DOI: 10.6277/TER.2016.444.1

The Relationships Among the Demand for Reinsurance, Liquidity, and Leverage in the U.S. Property-Liability Insurance Industry

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Using pooled time-series and cross-sectional data from 1994 to 2006, we examine the interrelations among the demand for reinsurance, liquidity, and leverage in the U.S. property-liability insurance industry. Three structural equations are simultaneously estimated on the basis of a two-stage least squares paradigm. On the one hand, the empirical results indicate that insurers' liquidity and reinsurance demand are substitutes for each other, and the same relationship is found for liquidity and leverage. On the other hand, our empirical findings support the fact that reinsurance demand and leverage are complementary.

Keywords: demand for reinsurance, liquidity, leverage, capital structure
JEL classification: G22, G32, G33

1 Introduction

In the global property-casualty insurance market, the U.S. domestic market is definitely important. The U.S. market experienced catastrophe losses totaling $57.9 billion in 2012, which accounted for over 90% of global insured

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經濟論文叢刊 (*Taiwan Economic Review*), 44:4 (2016), 543–576。
國立台灣大學經濟學系出版

losses. During the same time, the surplus for U.S. property-casualty insurers increased by 5.1% compared to 2011. These changes were attributed to lower catastrophe losses that resulted in decreasing leverage and reinsurance demand. In addition, U.S. property-casualty insurers have an average liquidity position of about 82.4%, a level that can be observed as being fairly conservative.[1] As a whole, there seems to be an implicit interrelationship among the demand for reinsurance, leverage, and liquidity of U.S. property-casualty insurers, and this motivates us to further examine the U.S. property-liability insurance industry.

In this article, three issues, namely the demand for reinsurance, liquidity, and leverage in the U.S. property-liability insurance industry, are examined simultaneously based on a two-stage least squares (2SLS) paradigm. Though the relationships among the demand for reinsurance, liquidity, and leverage have been analyzed separately in different papers, to the best of our knowledge, our research would be the first to study the relationships among all three issues in a simultaneous framework.

Reinsurance is a critical decision, enabling insurers to transfer their risks to reinsurers. Indemnities from reinsurers provide insurers with an urgent source of liquidity when risk occurs. Consequently, primary insurers treat reinsurance as an effective risk management method. Mayers and Smith (1982) provide several reasons why corporations purchase insurance, and many researchers have further examined the hypotheses they provided using empirical data of the demand for reinsurance (see Mayers and Smith (1990), Garven and Lamm-Tennant (2003), Cole and McCullough (2006), Wang et al. (2008), Yanase (2015), Shiu (2011), Chang (2015)).

Liquidity risk is also a crucial issue for financial institutions. For example, many firms suffered severely from financial pressures and liquidity constraints during the 2008–2009 global financial crisis. Previous studies also indicate that a firm's liquidity is determined by firm-specific characteristics, such as firm size, organizational form, return spread, and premium earned growth rate (see John (1993), Kim, Mauer, and Sherman (1998), Almeida, Campello, and Weisbach (2002), Bruinshoofd and Kool (2002), Dittmar, Mahrt-Smith, and Servaes (2002), Shiu (2006), Chang and Tsai (2014), Chang and Yang (2016)).

Capital structure decisions have always been important in corporate finance. Previous studies have proposed a number of distinct hypotheses for

[1] See the NAIC (2012).

the leverage problem and other variables. For example, Ferreira and Vilela (2004) argue that leverage serves as a firm's ability to issue debt, and Opler et al. (1999) propose that a high leverage ratio reduces cash holdings by managers. Hence, it is an essential issue to determine the leverage level of a firm.

The property-liability insurance industry provides a suitable environment for researchers to examine simultaneously the issues of the demand for reinsurance, liquidity, and leverage.[2] The short-term contractual characteristics of property-liability insurers force managers to pay close attention to liquidity to avoid unexpected or emergent cash demands. Their business operating characteristics encourage property-liability insurers to rely more on reinsurance than life insurers. Furthermore, unlike the case of corporate firms, high leverage is the norm for financial institutions such as property-liability insurers, where leverage is primarily the ratio of the firms' reserves to surplus. Therefore, our analysis contributes to the past literature in that the relationships among the demand for reinsurance, liquidity, and leverage in the property-liability insurance industry may be different from those in non-financial industries.

Using unbalanced panel data from the U.S. property-liability insurance industry in the period between 1994 and 2006, we find that liquidity and reinsurance demand are jointly determined and both operate as substitutes of each other.[3] Our empirical results also support the finding that liquidity and leverage are mutual substitutes. Finally, consistent with Shiu (2011), we find a complementary relationship between reinsurance demand and leverage.[4]

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[2]Baranoff and Sager (2002) explore the relationship between capital and risk in the U.S. life insurance industry using a simultaneous-equation model with three equations expressing the interrelations among asset risk, product risk, and capital. Shim (2010) conducts a simultaneous equations model to examine the impact of capital-based regulation on the insurer's risk and capital adjustments in the U.S. property-liability insurance industry. We follow these literature and use the structural equations to combine the three endogenous variables into a single framework.

[3]Several researchers, such as Main (1982) and Main (1983a), Hau (2006), and Regan and Hur (2007), examine how liquidity influences corporate insurance purchases but they treat liquidity as an exogenous variable in determining the demand for insurance.

[4]The three pairs of causality relations hold, irrespective of single or group subsampling, with or without time fixed effects, with or without lagged endogenous variables, and excluding analyses of extreme values.

The remainder of this paper is organized as follows. Section 2 reviews the literature and presents our hypotheses. Section 3 describes the variables used in our analysis. Section 4 shows the unbalanced panel data and introduces the methodology and the empirical framework. Section 5 offers our empirical results, and section 6 concludes the paper.

2 Literature Review and Hypotheses

2.1 Reinsurance Demand and Liquidity

Researchers have previously examined how liquidity influences corporate insurance purchases (see Main (1982) and Main (1983a), Hau (2006), Regan and Hur (2007)). However, most of these studies treat liquidity as an exogenous variable in determining the demand for insurance, while the relationship between reinsurance demand and liquidity is rarely examined in the property-liability sector. Niehaus and Mann (1992) argue that futures contracts can improve an insurer's liquidity and satisfy the demand for immediacy when facing expected losses, because the insurer can trade underwriting risk in the futures market. This implies that reinsurance demand and the liquidity provided by futures contracts tend to be substitutive. Following the rationale of Hau (2006) and Niehaus and Mann (1992), we propose that liquidity and reinsurance demand are jointly determined.[5] As asset allocation decisions are costly to make, CEOs may tend to maintain a high level of reinsurance to avoid the transaction costs involved in liquidating their invested assets in the market. In addition, CEOs who intend to retain a high level of business may need to maintain a high level of liquidity to avoid potential risks. Consequently, we suggest that the insurer's liquidity and reinsurance demand are substitutes for each other. We further treat liquidity as an endogenous variable so that the insurer's liquidity and reinsurance demand are jointly and simultaneously determined. We refer to this relationship as the *substitute hypothesis*.

