute hypothesis indicates that higher liquidity insurers tend to demand less reinsurance (Chang and Jeng 2015; Hau 2006). However, it is predicted that the impact of liquidity maintenance on demand for reinsurance in the lower quantiles also differs from demand in the higher quantiles. Likewise, since the negative marginal effect of reinsurance on underwriting risk is likely to lessen in the higher reinsurance quantiles, the effect of liquidity maintenance on reinsurance is likely to decrease in the higher quantiles. Thus, for each increment of liquidity maintenance, an insurer with a high level of reinsurance will need “less” reinsurance to uphold its target level of underwriting risk. On the contrary, based on the argument similar to those above, to sustain its target level of underwriting risk, an insurer with a low level of reinsurance will need “more” reinsurance for each increment of liquidity maintenance in the lower reinsurance quantiles. The reason is that insurers in the lower reinsurance quantiles encounter more financial pressures or bankruptcy costs. This forces insurers to gradually increase their demand for reinsurance, even if they possess liquid assets. Accordingly, it is predicted that the determinants of demand for reinsurance across the reinsurance distribution are also different for other explanatory variables. Consequently, this study sets out to test the following hypotheses:

Hypothesis 1: The impact of firm-specific characteristics on demand for reinsurance is different for firms at opposite ends of the demand distribution.

Hypothesis 2: The predictions of determinants of reinsurance differ between the 2SLS approach and 2SQR approach.

4Overall, one can surmise that the influence of other explanatory variables (e.g., organizational form, profitability, tax issues, and loss of reserves) on demand for reinsurance is also distinct at the lower and higher reinsurance quantiles.
The traditional analysis of demand determinants employs the OLS/2SLS approach (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008; Yanase 2015). The 2SLS approach relies on an *a priori* distributional assumption of the dependent variable. In addition, the 2SLS approach always accepts a homogeneous influence of the dependent variable, which increases the estimation bias, especially when the dependent variable is heterogeneous.

In contrast to the 2SLS approach, the QR/2SQR approach, which presents a more complete picture of the covariate effect, allows us to examine the differential effects across the demand for reinsurance distribution when a set of percentiles is modeled. Thus, one could conduct an assessment at the tails of the dependent variable by identifying the determinants separately. In addition, the 2SQR approach is robust and less sensitive to the presence of outliers or skewed tails. To sum up, the 2SQR approach is more efficiently provide insightful information than the 2SLS approach, especially at the tails of the reinsurance distribution. This study then hypothesizes that

**Hypothesis 3:** The 2SQR approach complements the 2SLS approach in terms of providing efficient estimation and insightful information.

### 2.2 Description of Variables

Prior studies always adopted the reinsurance ratio as a proxy for the insurer’s demand for reinsurance (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008; Yanase 2015). In accordance with prior research, the insurer’s reinsurance ratio (Reins), which is defined as (affiliated reinsurance ceded + nonaffiliated reinsurance ceded)/(direct business written plus reinsurance assumed), is also used.

The literature suggests that several firm-specific characteristics, such as bankruptcy, tax issues, profitability, concentration level, organizational form, liquidity risk, solvency concerns, and business mix, may affect the insurer’s demand for reinsurance (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008; Yanase 2015). Accordingly, these firm-specific characteristics and hypotheses are then introduced as follows.

With regard to bankruptcy characteristics, three variables are adopted: firm size, leverage, and loss development. In accordance with the hypotheses of bankruptcy cost, agency cost, risk bearing, and renting capital, leverage is predicted to be positively related to the demand for reinsurance (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant, 2003; Shiu, 2011; Wang et al. 2008). It is predicted that insurers writing more business relative to their surpluses should have a higher insolvency probability; therefore, greater leverage tends to produce a higher demand for reinsurance. The measurement of the insurer’s leverage is defined as the direct business written to surplus (Leverage)⁵.

As suggested in previous studies (Chang and Jeng 2015; Christensen, Hoyt, and Paterson 1999; Cole and McCullough 2006; Gaver and Paterson 1990; Grace 1990; Petroni 1992; Shiu 2011; Wang et al. 2008; Weiss 1985), potential financial constraints also play an important role in demand for reinsurance. Insurers with a positive loss development (i.e., under-loss reserving) will purchase more reinsurance contracts to surmount their potential financial constraints, whereas insurers will purchase less if they have a negative loss development (i.e., over-loss reserving). In addition, Harrington and Danzon (1994) indicate that insurers may hide their underreported claim liability and capital inadequacy by using reinsurance. To sum up, the positive relationship between loss reserve and demand for reinsurance is expected. Following Cole and McCullough (2006), two-year loss development (2-years_loss), which is defined as the development in estimated losses and loss expenses incurred 2 years before the current year and prior year (scaled by policyholders’ surplus), is chosen to proxy the insurer’s potential financial constraints.

Hau (2006) proposed that an insurance contract can provide additional liquidity to a nonfinancial firm, which implies that the relationship between corporate insurance demand and liquidity is substitutive. Based on his argument, this study extends his rationale to the insurance industry and argues that reinsurance contracts provide extra liquidity for primary insurers. In addition, insurers with more liquid assets have an increased ability to mitigate unexpected and/or emergent demand for cash, thus reducing their demand for reinsurance (Chang and Jeng 2015). Therefore, it is predicted that the insurer’s liquidity is negatively related to its demand for reinsurance. The liquidity (Liq) measurement is defined as the sum of cash and invested assets divided by total assets.

