Reinsurance Demand and Liquidity Creation: A Search for Bicausality*

Denise Desjardins,† Georges Dionne,† and N'Golo Koné‡

20 January 2022

Abstract

Our main objective is to establish reciprocal links between reinsurance demand and liquidity creation. Early articles propose that financial institutions enhance economic growth by creating liquidity in the economy. However, liquidity creation exposes firms to liquidity risk because they make themselves illiquid when they create liquidity in the economy. In the insurance industry, unexpected claims can be protected through reinsurance, which introduces a trade-off between the demand for reinsurance and the creation of liquidity. This trade-off can be significant for insurers that have fewer diversification opportunities. Our empirical results, from regularized GMM and ML-SEM estimation methods, show positive bicausal effects between liquidity creation and reinsurance demand for small insurers. The link between the two activities is not significant for large insurers. In all estimations, the standard GMM model is rejected. Our results may have policy implications for liquidity risk management.

Keywords: Reinsurance demand; liquidity creation; liquidity risk management; bicausality; GMM; ML-SEM; policy implication; insurer regulation.

JEL codes: G20, G21, G22, G32, G38.

* This research was financed by the SCOR Corporate Foundation for Science, a research foundation belonging to the SCOR Group, and by SSHRC Canada (grant number 435-2019-1183). We do not have any conflict of interest with the sponsors.

† Canada Research Chair in Risk Management and Department of Finance, HEC Montréal. Corresponding author: Georges Dionne, Canada Research Chair in Risk Management, HEC Montréal, 3000 Côte-Ste-Catherine, Room 4.454. Phone: 1-514-340-6596. Email: georges.dionne@hec.ca.

‡Departments of Economics, Université de Montréal and Queen's University.

1. Introduction

Insurers play an important role in aggregate investment activities. US property and casualty (P&C) insurers' investment assets represented $1.7 trillion in 2017 (Center for Capital Markets Competitiveness, 2019). The unique business model of insurance companies creates a distinct set of investments in the economy. By investing policyholder premiums, insurers deploy capital on lower-volatility investments that provide more resilience during crises than do those of other investors. But this source of stability can be fragile because insurers face significant aggregate insurable risks such as climate risk, digital disruptions, cyberattacks, and pandemics. Because liquidity creation is a risky activity, it may affect the demand for reinsurance. Conversely, more reinsurance opens accessibility to liquidity creation.

Our main contribution to the literature is to document the reciprocal roles of liquidity creation and reinsurance demand. Our main objective is to investigate the dual relationship between insurers' liquidity creation and reinsurance demand in US property-liability insurance companies. Do investing insurers buy more reinsurance, and conversely, do insurers buying reinsurance invest more in illiquid assets or create more liquidity in the economy?

We show there are reciprocal causal links between reinsurance demand and liquidity creation for small insurers using regularized GMM methods of estimation (Carrasco and Nayihouba, 2020). The links between the two activities are not significant for large insurers and are mixed for medium insurers. In terms of robustness, these results are shown to be equivalent to those obtained from the ML-SEM method of estimation. Economic recessions affect the relationship between liquidity creation and reinsurance demand and the nature of the recession matters, which is an important conclusion for policy implications.

Investment financing is associated with liquidity creation in the literature. Early theoretical contributions on liquidity creation (Bryant, 1980; Diamond and Dybvig, 1983) propose that financial institutions enhance economic growth by creating liquidity in the economy. Liquidity creation means that financial institutions invest in relatively illiquid assets with relatively liquid liabilities. Banks provide illiquid debt to borrowers and receive liquid deposits from depositors. This is the main role of financial intermediation. Holmstrom and Tirole (1998) and Kashyap et al (2002) document that banks also create liquidity off the balance sheet through loan commitments. By creating liquidity for their borrowers, financial institutions increase liquidity in the economy but become less liquid themselves.[1] For example, insurers that invest in illiquid assets may reduce their capacity to pay unanticipated claims quickly

The empirical measure of liquidity creation was developed for banks by Berger and Bouwman (2009) who distinguish between two important bank activities: liquidity creation and risk transformation. Insurers actively transform risk, but the extent of their involvement in liquidity creation is less documented. Choi et al (2013) is the first contribution to measure liquidity creation in the insurance industry. They do not consider reinsurance demand. This important dual relationship has not been studied in the banking literature, although Fungacova et al (2010) investigates the effect of deposit insurance on banks' liquidity creation and finds no significant relationship. Our estimation results were obtained from a dynamic panel of 34,376 observations over 23 years. When compared with the previous contributions on liquidity creation in the insurance industry (Choi et al, 2013; Alhassan and Biekpe, 2019), we obtain similar results on the importance of liquidity creation in insurers' financial statements.

