Do insurers partially adjust their liquidity toward target levels? Evidence from the U.S. Property-Liability Insurance Industry

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Abstract

This article studies whether insurers operating in the U.S. have targeted liquidity levels and how this target is achieved when it exists. The evidence suggests that the trade-off adjustment behavior of an insurer’s liquidity is affirmed. Insurers that achieve liquidity above their targets adjust faster than insurers with liquidity below their targets which proposes that low investment returns concern dominates the arguments about bankruptcy costs and speculative motivation. Additionally, the substitution effect of leverage and the combined effects of the interaction between an insurer’s deviation from the target liquidity and its leverage play a substantial role in insurers’ liquidity adjustments.

Key words: Optimal liquidity, targeted liquidity, partial adjustment model, asymmetric partial adjustment, speed of adjustment

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本文探討美國產物保險公司是否存在目標流動性及如何調整到流動性目標值。實證結果支持抵換型式的調整過程。流動性在目標值之上的公司其調整速度會比在目標值之下的快，此結果說明低報酬率的考量是比破產成本和投資動機重要的。另外，財務槓桿的替代效果與流動性偏離目標值和財務槓桿的交互效果對流動性的調整也是重要的。

關鍵詞：最適流動性、目標流動性、部份調整模型、不對稱部份調整、調整速度
I. Introduction

Liquidity maintenance is a critical issue for non-financial firms and financial institutions. During the 2008 to 09 global financial crisis, many famous financial institutions such as Northern Rock, Washington Mutual, Merrill Lynch, Morgan Stanley, Goldman Sachs Group, and American International Group (AIG) encountered immense financial pressure and a liquidity crunch. These potentially severe threats ultimately forced financial institutions to maintain more sufficient cash holdings and liquid assets (liquidity) to meet the unexpected cash needed during periods of economic recession.

The literature has provided evidence about how corporate liquidity is determined.\(^1\) Kim, Mauer, and Sherman (1998), Bruinshoofd and Kool (2002), and Hirth and Uhrig-Homburg (2010) show that firms intend to preserve an optimal liquidity level because they have to balance the costs and benefits of holding liquid assets. Bruinshoofd and Kool (2002) suggest that firms tend to have targeted liquidity in the long run, but they passively respond to exogenous shocks in the short run. Ozkan and Ozkan (2004) and Venkiteshwaran (2011) discuss the optimal cash holding levels for U.S. non-financial firms. They find that firms adjust their cash holding levels over time, which indicates that firms do have targeted liquidity levels and correct the deviation from their targeted liquidity gradually.\(^2\) In sum, firms intend to sustain an optimal liquidity level in terms of trade-offs between the costs and benefits of liquidity maintenance. Accordingly, we postulate that financial institutions also intend to preserve optimal liquidity levels to avoid financial pressure and liquidity constraints. They possess high incentives to adjust their liquidity to achieve the targeted levels over time.\(^3\)

The property-liability insurance industry provides a natural environment to examine insurers’ liquidity adjustment decisions. In general, most contracts have a short-term time horizon, so short-term operating characteristics force managers to pay much attention to firms’ liquidity levels and potentially unexpected cash demands. Specifically, short-run policy cycles result in higher cash flow volatility, which drives insurers to preserve sufficient liquid assets to relieve their urgent liquidity demand. Further, insurers may encounter considerable investment losses from market risks


\(^2\) Notably, the meanings of a firm’s liquidity and cash holdings are distinct. Nevertheless, the literature suggests that they are all liquidity measurements (e.g., Anderson and Carverhill, 2012). Even though the definitions of these two measurements differ, similar implications and arguments exist in the corporate finance theory for firms. Thus, in this study, literature is cited for both cash holdings and liquid assets and referred to the firm’s liquidity.

\(^3\) The adjustment behavior (speed) between non-financial firms and financial institutions may be very different. It is known that the operating characteristics and regulation environment for the financial industry is different from those of the non-financial industry. For example, the leverage ratio is higher and the regulation is heavier for the financial industry. In addition, financial institutions always maintain a higher level of liquidity than non-financial firms do. In this study, we demonstrate that the average liquidity ratio is approximately 83.24% for insurers, whereas it is 8.1% for non-financial firms (Kim, Mauer, and Sherman, 1998).
and counterparty credit risks during global financial crises. Moreover, in the event of a catastrophe, insurers also have to prepare additional liquidity for unexpected claims from policyholders even though they have transferred these non-diversifiable risks to reinsurance markets. In sum, it is crucial for insurers to preserve higher levels of liquidity to mitigate unexpected cash demands.

To maintain sufficient liquidity, we postulate that insurers also intend to sustain targeted liquidity levels; therefore, it is predicted that they would adjust their liquidity toward the targeted level over time by considering the trade-offs between costs and benefits of holding liquidity. Insurers with higher liquidity levels tend to benefit from lower liquidity risk, financial distress, and bankruptcy costs as well as from underinvestment problems. In contrast, higher liquidity tends to produce higher agency costs of cash abused by managers (Jensen, 1986; Cox, Well, and Gaver, 1995; Hirth and Uhrig-Homburg, 2010) and a lower return on investment (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999). On the other hand, in the case of insurers with lower liquidity, the reverse is true. Thus, it is critical for insurers to maintain optimal liquidity levels. To the best of our knowledge, this is the first to discuss the existence of insurers’ optimal liquidity and its adjustment behavior. To fill this research gap in the literature, we intend to examine whether insurers would like to maintain targeted liquidity and how and when they adjust to their targeted liquidity if targeted liquidity exists.

This study visits the issue of whether insurers’ behaviors are consistent with the existence of targeted liquidity and asymmetric liquidity adjustments. We employ unbalanced panel data for the U.S. property-liability insurance industry from 2006 to 2010 and apply a partial adjustment model to examine (1) whether insurers tend to have targeted liquidity and adjust to the targeted level over time, (2) whether asymmetric partial adjustments of liquidity exist between organizations with liquidity above and below their targets, (3) whether the adjustment speed for insurers with high or low leverage is distinct, and (4) finally we analyze the relationship between deviations from the targeted liquidity and leverage.

We find that the argument posed by the trade-off behavior theory is supported. The costs and benefits of liquidity maintenance drive insurers to pursue optimal liquidity. We further find that insurers with liquidity above their target levels adjust faster than those with liquidity below their target levels. This suggests that the arguments of bankruptcy costs (financial pressure) and speculative motivation are contradictory. Furthermore, substitution effects force low-leverage insurers to adjust their liquidity positions toward targeted levels faster than high-leverage insurers (John, 1993; Ferreira and Vilela, 2004; Kalcheva and Lins, 2007). Finally, while taking into account both insurers’ leverage positions and their deviations of liquidity, the evidence of high and low leverage analysis supports the financial pressure hypothesis and the monitoring hypothesis in cases of insurers with liquidity that is above their targets.
Additionally, given cases of low leverage, the adjustment speed for insurers with above-target liquidity is faster than those with below-target liquidity. Again, the arguments of bankruptcy costs (financial pressure) and speculative motivation are not supported by evidence. The low returns earned (inefficient liquid assets) may be the major reason to uphold this finding.

The potential contributions of this article are as follows: First, this is the first to discuss the adjustment behavior of insurers’ liquidity, which could fill a research gap in the literature. Second, similarly to non-financial firms, we provide evidence of the existence of targeted liquidity for the U.S. property-liability insurance industry, and the result is consistent with the trade-off behavior theory. Third, we prove that insurers with above- or below-target liquidity and with high or low leverage positions behave asymmetrically when adjusting liquidity levels. The joint effects between insurers’ deviations from the targeted liquidity and how much it is leveraged substantially influence insurers’ liquidity decisions.

The article is organized as follows: in Section II, we discuss the literature review of liquidity and adjustment behavior. Section III presents empirical models, variables descriptions, and the development of hypotheses. In Section IV, we present the data, showing the estimation results, and provide some robustness checks. Finally, concluding remarks can be found in Section V.

II. Literature Review

Liquidity is important for corporate financial management. Firms with lower liquidity tend to have higher default risk, but firms with excess liquidity may not be utilizing their assets optimally. Both situations will eventually decrease a firm’s value. Hence, how to determine a firm’s optimal liquidity level is a critical issue. The literature on this issue has provided insightful evidence and arguments for a firm’s liquidity determinants and financial decisions, such as agency cost arguments, investment decisions, efficiency debates, and demand for insurance issuance.4,5

Brealey and Myers (1996) suggest that the value of corporate liquidity maintenance does not have an explicit solution in finance theory yet. Generally, most firms invest large sums of money in liquid assets in order to avoid and/or mitigate liquidity risk. Nevertheless, firms with excess liquidity may face high opportunity costs and low investment returns. Excess operational cash tends to result in dormant assets, inefficient cash holdings, and inefficient investments as well as higher agency costs. In


5 As indicated in Footnote 2, the literature suggests that a firm’s cash holdings are also treated as an alternative liquidity measurement. The stream of the cash holding literature also presents a vital connection between a firm’s financing policies and cash holding levels. Both liquidity measurements have similar implications and arguments on the corporate finance theory (e.g., Opler et al., 1999; Colquitt, Sommer, and Godwin, 1999; Ozkan and Ozkan, 2004; Clark, Francis, and Hasan, 2009; Riddick and Whited, 2009; Yen, 2009; Lian, Xu, and Zhou, 2010; Lins, Servaes, and Tufano, 2010; Venkiteshwaran, 2011; Alles, Lian, and Xu, 2012).
contrast, firms with lower liquidity may not only miss investment opportunities but also face higher financial pressure if they have urgent cash demands. Consequently, firms possess an incentive to consider both costs and benefits while holding liquid assets.

Kim, Mauer, and Sherman (1998) provide a theoretical and empirical investigation on firms’ liquidity. They indicate that the optimal amount of liquidity is determined by a trade-off between the costs and benefits of investments. Bruinshoofd and Kool (2002) propose two opposing theoretical arguments—trade-off and pecking order behavior theories—as motivations for firms’ targeted liquidity holding. To achieve a balance of costs and benefits, their empirical results show that in the long run, the trade-off behavior tends to be supported. To sum up, these studies provide solid evidence that firms tend to preserve optimal liquidity when liquidity management is implemented.

The trade-off behavior argument indicates that an optimal liquidity level is determined by trading off between marginal costs and marginal benefits of liquidity holdings. The benefits of liquidity maintenance are generated from a number of sources, including reductions in external financing costs (Almeida, Campello, and Weisback, 2002), more strategic advantages in the competitive product markets with more cash reserves (Haushalter, Klasa, and Maxwell, 2007), and more financial flexibility (Gamba and Triantis, 2008). In contrast, the major costs of liquidity maintenance are the opportunity costs resulting from holding liquidity with low returns (Opler et al., 1999) and the agency costs of high excess cash (Jensen, 1986; Cox, Well, and Gaver, 1995; Hirth and Uhrig-Homburg, 2010). Many hypotheses are proposed to show that firms do have targeted liquidity, for instance through the agency cost theory, trade-off theory, transaction costs theory, and financial distress costs theory (e.g., Huberman, 1984; Schilling, 1996; Opler et al., 1999; Bruinshoofd and Kool, 2002; Ogundipe, Salawu, and Ogundipe, 2012).