To reduce the probability of insolvency, small insurers tend to purchase more reinsurance contracts than large insurers (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Hoyt and Khang 2000; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008; Weiss and Chung 2004; Yanase 2015). Thus, a negative relationship between firm size and demand for reinsurance is predicted. In this study, the natural logarithm of total assets is used to measure firm size (Size).

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⁵As the anonymous referee points out, many prior studies also use liabilities to assets as a proxy for leverage. This study also use liabilities to assets to reexamine the 2SQR for robustness check. Overall, the results are consistent to the main findings of Table 3. This study does not tabulate those specific results here. For a consistent comparison, in this paper we follow previous studies (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Shiu 2011; Wang et al. 2008) and use the ratio direct business written to surplus to measure the insurer’s leverage. I sincerely thank the anonymous referee for pointing out this important issue.
This study also uses tax-exempt investment income relative to total investment income (\(\text{Tax\_ex}\)) as a proxy to capture the influence of expected tax liability and/or tax-favored assets. Smith and Stulz (1985) and Mayers and Smith (1990) indicate that insurers can reduce their earnings volatility through reinsurance purchasing, thereby reducing their expected tax liability. Garven and Lamm-Tennant (2003) propose that insurers can benefit from reinsurance purchasing in terms of mitigating the costs of huge unexpected losses and enhancing investments in tax-favored assets. Thus, a positive relationship between the tax-exempt factor and the demand for reinsurance is predicted. However, the empirical findings of Adams, Hardwick, and Zou (2008), Graham and Rogers (2002), and Shiu (2011) do not support the positive influence of tax-exempt factors on demand for reinsurance. In addition, Adams, Hardwick, and Zou (2008) and Shiu (2011) further propose that insurers with a higher marginal tax rates will purchase less reinsurance to decrease expected tax liabilities. To sum up, the expected sign between the tax-exempt factor and the demand for reinsurance is mixed.

Insurers with higher profits tend to demand less reinsurance because they have higher payment capacity and cash flows to confront loss claims and financial pressures (Chang and Jeng 2015; Cole and McCullough 2006; Mayers and Smith 1990; 2004; Powell and Sommer 2007; Shiu 2011; Wang et al. 2008). To control for profitability impacts on demand for reinsurance, the insurer’s profitability, that is, the insurer’s return on assets (\(\text{ROA}\)), is adopted, which is defined as net income plus tax and interest expenses, divided by total assets.

The degrees of business concentration (\(\text{Bus\_H}\)) and geographic concentration (\(\text{Geo\_H}\)) also influence the insurer’s reinsurance decision. The business Herfindahl Index is defined as the 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 26 lines of insurance; in addition, the geographic Herfindahl Index 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 (Chang and Jeng 2015; Cole and McCullough 2006; Kim, Mayers, and Smith 1996; Mayers and Smith 1990; Shiu 2011; Wang et al. 2008). The argument for risk diversification indicates that insurers with a higher concentration in a given line of business, or in a given geographic area, may have higher incentives to purchase more reinsurance. In contrast, the real services hypothesis indicates that reinsurers not only provide protection against unexpected losses but also supply real services via specialized knowledge and economies of scale. Thus, to obtain more technical support from reinsurers, less business- or geographic-concentrated insurers may demand more reinsurance. In addition, Shiu (2011) indicates that more concentrated insurers could specialize in, and may underwrite less volatile lines of business, or less-risky contracts and, therefore, demand less reinsurance. In sum, the predictions between business and geographic concentrations and the demand for reinsurance are undetermined.

Since the organizational form hypothesis indicates that stock insurers can benefit from diversification (outside shareholders) and/or from a lower cost of raising external capital, this suggests that stock insurers tend to purchase less reinsurance than mutual insurers (Mayers and Smith 1990). On the contrary, the agency cost hypothesis proposes that insurers’ purchases of more reinsurance could mitigate the underinvestment problem among residual claimholders (Adams 1996; Shiu 2011). Consistent to the agency cost hypothesis, Adams (1996) and Shiu (2011) find that stock insurers purchase more reinsurance than mutual insurers. Summing up, this study proposes that the prediction effect of the organizational form is mixed. The stock dummy variable (\(\text{Stock}\)) is used to control for the organizational form effect, which is defined to be 1 if the insurer is the stock insurer, and 0 otherwise.

To control for the systematic difference between a single firm (nonaffiliated insurer) and a firm belonging to a group (affiliated insurer), the single dummy variable (\(\text{Single}\)) is used. It equals 1 if the insurer is nonaffiliated, and 0 if it is affiliated. A negative relationship between the single dummy variable and the demand for reinsurance is expected because insurers belonging to a group are able to shift profits within the group and thus, reduce tax payments (Chang and Jeng 2015; Cole and McCullough 2006; Wang et al. 2008).