[1] Bai et al. (2018) develop a similar index of liquidity creation for banks, but its interpretation is converse to that of Berger and Bouwman (2009) in that creating liquidity makes banks more liquid. In this research, we use the definition from Berger and Bouwman (2009).

The second objective of this study is more technical. It consists of analyzing the causal relationship between insurers' liquidity creation and their demand for reinsurance, rather than merely the statistical link. Obtaining a causal relationship is an important result in empirical research because a simple observed correlation between two variables may arise by reverse causality, and any relationships found between liquidity creation and reinsurance demand will be less convincing if causality is not established statistically.

Beside than showing there are reciprocal causal links between reinsurance demand and liquidity creation for less-diversified insurers using regularized GMM methods of estimation (Carrasco and Nayihouba, 2020), we also verify that the standard GMM approach underestimates the cross effects between reinsurance demand and liquidity creation. We always reject the standard GMM model regardless of the length of the panel or the number of observations.

Establishing this dual relationship between liquidity creation and reinsurance demand is important to understand how active liquidity creators hedge their corresponding liquidity risk. Since the 2007–2008 financial crisis, various regulatory entities around the world have strengthened the regulation of insurers' liquidity risk management. Our results clearly show that reinsurance coverage for large claims exposure is an important element to be considered when evaluating equilibrium liquidity risk in insurers' financial statements, as suggested in a range of new regulatory proposals for liquidity risk management. For the entire industry, we show that the last global financial crisis of 2007–2008 increased the demand for reinsurance at a significance level of 5%. This financial crisis had no impact on liquidity creation for all insurers together. By contrast, the 2001 dot-com recession had a positive impact on liquidity creation, at

5%, but did not affect the demand for reinsurance. It seems that the nature of the recession matters, and these effects vary by insurer size.

We first discuss the main empirical results on liquidity creation in the literature and motivate our research in Section 2. We present the basic framework of liquidity creation for insurers and our main hypotheses in Section 3. We then describe our variables and data in Section 4 and in Section 5. We test for potential endogeneity between liquidity creation and reinsurance demand in Section 6. The GMM econometric model for testing causality between liquidity creation and reinsurance demand is presented and estimated in Section 7. The ML-SEM model is presented and estimated in Section 8. Extensions of the main results to business cycles are discussed in Section 9, and an analysis of the control variable results is provided in Section 10. This is followed by the conclusion to the paper. Additional results are presented in the Online Appendix.

2. Literature review and research motivation

2.1 *Literature review*

Berger and Bouwman (2009) show that large banks created most of the banking liquidity in the US over the 1993–2003 period. These banks were responsible for 81% of industry liquidity creation yet represented only 2% of the sample observations. Bank liquidity creation is shown to be positively correlated with bank value. Berger and Bouwman (2009) also find that the relationship between liquidity creation and capital is positive for large banks and negative for small banks, an important result for banks' regulation. In a world without financial intermediaries, depositors would hold the illiquid debt (Bouwman, 2014).

Choi et al (2013) uses the approach from Berger and Bouwman (2009) and finds that insurers destroy liquidity rather than create it. It is not clear that liquidity destruction is the appropriate term, even when the average liquidity creation ratio is negative, because insurers are active investors in the economy. Technically, the liquidity creation ratio of insurers is negative because they are more involved in buying liquid or marketable assets than in investing in less-liquid assets. Buying more liquid assets reduces liquidity creation in the economy, as defined for banks, because liquidity remains within the financial institutions. In this article, we will instead refer to negative liquidity creation in the economy for enterprises more involved in liquid investments, and positive liquidity creation in the economy for enterprises more involved in illiquid investments.