[5] It is likely that this substitute relationship does not hold in a long-tail business as the high liquidity of insurers may not be able to provide emergent cash flows in time for such business. In a robustness check of equations (5) and (6), we control for the variable of the long-tail percentage of business; however, the result is not materially different. We thank an anonymous referee for this suggestion.

2.2 Liquidity and Leverage

The substitute relationship between liquidity and leverage proposes that debt serves as a ready source of financing, so a firm can use debt as a substitute for liquidity (see John (1993)). Moreover, the argument of agency costs of managerial discretion indicates that firms with a high debt ratio must reduce managers' discretion and prohibit them from holding excess cash in hand (see Myers and Rajan (1998), Opler et al. (1999)). Thus, the restrictions imposed by a debt contract can force a company to reduce its liquid assets. Based on the arguments above, we suggest that insurer liquidity and leverage are substitutes for each other, and we thus expect the relationship between liquidity and leverage to be negative.

Some prior studies present conflicting predictions. Alternative arguments (e.g., financial pressure and monitoring hypotheses) predict that financial pressure increases the need for precautionary liquidity so as to avoid the threat of bankruptcy. Firms tend to maintain higher liquidity to convince policyholders or regulators that their operations are stable (see de Haan (1997), Ees et al. (1998), Opler et al. (1999), Faulkender (2002)). Panno (2003) focuses on the effect of liquidity upon leverage and states that firms with a higher liquidity ratio may support a higher debt ratio, because they can meet short-term obligations in a timely manner. Thus, these studies predict that the insurer's liquidity and leverage will exhibit a complementary and positive relationship.

It should be noted that most previous studies apply their analysis of liquidity and leverage to non-financial firms. As mentioned above, it is normal for insurers to have high leverage as it reflects their business condition. Hence, it is unclear whether the previous argument regarding the relationship between liquidity and leverage also holds for insurers. Therefore, we propose that the relationship between liquidity and leverage is characterized as being either a *complement* or a *substitute*, and the results should be determined empirically.

2.3 Reinsurance Demand and Leverage

Another strand of research focuses on the relationship between reinsurance demand and leverage in the property-liability field. According to the expected bankruptcy cost hypothesis and the agency cost theory, insurers with higher leverage tend to purchase more reinsurance to reduce their probability of insolvency (see 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 (2015)). In addition, under the renting capital hypothesis, insurers with a higher level of reinsurance choose higher debt ratios, because reinsurance reduces the strain on insurers' capital (see Adiel (1996), Chen, Hamwi, and Hudson (2001)). Using a dataset consisting of the U.K. non-life insurance industry, Shiu (2011) finds that the demand for reinsurance and leverage are joint decisions, and his results show a commutative complementary relationship between the two. We refer to this relationship as the *complement hypothesis*, and in the analysis below we examine if this relationship continues to hold by using data from the U.S. property-liability insurance industry.

3 Variable Description

3.1 Endogenous Variables

Most previous studies use the reinsurance ratio as a proxy for an insurer's demand for reinsurance (see, for example, Mayers and Smith (1990), Cole and McCullough (2006), Shiu (2011)). Thus, we use *Reins* to measure an insurer's demand for reinsurance. *Reins* is defined as (affiliated reinsurance ceded + non-affiliated reinsurance ceded)/(direct business written plus reinsurance assumed). Kim, Mauer, and Sherman (1998) define liquidity as the ratio of cash plus marketable securities to the book value of total assets. Following their rationale, the main liquidity measurement used in this paper, *Liq_cia*,[6] is defined as the sum of cash and invested assets divided by total assets. Finally, following Cole and McCullough (2006), Yanase (2015), Wang et al. (2008), Shiu (2011), and Chang (2015), we measure an insurer's

[6]The other reason we use total assets as the denominator of the liquidity measurement is to consider the possibility that insurers could use liquidity assets for some purposes - for instance, the precautionary purpose for investment losses during a financial crisis or for the execution of positive NPV projects in the near future. Following an anonymous referee's suggestion, we also use reserves as the denominator of the liquidity measurement. Most of the results are consistent with our main results except that the alternative liquidity measurement is positively related to reinsurance demand. Since a lower reserve tends to result in a higher value of the new liquidity measure as well as higher demand for reinsurance, we conjecture that it is plausible that insurers demand more reinsurance if they have a lower reserve.

Table 1: The Signs of the Expected Relationships among Reinsurance Demand, Liquidity and Leverage

	Reinsurance Demand	Liquidity	Leverage
Reinsurance Demand		−	+
Liquidity	−		+/−
Leverage	+	+/−	

Leverage in terms of the ratio of direct business written to surplus.[7]

Table 1 summarizes the signs of the expected relations between the endogenous variables. The signs in the table are based on the preceding discussion.

3.2 Exogenous Variables

First, we refer to prior studies on reinsurance to identify the explanatory variables for the reinsurance equation (see, for example, Mayers and Smith (1990), Cole and McCullough (2006), Shiu (2011), Chang (2015)). Second, the explanatory variables of the leverage equation are identified according to Cummins and Sommer (1996), Baranoff and Sager (2002) and Baranoff and Sager (2003), and Shiu (2011). Third, the explanatory variables used in the liquidity equation are obtained from the existing literature on liquidity (see, for example, John (1993), Kim, Mauer, and Sherman (1998), Opler et al. (1999), Shiu (2006), Chang and Yang (2016)). In this study we include these firm-specific characteristics in our empirical analysis. We present the definitions and hypotheses for these explanatory variables below.[8]

[7]It is also argued that net written premium or reserve can be used as the numerator of the leverage proxy. However, as one of our models examines the leverage-reinsurance relationship, it may not be appropriate to use net written premium as the numerator of leverage, because the reinsurance factor is thus excluded. Robustness checks also show that the results of using net written premium or reserves as the numerator are indifferent to our current results. We are thankful for one referee's suggestion for this.