Since optimal liquidity is always pursued, marginal costs and marginal benefits of liquidity holdings will drive firms to adjust their liquidity toward the targeted level. Some literature indicates that firms adjust their cash holdings or liquidity toward targeted levels over time (e.g., Opler et al., 1999; Bruinshoofd and Kool, 2002; Ozkan and Ozkan, 2004; Garcia-Teruel and Martinez-Solano, 2008; Riddick and Whited, 2009; Yun, 2009; Bigelli and Sanchez-Vidal, 2012; Lian, Xu, and Zhou, 2010; Venkiteshwaran, 2011; Alles, Lian, and Xu, 2012). Specifically, Ozkan and Ozkan (2004) apply a partial adjustment model to analyze corporate cash holdings for U.K. firms. Their empirical results suggest that a dynamic model is better suited for the cash holding behavior than the static model in the extant literature. Additionally, Lian, Xu and Zhou (2010) and Alles, Lian, and Xu (2012) adopt a dynamic adjustment model to examine the cash holdings. Also, the dynamic trade-off theory of cash holdings is supported. They conclude that the precautionary motive of holding
sufficient cash arises from firms’ financial constraints for China-listed firms. Ogundipe, Salawu, and Ogundipe (2012) argue that firms cannot rapidly adjust to the targeted cash level due to the fact that adjustment costs are costly. In their dynamic framework, they find that firm-specific characteristics do influence the adjustment speed of liquidity and play an important role in the liquidity adjustments. Empirical evidence suggests that when actual liquidity or cash holdings deviate from the targeted level, firms tend to adjust their liquidity or cash holdings toward the targeted levels gradually as a whole.

III. Empirical Models and Hypotheses Development

Asymmetric partial adjustment on firms’ leverage is well explored in the financial literature. Byoun (2008) and Dang, Garrett, and Nguyen (2011) employ an asymmetric partial adjustment model to examine firms’ leverage in terms of the costs of deviation and adjustment from targeted leverage. In this study, we follow their rationale and methodology to discuss the partial adjustment on insurers’ liquidity.

A. Estimation of Targeted Liquidity

In accordance with previous studies, the partial adjustment model of liquidity can be expressed as follows,

\[ L_{i,t-1} - L_{i,t-1} = \alpha (L^*_{i,t-1} - L_{i,t-1}) + \varepsilon_{i,t}, \]  

where \( L_{i,t} \) and \( L_{i,t-1} \) are liquidity ratios for firm \( i \) at time \( t \) and \( t-1 \), respectively. \( \alpha \) is the ratio of actual liquidity change to desired movement toward targeted change, i.e., \((L_{i,t} - L_{i,t-1})/(L^*_{i,t} - L_{i,t-1})\) and is defined as the “adjustment speed.” \( \varepsilon_{i,t} \) is the well-behaved error term. \( L^*_{i,t} \) is the targeted liquidity ratio that is unobservable and is defined as Equation (2),

\[ L^*_{i,t} = X_{i,t-1} \beta. \]  

Empirically, to estimate the target liquidity, we regress actual liquidity on most lagged firm-specific characteristics, and the regression model is set as Equation (3),

\[ L_{i,t} = X_{i,t-1} \beta + \delta_{i,t}, \]  

where \( X_{i,t-1} \) are lagged firm-specific characteristics. \( \beta \) are estimated coefficients. \( \delta_{i,t} \) are well-behaved error terms. Other control variables include dummy years. We use the fitted value of Equation (3) as a proxy for insurers’ targeted liquidity, which is represented as follows.

\[ \hat{L}^*_{i,t} = X_{i,t-1} \hat{\beta}. \]

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6 The partial adjustment model minimizes the sum of these two costs and proves that firms adjust their leverage from actual to targeted leverage over time. Numerous studies have attempted to adopt a standard partial adjustment model to discuss firms’ leverage (e.g., Flannery and Rangan, 2006; Byoun, 2008; Lemmon, Roberts, and Zender, 2008; Liu, 2009; Faulkender et al., 2012).

7 We thank the anonymous reviewer who suggested the use of different models to estimate targeted liquidity for the robustness checks. In this study, we provide five distinct targeted estimation models to generate the fitted value for liquidity, including (1) pooled estimation without control fixed and random effects, (2) year and firm fixed effects, (3) year and firm random effects, (4) mixed effect models (MEM) with restricted maximum likelihood (REML), which allow cross-sectional heteroskedastic and time-wise autoregressive covariance (Byoun, 2008), and (5) MEM with REML where control variables contain the interaction effects between the crisis dummy and all independent variables.
Kim, Mauer, and Sherman (1998) and Bruinshoofd and Kool (2002) propose that liquidity measures are defined as the sum of cash and marketable securities to total assets. Likewise, following these studies, we use \((\text{cash + invested asset}) / \text{assets}\) to measure insurers’ liquidity, which is named \(\text{Liq}^{8}\).

To estimate the insurer’s targeted liquidity, we refer to prior studies on liquidity to identify explanatory variables for Equation (3) (John, 1993; Kim, Mauer, and Sherman, 1998; Almeida, Campello, and Weisbach, 2002; Bruinshoofd and Kool, 2002; Dittmar, Smith, and Servaes, 2002; Shiu, 2006; Chang and Tsai, 2014; Chang and Jeng, 2015). They are described as follows.

**Reins:** The rationale of Niehaus and Mann (1992) and Hau (2006) indicates that a firm’s liquidity and demand for corporate insurance might be substituted. Hence, we include reinsurance demand in the regression analysis, which is defined as \((\text{affiliated reinsurance ceded + nonaffiliated reinsurance ceded}) / (\text{direct business written plus reinsurance assumed})\).

**Leverage:** John (1993), Ferreira and Vilela (2004), and Kalcheva and Lins (2007)

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8 We thank the anonymous reviewer who suggested that stocks and bonds are motivated by long-term investment. We totally agree with this viewpoint. However, when insurers have urgent liquidity demands (e.g., catastrophic loss, large investment losses, or other urgent liquidity demand), they also have to sell stocks and bonds as well as illiquid assets if necessary. For example, during the global financial crisis, the American International Group (AIG) sold its affiliate, the Nan Shan Life Insurance Company to repay the debt from the U.S. government. Also, Citigroup sold its host building in New York City to repay the debt. Thus, fire sales could occur if firms’ financial health is poor. Consequently, following Kim, Mauer, and Sherman (1998), and Bruinshoofd and Kool (2002), we adopt cash plus invested asset to total assets \((\text{Liq}_\text{cia})\) to examine the partial adjustment models. In addition, other liquidity measurements are implemented as robustness checks. These include (1) net operating cash flows to total assets \((\text{Liq}_\text{cfa}; \text{Gaver and Pottier, 2005})\), (2) cash and short-term investments to the sum of cash and total investments \((\text{Liq}_\text{ci}; \text{Gaver and Pottier, 1999; Hsu, Huang, and Lai, 2015})\), (3) cash and investments in bonds and stocks to total assets \((\text{Liq}_\text{cssba}; \text{Choi et al., 2013})\), (4) the sum of bonds, stocks, preferred and common, cash, cash equivalents, and short-term investments, receivables for securities investment income due accrued, and eliminate the investments in parent, sub and affiliates to total assets \((\text{Liq}_\text{iris}; \text{IRIS Property Casualty Liquidity Ratio})\), and (5) cash plus short-term investments (marketable securities) to assets \((\text{Liq}_\text{csia}; \text{Martinez-Sola, Garcia-Teruel, and Martinez-Solano, 2008})\). Overall, we find that the empirical results of \(\text{Liq}_\text{iri}\) and \(\text{Liq}_\text{cssba}\) (named Liq1) are consistent with and similar to our main results \((\text{Liq})\), whereas \(\text{Liq}_\text{csia}\), \(\text{Liq}_\text{ci}\), and \(\text{Liq}_\text{csba}\) (named Liq2) are not. We find that the adjustment speed of Liq2 is greater than that of Liq1. Furthermore, precautionary motivations and financial pressure force insurers with below-target liquidity to adjust their liquidity toward target faster than insurers with above target liquidity. Additionally, the financial pressure and monitor hypotheses are supported because we find that insurers with more leveraged positions have faster adjustment speeds than those with do less leveraged positions. We provide some plausible reasons to explain these inconsistent results. First, the difference (long-term investments, semi-liquid assets, and illiquid assets) between Liq1 and Liq2 plays an important role in these inconsistent results. Selling the long-term investments, semi-liquid assets, and illiquid assets is difficult and time consuming (costs; fire sales). As a result, the incentives and motivations of Liq1 should differ from those of Liq2. In addition, since the definitions of liquidities are distinct, it is expected that different empirical results may emerge. However, we do not discuss this issue in this study and leave it to further research in the near future.

9 We thank the anonymous reviewer who suggested that we have to identify explanatory variables in the cash holding related literatures, such as Colquitt, Sommer, and Godwin (1999). This study refers to prior studies on liquidity but not cash holdings to identify explanatory variables and estimate the insurer’s targeted liquidity. We cannot deny that cash holdings are a type of liquidity measurement, but they still possess some differences. The nature of cash holdings is more similar to cash flow (or free cash flow) so that its motivations may differ from the liquidity. In addition, cash holdings can be treated as a part of a firm’s liquidity, and thus it may not be a good proxy for a firm’s real liquidity. Based on these reasons, we refer to prior studies on liquidity to identify explanatory variables and estimate the insurer’s targeted liquidity.
propose that highly leveraged firms have a lesser need to maintain high liquidity. Thus, a negative relationship between leverage and liquidity is proposed. The leverage is defined as total liabilities / assets.

**TaxEx**: We define it as the tax-exempt investment income relative to total investment income. It is a proxy for the expected tax liability or tax-favored assets. We predict that it is inversely related to liquidity.

**Bus_H** and **Geo_H**: Shiu (2006), Chang and Tsai (2014), and Chang and Jeng (2015) suggest that business and geographic concentrations also influence the insurer’s liquidity decisions. Thus, we use geographic and business Herfindahl indices as proxies for insurers’ business and geographic concentrations. ¹⁰ Business and geographic concentrations are predicted to be positively related to liquidity.

**2_year_loss**: We use two-year loss development to measure insurers’ financial constraints. The positive value suggests that insurers tend to have a smaller loss reserve so that they will increase liquidity to reduce financial constraints. In contrast, the negative value implies that they will reduce liquidity.

**Size**: We use a natural logarithm of total assets as a proxy for firm size. It is predicted that liquidity is negatively related to firm size (Kim, Mauer, and Sherman, 1998; Opler et al., 1999; Bruinshoofd and Kool, 2002; Dittmar, Mahrt-Smith, and Servaes, 2003; Shiu, 2006; Chang and Tsai, 2014; Chang and Jeng, 2015).