It should be noted that commercial lines (\(\text{Com\_line}\)) are essentially more risky and contain higher claim volatility than personal lines\(^6\). Based on the risk-taking viewpoint, insurers that write more commercial lines also tend to purchase more reinsurance. In addition, a higher claims volatility pattern also forces insurers to rely more on reinsurance contracts (Adams, Hardwick, and Zou 2008; Graham and Rogers 2002; Graham and Smith 1999). Consequently, it is expected that insurers that write greater volumes of commercial lines are more likely to purchase reinsurance. The commercial lines ratio is defined as: (direct premium written of fire, allied lines, farm owners multiple peril, commercial multiple peril, mortgage guaranty, ocean marine, inland marine, financial guaranty, medical malpractice-occurrence, medical malpractice-claims made, earthquake, group accident and health, credit accident and health (group and individual), other accident and health, workers’ compensation, other liability -occurrence, other liability-claims made, products liability-occurrence, products liability-claims made, commercial auto liability, aircraft (all perils), fidelity, surety, burglary and theft, boiler and machinery, and credit), divided by direct business written.

\(^6\)I sincerely thank the anonymous referee who proposed that the underwriting portfolio has been considered to have an effect on demand for reinsurance. Thus, this study uses a commercial lines ratio to control underwriting mix effects on the insurer’s demand for reinsurance.
Insolvency concerns also have an important influence on demand for reinsurance. Chen, Hanwi, and Hudson (2001) and Shiu (2011) point out that insurers with a higher probability of insolvency tend to purchase more reinsurance. The reason is that an insolvent insurer with higher levels of reinsurance is better positioned to confront higher external financial costs in the capital markets. This study adopts the natural logarithm of the RBC ratio (LnRBC) to proxy an insurer’s degree of insolvency. The RBC ratio is defined as (Total Adjusted Capital *100)/(2*Authorized Control Level), where the items are collected from the five-year historical annual statement from the National Association of Insurance Commissioners (NAIC).

The literature also suggests that the variation effects among the different lines of business may influence the insurer’s reinsurance decisions, because some lines of business may have particular effects on their demand for reinsurance; for instance, liability related lines, in which higher agency costs give the insurer greater incentive to purchase more reinsurance. Consequently, this article also uses premiums written in each line of business (W(i)) to control for the impact of variations in lines of business on demand for reinsurance (Chang and Jeng 2015; Cole and McCullough 2006; Mayers and Smith 1990; Shiu 2011; Shortridge and Avila 2004; Wang et al. 2008). Finally, year dummies are also included to control time-series heterogeneous effects as a whole.

3. Methodology

Based on the logic of Cummins and Sommer (1996) and Baranoff and Sager (2002; 2003), Shiu (2011) concludes that the insurer’s leverage has endogenous influence in determining the insurer’s demand for reinsurance. Thus, insurers tend to have a target underwriting risk as a result to determine their demand for reinsurance and leverage simultaneously. Chang and Jeng (2015) further propose that liquidity maintenance also produces an important endogenous effect on demand for reinsurance. Likewise, for approaching underwriting risk targets, insurers determine their demand for reinsurance, liquidity, and leverage endogenously and simultaneously. According to the argument of Chang and Jeng (2015) and Shiu (2011), the 2SQR paradigm is performed to correct the endogeneity bias, by replacing the endogenous regressors with their fitted values of the reduced-form equations in this study (Amemiya 1982; Chen and Portnoy 1996; Kim and Muller 2004; Powell 1983). The traditional 2SLS approach only captures the average effects of covariates on demand for reinsurance. However, the 2SQR approach not only explores potentially differential effects across the reinsurance distribution but also provides further insightful information on how the insurer’s demand for reinsurance is determined. Therefore, this study intends to complement the literature gap in terms of the 2SQR approach.

The 2SQR estimation procedure is introduced as follows. Consider a linear model describes as:

\[ Y_1 = \beta_0 + Y_2 \beta_1 + Z_2 \beta_2 + \epsilon \]  

(1)

\[ Y_2 = \alpha_0 + Z_2 \alpha_1 + \nu \]  

(2)

where \( Y_1 \) is the dependent variable of interest, \( Y_2 \) is the endogenous regressor, \( Z_2 \) is an exogenous vector of \( Y_1 \), \( Z_2 \) is the exogenous vector of \( Y_2 \), \( \epsilon \) is the unobserved structural error term of \( Y_1 \), and \( \nu \) is the disturbance terms of \( Y_2 \). Let \( Z = [1, Z_1, Z_2] \) be a vector of all exogenous variables. The endogeneity of \( Y_2 \) is due to dependence between \( \epsilon \) and \( \nu \), conditional on \( Z \).

In the first stage, the reduced-form equations are set as:

\[ Y_2 = Z_2 \Psi + \nu \]  

(3)

From equation (3), the fitted values could be generated, i.e., \( \hat{Y}_2 = Z_2 \hat{\Psi} \).