[8]Following an anonymous referee's suggestion, we first run the correlation matrices for explanatory variables currently used with each of the endogenous variables, i.e. reinsurance demand, liquidity, and leverage, to identify those suitable variables to be adopted. After excluding the less related variables from our three-equation simultaneous models, we find

First, concerning bankruptcy characteristics, two variables are adopted: firm size (*Size*) and potential financial constraints *(2years_loss)*. We use a natural logarithm of admitted assets as a proxy for firm size. We predict a negative relationship between firm size and demand for reinsurance, because small insurers tend to purchase more reinsurance to reduce their probability of insolvency. Additionally, Kim, Mauer, and Sherman (1998), Bruinshoofd and Kool (2002), Opler et al. (1999), and Shiu (2006) suggest that larger insurers tend to possess lower liquidity than smaller insurers. Thus, a negative relationship between an insurer's liquidity level and firm size is predicted. Regarding firm size and leverage, Cummins and Sommer (1996) and Baranoff and Sager (2003) note that larger firms tend to be more diversified than smaller firms. As a result, larger firms are expected to require less capital to meet a given solvency target. In other words, firm size is positively related to leverage. A similar argument is presented in the trade-off theory, which predicts that larger firms generally have less volatile cash flows and are more diversified. Thus, such firms are able to maintain a higher level of leverage (see Frank and Goyal (2009), Shiu (2011)). In contrast, the prediction of the pecking order theory contradicts that made by the trade-off theory.

Second, we use a two-year loss development (*2years_loss*) as a proxy for an insurer's potential financial constraints. As suggested by previous research, such as Weiss (1985), Grace (1990), Petroni (1992), Christensen, Hoyt, and Paterson (1999), Gaver and Paterson (1999), Cole and McCullough (2006), and Wang et al. (2008), potential financial constraints can influence the demand for reinsurance. An insurer with a positive loss development (under loss reserves) will purchase more reinsurance to mitigate its potential financial constraints, whereas an insurer will purchase less reinsurance if the insurer has a negative loss development (over loss reserves). Shiu (2006) also notes that potential financial constraints influence an insurer's liquidity. In general, an insurer with a positive loss development (a loss reserve that is too small) will increase liquidity to mitigate its potential financial constraints. In contrast, if an insurer has a negative loss development (a loss reserve that is too large), then the insurer will decrease liquidity.

To control the systematic difference between a single firm (non-affiliated) and a firm belonging to a group (affiliated), Cole and McCullough (2006) and Wang et al. (2008) use a group dummy variable to analyze the influ-

that except for the liquidity measure in the reinsurance equation which is insignificant, other results are all consistent with our main findings. We are thankful for the referee's suggestion.

ence of affiliation on the demand for reinsurance. Similarly, we use the *Single* dummy variable to control for the difference between affiliated and non-affiliated firms. The *Single* dummy variable equals 1 if an insurer is non-affiliated and 0 if it is affiliated. A negative relationship between the single dummy variable and the demand for reinsurance is expected, because insurers that belong to a group can shift profits within the group and reduce tax payments. Following Shiu (2006) suggestion, the current study uses the single dummy variable to control for the difference between affiliated and non-affiliated firms. A positive relationship between the single dummy variable and liquidity is expected. In addition, based on the arguments of Cummins and Sommer (1996) and Baranoff and Sager (2003), we claim that the single dummy variable is positively related to an insurer's leverage level.

The organizational form hypothesis suggests that stock insurers tend to purchase less reinsurance than mutual insurers, because the former can take advantage of risk diversification (outside shareholders) or a lower cost of raising capital from the capital market (see Mayers and Smith (1990)). In contrast, the agency cost hypothesis proposes that stock insurers tend to purchase more reinsurance than mutual insurers, because the additional reinsurance can mitigate the underinvestment problem among residual claimholders. Consistent with the agency cost hypothesis, Adams (1996) findsthat in New Zealand's life insurance industry, stock insurers tend to purchase more reinsurance than mutual insurers. Additionally, Shiu (2011) study of U.K. non-life insurers also shows that stock insurers demand more reinsurance than mutual insurers. Consequently, we propose that organizational form predictions vary. We use the *Stock* dummy variable to control for the organizational form effect, which is defined as 1 if an insurer is a stock insurer and 0 otherwise. Furthermore, mutual insurers are expected to maintain more liquidity than stock insurers. The agency cost hypothesis suggests that mutual insurers are less likely to face an agency cost of debt than are stock insurers. Because the owners of mutual insurers are generally policyholders (debt holders), mutual insurers suffer less from the agency cost of debt. Baranoff and Sager (2003) note that monitoring increases firm value and thus encourages managers to seek rewards from risky and complex products. Therefore, according to the monitoring hypothesis, a stock firm tends to hold less capital. We predict that the relationship between a stock firm and leverage is positive.

Prior studies also suggest that two real-service proxies influence the insurers' reinsurance decisions: the geographic Herfindahl index (*Geo_H*), which provides a proxy for geographic concentration, and the line of business Herfindahl index (*Bus_H*), which provides a proxy for the line of business concentration (see Mayers and Smith (1990), Kim, Mayers, and Smith, Jr. (1996), Cole and McCullough (2006), Wang et al. (2008), Yanase (2015)).[9] The real-services hypothesis states that reinsurers both provide protection of unexpected losses and supply real services in terms of specialized knowledge. Consequently, the real-services hypothesis implies that insurers that are less concentrated in terms of business or geography may demand more reinsurance. In contrast, from the perspective of risk diversification, insurers with a higher concentration in a given line of business or geographic area may have a higher incentive to purchase more reinsurance. Hence, predictions based on business and geographic concentrations are mixed. In addition, business and geographic concentrations are critical, firm-specific characteristics for an insurer's liquidity. According to Shiu (2006), a positive relationship between an insurer's liquidity and business or geographic concentration is predicted. However, in his empirical analysis, Shiu (2006) provides an inconsistent result.

Prior literature indicates that firms with higher profits tend to demand less reinsurance, because they have a higher capacity to weather losses and financial pressures (see Mayers and Smith (1990), Powell and Sommer (2007), Mayers and Smith (2004), Cole and McCullough (2006), Wang et al. (2008)). To measure an insurer's profitability, we adopt the return on assets (*Roa*), which is defined as the net income plus tax and the interest expense divided by the total assets.

Kim, Mauer, and Sherman (1998) use *Rspread*, which is defined as the return on assets minus the risk-free rate (the return on U.S. Treasury bills), to measure firm profitability. These authors argue that more profitable firms tend to have less demand for liquidity. Thus, the expected relationship between liquidity and profitability is negative. Following their rationale, we expect more profitable insurers to have less liquidity demand. In contrast,

[9]The definition of the geographic Herfindahl index follows Kim, Mayers, and Smith, Jr. (1996) and Wang et al. (2008), who define the index 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. Moreover, 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.