According to Choi et al (2013), the average annual liquidity creation ratio ranged from −47% to −58% of the total assets of US P&C insurers during the period 1998–2007. Insurers' liabilities are less liquid, and their assets are more liquid than is the case for banks. Regulators ask insurers to keep significant reserves and assets that are easy to liquidate. In the data of Choi et al (2013), larger insurers account for more than 65% of liquidity creation, yet they represent only 3% of the insurance industry. One explanation for the difference between banks and insurers is the ratio of equity to assets. In the data of Choi et al (2013), this ratio for insurers is 45%, compared to about 10% for banks in Berger and Bouwman's (2009) study.

Choi et al (2013) are the first to separate the items on insurers' balance sheets (assets, liabilities, and surplus) into the categories of liquid, semi-liquid, or illiquid. This classification is based on the amount of difficulty, cost, and time needed for insurers to meet their contractual obligations in obtaining liquid funds or paying off their liability. They also analyze the impact of insurers' surplus level on liquidity creation, while controlling for firm-specific variables. They verify that insurer capital is negatively related to the level of liquidity creation, supporting the *financial fragility-crowding out* hypothesis, over the whole period and for all insurer sizes, while for the banking industry this negative relationship is observed only at the small size. More recently, Alhassan and Biekpe (2019) obtained similar results for the insurance industry in South Africa. None of these relationships between capital and liquidity creation for banks and insurers are causal, however.[2]

There is one exception for the banking industry. Horváth et al (2012) obtains a Granger negative relationship between bank capital and liquidity creation. But their liquidity creation categories are based on asset and liability maturities instead of types of assets, as in the literature and in this study.

2.2 *Research motivation*

Finding a causal link in the dual relationship between insurers' investments and reinsurance demand is important for at least three reasons. First, an insurer with a high level of liquidity creation will hold more illiquid assets and will be considered riskier by the regulator and possibly the policyholders. If a riskier insurer receives more claims than expected, it may have to sell illiquid assets quickly, at a lower price, to pay the corresponding claims. There is thus a trade-off between getting higher returns on risky investments and being able to compensate clients at a low cost when unexpected claims happen. However, unexpected claims can be protected through reinsurance, which introduces a second trade-off between reinsurance demand and liquidity creation. This trade-off can be more significant for smaller insurers that have fewer diversification opportunities or risk-management activities. It then becomes important to know if the dual relationship between insurers' investments and reinsurance demand is statistically significant for all insurers as well as for different sizes of insurance firms.

---

[2] Liu et al (2016) analyze the links between insurers' liquidity and reinsurance utilization. They do not consider liquidity creation. See also Li and Shiu (2021) on reinsurance demand and debt capacity.

The second reason why the relationship between insurers' investments and reinsurance demand is important relates to the stabilizing role played by insurers' investments in the economy. As documented by the Center for Capital Markets Competitiveness (2019), the funding structure of insurers' investments is generally much more stable than that of commercial banks. Insurance companies' liabilities are largely made up of contingent claims based on the occurrence of specified events, such fire in a property. Because these claims are often considered independent, insurers engaged in traditional insurance activities are less financially vulnerable and have less pressure to sell assets during declining markets. This analysis does not consider the potentially systemic nature of recent risks faced by insurers. Unfortunately, we do not have access to data on all these new aggregate risks, such as climate events, digital disruptions, cyberattacks, and even pandemic events, but they are documented as becoming important in the insurance industry. They also affect the relationship between insurers and reinsurers (Munich Re, 2020). Instead, we will analyze how the bicausality relationship between liquidity creation and reinsurance demand was affected during the 2007–2008 financial crisis, as a first step in considering the effect of the potential presence of aggregate liquidity risk in insurers' portfolios. For comparison, we will also consider the 2001 dot-com recession, which is considered less related to liquidity risk for financial institutions but more related to liquidity creation.

Finally, finding a significant link between insurers' liquidity creation and reinsurance demand will have an impact on the regulation of liquidity for insurers with a high-risk exposure in illiquid assets. Since the recent financial crisis, many proposals have been discussed by different regulatory agencies to improve the granularity and efficiency of insurers' liquidity risk management (Thimann, 2014). Capital risk management is no more sufficient for controlling risky insurers that are investing in less liquid and more volatile assets. In these proposals, the role of reinsurance coverage in providing liquidity protection is considered an important component of insurers' liquidity risk management, although no documented statistical link has yet been made between liquidity creation and reinsurance demand, to our knowledge.