(2011), and Chang and Jeng (2015). These variables include demand for reinsurance, liquidity, firm size, business and geographic Herfindahl indices, single firm dummy, intra-group Herfindahl Index, New York-licensed dummy, marketing channel dummy, organizational form dummy, return on capital, natural logarithm of the RBC ratio, and year dummies. The explanatory variables that are used in the liquidity equation are obtained from the existing literature (Bruinshoofd and Kool 2002; Chang and Tsai 2014; Chang and Jeng 2015; John 1993; Kim, Mauer, and Sherman 1998; Opler et al. 1999; Shiu 2006). These variables contain demand for reinsurance, leverage, business and geographic Herfindahl indices, 2 years’ loss development, firm size, stock dummy, single firm dummy, return spread, firm growth rate, cash flow volatility, reserves of liability and property lines, claims of liability and property lines, and year dummies. The result of Hausman’s specification test (F value = 423, rejecting the null hypothesis) indicates that the endogeneity influences of the insurer’s leverage and liquidity do exist.

10Instrument variables for the reduced-form equations consist of all exogenous, control, and year dummy variables of demand for reinsurance, liquidity, and leverage equations.
Table 1  Summary Statistics of Numerical Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Minimum</th>
<th>Mean</th>
<th>Median</th>
<th>Maximum</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reins</td>
<td>0.0000</td>
<td>0.3878</td>
<td>0.3449</td>
<td>0.9632</td>
<td>0.2903</td>
</tr>
<tr>
<td>Leverage</td>
<td>0.0419</td>
<td>1.7788</td>
<td>1.1542</td>
<td>12.4190</td>
<td>2.0024</td>
</tr>
<tr>
<td>2_years_loss</td>
<td>-0.0005</td>
<td>-0.0000</td>
<td></td>
<td></td>
<td>0.0004</td>
</tr>
<tr>
<td>Size</td>
<td>14.5017</td>
<td>18.3070</td>
<td>18.2111</td>
<td>22.9579</td>
<td>1.8366</td>
</tr>
<tr>
<td>Liq</td>
<td>0.2827</td>
<td>0.8284</td>
<td>0.8621</td>
<td>0.9927</td>
<td>0.1350</td>
</tr>
<tr>
<td>Tax_ex</td>
<td>0.0000</td>
<td>0.2899</td>
<td>0.2301</td>
<td>0.9566</td>
<td>0.2625</td>
</tr>
<tr>
<td>ROA</td>
<td>-0.1631</td>
<td>0.0395</td>
<td>0.0408</td>
<td>0.2296</td>
<td>0.0592</td>
</tr>
<tr>
<td>Bus_H</td>
<td>0.1403</td>
<td>0.5796</td>
<td>0.5122</td>
<td>1.0000</td>
<td>0.3033</td>
</tr>
<tr>
<td>Geo_H</td>
<td>0.0420</td>
<td>0.5684</td>
<td>0.5272</td>
<td>1.0000</td>
<td>0.3857</td>
</tr>
<tr>
<td>Stock</td>
<td>0.0000</td>
<td>0.6781</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.4672</td>
</tr>
<tr>
<td>Single</td>
<td>0.0000</td>
<td>0.4093</td>
<td>0.0000</td>
<td>1.0000</td>
<td>0.4918</td>
</tr>
<tr>
<td>Com_line</td>
<td>0.0000</td>
<td>0.6310</td>
<td>0.8383</td>
<td>1.0000</td>
<td>0.3990</td>
</tr>
<tr>
<td>LnRBC</td>
<td>0.2425</td>
<td>2.1947</td>
<td>2.1403</td>
<td>4.7270</td>
<td>0.7673</td>
</tr>
<tr>
<td>Obs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.626</td>
</tr>
</tbody>
</table>

The dependent variable is Reins, which is defined as (affiliated reinsurance ceded + nonaffiliated reinsurance ceded)/(direct business written plus reinsurance assumed). Leverage is defined as the ratio of direct business written-to-surplus. The variable of 2_years_loss is two-year loss development and equals the development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by policyholders’ surpluses. The proxy of firm size is Size, and is defined as the natural logarithm of total assets. The Liq is defined as the sum of cash plus invested assets-to-total assets. The variable of Tax_ex is defined as tax-exempt investment income relative to total investment income. And ROA is defined as net income plus tax and interest expense, divided by total assets. The Bus_H variable is the line of business Herfindahl Index, which is defined as the 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. Conversely, the Geo_H variable is the geographic Herfindahl Index, 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. The organizational form dummy variable is Stock, which is to indicate stock or mutuals. It equals 1 if the insurer is a stock, and 0 if it is a mutual. The single dummy variable is Single, which is to indicate an affiliated or nonaffiliated insurer. It equals 1 if the insurer is nonaffiliated, and 0 if it is affiliated. Com_line represents the proportion of the insurer’s commercial lines of business. Finally, LnRBC is defined as the natural logarithm of RBC ratio. In this study, total firm-year observations are 5,626.

Note a: The mean value of 2_years_loss equals to $-4.6591 \times 10^{-5}$ rather than 0.

Note b: The median value of 2_years_loss equals to $-3.2263 \times 10^{-5}$ rather than 0.

In the second stage, $Y_2$ in equation (1) is replaced by $Y_2^*$; then, the 2SQR estimator of $\hat{f}(\tau)$ is the solution to the following minimization problem:

$$
\text{Min}_{\beta \in \mathbb{R}^p} \sum_{i=1}^{n} \tau_i (Y_i - \hat{Y}_i, \beta_i) + \sum_{i=1}^{n} (1-\tau_i) (Y_i - \hat{Y}_i, \beta_i)
$$

To examine the distinct influences on determinants of the insurer’s demand for reinsurance between higher and lower demand for reinsurance quantiles, the equality test of estimated parameters of each variable across quantiles will be implemented. In addition, diagnostic tests of model fitness are also conducted to test whether the distribution of the distances of demand for reinsurance is normal and whether the quantile regression fits the data appropriately.