Shiu (2006) uses the one-period lagged return on assets as a proxy for an insurer's profitability, whereby he argues that the insurer's profitability is positively related to its liquidity demand. According to Kim, Mauer, and Sherman (1998), because we adopt *Rspread* as a proxy for an insurer's profitability, the relationship between liquidity and profitability is predicted to be negative.

Baranoff and Sager (2003) use the return of capital (*Roc*) as a proxy for firm profitability, and their empirical findings indicate that a firm's profitability is positively related to its capital holdings (i.e., negatively related to leverage). Furthermore, the pecking order theory suggests that profitable firms tend to have lower leverage than unprofitable firms (see Titman and Wessels (1988), Frank and Goyal (2009), Shiu (2011)). However, more profitable firms tend to encounter lower bankruptcy costs and to seek tax benefits through debt. As a result, more profitable firms possess higher leverage. Hence, the relationship between firm profitability and leverage is mixed.[10]

We additionally use tax-exempt investment income relative to total investment income (*Tax_ex*) as a proxy for the expected tax liability or tax-favored assets. Mayers and Smith (1990) and Smith and Stulz (1985) note that insurers can reduce their earnings volatility through the purchase of reinsurance, and thus lessen their expected tax liability. Garven and Lamm-Tennant (2003) note that insurers can benefit from purchasing reinsurance in terms of mitigating the cost of large unexpected losses and enhancing investment in tax-favored assets. As a result, a positive relation is predicted.

John (1993) argues that a firm's growth opportunity may affect its liquidity decision. If a firm's sales growth and corresponding cash flow increase the firm's liquid reserves faster than they can be used, then a firm with a higher sales growth will possess less liquidity. Following the same rationale, we measure an insurer's growth opportunity using the premium earned growth rate (*Growth*), which is defined as the natural logarithm of the net premium written in year t to the net premium written in year t-1. Thus, a negative relationship between sales growth and liquidity is predicted.[11]

[10] For consistency with the past literature, we adopt Return on Assets (ROA) in the reinsurance equation and Return of Capital (ROC) in the leverage equation. We further implement robustness tests in terms of (1) using Roa in all equations, (2) using Roc in all equations, and (3) adopting both Roa and Roc in all equations. Overall, the results are consistent with the main findings. We thank one anonymous referee for this suggestion.

[11] We sincerely thank an anonymous referee who proposed that the premium earned

According to Cummins and Sommer (1996), the leverage equation also includes the national dummy variable (*National*), which equals 1 for insurers that operate nationally and 0 for regional insurers. National insurers tend to issue more diverse policies and encounter higher costs associated with monitoring policyholders. As a result, the managerial discretion hypothesis implies that policyholders may demand higher capital (lower leverage) from a national insurer. We expect a negative coefficient for the national dummy variable in the leverage equation.

The regulatory cost hypothesis states that insurers operate under rigorous licensing conditions and that the solvency surveillance system tends to impose regulatory costs on firms if insurers are in a relatively weak financial condition (see Cummins and Sommer (1996)). As a result, we introduce the New York dummy variable (*Newyork*) in the leverage equation. The regulatory cost hypothesis leads to a predicted negative coefficient for *Newyork* in the leverage equation.

Insurers with independent agents tend to have lower capital ratios than insurers with exclusive agents, because the former can bear higher levels of insolvency risk than insurers with exclusive agency (see Regan (1997), Cummins and Sommer (1996)). Thus, it is predicted that the independent agency marketing system is positively related to the firm leverage level. In this study we also include an agency dummy variable (*Agency*) in the leverage equation as a proxy for an insurer's marketing channel, which equals 1 if an insurer is an independent agency and 0 otherwise.

To capture the effects of group structure on insurer capitalization, Cummins and Sommer (1996) propose another factor, the intra-group Herfindahl index (*Intra_g_H*), which is based on net premiums written. These researchers claim that the intra-group Herfindahl index is inversely related to the capital ratio (i.e., positively related to leverage). To control for the degree of regulatory pressure, we use the natural logarithm of the RBC ratio[12] (*lnRBC*) to account for regulatory influences on capital (see Baranoff and Sager (2002) and Baranoff and Sager (2003)). Insurers with a higher RBC

growth rate may influence an insurer's reinsurance demand and leverage. A robustness test of adopting the premium earned growth rate into reinsurance and leverage equations is made, but the results are similar to the main finding of this study. We do not tabulate those results here.

[12]The RBC ratio is defined as (Total Adjusted Capital $\times$ 100)/ (2 $\times$ Authorized Control Level RBC).

ratio believe that they are healthier than firms with a lower RBC ratio and that they can therefore maintain lower capital. Thus, we predict a negative coefficient between RBC regulatory forbearance and capital (i.e., positively related to leverage).

Shiu (2011) and Fier, McCullough, and Carson (2013) note that insurers may adjust their reinsurance or leverage to the desired levels. Therefore, the lagged dependent variables may affect current reinsurance demand or leverage. Thus, we also include one-period lagged endogenous variables to detect the target adjustments of reinsurance demand, liquidity and leverage.

Other control variables include the ratios of the premiums written in each line of business to the premiums written in all 26 lines of business and year dummies (see Mayers and Smith (1990), Cole and McCullough (2006), Wang et al. (2008)). Table 2 provides the definitions, predictions, and arguments of hypotheses for all explanatory variables used in the 2SLS simultaneous equations.

4 Data and Model Specification

4.1 Data

Our sample is constructed from information provided in the annual reports of NAIC (National Association of Insurance Commissioners) for all U.S. property-liability insurance companies. The sample covers the 13-year period from 1994 to 2006, originally comprising 3,422 insurers. To be included in the sample, each company must have complete data for all of the explanatory variables for each year. After removing insurers with missing data, 2,628 insurers remain. We then exclude insurers that operate as professional reinsurers, to whom reinsurance accounts for more than 75% of their total premiums written (see Cole and McCullough (2006), Powell and Sommer (2007), Shiu (2011)). This brings the sample size to 2,430 insurers. In addition, companies with unreasonable values for all of the variables are excluded from our empirical analysis.[13] Thus, the final sample comprises 2,180 insurers and 11,571 firm-year observations with an average of 5.3

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

Table 2: Summaries of definitions, predictions, and the arguments of hypotheses for all explanatory variables