**Stock**: The arguments of owner-manager conflicts and rising capital hypothesis indicate that stocks can hold less liquidity (Colquitt, Sommer, and Godwin, 1999; Harrington and Niehaus, 2002). The agency costs of debt hypothesis propose that stocks should hold more cash or liquidity than mutual funds (Opler et al., 1999). In sum, the relationship between organizational forms and liquidity is mixed. We use a **stock**, a dummy variable, to control the difference between organization forms of stocks and mutual funds. It equals 1 if the insurer is a stock insurer and 0 if the insurer is a mutual insurer.

**Single**: According to Shiu (2006), Chang and Jeng (2015), and Chang and Tsai (2014), we include a dummy, **single**, to control for the difference between affiliated and non-affiliated insurers. It equals 1 if the insurer is non-affiliated and 0 otherwise. We predict that the insurer’s liquidity is positively related to the single dummy.

**ROA**: The return on assets is a measurement of an insurer’s profitability, which is defined as net income plus tax and interest expenses divided by total assets. According to Kim, Mauer, and Sherman (1998), the prediction of the relationship between liquidity and profitability is negative.

**Rspread**: Similar to **ROA**, Kim, Mauer, and Sherman (1998) use the return on

¹⁰ The definition of the geographic Herfindahl index follows that by Kim, Mayers, and Smith (1996), which defines it 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. Similar to the geographic Herfindahl index, 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.
assets minus the risk-free interest rate (e.g., Treasury Bills rate) to measure a firm’s profitability, and the prediction is the same with ROA.

Std_cf: As suggested by Kim, Mauer, and Sherman (1998) and Opler et al. (1999), firms with higher cash flow volatility tend to maintain a higher level of liquidity to meet unexpected demand. Thus, we predict that an insurer’s liquidity and the variance of cash flow are positive.\(^{11}\)

Prem_increase: John (1993) argues that the growth opportunity of firms can affect firms’ liquidity strategies. He employs the average compound growth ratio of sales as a firm’s growth opportunity, and predicts that the sales growth rate is negatively related to liquidity. In this study, we use the premium earned growth rate as a proxy for firms’ growth opportunities.

B. Symmetric Partial Adjustment Model

According to Byoun (2008) and Dang, Garrett, and Nguyen (2011), a primary symmetric partial adjustment model of liquidity, Equation (1), can be rewritten as,

\[
\Delta L_{i,t} = \alpha_0 + \alpha_1 TDL_{i,t} + \gamma_{i,t},
\]

where \(\Delta L_{i,t} = L_{i,t} - L_{i,t-1}\). \(\alpha_0\) is a constant term, \(\alpha_1\) is an estimated coefficient of adjustment speed, and \(\gamma_{i,t}\) are well-behaved error terms. \(TDL_{i,t} = L_{i,t} - L_{i,t-1}\) and is the gap between targeted and actual liquidity for firm \(i\) at time \(t\).

While liquidity maintenance is in imbalance, a perfect and complete market would dictate that firms can adjust their liquidity toward the targeted level immediately. Nevertheless, market friction and adjustment costs exist in the real world so that firms may not be able to adjust their liquidity toward the targeted level instantaneously. Consequently, the evolution of liquidity for a firm will follow a partial adjustment process. We refer to it as a trade-off adjustment behavior. In sum, the prediction of \(\alpha_1\) ranges from 0 to 1.\(^{12}\)

\[H_1: 0 < \alpha_1 < 1.\]

C. Asymmetric Partial Adjustment Model

Based on \(H_1\) being supported, we then discuss asymmetric adjustment behavior for insurers that are above and below their targeted liquidity. The model can be expressed as follows,

\[
\Delta L_{i,t} = \alpha_2 + \alpha_3 TDL_{i,t} D_{i,t}^a + \alpha_4 TDL_{i,t} D_{i,t}^b + \zeta_{i,t},
\]

where \(\alpha_2\) is a constant term, and \(\alpha_3\) and \(\alpha_4\) are estimated coefficients of adjustment speeds for above- and below-target liquidity, respectively. If \(TDL_{i,t} < 0\), then we defined \(D_{i,t}^a = 1\), which represents the above-target liquidity, and 0 otherwise. On the other hand, if \(TDL_{i,t} \geq 0\), then \(D_{i,t}^b = 1\), which represents the below-target

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\(^{11}\) The variability of cash flow is defined as the standard deviation of the cash flow ratio over year \(t\) and year \(t-2\), where the cash flow ratio is defined as the net operating and investment income plus additional capital changes paid in (before interest, tax, and dividends) divided by the total assets.

\(^{12}\) Following the rationale of Guney, Ozkan, and Ozkan (2003) and Ozkan and Ozkan (2004), \(\alpha_0\) is equal to 0. However, Byoun (2008) indicates that the constant in Equation (5) captures the mean tendency of non-target adjustment behavior so that it need not be 0.
liquidity, and 0 otherwise. $\zeta_{it}$ represents well-behaved error terms. Similar to the previous arguments, it is predicted that $\alpha_2$ equals 0 and $\alpha_3$ and $\alpha_4$ range from 0 to 1.

It is of importance to know that an insurer’s liquidity is above or below the target. An insurer with high liquidity tends to benefit from lower liquidity risk, financial distress, and bankruptcy costs as well as from fewer underinvestment problems. On the contrary, some defects are generated if insurers have high liquidity levels, such as higher agency costs and lower returns on investment. In contrast, the inverse arguments will be presented if an insurer has lower liquidity. Based on these reasons, it is critical for insurers to maintain optimal liquidity.

Miller and Orr (1966) argue that bankruptcy costs will influence the firm’s cash holdings. Firms with higher bankruptcy costs tend to hold more cash in hand. Precautionary motivations may cause firms that fall into financial distress to hold more cash to avoid higher financing costs and to reduce the possibility of bankruptcy (Myers, 1977; Opler et al., 1999; Han and Qiu, 2007; Ogundipe, Salawu, and Ogundipe, 2012). Additionally, speculative motivations suggest that firms that intend to maintain higher cash levels keep a competitive advantage in the product markets, so as to grab profitable investment opportunities or to seize higher market shares from their competitors (Acharya, Almeida, and Campello, 2007; Haushalter, Klasa, and Maxwell, 2007; Fresard, 2010). Ozkan and Ozkan (2004), Bruinshoofd and Kool (2009), and Venkiteshwaran (2011) conclude that firms with excess cash are slower to return to optimal levels than those with deficiencies.

On the basis of the arguments above, we postulate that firms with liquidity below their target levels tend to confront more financial pressure, liquidity risk, and bankruptcy costs than those with liquidity above their target level. Thus, firms possess strong incentives to increase their liquidity when they hold insufficient liquid assets. We then expect the adjustment speed of firms with liquidity below their targets to be faster than that of firms with liquidity above their targets.

$$H_2: \alpha_3 > \alpha_4.$$  

D. Asymmetric Partial Adjustment Model with Leverage

We then discuss the asymmetric partial adjustment model for liquidity in the case of firms with high leverage or with low leverage. The model can be written as follows.

$$\Delta L_{it} = \alpha_5 + (\alpha_6 L\text{Lev}_{it} + \alpha_7 H\text{Lev}_{it})T\text{D}\text{L}_{it} + \tau_{it},$$  

where $\alpha_5$ is a constant, and $\alpha_6$ and $\alpha_7$ are estimated coefficients of adjustment speeds for high and low leverage insurers, respectively. $H\text{Lev}_{it}$ and $L\text{Lev}_{it}$ are high and low leverage levels for firm $i$ at time $t$. $\tau_{it}$ represents well-behaved error terms.

John (1993) suggests that firms could borrow from external capital markets so

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13 In this study, “high-leveraged” and “low-leveraged” are defined as insurers’ leverage ratio in comparison with the median leverage of the industry as a whole. We also adopt different criteria, such as the first quantile (Q1) and third quantile (Q3) leverage levels of the whole industry, to re-examine the empirical results. Overall, the empirical results are consistent with our main findings. We do not tabulate those results here.
that debt could provide a ready source of financing. Thus, firms could use debt as a substitute for cash holdings (liquidity), and then reduce the firm’s liquidity. Ferreira and Vilela (2004) and Kalcheva and Lins (2007) argue that leverage can be a proxy for a firm’s ability to issue debt. As a result, it is expected that firms with a greater ability to raise debt would hold less cash. Moreover, Kim, Mauer, and Sherman (1998) also propose that firms with high leverage positions are those less likely to be in financial distress or have more access to debt markets. Hence, they do not need to maintain high liquidity levels\footnote{We thank the anonymous reviewer who suggested that the liability structure of insurers is not the same as that of the non-financial firms of Kim, Mauer, and Sherman (1998). According to Note 14 of Chang and Tsai (2014), they argue that the liability components of insurers are the unearned premium reserves, loss reserves, and other liabilities. Even though the liability structure of insurers is different from that of non-financial firms, it still resembles the properties of debt. Specifically, an insurer’s liability reserves could be regarded as a fund that borrows from policyholders such that it has the main feature of debt. Insurers with higher sales growth indicate that liabilities and cash inflow will increase. The increasing cash inflow would decrease the liquidity demand. Conversely, insurers with a higher net premium also tend to encounter higher amounts of loss claims; therefore, insurers would like to hold more liquid assets for precautionary purposes. According to these arguments, we could borrow conventional theories of debt financing to support our prediction of the relationship between an insurer’s leverage and liquidity.}

From the agency costs of a managerial discretion viewpoint, Myers and Rajan (1998), and Opler et al. (1999) propose that firms with high debt ratios reduce managerial discretion as well as telling managers to hold excess cash in hand. Thus, the restrictions of debt contracts will force managers to reduce some current liquidity. Similar results are presented in Colquitt, Sommer, and Godwin (1999), Faulkender (2002), and Ozkan and Ozkan (2004).

On the basis of the above arguments, we refer to it as the substitute effect hypothesis as a whole. We expect that the relationship between liquidity and leverage is negative. Since debt could provide a ready source of financing, high-leveraged firms tend to demand less liquidity than low-leveraged firms. Consequently, the speed of adjustment toward the targeted liquidity of high-leveraged firms is expected to be slower than that of low-leveraged firms. We then hypothesize

\[
H_3: \alpha_6 > \alpha_7.
\]

Prior studies also provide conflicting predictions. Opler et al. (1999) argue that firms with high leverage have difficulty in raising additional funds, so they may intend to hold more cash (liquidity) in hand in order to take advantage of profitable investment opportunities. Panno (2003) indicates that firms with high liquidity might have a relatively higher debt ratio, because higher leverage firms should possess a greater ability to meet short-term obligations when debt is due. On the aspect of financial pressure or bankruptcy costs, financial pressure increases the need for liquidity. Both Haan (1997) and Ees et al. (1998) argue that high-leveraged firms face a higher degree of uncertainty regarding future access to debt financing, so they desire to hold higher precautionary liquid assets. Faulkender (2002) also finds that firms with greater leverage hold more cash for preventative purposes.
The discussion of the financial pressure hypothesis (the bankruptcy cost hypothesis) implies a positive relationship between a firm’s liquidity and its leverage. High-leveraged firms tend to have more financial pressure, so they need more liquidity for precautionary purposes. Thus, high-leveraged firms tend to demand more liquidity than low-leveraged firms.