4. Data and Empirical Results

4.1 Data

An analysis is performed using data from property-liability insurance companies in the NAIC for the years 2006-2010, which originally comprised 3,007 insurers. To be included in the sample, each company needed a complete data set for each single year. Thus, insurers with missing data were deleted, and 2,060 insurers remained. Companies with unreasonable values (or illogical values) for all variables were also excluded from the empirical analysis. Subsequently, 1,869 insurers remained. Insurers that operated as professional reinsurers and whose reinsurance accounts for more than 75% of their total premium written were also excluded (Chang and Jeng 2015; Cole and McCullough 2006; Powell and Sommer 2007; Shiu 2011). Finally, the exclusions left this study with complete data for 1,773 insurers and 5,626 firm-year observations. In addition, to control for the outlier problem, the variables used in this study were winsorized at the 1st and 99th percentiles, except for the dummy variables, to avoid the influences of extreme values.

Summary statistics for all variables of the pooled time-series and cross-sectional data are shown in Table 1. The mean value of reinsurance ratio (Reins) is 38.78%, with 29.03% standard deviation. The average liquidity (Liq) is 82.84%, which proposes that insurers are conservative, and ranges from a minimum

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$^{13}$This study provides the Quantile-Quantile probability plots and a histogram of the standardized residuals to examine the model fitness issue.

$^{12}$For instance, the reinsurance ratio $<0$ and $>1$, leverage $<0$, the geographic and business Herfindahl Index $>1$ and/or $<0$.

$^{13}$Table 1 does not report the numbers of other control variables and year dummies.
### Table 2 Description of Each Reinsurance Decile

<table>
<thead>
<tr>
<th>Quantile (by Reins)</th>
<th>Reins</th>
<th>Leverage</th>
<th>2_years_loss</th>
<th>Size</th>
<th>Liq</th>
<th>Tax_ex</th>
<th>ROA</th>
<th>Bus_H</th>
<th>Geo_H</th>
<th>Stock</th>
<th>Single</th>
<th>Com_line</th>
<th>LnRBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decile 1</td>
<td>0.004137</td>
<td>1.118060</td>
<td>-0.000058</td>
<td>17.245666</td>
<td>0.876403</td>
<td>0.252018</td>
<td>0.045072</td>
<td>0.802135</td>
<td>0.712641</td>
<td>0.672598</td>
<td>0.692171</td>
<td>0.612626</td>
<td>2.174689</td>
</tr>
<tr>
<td>Decile 2</td>
<td>0.062208</td>
<td>1.081464</td>
<td>-0.000060</td>
<td>18.871230</td>
<td>0.875575</td>
<td>0.339534</td>
<td>0.047720</td>
<td>0.609423</td>
<td>0.627612</td>
<td>0.559503</td>
<td>0.515098</td>
<td>0.595032</td>
<td>2.237085</td>
</tr>
<tr>
<td>Decile 3</td>
<td>0.128992</td>
<td>1.066560</td>
<td>-0.000068</td>
<td>18.203086</td>
<td>0.878652</td>
<td>0.288590</td>
<td>0.044937</td>
<td>0.592172</td>
<td>0.648270</td>
<td>0.484902</td>
<td>0.607460</td>
<td>0.683694</td>
<td>2.256226</td>
</tr>
<tr>
<td>Decile 4</td>
<td>0.204423</td>
<td>1.133036</td>
<td>-0.000054</td>
<td>18.276856</td>
<td>0.868618</td>
<td>0.271064</td>
<td>0.038916</td>
<td>0.566243</td>
<td>0.630890</td>
<td>0.477798</td>
<td>0.591474</td>
<td>0.724015</td>
<td>2.174001</td>
</tr>
<tr>
<td>Decile 5</td>
<td>0.296463</td>
<td>1.057482</td>
<td>-0.000052</td>
<td>18.350109</td>
<td>0.853708</td>
<td>0.297925</td>
<td>0.040732</td>
<td>0.563620</td>
<td>0.589530</td>
<td>0.602131</td>
<td>0.481350</td>
<td>0.714537</td>
<td>2.118127</td>
</tr>
<tr>
<td>Decile 6</td>
<td>0.397602</td>
<td>1.208593</td>
<td>-0.000054</td>
<td>18.386295</td>
<td>0.844434</td>
<td>0.276412</td>
<td>0.038239</td>
<td>0.560102</td>
<td>0.570560</td>
<td>0.714032</td>
<td>0.373002</td>
<td>0.683203</td>
<td>2.112463</td>
</tr>
<tr>
<td>Decile 7</td>
<td>0.501128</td>
<td>1.353575</td>
<td>-0.000042</td>
<td>18.562312</td>
<td>0.824773</td>
<td>0.283955</td>
<td>0.034427</td>
<td>0.547629</td>
<td>0.527982</td>
<td>0.781528</td>
<td>0.275311</td>
<td>0.585215</td>
<td>2.097266</td>
</tr>
<tr>
<td>Decile 8</td>
<td>0.618948</td>
<td>1.967296</td>
<td>-0.000041</td>
<td>18.629498</td>
<td>0.771898</td>
<td>0.314131</td>
<td>0.035036</td>
<td>0.516053</td>
<td>0.480248</td>
<td>0.820604</td>
<td>0.218472</td>
<td>0.553057</td>
<td>2.081015</td>
</tr>
<tr>
<td>Decile 9</td>
<td>0.762807</td>
<td>2.856313</td>
<td>-0.000024</td>
<td>18.380166</td>
<td>0.761911</td>
<td>0.290281</td>
<td>0.038118</td>
<td>0.521430</td>
<td>0.467961</td>
<td>0.824156</td>
<td>0.204263</td>
<td>0.594052</td>
<td>2.153748</td>
</tr>
<tr>
<td>Decile 10</td>
<td>0.903078</td>
<td>4.961837</td>
<td>-0.000014</td>
<td>18.162235</td>
<td>0.721078</td>
<td>0.303219</td>
<td>0.035555</td>
<td>0.517643</td>
<td>0.427948</td>
<td>0.844643</td>
<td>0.133929</td>
<td>0.56413</td>
<td>2.544634</td>
</tr>
</tbody>
</table>