Panel A Reinsurance Equation

Variables	Definition	Prediction	Literature
Reins_lag1	Lagged reins ratio by 1 year	+	Shiu (2011); Fier, McCullough, and Carson (2013)
Tax_ex	Tax-exempt investment income relative to total investment income	+	Mayers and Smith (1990); Smith and Stulz (1985); Garven and Lamm-Tennant (2003)
Roa	Net income plus tax and interest expense divided by admitted assets	−	Mayers and Smith (1990); Powell and Sommer (2007); Mayers and Smith (2004); Cole and McCullough (2006); Wang et al. (2008)
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	+/−	Mayers and Smith (1990); Kim, Mayers, and Smith, Jr. (1996); Cole and McCullough (2006); Wang et al. (2008); Yanase (2015)
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	+/−	Mayers and Smith (1990); Kim, Mayers, and Smith, Jr. (1996); Cole and McCullough (2006); Wang et al. (2008); Yanase (2015)
2 years_loss	Development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by the policyholders' surplus	+	Weiss (1985); Grace (1990); Petroni (1992); Christensen, Hoyt, and Paterson (1999); Gaver and Paterson (1999); Cole and McCullough (2006); Wang et al. (2008)

Table 2: Summaries of definitions, predictions, and the arguments of hypotheses for all explanatory variables

Panel A Reinsurance Equation			
Variables	Definition	Prediction	Literature
Size	Natural logarithm of admitted assets	−	Mayers and Smith (1990); Garven and Lamm-Tennant (2003); Cole and McCullough (2006); Wang et al. (2008); Yanase (2015); Shiu (2011)
Stock	Equal to 1 for a stock insurer and 0 for a mutual insurer	+/−	−, Mayers and Smith (1990) +, Adams (1996); Shiu (2011)
Single	Equal to 1 if for a non-affiliated insurer and 0 for an affiliated insurer	−	Cole and McCullough (2006); Wang et al. (2008)
W(i)	The ratios of the premiums written in each line of business to the premiums written in all 26 lines of business		Mayers and Smith (1990); Cole and McCullough (2006); Wang et al. (2008)
Panel B Liquidity Equation			
Variables	Definition	Prediction	Literature
Liq_cia_lag1	Lagged liquidity by 1 year	+	Shiu (2006)

Table 2: Summaries of definitions, predictions, and the arguments of hypotheses for all explanatory variables

Panel B Liquidity Equation

Variables	Definition	Prediction	Literature
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	+	Shiu (2006)
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	+	Shiu (2006)
2 years_loss	Development of estimated losses and loss expenses incurred two years before the current and prior year, scaled by the policyholders' surplus	+	Shiu (2006)
Size	Natural logarithm of admitted assets	−	Kim, Mauer, and Sherman (1998); Bruinshoofd and Kool (2002); Opler et al. (1999); Shiu (2006)
Stock	Equal to 1 for a stock insurer and 0 for a mutual insurer	−	Shiu (2006)
Single	Equal to 1 if for a non-affiliated insurer and 0 for an affiliated insurer	+	Shiu (2006)
Rspread	Return on assets minus return on Treasury bills	−	Kim, Mauer, and Sherman (1998)

Table 2: Summaries of definitions, predictions, and the arguments of hypotheses for all explanatory variables

Panel C Leverage Equation			
Variables	Definition	Prediction	Literature
Growth	Premium earned growth rate ($\log(w(t)/w(t-1))$)	−	John (1993)
Leverage_lag1	Lagged leverage by 1 year	+	Shiu (2011); Fier, McCullough, and Carson (2013)
Size	Natural logarithm of admitted assets	+/−	−, Cummins and Sommer (1996); Baranoff and Sager (2003) +, Frank and Goyal (2009); Shiu (2011)
Stock	Equal to 1 for a stock insurer and 0 for a mutual insurer	+/−	−,Baranoff and Sager (2003); Harrington and Niehaus (2002); Weiss and Cheng (2012); Fier, McCullough, and Carson (2013) +, Weiss and Cheng (2012)
Single	Equal to 1 if for a non-affiliated insurer and 0 for an affiliated insurer	−	Cummins and Sommer (1996); Baranoff and Sager (2003)
National	Equal to 1 for insurers operating nationally and 0 for regional insurers	−	Cummins and Sommer (1996); Mayers and Smith (1988)
Intra_g_H	Intra-group Herfindahl index based on net premium written	+	Cummins and Sommer (1996)

Table 2: Summaries of definitions, predictions, and the arguments of hypotheses for all explanatory variables

Panel C Leverage Equation			
Variables	Definition	Prediction	Literature
Newyork	Equal to 1 for an insurer licensed in New York and 0 otherwise	−	Cummins and Sommer (1996)
Agency	Equal to 1 for independent agency insurers and 0 otherwise	+	Regan (1997); Cummins and Sommer (1996)
Roc	Return on capital	+/−	−, Baranoff and Sager (2003) +, Titman and Wessels (1988); Frank and Goyal (2009); Shiu (2011)
LnRBC	Natural logarithm of RBC ratio ((Total Adjusted Capital ∗ 100)/(2 ∗ Authorized Control Level RBC))	−	Baranoff and Sager (2002) and Baranoff and Sager (2003)

years each.[14] To control the outlier problem, we ensure that all of the variables used in this study are winsorized at the 1^{st} and 99^{th} percentiles to avoid the influence of extreme values, except for the dummy variables such as the stock, single, and national dummy variables.[15]

Table 3 shows summary statistics for all of the variables for the pooled time series cross-sectional data.[16] The average value of the reinsurance ratio (*Reins*) is approximately 39.5%, and its standard deviation is approximately 29.53%. The average liquidity measurement (*Liq-cia*) is 80.81%. Moreover, liquidity ranges from a minimum of 0.00% to a maximum of 99.33% of total assets. The mean value of leverage for U.S property-liability insurers is approximately 2.0485 and ranges from 0.0209 to 14.5072. In addition, Table 3 presents that approximately 69.98% of the analyzed insurers are stock insurers. Moreover, 36.86% are single insurers according to the database.[17] Furthermore, we find that the return on assets and that on capital are approximately 3.78% and 8.75%, respectively. Overall, the mean values for most of the variables are similar to those in prior studies and represent an appropriate sample selection.

Table 4 reports the Pearson and Spearman-rank correlation coefficients for three endogenous variables: reinsurance demand, liquidity, and leverage. Before controlling for the interaction influence of firm-specific characteristics, we find that the reinsurance demand of insurers is inversely related to liquidity, and this relationship consistently supports the substitute hypothe-

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[14]Because our 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 is 13.

[15]For the extreme value robustness check, we also delete those values less than the 1^{st} percentile and greater than the 99^{th} percentile from the data, which encompass 9,533 firm-year observations. The regression results are similar to the results that are obtained by winsorization.

[16]The variables that are shown in Table 2 include all of the endogenous and control variables in the reinsurance, liquidity, and leverage equations. We do not report the summary statistics of other control variables and year dummies.