This aspect of the monitoring hypothesis suggests that high-leveraged insurers may indeed be subject to more outside monitoring by policyholders and regulators (Opler et al., 1999). Firms tend to maintain more liquidity to convince policyholders that the firm is trusted. Therefore, we expect that high-leveraged firms adjust their liquidity toward targeted liquidity faster than low-leveraged firms.

In sum, based on the financial pressure (the bankruptcy cost) hypothesis and the monitoring hypothesis, we predict that the adjustment speed of high-leveraged firms is faster than that of low-leveraged ones.

\[ H^b_3 : \alpha_6 < \alpha_7. \]

**E. Asymmetric Partial Adjustment Model: Deviations from Targeted Liquidity Interact with Leverage**

We further examine whether insurers with high or low leverage tend to have a distinct adjustment speed of liquidity in a given case of above- or below-targeted liquidity, respectively. The model can be expressed as follows,

\[
\Delta L_{i,t} = \alpha_8 + (\alpha_9 L\text{Lev}_{i,t} + \alpha_{10} H\text{Lev}_{i,t})TDL_{i,t}D_t^a + (\alpha_{11} L\text{Lev}_{i,t} + \alpha_{12} H\text{Lev}_{i,t})TDL_{i,t}D_t^b + \varphi_{i,t},
\]

where \( \alpha_8 \) is a constant term. \( \alpha_9, \alpha_{10}, \alpha_{11}, \) and \( \alpha_{12} \) are estimated coefficients of adjustment speeds for high-leveraged and low-leveraged firms interacting with above- or below-target liquidity, respectively. \( \varphi_{i,t} \) represents well-behaved error terms. Likewise, we expect that \( \alpha_8 \) equals 0, and \( \alpha_9, \alpha_{10}, \alpha_{11}, \) and \( \alpha_{12} \) range from 0 to 1.

**E.1. Asymmetric Adjustment toward Targeted Liquidity—Firms with Over-Liquidity**

Given the case of firms with above-target liquidity, firms tend to demand less liquidity. The substitute effect hypothesis suggests that debt can act as a substitute for corporate cash holdings (liquidity) so that the adjustment speed of liquidity of low-leveraged firms is greater than that of high-leveraged firms (John, 1993; Ferreira and Vilela, 2004; Kalcheva and Lins, 2007). Nevertheless, on the other hand, given firms with above-target liquidity, firms with high leverage and with above-target liquidity simultaneously tend to hold excess liquidity. This results in a disadvantage in holding too much cash or liquid assets on hand. The case raises the costs of liquidity in terms of reducing investment income from highly yielding assets (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999) and of increasing agency costs of excess cash flow (Jensen, 1986; Cox, Well, and Gaver, 1995; Hirth and Uhrig-Homburg, 2010). Therefore, given the case of firms with above-target liquidity, we argue that the adjusted speed of liquidity of a firm with high leverage is greater...
than that of a firm with low leverage. We then hypothesize it as follows.

\[ H_{4}^{au} : \alpha_{9} < \alpha_{10} . \]

On the other hand, based on the financial pressure hypothesis (the bankruptcy cost hypothesis), prior studies present that firms with high leverage may hold more cash (liquidity) for preventative purposes; hence, we expect that high-leveraged firms adjust toward their targeted levels faster than low-leveraged firms (Haan, 1997; Ees et al., 1998; Faulkender, 2002). Even so, given firms with above-target liquidity (i.e., less liquidity demand), firms with high leverage (i.e., need more liquidity) may adjust their liquidity toward targeted levels slower than those with low leverage.

The monitoring hypothesis suggests that high-leveraged firms are subject to outside monitoring so that firms need to maintain more liquidity to provide a commitment or send a signal to policyholders and/or regulators. Accordingly, with arguments of the financial pressure hypothesis, given the case of firms with above-target liquidity, high-leveraged firms tend to adjust toward their targeted liquidity more slowly than low-leveraged firms.

In sum, given the case of above-target liquidity, the financial pressure (the bankruptcy cost) and monitoring hypotheses propose that the adjusted speed of firms with high leverage is lower than that of firms with low leverage, which is set as

\[ H_{4}^{ab} : \alpha_{9} > \alpha_{10} . \]

E.2. Asymmetric Adjustments toward Targeted Liquidity—Firms with Under-Liquidity

In contrast to firms with too much liquidity, firms with below-target liquidity tend to demand more liquidity. On the basis of the substitute effect hypothesis, the adjustment speed of low-leveraged firms is greater than that of high-leveraged firms (John, 1993; Ferreira and Vilela, 2004; Kalcheva and Lins, 2007). Besides, firms with below-target liquidity tend to demand more liquidity than those with above-target liquidity. Integrating these two impacts together for insurers, we postulate that the adjustment speed of liquidity for firms with low leverage is greater than that for firms with high leverage, given the case of firms with below-target liquidity.

\[ H_{4}^{ba} : \alpha_{11} > \alpha_{12} . \]

In accordance with the financial pressure (the bankruptcy cost) and monitoring hypotheses, we can likewise conclude that the adjustment speed of liquidity for firms with low leverage is smaller than that for firms with high leverage, given the case of firms with below-target liquidity.

\[ H_{4}^{bb} : \alpha_{11} < \alpha_{12} . \]

E.3. Asymmetric Adjustments toward Targeted Liquidity—Firms with High or Low Leverage

Given both cases of firms with high or low leverage, it is predicted that the substitute effect, the financial pressure, and the monitoring hypotheses have similar impacts on the adjustment speed, not only for firms with above-target liquidity but
also for those with below-target liquidity. Thus, following the arguments of $H_2$, the adjustment speed of firms with above-target liquidity is lower than that of firms with below-target liquidity in both cases of firms with high and low leverage. This is because firms with below-target liquidity tend to confront more financial pressures, liquidity risks, and bankruptcy costs than those with above-target liquidity (Opler et al., 1999; Ogundipe, Salawu, and Ogundipe, 2012). The hypotheses then are addressed as follows

$$H^L_4: \alpha_9 < \alpha_{11}, \text{ and } H^H_4: \alpha_{10} < \alpha_{12}.$$  

IV. Data and Empirical Results

A. Data

We construct our sample that includes all available U.S. property-liability insurers in the National Association of Insurance Commissioners (NAIC) dataset from 2006 to 2010. Originally, the total number of insurers used in this study was 2,950. The samples used have to conform to the following requirements. First, missing data for insurers is removed. Second, insurers with negative assets, surplus and/or net premium assets are also deleted. Third, we then delete non-logical values for variables. Since the regression model includes lagged variables, we have to exclude any insurer with less data than two consecutive years. To avoid the influence of extreme observations, variables adopted in this study are winsorized at the 1st and 99th percentiles, except dummy variables (e.g., single and stock dummy variables). Finally, with the requirements embedded above for variables used, the sample size is reduced to a total of 1,767 available insurers and is comprised of 6,416 firm-year observations.

An overview of the variables used in this study is presented in Table I. The mean of $Liq$ is about 83.24%. It implies that insurers’ liquidity positions are fairly conservative. Furthermore, $Liq$ ranges from 25.41% to 99.61% and presents a less volatile pattern. In addition, Table I shows that the return on assets is about 4.64%. Exactly 67.72% of our observations are stock insurers. Also, 39.68% of observations are single insurers. The premium earned growth rate on average is about 3.3%. We also find that both $Bus_H$ and $Geo_H$ are more than 55%, which suggests that most insurers are fairly diversified in terms of business and geographic location. Overall, the values for most variables are similar to those in previous studies (Colquitt, Sommer, and Godwin, 1999; Gaver and Pottier, 2005; Shiu, 2006; Chang and Jeng, 2015; Chang and Tsai, 2014). It also implies that the sample used in this study is fairly appropriate. The last two columns are the mean and median difference test for crisis

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15 For a robustness check, we also re-examine the results of partial adjustment models for Equations (5), (6), (7), and (8) in terms of the cases of (1) deleting extreme values and (2) not considering winsorized methodology. Overall, the empirical results are consistent with our main findings. However, the adjustment speed of Case (2) is faster than that of Case (1). It implies that extreme values, on average, may significantly impact insurers’ liquidity adjustment. We do not tabulate those results here.

16 The standard deviation of $Liq$ is approximately 14.06%.
and non-crisis sub-periods for all variables. Also, from Table I, we find that most variables present a significant difference between crisis and non-crisis sub-periods.

B. Empirical Results

This section presents the estimation of targeted liquidity and the evidence from various analyses for the liquidity adjustment speed, including asymmetric adjustments and the interactions of the deviation from targeted liquidity with leverage. We further provide some robustness tests to enhance our main findings.

B.1. Estimation of Targeted Liquidity

To analyze the insurer’s liquidity partial adjustment, we first generate the fitted values from a panel regression. It should be noted that different targeted estimation models may result in some different impacts on the insurer’s liquidity partial adjustment. Thus, in this study, we provide five distinct targeted estimation models to generate the fitted value for liquidity, which includes (1) a pooled estimation without control of fixed and random effects, (2) year and firm fixed effects, (3) year and firm random effects, (4) mixed effect models (MEM) with restricted maximum likelihood (REML), which allows cross-sectional heteroskedastic and time-wise autoregressive covariance (Byoun, 2008), and (5) MEM with REML where control variables contain the interaction effects between the crisis dummy and all independent variables. The estimation results for Equation (3) are presented in Table II.

The coefficients of firm-specific characteristics indicate how firm-specific factors exert their influence on the level of targeted liquidity. The regression results of these five estimation models are consistent. Table II suggests that Liq are positively affected by Size, Geo_H, and Stock, whereas Reins, Leverage, 2_years_loss, and Prem_increase are negatively related. In contrast, some other parameters are not, e.g., Size and Std_cf. It is predicted that larger insurers tend to demand less liquidity because they do possess the capital to mitigate liquidity pressure; however, the significant and positive results emerge for the Size variable. We surmise that larger insurers tend to more easily develop new business because they could generate more cash. Consequently, insurers with higher cash inflow tend to have a higher liquidity as a whole. In addition, although the coefficients of Std_cf are inconsistent with the prediction, the results are weak and insignificant for different estimation models. Overall, the estimation results exhibit that most firm-specific characteristics play an important role in the estimation of an insurer’s targeted liquidity.

B.2. The Results of Partial Adjustment

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17 We thank the anonymous reviewer who suggested that it is critical to understand the difference between crisis and non-crisis sub-periods for all variables.

18 The fitted value from panel regression specified by Equation (3) is used as a proxy for insurers’ targeted liquidity. Since the estimation results of these five models are similar, we only use the fitted value of MEM with an REML model as a proxy for insurers’ targeted liquidity hereafter.
In Table III, we show insurers’ actual liquidity, targeted liquidity, and the deviation from the targeted liquidity ratios. The numbers show that actual liquidity is less than the targeted liquidity during the 2008 global financial crisis period (from 2008 to 2010). We surmise that a plausible explanation is that insurers may have encountered higher liquidity risk, investment loss, and financial pressure during the 2008 global financial crisis. The realized loss and direct and/or indirect costs of financial pressure reduce the insurers’ actual liquidity so that its actual liquidity tends to be lower than the targeted liquidity as a whole.