This table presents the means of each reinsurance decile for all variables. The decile 1 is the group of the lowest Reins group, whereas decile 10 is the highest Reins group. The Reins is defined as (affiliated reinsurance coded + nonaffiliated reinsurance ceded)/(direct business written plus reinsurance assumed). Concerning about Leverage, it is defined as the ratio of direct business written-to-surplus. The variable of 2_years_loss is two-year loss development and equals the development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by policyholders’ surpluses. The proxy of firm size is Size, and it is defined as natural logarithm of total assets. The Liq is defined as the sum of cash plus invested assets-to-total assets. The variable of Tax_ex is defined as tax-exempt investment income relative to total investment income. And ROA is defined as net income plus tax and interest expense, divided by total assets. The Bus_H variable is the line of business Herfindahl Index, which is defined as the 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. Conversely, the Geo_H variable is the geographic Herfindahl Index, 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. The organizational form dummy variable is Stock, which is to indicate stock or mutuals. It equals 1 if the insurer is a stock, and 0 if it is a mutual. The single dummy variable is Single, which is to indicate an affiliated or nonaffiliated insurer. It equals 1 if the insurer is nonaffiliated, and 0 if it is affiliated. Com_line represents the proportion of the insurer’s commercial lines of business. Finally, LnRBC is defined as the natural logarithm of RBC ratio.
of 28.27% to a maximum of 99.27% of the total assets. The mean value of leverage is approximately 1.7788 and ranges from 0.0419 to 12.4190. The mean (median) of two-year loss development ($2_{\text{years\_loss}}$) is $-4.6591 \times 10^{-5}$ ($-3.2263 \times 10^{-5}$), which indicates that insurers tend to create over loss reserving. In addition, Table 1 shows that 67.81% of observations are for stock insurers and that 40.93% of these are listed as single insurers in the database. Overall, the summary statistics for the explanatory variables are similar to those reported in previous studies (Chang and Jeng 2015; Cole and McCullough 2006; Fier, McCullough, and Carson 2013; Garven and Lamm-Tennant 2003; Mayers and Smith 1990; Wang et al. 2008) and indicates that the sample selection in this study is appropriate.

Table 2 reports the mean values of explanatory variables for 10 quantile deciles of the insurer’s reinsurance distribution. Overall, before considering the interactive impacts among explanatory variables, most explanatory variables tend to have different patterns in the lower and higher reinsurance quantiles. For instance, as reinsurance quantiles increase, the mean values of $\text{Liq}$, $\text{ROA}$, $\text{Bus\_H}$, $\text{Geo\_H}$, and $\text{Single}$ decrease, whereas the averages of $\text{Tax\_ex}$ and $2_{\text{years\_loss}}$ increase. Interestingly, $\text{Leverage}$, $\text{Stock}$, and $\ln\text{RBC}$ present a U-shape from the lower reinsurance deciles to the higher reinsurance deciles, whereas an inverse U-shape emerges for $\text{Size}$ and $\text{Com\_line}$. These important features of higher and lower reinsurance quantiles imply that analysis using the traditional 2SLS approach may be biased or insufficient. Thus, this study proposes the 2SQR approach to resolve the inadequacies of the traditional 2SLS approach.