[17]The transaction argument regarding internal capital markets states that the reinsurance decisions of unaffiliated insurers may differ from those of affiliated insurers (see Mayers and Smith (1990), Garven and Lamm-Tennant (2003), Powell and Sommer (2007), Shiu (2011)). As a result, we separate our observations into two categories, single and group insurer subsamples, which consist of 4,166 and 7,405 firm-year observations, respectively. The empirical results are consistent with our main findings.

Table 3: Summary Statistics for the Numerical Variables

Variables	Minimum	Mean	Median	Maximum	Std. Dev.
Dependent variables					
Reins	0.0000	0.3950	0.3489	0.9886	0.2953
Liq_cia	0.0000	0.8081	0.8644	0.9933	0.2026
Leverage	0.0209	2.0485	1.3998	14.5072	2.2717
Explanatory variables					
Reins_lag1	0.0000	0.3883	0.3369	0.9793	0.2944
Liq_cia_lag1	0.0000	0.8116	0.8691	0.9941	0.2033
Leverage_lag1	0.0159	2.0494	1.4257	14.0921	2.2340
Tax_ex	0.0000	0.2933	0.2265	0.9562	0.2624
Roa	−0.1601	0.0378	0.0367	0.2447	0.0599
Bus_H	0.1361	0.5325	0.4780	1.0000	0.2885
Geo_H	0.0432	0.5695	0.5419	1.0000	0.3811
2years_loss	−0.0005	0.0000	0.0000	0.0007	0.0002
Size	14.3779	18.0707	17.9646	22.7268	1.7944
Stock	0.0000	0.6998	1.0000	1.0000	0.4584
Single	0.0000	0.3686	0.0000	1.0000	0.4824
Rspread	−0.1983	0.0021	0.0010	0.2192	0.0628
Growth	−1.3214	0.1219	0.0673	2.4167	0.4554
National	0.0000	0.3331	0.0000	1.0000	0.4714
Intra_g_H	0.1801	0.6232	0.4714	1.0000	0.3102
Newyork	0.0000	0.3195	0.0000	1.0000	0.4663
Agency	0.0000	0.7120	1.0000	1.0000	0.4529
Roc	−0.5616	0.0875	0.0892	0.5593	0.1617
lnRBC	0.2965	2.0810	1.9647	5.1689	0.8382
Firm-year observations	11,571				

Note: All of the dependent variables are at their current terms, and all of the explanatory variables are lagged for one year. The variables *Reins_lag1, Liq_cia_lag1* and *Leverage_lag1* are specified to distinguish them from the endogenous variables.

sis. In addition, the relationship between reinsurance demand and leverage is significantly positive. This result is consistent with Shiu (2011) and with the complement hypothesis whereby insurers with higher leverage tend to pur-

Table 4: Correlations among the Endogenous Variables

Correlation (p-value)	*Reinsurance*	*Liquidity*	*Leverage*
Reinsurance		−0.27521	0.40704
		< 0.0001	< 0.0001
Liquidity	−0.22110		−0.48623
	< 0.0001		< 0.0001
Leverage	0.46799	−0.29286	
	< 0.0001	< 0.0001	

chase more reinsurance and vice versa. Finally, the correlation test indicates that liquidity is significantly negatively related to leverage. This evidence supports the hypothesis that the relationship between liquidity and leverage is substitutive. Debt tends to serve as a ready source of financing, and a firm can use debt as a substitute for liquidity.

4.2 Model Specification

According to the arguments above, the insurer's demand for reinsurance, liquidity, and leverage should be jointly assessed. Therefore, we intend to investigate the paired commutative relationships among the insurer's reinsurance demand, liquidity, and leverage. We apply a three-equation simultaneous model to examine these commutative relationships based on a 2SLS paradigm.[18] The model is constructed as follows:

$$Reins_{i,t} = f_1\left(Liq_{i,t}, Lev_{i,t}, X_{1,i,t-1}\right) + \epsilon_{1,i,t}, \tag{1}$$

$$Liq_{i,t} = f_2\left(Reins_{i,t}, Lev_{i,t}, X_{2,i,t-1}\right) + \epsilon_{2,i,t}, \tag{2}$$

$$Lev_{i,t} = f_2\left(Reins_{i,t}, Liq_{i,t}, X_{3,i,t-1}\right) + \epsilon_{3,i,t}, \tag{3}$$

where $Reins_{i,t}$ represents the demand for reinsurance by insurer i in year t, and $Liq_{i,t}$ is the liquidity of insurer i in year t. In addition, $Lev_{i,t}$ denotes the leverage of insurer i in year t. In this model, insurers determine

[18]According to Wooldridge (2002), in the first stage, the exogenous variables of the reduced form consist of all of the explanatory variables (X_1, X_2, and X_3) that are used in the three structural equations. We then can figure out the fitted value of endogenous variables. In the second stage, we replace the endogenous variables by their fitted value generated from the first stage and re-run equations (1), (2), and (3).

their demand for reinsurance, liquidity, and leverage endogenously, simultaneously, and interrelatedly. Moreover, $X_{1,i,t-1}$, $X_{2,i,t-1}$ and $X_{3,i,t-1}$ include the lagged endogenous variables, the lagged explanatory variables, other control variables, and year dummies for the demand for reinsurance, liquidity, and leverage equations, respectively, while $\epsilon_{1,i,t}$, $\epsilon_{2,i,t}$, and $\epsilon_{3,i,t}$ represent randomly distributed disturbances (structural errors).[19,20] The lagged endogenous and lagged explanatory variables are used to mitigate the problem of endogeneity between the dependent and explanatory variables (see Shiu (2011)).

Prior to presenting our empirical results, we must first confirm the validity of applying a simultaneous system to reinsurance demand, liquidity, and leverage. We implement the Hausman test of endogeneity, and the test results indicate that the null hypothesis is rejected.[21] In other words, an endogeneity problem does exist among the insurer's reinsurance demand, liquidity, and leverage. Furthermore, the simultaneous equation specification satisfies both the order and rank conditions.[22] It is thus appropriate to propose a simultaneous equations model with the 2SLS estimation method to analyze our concerns in this study.

5 Empirical Results

The results for the 2SLS estimation of the three-equation simultaneous model for reinsurance demand, liquidity, and leverage are in Tables 5, 6, and 7, respectively. We report the parameter estimates, associated standard errors, T-statistics and P-values of each variable for each equation in the structural models.

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[19]We find that the regression specifications with or without year dummies (the time fixed effect) and with or without the lagged endogenous variables present similar results to our main findings.

[20]The Hausmen fixed effect F tests indicate that the fixed effect does exist for the three equations. Additionally, the Hausman and BP random effect tests are applied to examine the appropriateness of using the fixed effect or random effect model (see Breusch and Pagan (1980)). The results of these two tests show that the null hypotheses for the three equations are rejected, respectively, implying that fixed effect models are appropriate for use in these equations.