Furthermore, Figure 1 shows that the actual liquidity presents a mean reverting behavior from 2006 to 2010, which indicates that insurers tend to have a targeted liquidity and they adjust toward the target over time, which is consistent with the trade-off behavior theory (or $H_1$). The reverting pattern shows the results of Table III and that the realized loss and direct and/or indirect costs of financial pressure resulted in a reduction of the insurer’s actual liquidity during the 2008 global financial crisis.

Table IV reports the results of partial adjustment models by controlling year and firm fixed effects for Equations (5), (6), (7), and (8) for different targeted liquidity estimations in Table II, respectively. First of all, Panel A of Table IV shows that the adjustment speeds range from 53.78% to 71.37% across different targeted estimation models. It implies that adjustment costs as well as deviation costs from the targeted liquidity for insurers exist and that insurers gradually adjust their actual liquidity toward their target at a speed of 64.94% (on average) within a year. The results are consistent with the argument of the trade-off behavior theory and support the hypothesis $H_1$. Costs and benefits of holding liquid assets drive insurers to pursue targeted liquidity levels.

We next examine the asymmetric adjustment speed of liquidity in terms of above- and below-target liquidity. We test this directly by regressing the actual liquidity change on a desired movement toward a targeted change and how it interacts with above- and below-target liquidity indicators. Panel B of Table IV shows that the adjustment speed of insurers with above-target liquidity is faster than that of insurers with below-target liquidity for most models (i.e., $\alpha_3 > \alpha_4$), except for a random model. Also, the tests of parameter equality on speeds between above- and below-target liquidity are rejected. These results indicate that the arguments of bankruptcy costs (financial pressure) and speculative motivation are not supported. We propose that the reason that the $H_2$ is not sustained is that low returns raise concerns (inefficient liquid assets holding) while insurers maintain a position of over-liquidity (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999). In accordance with

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19 The $\chi^2$ values of the likelihood ratio test are provided to examine if the coefficient estimates are equal (above-target and below-target liquidity, high and low leverage, and the interaction of above-target and below-target liquidity and high and low leverage).
Table I, insurers always maintain fairly conservative liquidity in hand (83.24% on average), so it is expected that insurers tend to face less financial pressure and liquidity risk. An over position of liquidity will force insurers to invest in inefficient liquid assets more (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999) and/or encounter higher agency costs of excess cash holdings (Jensen, 1986; Cox, Well, and Gaver, 1995; Hirth and Uhrig-Homburg, 2010), so they tend to adjust their liquidity toward targeted levels.

Panel C of Table IV shows that high-leveraged insurers adjust their liquidity toward a targeted level slower than do low-leveraged insurers for all different targeted liquidity estimations even if the tests of parameter equality on speeds between high- and low-leveraged insurers are not rejected (Columns (2), (4), and (5)), which is consistent with $H_3^a$ that debt could provide a ready source of financing so that firms could use debt as a substitute for liquidity (e.g., John, 1993; Kim, Mauer, and Sherman, 1998; Ferreira and Vilela, 2004; Kalcheva and Lins, 2007). These results are consistent with the substitute effect hypothesis, whereas the financial pressure hypothesis and the monitoring hypothesis are not supported.

According to Panels B and C of Table IV, we find that the asymmetric partial adjustment does exist for insurers with above- or below-target liquidity as well as with high or low leverage. Panel D of Table IV intends to detect the adjustment speed of liquidity in terms of the interactions between an insurer’s deviation from the targeted liquidity and its leverage. First of all, given the case of insurers with above-target liquidity, Panel D of Table IV shows that the adjusted speed of insurers with high leverage is significantly slower than that of insurers with low leverage for all models (i.e., $\alpha_9 > \alpha_{10}$), which supports the financial pressure hypothesis and the monitoring hypothesis ($H_4^{ab}$). A plausible explanation is that insurers tend to demand less liquidity given the case of above-target liquidity, but they intend to increase liquidity to avoid financial pressure while they face higher leverage (higher financial pressure). Combining these two contradictory effects, they aim to adjust their liquidity toward a targeted level. On the other hand, given the case of insurers with below-target liquidity, the reserve results emerge (i.e., $\alpha_{11} < \alpha_{12}$), which supports the financial pressure hypothesis and the monitoring hypothesis ($H_4^{ba}$). Likewise, a plausible explanation is that insurers tend to both demand more liquidity given the case of below-target liquidity and increase liquidity to avoid financial pressure while they face higher leverage (higher financial pressure). Combining these two resembling effects, they tend to adjust their liquidity toward a targeted level rapidly.

Furthermore, given the case of insurers with low leverage, five different models show that the adjusted speed of insurers with above-target liquidity is significantly faster than that of insurers with below-target liquidity (i.e., $\alpha_9 > \alpha_{11}$), which contradicts the $H_4^b$ hypothesis. Similarly to the argument in Panel B of Table IV, a plausible reason is that low returns are concerning when insurers possess an
overabundance of liquid assets (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999). In addition, given the case of insurers with high leverage positions, the empirical results show that $\alpha_{10} < \alpha_{12}$; however, the tests of parameter equality on speeds between above- and below-target liquidity are not rejected. The evidence indicates that insurers with below-target liquidity seem not to face more finance pressures, liquidity risks, and bankruptcy costs, so that the $H_4^H$ hypothesis is not supported.

C. Robustness Checks

In this study, the following robustness checks are considered: global financial crisis analysis, long and short duration of liability analysis, and underwriting cycle analysis.20 We discuss these robustness checks below.

C.1. Global Financial Crisis Analysis

Table III and Figure 1 indicate that insurers’ actual liquidity was less than the targeted liquidity during the period from 2008 to 2010. It is of importance for insurers, investors, consumers, and regulators to analyze insurers’ liquidity adjustment behavior during this severe liquidity crunch period. For a robustness check, we then implemented a subsample analysis for the 2008 global financial crisis.21 Accordingly, Equations (7) and (8) can be rewritten as follows.

$$\Delta L_{it} = \alpha_{13} + (\alpha_{14} \text{Crisis}_{it} + \alpha_{15} \text{Noncrisis}_{it})TDL_{it} + \psi_{it}, \quad (9)$$

$$\Delta L_{it} = \alpha_{16} + (\alpha_{17} \text{Crisis}_{it} + \alpha_{18} \text{Noncrisis}_{it})TDL_{it}D^a_{it} + (\alpha_{19} \text{Crisis}_{it} + \alpha_{20} \text{Noncrisis}_{it})TDL_{it}D^b_{it} + \kappa_{it}. \quad (10)$$

The results are presented in Table V. Overall, we find that the empirical results of crisis1 and crisis2 are similar not only for financial crisis sub-periods analysis but also for financial crisis dummy variables analysis. For financial crisis sub-periods analysis, the empirical results show that insurers adjust their liquidity toward targeted liquidity faster during a global financial crisis (Panel A in Table V; 90.58% on average) than during a non-global financial crisis.22 The insurers should have higher financial pressure during a global financial crisis than in the absence of one. This is because the insurers have higher cash flow volatility or investment loss. Therefore, on the basis of the financial pressure hypothesis, the insurer adjusts their liquidity toward targeted

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20 We thank the anonymous reviewers who suggested that these robustness checks are substantial in polishing this study.
21 We re-examine the partial adjustment models by two different crisis sub-samples, crisis1 and crisis2, for the robustness checks. Crisis1 represents the financial crisis period from 2007 to 2009. Crisis2 represents the financial crisis period from 2008 to 2010 (with a delay effect of the data report to NAIC). The analyses include crisis sub-periods and crisis dummy variables.
22 The adjustment speed in Panel A of Table 4 is approximately 64.94% on average (for the whole period; from year 2006 to year 2010). Consequently, it implies that insurers adjust their liquidity faster during a global financial crisis than in the absence of a crisis.
liquidity levels faster during a global financial crisis than in the absence of one. Moreover, insurers with above-target liquidity have faster adjustment speeds than do insurers with below-target liquidity (Panel B of Table V), which is consistent with our main findings. However, the over-adjustment emerge from insurers with above-target liquidity. In addition, Panel C of Table V shows that insurers with high leverage have faster adjustment speeds than do insurers with low leverage during financial crisis periods. These results are consistent with the financial pressure hypothesis since high-leveraged insurers encounter more severe financial pressure during a financial crisis period as a result of adjusting their liquidity faster. Furthermore, the results of Panel D of Table V are both consistent with Panel B and C of Table V.

For the financial crisis dummy variables analysis, overall, the results of Panel E of Table V are consistent with Panel A of Table V. The results enhance the argument of the financial pressure hypothesis. Insurers adjust their liquidity toward targeted liquidity faster during a global financial crisis than in the absence of a crisis. Panel F of Table V shows that (1) given insurers with above- or below-target liquidity, insurers adjust their liquidity toward targeted liquidity faster during a global financial crisis, which is consistent with the argument of the financial pressure hypothesis; and (2) during a global financial crisis, insurers with above-target liquidity have a faster adjustment speed than those with below-target liquidity, which is consistent with the argument of the low returns earned hypothesis (inefficient liquid assets holding) while insurers maintain more liquidity (Brealey and Myers, 1996; Kim, Mauer, and Sherman, 1998; Opler et al., 1999).

C.2. Long and Short Duration Analysis

Since a short-run policy cycle induces higher cash flow volatility, insurers have to preserve sufficient liquid assets. It implies that an insurer’s need for cash clearly depends on the payout for the lines of business that the insurer writes. The insurers with a higher short-tail ratio may face larger financial pressure. Therefore, the insurers with higher short-tail ratios require high liquidity levels. Moreover, the insurers with higher short-tail ratios have faster adjustment speeds than those with lower short-tail ratios. We further try to investigate the effects of duration of liability on liquidity adjustment. Accordingly, Equations (7) and (8) can be rewritten as follows

\[ \Delta L_{it,t} = \alpha_{21} + (\alpha_{22} SDur_{it,t} + \alpha_{23} LDur_{it,t})TDL_{it,t} + \omega_{it,t}, \quad (11) \]

\[ \Delta L_{it,t} = \alpha_{24} + (\alpha_{25} SDur_{it,t} + \alpha_{26} LDur_{it,t})TDL_{it,t} D_{it,t}^b + (\alpha_{27} SDur_{it,t} + \alpha_{28} LDur_{it,t})TDL_{it,t} D_{it,t}^b + \theta_{it,t}. \quad (12) \]

The \( LDur_{it,t} (SDur_{it,t}) \) is the long-duration dummy (short-duration dummy). It equals 1 if the insurer’s long-tail ratio is greater (smaller or equal) than the median
long-tail ratio of the whole industry and 0 otherwise. The empirical results are shown in Column (1) of Table VI. Consistent with the prediction, Panel A of Table VI (Column (1)) shows that insurers with a higher short-tail ratio have a faster adjustment speed than those with a lower short-tail ratio. In addition, given insurers with above- or below-target liquidity, Panel B of Table VI (Column (1)) also reports that insurers with a higher short-tail ratio have a faster adjustment speed than those with a lower short-tail ratio. On the other hand, given the cases of insurers with higher long-tail or higher short-tail ratios, insurers with above-target liquidity have faster adjustment speeds than those with below-target liquidity, which supports the low returns earned hypothesis again.