4.2 Empirical Results

Model fitness checks should be done before the empirical analysis. This study implements two diagnostic tests of model fitness, a histogram of the standardized residuals and the quantile-quantile plot diagnostic to scrutinize whether the data is well-fitted or not. Figure 1 to Figure 10 describe the model fitness patterns for the standardized residuals and the quantile-quantile plot diagnostic. Figure 1 to Figure 5 suggest that higher quantile regressions ($\tau = 0.5, 0.75, \text{and} 0.9$) fit the data well, whereas lower quantile re-
Some independent variables are consistent to the predictions for both the 2SLS and 2SQR models: Reinsurance is negatively related to Tax_ex, ROA, Bus_H, Geo_H, Single and Size, and is positively related to Leverage, Stock, Com_line, and LnRBC. In Table 3, both the 2SLS and 2SQR models propose that the tax-exempt factor is negatively related to the insurer’s demand for reinsurance, which is inconsistent with the suggestions of Smith and Stulz (1985), Mayers and Smith (1990), and Garven and Lamm-Tennant (2003). However, these results are closer to the findings of Shiu (2011). To decrease expected tax liabilities, an insurer with a higher marginal tax rate will purchase less reinsurance. Furthermore, geographic and business diversified insurers tend to demand more reinsurance than nongeographic and nonbusiness diversified insurers. These results suggest that insurers tend to rely on more real services via specialized knowledge and economies of scale from reinsurers. Moreover, consistent with Shiu (2011), more concentrated insurers could specialize in, and may underwrite, less volatile lines of business or less-risky insured and therefore demand less reinsurance. In addition, the results of the stock dummy variable (Stock) indicate that the agency cost hypothesis is supported for both the 2SLS and 2SQR models (Adams 1996; Shiu 2011). To mitigate the underinvestment problem among residual claimholders, stock insurers purchase more reinsurance than mutual insurers.

As expected, the results displayed in Table 3 show that both the 2SLS and 2SQR models present a negative relationship between the single dummy variable (Single) and the demand for reinsurance. Single insurers tend to demand less reinsurance because they cannot benefit in terms of shifting profits within the group and thereby reduce tax payments (Chang and Jeng 2015; Cole and McCullough 2006; Shiu 2011; Wang et al. 2008). Moreover, consistent with the argument of greater ability to confront losses and financial pressures, higher profitability insurers tend to demand less reinsurance than lower profitability insurers. In addition, consistent with the literature, this study also finds that smaller insurers tend to confront a higher probability of insolvency and, therefore, purchase more reinsurance contracts than larger insurers.

In Table 3, the coefficients of Leverage are significantly positively related to the demand for reinsurance for both the 2SLS and 2SQR models. These results are consistent with the hypotheses of bankruptcy cost, agency cost, risk bearing, and renting capital (Chang and Jeng 2015; Cole and McCullough 2006; Garven and Lamm-Tennant 2003; Shiu 2011; Wang et al. 2008). In addition, the empirical results indicate that the impacts of leverage on insurers’ demand for reinsurance differ between the lower and higher quantiles. The effect of leverage on reinsurance is likely to increase in higher levels of reinsurance. Consequently, for each increment leverage, an insurer with a high level of reinsurance will need “more” reinsurance to maintain its underwriting risk at a target level. In contrast, for each additional unit of leverage, an insurer with a low level of reinsurance will need “less” reinsurance in the lower quantiles.
### Table 3  Empirical Results

<table>
<thead>
<tr>
<th>Expected sign</th>
<th>2SLS</th>
<th>2SQR Quantiles ($\tau=0.1$, $0.25$, $0.5$, $0.75$, and $0.9$)</th>
<th>Test of Equality ($X^2$ Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.1</td>
<td>0.25</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.8390  ***</td>
<td>0.5251  ***</td>
<td>0.3658</td>
</tr>
<tr>
<td>Leverage</td>
<td>+</td>
<td>0.0789  **</td>
<td>-0.0086</td>
</tr>
<tr>
<td>2_years_loss</td>
<td>+</td>
<td>-9.9097  **</td>
<td>-24.7115 ***</td>
</tr>
<tr>
<td>Size</td>
<td>-</td>
<td>-0.0128  ***</td>
<td>-0.0017</td>
</tr>
<tr>
<td>Liq</td>
<td>-</td>
<td>-0.6086  ***</td>
<td>-0.5302  ***</td>
</tr>
<tr>
<td>Tax_ex</td>
<td>+/-</td>
<td>-0.0448  ***</td>
<td>-0.0006</td>
</tr>
<tr>
<td>ROA</td>
<td>-</td>
<td>-0.2026  **</td>
<td>0.0219</td>
</tr>
<tr>
<td>Bus_H</td>
<td>+/-</td>
<td>-0.1050  ***</td>
<td>-0.0920  ***</td>
</tr>
<tr>
<td>Geo_H</td>
<td>+/-</td>
<td>-0.0652  ***</td>
<td>-0.0086</td>
</tr>
<tr>
<td>Stock</td>
<td>+/-</td>
<td>0.0717  ***</td>
<td>0.0410  ***</td>
</tr>
<tr>
<td>Single</td>
<td>-</td>
<td>-0.1458  ***</td>
<td>-0.0140  ***</td>
</tr>
<tr>
<td>Com_line</td>
<td>+</td>
<td>0.0779  ***</td>
<td>0.0752  ***</td>
</tr>
<tr>
<td>LnRBC</td>
<td>+</td>
<td>0.1001  ***</td>
<td>0.0094  *</td>
</tr>
<tr>
<td>Obs.</td>
<td>5,626</td>
<td>5,626</td>
<td>5,626</td>
</tr>
</tbody>
</table>