[21]The null hypothesis of the Hausman endogeneity test states that no endogeneity exists among variables.

[22]See Wooldridge (2002) for the identification check procedure.

Table 5: Reinsurance equation results

Dependent variable, Reinsurance *(Reins)*				
Variables	Coefficient	S.E.	T-statistics	P-value
Constant	0.2121	0.0222	9.5300	< .0001
Liq_cia	−0.0264	0.0116	−2.2700	0.0231
Leverage	0.0042	0.0007	6.4100	< .0001
Reins_lag1	0.8812	0.0047	187.9500	< .0001
Tax_ex	−0.0002	0.0041	−0.0500	0.9639
Roa	−0.1015	0.0183	−5.5500	< .0001
Bus_H	−0.0115	0.0049	−2.3400	0.0195
Geo_H	−0.0124	0.0033	−3.7400	0.0002
2 years_loss	15.6591	6.8634	2.2800	0.0225
Size	−0.0055	0.0008	−7.0000	< .0001
Stock	0.0101	0.0026	3.9100	< .0001
Single	−0.0274	0.0027	−10.1300	< .0001
R_square	0.86371			
Adj_R_square	0.86317			
F value	1,587.82***			
Firm-year Observations	11,571.00			

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

5.1 Reinsurance Equation Results

Table 5 shows the regression results of the reinsurance equation. The results indicate that the coefficient of liquidity (*Liq_cia*) is significantly negative. The result implies that insurers with higher liquidity tend to reduce their demand for reinsurance, because insurers with more liquid assets tend to possess a greater ability to respond to unexpected cash demands. The coefficient of *Leverage* is positively and significantly related to the demand for reinsurance, implying that insurers with a higher leverage level tend to reinsure to a greater extent. The result is also consistent with prior findings.

The profitability (*Roa*), firm size (*Size*), and single firm (*Single*) variables are negatively and significantly related to demand for reinsurance. These results are consistent with our expectations. More profitable firms demand less reinsurance, because they have a greater capacity to weather the threat of unexpected losses and financial pressures. Moreover, large firms tend to possess a greater ability to bear insolvency risks and thus purchase less reinsurance. In addition, a group firm tends to purchase more reinsurance, because it can benefit from shifting profits within the group and reducing its tax payments through the internal capital market.

Regarding business and geographic concentrations (*Bus_H* and *Geo_H*), we find that coefficients of both *Bus_H* and *Geo_H* are significantly negative with demand for reinsurance, which is consistent with the real service hypothesis rather than the risk diversification hypothesis (see Cole and McCullough (2006)). The real service hypothesis states that less business-concentrated or geographically-concentrated insurers may demand and purchase additional reinsurance, because reinsurers can provide more specialized knowledge support. We further find that the coefficient of the *Stock* dummy variable is positive and significant, implying that stock insurers tend to demand more reinsurance than mutual insurers. This result contradicts the prediction of a lower cost to raise funds from the capital market, but is consistent with the agency cost hypothesis, which further states that stock insurers tend to purchase more reinsurance to mitigate the underinvestment problem among residual claimants (see Adams (1996), Shiu (2011)). Finally, the coefficient of the lagged reinsurance ratio (*Reins_lag1*) implies that insurers close approximately 11.88% ($= 1 - 0.8812$) of the gap between the current and desired reinsurance ratios within one year. This result means that insurers tend to have a target reinsurance ratio.

5.2 Liquidity Equation Results

Table 6 shows the results for the liquidity equation. The coefficient of the reinsurance (*Reins*) variable is significantly negative on the insurer's liquidity demand. This reverse causality relationship indicates that an insurer with a higher reinsurance agreement will indemnify itself more from the reinsurer when encountering large urgent claims (see Hau (2006), Niehaus and Mann (1992)).

The coefficient of *Leverage*, the other endogenous variable, is significantly negative. The literature predicts that leverage is negatively related to liquidity, because debt provides a ready source of financing such that firms can use debt as a substitute for liquidity maintenance (see, for example,

Table 6: Liquidity equation results

Dependent variable, Liquidity (*Liq_cia*)				
Variables	Coefficient	S.E.	T-statistics	P-value
Constant	0.2268	0.0126	18.0400	< .0001
Reins	−0.0262	0.0034	−7.6900	< .0001
Leverage	−0.0044	0.0004	−10.2000	< .0001
Liq_cia_lag1	0.7714	0.0060	128.9100	< .0001
Bus_H	0.0006	0.0027	0.2200	0.8261
Geo_H	−0.0039	0.0021	−1.8400	0.0657
2 years_loss	4.1300	4.6680	0.8800	0.3763
Size	−0.0007	0.0005	−1.3600	0.1743
Stock	0.0005	0.0016	0.3000	0.7631
Single	−0.0011	0.0018	−0.6000	0.5476
Rspread	−0.0139	0.0122	−1.1300	0.2571
Growth	−0.0029	0.0016	−1.8400	0.0661
R_square	0.86377			
Adj_R_square	0.86351			
F value	3,328.46***			
Firm-year Observations	11,571.00			

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

John (1993)).[23] Furthermore, Colquitt, Sommer, and Godwin (1999) and Ozkan and Ozkan (2004) find that cash holdings (liquidity) are negatively related to leverage. Thus, from the perspective of cash holdings, more highly leveraged insurers generally tend to hold less cash.

The coefficients of *Growth* are negative and weakly significant, which is consistent with the predictions of John (1993). When sales growth increases, the corresponding cash flow increases as well, and insurers have lower demand for liquidity reserves. Therefore, we find that insurers with higher

[23] John (1993), Bruinshoofd and Kool (2002), and Kim, Mauer, and Sherman (1998) use the debt ratio as a proxy for firm leverage, which is defined as the ratio of total debt (long-term debt plus debt in current liabilities) to the book value of assets. However, we define an insurer's leverage as net premium written to surplus.

sales growth possess less liquidity. Moreover, we find a weakly negative relationship between *Geo_H* and liquidity, which is inconsistent with our expectations. Certain variables are insignificant such as the *Stock* dummy, *Single* dummy, *Rspread*, and *Size*. The coefficient of the lagged liquidity measure (Liq_cia_lag1) is positively significant, and thus an insurer tends to have a liquidity target, and its adjustment speed is approximately 22.86% $(= 1 - 0.7714)$ (see Bruinshoofd and Kool (2002)).