[Inserts Table VI about here]

**C.3. Underwriting Cycle Analysis**

It is noted that many lines of property-liability insurance have a cycle in premiums and insurer operating profits known as the underwriting cycle. The underwriting cycle can be described in terms of a periodic soft and hard market. In a hard market, insurers have larger financial pressure. Therefore, on the basis of the financial pressure hypothesis, the insurer adjusts their liquidity toward targeted liquidity faster during a hard market than during a soft market. We further try to investigate the underwriting cycle effect for liquidity adjustment. Accordingly, Equations (7) and (8) can be rewritten as follows,

\[
\Delta L_{t,t} = \alpha_{29} + (\alpha_{30}Soft_{t,t} + \alpha_{31}Hard_{t,t})TDL_{t,t} + \rho_{t,t}
\]

\[
\Delta L_{t,t} = \alpha_{32} + (\alpha_{33}Soft_{t,t} + \alpha_{34}Hard_{t,t})TDL_{t,t}D_{t,t}^a + (\alpha_{35}Soft_{t,t} + \alpha_{36}Hard_{t,t})TDL_{t,t}D_{t,t}^p + \varepsilon_{t,t}
\]

[Insert Figure 2 about here]

We refer the loss ratio from year 2003 to year 2012 to identify soft and hard markets (Figure 2). If the loss ratio of the current year is relatively high (low), it is predicted that the insurance price will increase (decrease) during the next year. Thus, the next year can be regarded as a hard (soft) market. Accordingly, we define that years 2007, 2008, and 2010 are soft markets, whereas years 2006 and 2009 are hard markets. The empirical results are shown in Column (2) of Table VI. Inconsistent with the prediction, Panel A of Table VI (Column (2)) shows that insurers have faster

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23 Following Cummins and Nini (2002) and Weiss and Cheng (2012), the long-tail ratio is defined as total loss reserves divided by total losses incurred. In addition, the long-tail lines of business are those lines of farm owners multiple peril, homeowners multiple peril, commercial multiple peril, mortgage guaranty, ocean marine, medical malpractice–occurrence, medical malpractice–claims made, workers’ compensation, other liability-occurrence, other liability-claims made, products liability-occurrence, products liability-claims made, private passenger auto liability, commercial auto liability, aircraft (all perils), boiler and machinery, international, warranty, reinsurance-non-proportional assumed property, reinsurance-non-proportional assumed liability, reinsurance-non-proportional assumed financial lines, and aggregate write-ins for other lines of business.
adjustment speeds during a soft market than during a hard market. We posit that more business will be written during a soft market because of the lower insurance price. Insurers that underwrite more business tend to generate a higher cash inflow. Thus, if the insurers’ target liquidity deviates, more cash flow will allow them to adjust their liquidity toward a target. In addition, given insurers with above- or below-target liquidity, Panel B of Table VI (Column (2)) also reports that insurers during a soft market have faster adjustment speeds than during a hard market. On the other hand, given the cases during soft markets and hard markets, insurers with above-target liquidity have faster adjustment speeds than those with below-target liquidity, which also supports the low returns earned hypothesis.

V. Conclusion

Liquidity maintenance is a critical issue not only for financial institutions but also for non-financial firms during global financial crises. Sustaining an adequate liquidity level is important and could mitigate the liquidity risk and financial pressure firms confront. As a result, it is important to know whether insurers intend to maintain targeted liquidity and their adjustment behavior. Insurers raise some costs if the firm’s liquidity level deviates from its targeted liquidity. An insurer with higher liquidity can benefit from a lower liquidity risk, financial distress, and bankruptcy costs as well as a reduced underinvestment problem. However, it may encounter a higher agency cost and lower returns on investment. In contrast, the arguments are inverted for insurers with lower liquidity. As a whole, to maintain optimal liquidity is definitely an important objective for insurers.

This study visits the issue of whether U.S. insurers’ behaviors are consistent with the existence of targeted liquidity and their asymmetric liquidity partial adjustment. We find that the argument of the trade-off behavior theory is supported. Costs and benefits of liquidity maintenance drive insurers to pursue optimal liquidity. We further find that asymmetric liquidity partial adjustment exists, for instance, and that above-target-liquidity insurers adjust faster than below-target-liquidity insurers. Also, low leverage insurers adjust their liquidity toward the targeted level faster than high leverage insurers. Finally, interaction effects between above- and/or below-target liquidity and high and/or low leverage do play an important role in insurers’ liquidity adjustments. The joint effects between insurers’ deviations from targeted liquidity, and their leverage, influence insurers’ liquidity decisions substantially.

Our findings have potential practical and policy implications. For policyholders and regulators, it is worth noting that insurers with low liquidity tend to confront higher financial pressure and liquidity risk. Thus, policyholders and regulators should pay more attention to assess insurers’ liquidity maintenance levels. Another policy implication is that insurers with high liquidity tend to raise costs from unprofitable over-investments and increase agency costs of cash flow. For mitigating these costs, intensively monitoring insurers’ managers for the shareholders is required. Finally, we
note that insurers’ leverage may influence an insurer’s liquidity adjustment incentive. Since changing an insurer’s leverage affects deviations from the targeted liquidity, the substitute hypothesis does not hold again. It suggests that policyholders and regulators should take seriously insurers’ leverage positions while assessing insurers’ liquidity maintenance.
References


Cummins, J. David and Gregory P. Nini, 2002, Optimal capital utilization by financial


Han, Seungjin and Jiaping Qiu, 2007, Corporate precautionary cash holdings, *Journal of Corporate Finance* 13, 43-57.


Table I
Summary Statistics for U.S. Property-Liability Insurers
The sample consists of 6,416 firm-year observations with complete data for two or more adjacent years during the period from 2006 to 2010. Most variables are winsorized at the 1st and 99th percentiles to avoid extreme value influence. The dependent variable, \( \text{Liq} \), is defined as cash + invested asset / assets. The lagged independent variables include \( \text{Reins} \) (affiliated reinsurance ceded + nonaffiliated reinsurance ceded) / (direct business written plus reinsurance assumed), \( \text{Leverage} \) (direct business written / capital), \( \text{Tax}_\text{ex} \) (tax-exempt investment income relative to total investment income), \( \text{Roa} \) (return on all of assets), \( \text{Bus}_H \) (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), \( \text{Geo}_H \) (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), \( 2\_\text{years}_\text{loss} \) (incurred two years before the current and prior year, scaled by policyholders’ surplus), \( \text{Size} \) (log of total assets), \( \text{Stock} \) (equals 1 if the insurer is a stock and 0 if it is a mutual), \( \text{Single} \) (equals 1 if the insurer is non-affiliated and 0 otherwise), \( \text{Rspread} \) (return on assets minus return on Treasury bills), \( \text{Std}_\text{cf} \) (where the cash flow ratio is defined as net operating and investment income plus additional capital changes paid in (before interest, tax, and dividend) divided by total assets), and \( \text{Prem}_\text{increase} \) (the growth by using the premium earned growth ratio). The mean (t test) and the median (Kruskal-Wallis Median test) difference test for crisis and non-crisis sub-periods for all variables are showed in the last two columns.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>StdDev</th>
<th>Mean Test (t test)</th>
<th>Med Test K-W Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{Liq} )</td>
<td>0.2541</td>
<td>0.8324</td>
<td>0.8658</td>
<td>0.9961</td>
<td>0.1382</td>
<td>3.91 ***</td>
<td>5.40 ***</td>
</tr>
<tr>
<td>Independent Variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \text{Reins} )</td>
<td>0.0000</td>
<td>0.3754</td>
<td>0.3208</td>
<td>0.9666</td>
<td>0.2919</td>
<td>-3.42 ***</td>
<td>10.38 ***</td>
</tr>
<tr>
<td>( \text{Leverage} )</td>
<td>0.0243</td>
<td>0.5559</td>
<td>0.5943</td>
<td>0.9906</td>
<td>0.1864</td>
<td>4.02 ***</td>
<td>25.16 ***</td>
</tr>
<tr>
<td>( \text{Tax}_\text{ex} )</td>
<td>0.0000</td>
<td>0.2818</td>
<td>0.2206</td>
<td>0.9587</td>
<td>0.2615</td>
<td>-1.43</td>
<td>0.66</td>
</tr>
<tr>
<td>( \text{Roa} )</td>
<td>-0.1634</td>
<td>0.0464</td>
<td>0.0454</td>
<td>0.2412</td>
<td>0.0589</td>
<td>10.57 ***</td>
<td>128.40 ***</td>
</tr>
<tr>
<td>( \text{Bus}_H )</td>
<td>0.1388</td>
<td>0.5824</td>
<td>0.5181</td>
<td>1.0000</td>
<td>0.3005</td>
<td>-3.69 ***</td>
<td>13.68 ***</td>
</tr>
<tr>
<td>( \text{Geo}_H )</td>
<td>0.0416</td>
<td>0.5765</td>
<td>0.5500</td>
<td>1.0000</td>
<td>0.3846</td>
<td>-0.61</td>
<td>0.19</td>
</tr>
<tr>
<td>( 2_\text{years}_\text{loss} )</td>
<td>-0.0005</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0005</td>
<td>0.0001</td>
<td>12.90 ***</td>
<td>237.63 ***</td>
</tr>
<tr>
<td>( \text{Size} )</td>
<td>14.0073</td>
<td>18.3165</td>
<td>18.2454</td>
<td>23.3156</td>
<td>1.9740</td>
<td>1.51</td>
<td>1.87</td>
</tr>
<tr>
<td>( \text{Stock} )</td>
<td>0.0000</td>
<td>0.6772</td>
<td>1.0000</td>
<td>1.0000</td>
<td>0.4676</td>
<td>-1.14</td>
<td>1.30</td>
</tr>
<tr>
<td>( \text{Single} )</td>
<td>0.0000</td>
<td>0.3968</td>
<td>0.0000</td>
<td>1.0000</td>
<td>0.4934</td>
<td>0.72</td>
<td>0.51</td>
</tr>
<tr>
<td>( \text{Rspread} )</td>
<td>-0.1824</td>
<td>0.0208</td>
<td>0.0165</td>
<td>0.2055</td>
<td>0.0568</td>
<td>-2.17 **</td>
<td>16.56 ***</td>
</tr>
<tr>
<td>( \text{Std}_\text{cf} )</td>
<td>0.0000</td>
<td>0.0503</td>
<td>0.0277</td>
<td>0.3415</td>
<td>0.0622</td>
<td>-2.02 **</td>
<td>5.82 **</td>
</tr>
<tr>
<td>( \text{Prem}_\text{increase} )</td>
<td>-0.9962</td>
<td>0.0330</td>
<td>0.0077</td>
<td>1.4637</td>
<td>0.3084</td>
<td>9.11 ***</td>
<td>154.93 ***</td>
</tr>
</tbody>
</table>

Firm-year observations 6,416
Table II

Estimation on Determinants of U.S. Property-Liability Insurers’ Targeted Liquidity