This table presents the results of both the 2SLS approach (column 3) and the 2SQR approach with quantiles $\tau=0.1$, $0.25$, $0.5$, $0.75$, and $0.9$ (column 4 – 8). Column 2 reports the prediction signs of firm-specific characteristics. Column 9 shows the test of coefficients equality for each variable across quantiles. The dependent variable is Reins, which is defined as (affiliated reinsurance ceded + nonaffiliated reinsurance ceded)/(direct business written plus reinsurance assumed). Leverage is defined as the ratio of direct business written to-surplus. The variable of 2_years_loss is two-year loss development and equals the development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by policyholders’ surpluses. The proxy of firm size is Size, and is defined as the natural logarithm of total assets. The Liq is defined as the sum of cash plus invested assets-to-total assets. The variable of $\text{Tax}_{-ex}$ is defined as tax-exempt investment income relative to total investment income. And ROA is defined as net income plus tax and interest expense, divided by total assets. The Bus_H variable is the line of business Herfindahl Index, which is defined as the 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. Conversely, the Geo_H variable is the geographic Herfindahl Index, 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. The organizational form dummy variable is Stock, which is to indicate stock or mutuals. It equals 1 if the insurer is a stock, and 0 if it is a mutual. The single dummy variable is Single, which is to indicate an affiliated or nonaffiliated insurer. It equals 1 if the insurer is nonaffiliated, and 0 if it is affiliated. Com_line represents the proportion of the insurer’s commercial lines of business. Finally, LnRBC is defined as the natural logarithm of RBC ratio. In this study, total firm-year observations are 5,626. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.
Furthermore, consistent with the risk taking viewpoint and higher claims volatility argument, the results indicate that insurers that write more commercial lines (Com_line) tend to purchase more reinsurance (Adams, Hardwick, and Zou 2008; Graham and Rogers 2002; Graham and Smith 1999). Finally, both the 2SLS and 2SQR models suggest that insurers with higher probability of insolvency tend to purchase more reinsurance, which is consistent with the argument of insolvency concerns (Chen, Hamwi, and Hudson 2001; Shiu 2011).

Note that insurers in the higher reinsurance quantiles are safer than those in the lower reinsurance quantiles. Thus, it is predicted that the determinants on demand for reinsurance in the lower and higher quantiles are distinct. In other words, the influence of the demand for reinsurance for each variable may present a different sign, or a dissimilar impact (magnitude). This study further implements the tests of equality for each variable across the five quantiles ($\tau = 0.1, 0.25, 0.5, 0.75,$ and $0.9$). Testing these results indicates that there is a difference among the estimated parameters for all variables across the five quantiles, except Com_line, which indicates that Hypothesis 1 is supported. Specifically, Leverage, ROA, Geo_H, Single, and Size have larger impacts on demand for reinsurance in the higher reinsurance quantiles, whereas Bus_H presents an inverse result in the lower reinsurance quantiles. In addition, the evidence of Tax_ex, Stock, and LnRBC suggests that the influence on demand for reinsurance is larger in the median quantile. This study also finds that the signs of Liq and 2_years_loss are significantly different between the lower and higher reinsurance quantiles. However, the other remaining variables present a consistent sign regarding both lower and higher reinsurance quantities. Summing up, the evidence suggests that Hypothesis 2 is, as a whole, weakly supported.

Taken together with previous empirical results, the evidence presented by this study proposes that the 2SQR approach reports a definite and distinct impact on the demand for reinsurance for various reinsurance quantiles. As proposed, the traditional 2SLS approach was found to contain some inappropriate assumptions and therefore to produce a biased estimation. In contrast, the 2SQR approach provides efficient estimation and insightful information on the determinants of demand for reinsurance, which could compensate for the inadequacy of the traditional 2SLS approach. Overall, this study concludes that Hypothesis 3 is strongly supported.

5. Concluding Remarks

Instead of using the traditional 2SLS approach, this study proposes the 2SQR approach for examining the determinants of the insurer’s demand for reinsurance. This study finds that the determinants of demand for reinsurance are driven by the insurer’s specific quantile within the overall demand for reinsurance distribution. The empirical evidence shows that the parameters (signs) for liquidity and loss development vary within different reinsurance quantiles, which differentiates these findings from previous ones (Chang and Jeng 2015; Cole and McCullough 2006; Hau 2006; Shiu 2011; Wang et al. 2008). The evidence indicates that the traditional 2SLS approach may provide an insufficient or biased explanation for the determinants of insurers’ demand for reinsurance. In addition, although consistent evidence is presented for other firm-specific characteristics, the magnitudes of these effects on demand for reinsurance differ significantly across all reinsurance quantiles. Again, these new findings, which also differ from the literature, enrich the function of the 2SQR analysis in the lower and higher quantiles of the reinsurance distribution. To sum up, the 2SQR approach is more efficient and can provide more insightful information than the traditional 2SLS approach.

Reinsurance is an important issue for the primary insurers. Policyholders, policy makers, and/or regulators should pay more attention in their assessments of an insurer’s financial pressures and bankruptcy problems, especially for insurers operating with lower levels of reinsurance. In sum, it is of importance for policyholders, policy makers, and/or regulators to assess the insurer’s demand for reinsurance by considering the empirical implications of both the 2SLS and 2SQR models.
REFERENCES


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