5.3 Leverage Equation Results

Table 7 reports the results of the leverage equation. The coefficient of *Reins* denotes a significantly positive relationship with leverage, and thus the results show a positive reverse causality from reinsurance to leverage. Consistent with the renting capital hypothesis, insurers with more reinsurance tend to possess a higher level of debt (see Shiu (2011)). In addition, as Table 7 indicates, we find that the coefficient of *Liq_cia* is significantly and inversely related to leverage, which is also consistent with the rationale of the commutative substitute. Insurers with lower liquidity tend to hold higher debt, because they treat debt as a substitute for liquidity.

Firm size (*Size*) is negative and statistically significant with respect to leverage. This result indicates that larger insurers tend to have lower leverage, because large firms have higher internal funds and thus require less external capital according to the pecking order theory (see Frank and Goyal (2009)). The coefficient *Intra_g_H* is significantly positive. It is crucial to consider the impact of organizational structure on insurer leverage, and a high intra-group Herfindahl index implies fewer members in the group, thus a firm needs to possess higher leverage as its internal funds are lower. Consistent with past literature, such as Cummins and Sommer (1996), our results show that insurers with a higher intra-group Herfindahl index tend to have higher leverage than those with a lower index.

Single insurers in general tend to have less capital and thus naturally possess higher leverage. However, a contradictory result emerges: we find that the coefficient of the *Single* dummy variable is negatively related to leverage, which is inconsistent with the prediction of Cummins and Sommer (1996) and indicates that single insurers tend to reduce their leverage to mitigate the probability of bankruptcy or financial pressures, because they essentially have less internal funds.

The result for the *National* dummy variable is also inconsistent. Na-

Table 7: Leverage equation results

Dependent variable, Leverage				
Variables	Coefficient	S.E.	T-statistics	P-value
Constant	0.5049	0.1797	2.8100	0.0050
Reins	0.3851	0.0459	8.3900	< .0001
Liq_cia	−0.2364	0.1023	−2.3100	0.0209
Leverage_lag1	0.8843	0.0054	165.2200	< .0001
Size	−0.0286	0.0069	−4.1600	< .0001
Stock	0.0278	0.0217	1.2800	0.2003
Single	−0.1011	0.0512	−1.9700	0.0483
National	0.0680	0.0255	2.6600	0.0078
Intra_g_H	0.1788	0.0820	2.1800	0.0292
Newyork	0.0119	0.0244	0.4900	0.6245
Agency	0.0239	0.0209	1.1400	0.2528
Roc	−0.0294	0.0590	−0.5000	0.6187
LnRBC	0.0110	0.0129	0.8600	0.3907
R_square	0.81437			
Adj_R_square	0.81400			
F value	2,202.70***			
Firm-year Observations	11,571.00			

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

tional insurers tend to issue more diverse policies and thus incur higher policyholder monitoring costs (see Mayers and Smith (1988)). Asa result, policyholders may request a higher capital (lower leverage) commitment from national insurers. Nevertheless, the empirical result indicates that national insurers tend to have a higher level of leverage. A plausible explanation is that national insurers tend to produce more business, which results in a higher level of liability relative to their surplus. Thus, a significantly positive result emerges.

The coefficient for the lagged term of leverage *(Leverage_lag1)* implies that insurers close about 11.57% ($= 1 - 0.8843$) of the gap between current leverage and desired leverage within one year. It also implies that the insurers tend to have a target leverage level (see Flannery and Rangan (2006), Byoun (2008), Fier, McCullough, and Carson (2013)).

6 Conclusion

This study has examined the interrelations among reinsurance demand, liquidity and leverage for insurers in the U.S. property-liability insurance industry. Liquidity and reinsurance demand constitute important mechanisms that enable insurers to avoid unexpected demands for cash when they face severe claims in the insurance market. Using the rationale of Hau (2006) and Niehaus and Mann (1992), we argue that corporate insurance is a substitute for liquidity. Accordingly, we propose the *substitute hypothesis*. Shiu (2011) concludes that the demand for reinsurance and leverage form a complementary relationship, which is consistent with the *bankruptcy cost*, *agency cost*, *risk-bearing*, and *renting capital hypotheses*. The literature argues that debt can provide a ready source of financing such that insurers treat leverage as a substitute for liquidity. Furthermore, the argument regarding the agency costs of managerial discretion predicts a similar conclusion. In terms of these arguments, we conclude that insurers' liquidity and leverage operate as mutual substitutes. In contrast, the *financial pressure* (*bankruptcy cost*) and *monitoring hypotheses* propose a complementary relationship between liquidity and leverage.

Using pooled time-series and cross-sectional data from 1994 to 2006, we find that our main hypotheses are supported. The insurer's liquidity has a negative influence on reinsurance purchases, and an insurer with more reinsurance tends to maintain less liquidity, which supports the substitute argument. Consistent with the findings of Shiu (2011), the empirical result herein indicates that a complementary relationship exists between reinsurance demand and leverage for U.S. property-liability insurers. In addition, arguments regarding the substitutive relationship between liquidity and leverage are supported, which contradicts the *financial pressure* (*bankruptcy cost*) and *monitoring hypotheses*. This result indicates that leverage could provide a ready source of financing, and therefore could be used as a substitute for an insurer's liquidity.

Our findings in this paper justify the need for integrated risk management as pointed out by Doherty (2000). Reinsurance, leverage, and liquidity do not serve separately as tools for risk management. Instead, integrated strategies utilizing all three elements can help insurance companies reduce risk. Analyzing one without considering the other two might be a biased view for asset liability management in insurance companies.

This issue can be extended in some further directions. For a global viewpoint, an international analysis is suggested as it may reveal more general conclusions that could prove to be valuable for insurers. In addition, to control the potential impact from economic fluctuations upon the firm's capital structure, a longer horizon sample period can be examined. Additionally, it is reasonable to consider that an insurer's profitability is also an endogenous variable in this study. This may endogenously play an important role on the insurer's decisions regarding reinsurance demand, liquidity demand, and capital structure. Hence, it is recommended that a structural model incorporating these four endogenous variables be analyzed in the future.

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投稿日期: 2014年3月6日, 接受日期: 2015年3月20日

美國財產責任保險公司再保險、流動性及財務槓桿關係之分析

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本文採用1994–2006年結合時間序列與橫斷面資料分析美國財產責任保險公司再保險、流動性及財務槓桿之關係。本文採用二階段最小平方法來估計再保險需求、流動性及財務槓桿三條結構方程式。本文實證結果發現保險公司的再保險需求與流動性之間呈現替代的現象, 且流動性與財務槓桿之間亦呈現替代之關係。另外, 本文亦發現再保險需求與財務槓桿之間的關係則爲互補之現象。

關鍵詞: 再保險, 流動性, 財務槓桿, 資本結構
JEL 分類代號: G22, G32, G33