The dependent variable is the insurers’ liquidity, \( \text{Liq} \). Independent variables are those lagged variables presented in Table I. This study provides five distinct targeted estimation models to generate the fitted value for liquidity, including (1) a pooled estimation without control fixed and random effects, (2) year and firm fixed effects, (3) year and firm random effects, (4) mixed effect models (MEM) with restricted maximum likelihood (REML), which allows cross-sectional heteroskedastic and time-wise autoregressive covariance, and (5) MEM with REML where control variables contain the interaction effects between the crisis dummy and all independent variables. The whole sample consists of 6,416 firm-year observations and is winsorized at the 1st and 99th percentiles. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1)Pooled</th>
<th>(2)Fixtwo</th>
<th>(3)Rantwo</th>
<th>(4)MEM</th>
<th>(5)Crisis(MEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.8753 ***</td>
<td>0.7043 ***</td>
<td>0.7616 ***</td>
<td>0.7660 ***</td>
<td>0.7644 ***</td>
</tr>
<tr>
<td>Reins</td>
<td>-0.1716 ***</td>
<td>-0.0730 ***</td>
<td>-0.1105 ***</td>
<td>-0.1128 ***</td>
<td>-0.1111 ***</td>
</tr>
<tr>
<td>Leverage</td>
<td>-0.2858 ***</td>
<td>-0.0865 ***</td>
<td>-0.1641 ***</td>
<td>-0.1688 ***</td>
<td>-0.1733 ***</td>
</tr>
<tr>
<td>Tax_ex</td>
<td>0.0070</td>
<td>0.0060</td>
<td>0.0063</td>
<td>0.0062</td>
<td>0.0081</td>
</tr>
<tr>
<td>Roa</td>
<td>0.0353</td>
<td>-0.0129</td>
<td>-0.0340</td>
<td>-0.0344 *</td>
<td>0.0316</td>
</tr>
<tr>
<td>Bus_H</td>
<td>-0.0060</td>
<td>-0.0044</td>
<td>-0.0031</td>
<td>-0.0031</td>
<td>-0.0083</td>
</tr>
<tr>
<td>Geo_H</td>
<td>0.0013</td>
<td>0.0367 ***</td>
<td>0.0209 ***</td>
<td>0.0202 ***</td>
<td>0.0211 ***</td>
</tr>
<tr>
<td>Size</td>
<td>0.0095 ***</td>
<td>0.0147 ***</td>
<td>0.0102 ***</td>
<td>0.0102 ***</td>
<td>0.0107 ***</td>
</tr>
<tr>
<td>Stock</td>
<td>0.0079 **</td>
<td>-0.0010</td>
<td>0.0019</td>
<td>0.0021</td>
<td>0.0018</td>
</tr>
<tr>
<td>Single</td>
<td>0.0007</td>
<td>0.0135 **</td>
<td>0.0105 **</td>
<td>0.0103 **</td>
<td>0.0115 **</td>
</tr>
<tr>
<td>Rspread</td>
<td>0.0329</td>
<td>0.0108</td>
<td>0.0233</td>
<td>0.0238</td>
<td>-0.0222</td>
</tr>
<tr>
<td>Std_cf</td>
<td>-0.0214</td>
<td>-0.0235</td>
<td>-0.0267 *</td>
<td>-0.0268 *</td>
<td>-0.0030</td>
</tr>
<tr>
<td>Prem_increase</td>
<td>-0.0336 ***</td>
<td>-0.0089 ***</td>
<td>-0.0114 ***</td>
<td>-0.0116 ***</td>
<td>-0.0119 ***</td>
</tr>
<tr>
<td>Firm-year observations</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
</tr>
</tbody>
</table>
Table III
U.S. Property-Liability Insurers Deviation from Their Targeted Liquidity
This table shows the difference between actual liquidity and targeted liquidity for liquidity measurements from 2006 to 2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Obs.</th>
<th>Actual Liquidity</th>
<th>Targeted Liquidity</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>1,306</td>
<td>0.8386</td>
<td>0.8275</td>
<td>0.0112</td>
</tr>
<tr>
<td>2007</td>
<td>1,426</td>
<td>0.8418</td>
<td>0.8325</td>
<td>0.0093</td>
</tr>
<tr>
<td>2008</td>
<td>1,361</td>
<td>0.8203</td>
<td>0.8335</td>
<td>-0.0132</td>
</tr>
<tr>
<td>2009</td>
<td>994</td>
<td>0.8245</td>
<td>0.8291</td>
<td>-0.0046</td>
</tr>
<tr>
<td>2010</td>
<td>1,329</td>
<td>0.8347</td>
<td>0.8387</td>
<td>-0.0040</td>
</tr>
</tbody>
</table>
Table IV Estimation of Asymmetric Partial Adjustment Models for U.S. Property-Liability Insurers

This table shows the estimation results of liquidity partial adjustment models by controlling year and firm fixed effects for Equations (5), (6), (7), and (8). This study provides five distinct targeted estimation models to generate the fitted value for liquidity, including (1) pooled estimation without control fixed and random effects, (2) year and firm fixed effects, (3) year and firm random effects, (4) mixed effect models (MEM) with restricted maximum likelihood (REML), which allows cross-sectional heteroskedastic and time-wise autoregressive covariance, and (5) MEM with REML where control variables contain the interaction effects between the crisis dummy and all independent variables. The $\chi^2$ values of the likelihood ratio test are provided to examine that the coefficient estimates are equal (above-target and below-target liquidity, high and low leverage, and interaction of above-target and below-target liquidity and high and low leverage). The whole sample consists of 6,416 firm-year observations and is winsorized at the 1st and 99th percentiles. The testing models are set as follows.

\[
\Delta L_{ij} = \alpha_0 + \alpha_1 TDL_{ij} + \gamma_{ij}
\]

\[
\Delta L_{ij} = \alpha_2 + \alpha_3 TDL_{ij} D_{ij}^a + \alpha_4 TDL_{ij} D_{ij}^b + \zeta_{ij}
\]

\[
\Delta L_{ij} = \alpha_5 + (\alpha_6 LLev_{ij} + \alpha_7 HLev_{ij}) TDL_{ij} + \tau_{ij}
\]

\[
\Delta L_{ij} = \alpha_8 + (\alpha_{9} LLev_{ij} + \alpha_{10} HLev_{ij}) TDL_{ij} D_{ij}^a + (\alpha_{11} LLev_{ij} + \alpha_{12} HLev_{ij}) TDL_{ij} D_{ij}^b + \phi_{ij}
\]

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Pooled</th>
<th>(2) Fixtwo</th>
<th>(3) Rantwo</th>
<th>(4) MEM</th>
<th>(5) Crisis(MEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0758 ***</td>
<td>-0.0071</td>
<td>0.0592 **</td>
<td>-0.0009</td>
<td>-0.0013</td>
</tr>
<tr>
<td>TDL</td>
<td>0.5378 ***</td>
<td>0.7137 ***</td>
<td>0.5792 ***</td>
<td>0.7084 ***</td>
<td>0.7079 ***</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0658 **</td>
<td>-0.0086</td>
<td>0.0679 **</td>
<td>-0.0040</td>
<td>-0.0044</td>
</tr>
<tr>
<td>TDL*Da</td>
<td>0.5619 ***</td>
<td>0.7673 ***</td>
<td>0.5591 ***</td>
<td>0.7806 ***</td>
<td>0.7826 ***</td>
</tr>
<tr>
<td>TDL*Db</td>
<td>0.4838 ***</td>
<td>0.6456 ***</td>
<td>0.6391 ***</td>
<td>0.6101 ***</td>
<td>0.6080 ***</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0723 ***</td>
<td>-0.0073</td>
<td>0.0555 **</td>
<td>-0.0012</td>
<td>-0.0016</td>
</tr>
<tr>
<td>TDL*LLev</td>
<td>0.5075 ***</td>
<td>0.7254 ***</td>
<td>0.6200 ***</td>
<td>0.7191 ***</td>
<td>0.7190 ***</td>
</tr>
<tr>
<td>TDL*HLev</td>
<td>0.5185 ***</td>
<td>0.7051 ***</td>
<td>0.5524 ***</td>
<td>0.7006 ***</td>
<td>0.6999 ***</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0670 **</td>
<td>-0.0062</td>
<td>0.0696 **</td>
<td>-0.0006</td>
<td>-0.0011</td>
</tr>
<tr>
<td>TDL<em>Da</em>LLev</td>
<td>0.6191 ***</td>
<td>0.8909 ***</td>
<td>0.6318 ***</td>
<td>0.9003 ***</td>
<td>0.9025 ***</td>
</tr>
<tr>
<td>TDL<em>Da</em>HLev</td>
<td>0.5285 ***</td>
<td>0.6795 ***</td>
<td>0.5218 ***</td>
<td>0.7001 ***</td>
<td>0.7023 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>LLev</td>
<td>0.4900 ***</td>
<td>0.5108 ***</td>
<td>0.6181 ***</td>
<td>0.4651 ***</td>
<td>0.4648 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>HLev</td>
<td>0.4906 ***</td>
<td>0.7520 ***</td>
<td>0.6511 ***</td>
<td>0.7175 ***</td>
<td>0.7125 ***</td>
</tr>
<tr>
<td>$\alpha_3$, $\alpha_4$ Test</td>
<td>6.80 ***</td>
<td>8.89 ***</td>
<td>6.45 **</td>
<td>16.63 ***</td>
<td>17.73 ***</td>
</tr>
<tr>
<td>$\alpha_6$, $\alpha_7$ Test</td>
<td>10.38 ***</td>
<td>0.75</td>
<td>22.37 ***</td>
<td>0.60</td>
<td>0.64</td>
</tr>
<tr>
<td>$\alpha_9$, $\alpha_{10}$ Test</td>
<td>21.69 ***</td>
<td>37.05 ***</td>
<td>38.59 ***</td>
<td>33.10 ***</td>
<td>33.32 ***</td>
</tr>
<tr>
<td>$\alpha_{11}$, $\alpha_{12}$ Test</td>
<td>0.68</td>
<td>34.05 ***</td>
<td>1.55</td>
<td>33.52 ***</td>
<td>32.99 ***</td>
</tr>
<tr>
<td>$\alpha_9$, $\alpha_{11}$ Test</td>
<td>16.99 ***</td>
<td>50.92 ***</td>
<td>0.14</td>
<td>61.84 ***</td>
<td>63.36 ***</td>
</tr>
<tr>
<td>$\alpha_{10}$, $\alpha_{12}$ Test</td>
<td>1.36</td>
<td>2.29</td>
<td>13.87 ***</td>
<td>0.13</td>
<td>0.04</td>
</tr>
<tr>
<td>Firm-year obs.</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
<td>6,416</td>
</tr>
</tbody>
</table>
Table V
Estimation of Asymmetric Partial Adjustment Models for U.S. Property-Liability Insurers (Crisis Models)

This table shows the estimation results of the liquidity partial adjustment models by controlling year and firm fixed effects for Equations (5), (6), (7), (8), (9), and (10). The targeted estimation model is the MEM model. We re-examine the partial adjustment models by two different crisis sub-periods, crisis1 and crisis2, for robustness checks. Crisis1 represents the financial crisis period from 2007 to 2009. Crisis2 represents the financial crisis period from 2008 to 2010 (delay effect of the data report to NAIC). The analyses include crisis sub-periods (Columns (1) and (2)) and crisis dummy variables (Columns (3) and (4)). The \( \chi^2 \) values of the likelihood ratio test are provided to examine the coefficient estimates are equal (above-target and below-target liquidity, high and low leverage, interaction of above-target and below-target liquidity and high and low leverage, crisis and non-crisis period, interaction of above-target and below-target liquidity and crisis and non-crisis period). The whole sample consists of 6,416 firm-year observations and is winsorized at the 1st and 99th percentiles. The testing models are set as follows,

\[
\Delta L_t = \alpha_0 + \alpha_1 TDL_t + \gamma_t
\]
\[
\Delta L_t = \alpha_0 + \alpha_1 TDL_t \cdot D_a + \alpha_2 TDL_t \cdot D_b + \gamma_t
\]
\[
\Delta L_t = \alpha_0 + (\alpha_1 \text{LLev}_t + \alpha_2 \text{HLev}_t) TDL_t + \gamma_t
\]
\[
\Delta L_t = \alpha_0 + (\alpha_1 \text{LLev}_t + \alpha_2 \text{HLev}_t) TDL_t \cdot D_a + \gamma_t
\]
\[
\Delta L_t = \alpha_0 + (\alpha_1 \text{LLev}_t + \alpha_2 \text{HLev}_t) TDL_t \cdot D_b + \gamma_t
\]

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>(1) Crisis1 subsample</th>
<th>(2) Crisis2 subsample</th>
<th>(3) Crisis1 dummy</th>
<th>(4) Crisis2 dummy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0048</td>
<td>-0.0055</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL</td>
<td>0.8863 ***</td>
<td>0.9253 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.0068</td>
<td>-0.0098</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL*Da</td>
<td>1.2066 ***</td>
<td>1.0371 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL*Db</td>
<td>0.5071 ***</td>
<td>0.7769 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.0062</td>
<td>-0.0036</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL*LLev</td>
<td>0.8263 ***</td>
<td>0.8723 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL*HLev</td>
<td>0.9325 ***</td>
<td>0.9656 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.0068</td>
<td>-0.0086</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL<em>Da</em>LLev</td>
<td>1.1031 ***</td>
<td>1.0607 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL<em>Da</em>HLev</td>
<td>1.2830 ***</td>
<td>1.0354 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL<em>Db</em>LLev</td>
<td>0.5047 ***</td>
<td>0.6295 ***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDL<em>Db</em>HLev</td>
<td>0.5088 ***</td>
<td>0.8764 ***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Panel E  Asymmetric Partial Adjustment Model with crisis

<table>
<thead>
<tr>
<th></th>
<th>Estimate 1</th>
<th>Estimate 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0054</td>
<td>0.0021</td>
</tr>
<tr>
<td>TDL*crisis</td>
<td>0.8973 ***</td>
<td>0.8735 ***</td>
</tr>
<tr>
<td>TDL*noncrisis</td>
<td>0.5302 ***</td>
<td>0.5324 ***</td>
</tr>
</tbody>
</table>

### Panel F  Asymmetric Partial Adjustment Model with deviations from target(Crisis)

<table>
<thead>
<tr>
<th></th>
<th>Estimate 1</th>
<th>Estimate 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0034</td>
<td>-0.0015</td>
</tr>
<tr>
<td>TDL<em>Da</em>Crisis</td>
<td>0.9524 ***</td>
<td>0.9707 ***</td>
</tr>
<tr>
<td>TDL<em>Da</em>Noncrisis</td>
<td>0.6728 ***</td>
<td>0.6067 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>Crisis</td>
<td>0.8374 ***</td>
<td>0.7485 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>Noncrisis</td>
<td>0.3198 ***</td>
<td>0.4241 ***</td>
</tr>
</tbody>
</table>

### Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_3 - \alpha_4$ Test</td>
<td>133.19 ***</td>
<td>20.67 ***</td>
</tr>
<tr>
<td>$\alpha_6 - \alpha_7$ Test</td>
<td>10.34 ***</td>
<td>8.89 ***</td>
</tr>
<tr>
<td>$\alpha_9 - \alpha_{10}$ Test</td>
<td>10.60 ***</td>
<td>0.26</td>
</tr>
<tr>
<td>$\alpha_{11} - \alpha_{12}$ Test</td>
<td>0.00</td>
<td>17.99 ***</td>
</tr>
<tr>
<td>$\alpha_9 - \alpha_{11}$ Test</td>
<td>56.02 ***</td>
<td>29.71 ***</td>
</tr>
<tr>
<td>$\alpha_{10} - \alpha_{12}$ Test</td>
<td>108.86 ***</td>
<td>5.78 **</td>
</tr>
<tr>
<td>$\alpha_{14} - \alpha_{15}$ Test</td>
<td>222.30 ***</td>
<td>224.09 ***</td>
</tr>
<tr>
<td>$\alpha_{17} - \alpha_{18}$ Test</td>
<td>57.37 ***</td>
<td>113.80 ***</td>
</tr>
<tr>
<td>$\alpha_{19} - \alpha_{20}$ Test</td>
<td>155.47 ***</td>
<td>63.61 ***</td>
</tr>
<tr>
<td>$\alpha_{17} - \alpha_{19}$ Test</td>
<td>4.38 **</td>
<td>20.06 ***</td>
</tr>
<tr>
<td>$\alpha_{18} - \alpha_{20}$ Test</td>
<td>53.89 ***</td>
<td>12.45 ***</td>
</tr>
</tbody>
</table>

Firm-year obs. 6,416 6,416 6,416 6,416
Table VI
Estimation of Asymmetric Partial Adjustment Models for U.S. Property-Liability Insurers (Long and Short Durations and Soft and Hard Markets)

This table shows the estimation results of the liquidity partial adjustment models by controlling year and firm fixed effects for Equations (11), (12), (13), and (14). The targeted estimation model is the MEM model. A long-duration dummy (short-duration dummy), in this study, is defined as when insurers' long-tail ratio is greater (smaller and equal) than the median long-tail ratio of the whole industry. Based on the loss ratio from year 2003 to year 2012, we define that year 2007, 2008, and 2010 are soft markets, whereas year 2006 and 2009 are hard markets. The $\chi^2$ values of the likelihood ratio test are provided to examine the coefficient estimates are equal (short- and long-liability duration, interaction of above-target and below-target liquidity and short- and long-liability duration, soft and hard markets, interaction of above-target and below-target liquidity and soft and hard markets). The whole sample consists of 6,416 firm-year observations and is winsorized at the 1st and 99th percentiles. The testing models are set as follows,

$$\Delta L_{ij} = \alpha_{i1} + (\alpha_{i2}SDur_{ij} + \alpha_{i3}LDur_{ij})TDL_{ij} + \omega_{ij}$$
$$\Delta L_{ij} = \alpha_{i4} + (\alpha_{i5}SDur_{ij} + \alpha_{i6}LDur_{ij})TDL_{ij}D^*_ij + (\alpha_{i7}SDur_{ij} + \alpha_{i8}LDur_{ij})TDL_{ij}D^*_ij + \theta_{ij}$$
$$\Delta L_{ij} = \alpha_{i9} + (\alpha_{i10}Soft_{ij} + \alpha_{i11}Hard_{ij})TDL_{ij} + \rho_{ij}$$
$$\Delta L_{ij} = \alpha_{i12} + (\alpha_{i13}Soft_{ij} + \alpha_{i14}Hard_{ij})TDL_{ij}D^*_ij + (\alpha_{i15}Soft_{ij} + \alpha_{i16}Hard_{ij})TDL_{ij}D^*_ij + \omega_{ij}$$

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

<table>
<thead>
<tr>
<th>Variable (1) Long and Short durations</th>
<th>(2) Soft and Hard markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>Intercept</td>
</tr>
<tr>
<td>-0.0019</td>
<td>-0.0031</td>
</tr>
<tr>
<td>TDL*SDur</td>
<td>TDL*soft</td>
</tr>
<tr>
<td>0.7383 ***</td>
<td>0.8010 ***</td>
</tr>
<tr>
<td>TDL*LDur</td>
<td>TDL*hard</td>
</tr>
<tr>
<td>0.6772 ***</td>
<td>0.6008 ***</td>
</tr>
</tbody>
</table>

Panel B  Asymmetric Partial Adjustment Model with deviations from target

<table>
<thead>
<tr>
<th>Intercept</th>
<th>Intercept</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.0057</td>
<td>-0.0067</td>
</tr>
<tr>
<td>TDL<em>Da</em>SDur</td>
<td>TDL<em>Da</em>soft</td>
</tr>
<tr>
<td>0.8027 ***</td>
<td>0.8477 ***</td>
</tr>
<tr>
<td>TDL<em>Da</em>LDur</td>
<td>TDL<em>Da</em>hard</td>
</tr>
<tr>
<td>0.7614 ***</td>
<td>0.7225 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>SDur</td>
<td>TDL<em>Db</em>soft</td>
</tr>
<tr>
<td>0.6550 ***</td>
<td>0.7413 ***</td>
</tr>
<tr>
<td>TDL<em>Db</em>LDur</td>
<td>TDL<em>Db</em>hard</td>
</tr>
<tr>
<td>0.5558 ***</td>
<td>0.4260 ***</td>
</tr>
<tr>
<td>$\alpha_{22}$-$\alpha_{23}$ Test</td>
<td>$\alpha_{30}$-$\alpha_{31}$ Test</td>
</tr>
<tr>
<td>6.96 ***</td>
<td>80.13 ***</td>
</tr>
<tr>
<td>$\alpha_{23}$-$\alpha_{25}$ Test</td>
<td>$\alpha_{32}$-$\alpha_{34}$ Test</td>
</tr>
<tr>
<td>1.19</td>
<td>13.39 ***</td>
</tr>
<tr>
<td>$\alpha_{27}$-$\alpha_{28}$ Test</td>
<td>$\alpha_{35}$-$\alpha_{36}$ Test</td>
</tr>
<tr>
<td>4.54 **</td>
<td>61.10 ***</td>
</tr>
<tr>
<td>$\alpha_{25}$-$\alpha_{27}$ Test</td>
<td>$\alpha_{33}$-$\alpha_{35}$ Test</td>
</tr>
<tr>
<td>7.34 ***</td>
<td>4.40 **</td>
</tr>
<tr>
<td>$\alpha_{26}$-$\alpha_{28}$ Test</td>
<td>$\alpha_{34}$-$\alpha_{36}$ Test</td>
</tr>
<tr>
<td>14.06 ***</td>
<td>33.04 ***</td>
</tr>
<tr>
<td>Firm-year obs.</td>
<td></td>
</tr>
<tr>
<td>6,416</td>
<td>6,416</td>
</tr>
</tbody>
</table>
Figure 1. Actual and Target Liquidity Ratios for U.S. Property-Liability Insurers

Figure 2. Loss ratios from year 2003 to year 2012 for U.S. Property-Liability Insurers

Source: 2012 Property/Casualty & Title Industry Report by Financial Regulatory Services Department, NAIC.