Our data will make it possible to investigate the causality links between liquidity creation and reinsurance demand in a dynamic panel where the number of observations is quite large, and the number of periods is moderately large. We will first proceed with the Generalized Method of Moments (GMM) with fixed effects. Since the seminal work of Arellano and Bond (1991), the GMM procedure has become a very popular method for estimating parameters with dynamic panel data. However, when the number of moment conditions is very large, in a moderately large panel, bias estimates can be obtained with the standard GMM estimation method, particularly when the autoregressive parameter of the dependent variable is close to unity (Blundell and Bond, 1998; Doran and Schmidt, 2006; Okui, 2009). The covariance matrix of instruments (lagged values of explanatory variables) can considerably impact the properties of the estimators. Carrasco and Nayihouba (2020) propose a regularization approach based on different procedures for inverting the covariance matrix of instruments and reduce the potential bias verified through the standard GMM method. For robustness, we estimate the maximum likelihood with the structural equation modeling (ML-SEM) method.

3. Liquidity creation: The basic framework and hypotheses

3.1 Role of insurers in liquidity creation

The unique business model of insurance companies creates a distinct set of investments in the economy. By investing policyholder premiums, mainly earmarked for paying back insured claims, insurers deploy capital on lower-volatility investments that provide more resilience during crises than do those of other investors. For example, insurers finance infrastructure and homeownership investment projects. These investments mainly support households and local governments and are considered a source of stability for the financial markets. But this source of stability can be fragile because insurers face significant aggregate insurable risks.

Deloitte (2020) documents that most US state insurance regulators expect all types of insurers' climate risks to increase over the medium to long term. US state regulators and lawmakers are concerned about the insurance industry's response to climate risk events. Other significant and growing aggregate risks are digital disruptions, cyberattacks, and pandemics, to name a few. They are often qualified as becoming systemic in the industry, although this has not yet been proved. Two traditional mechanisms are usually used to reduce insurers' financial fragility: increasing aggregate premiums or increasing reinsurance coverage to maintain stability. Under strong competition, increasing premiums may become difficult to do. In this research, we focus on reinsurance coverage as a risk management activity to protect insurers' investments and maintain their resilience. We also consider the dual relationship where insurers with more reinsurance invest in riskier or less liquid investments.

An insurance company's basic business model involves receiving income from policyholders in the form of premiums, which are allocated to claims payouts, operating expenses, investments, and dividends to investors (Dionne and Harrington, 2014). Policyholder premiums are thus used, in part, to invest in assets that generate additional returns, which ultimately serve to pay future claims and dividends. P&C insurance policies are generally held for a one-year period, and liabilities are relatively unpredictable when insured risks are correlated, particularly in terms of severity (climate risks, for example). However, P&C insurance companies must always be ready to pay claims rapidly and, as a result, tend to be less leveraged than other financial institutions.

P&C insurers also invest differently than banks would, due to the average duration of their claims liabilities. This results in relatively more investments in more liquid asset classes such as corporate bonds and municipal securities. But many insurers play a significant role in less-liquid investments, such as infrastructure. These investment projects improve growth across the economy by creating more liquidity.

To use the terminology of liquidity creation in the banking literature (Berger and Bouwman, 2009), insurers create positive liquidity in the economy (positive liquidity creation) when they use liquid liabilities to invest in less-liquid investments and create negative liquidity in the economy (negative liquidity creation) when they use illiquid liabilities or surplus to invest in liquid assets (like bonds). Long-term illiquid investments create liquidity risks to insurers in the sense that they reduce the possibilities for reimbursing claims rapidly and at a low cost.

In this study we will use the liquidity creation ratio (liquidity creation divided by assets) as the measure of liquidity creation. We will see that this ratio is negative, on average, for P&C insurers because they keep significant liquidity in their balance sheet, in accordance with both their business model and regulations. This does not mean that they do not create liquidity in the economy, but they invest relatively less in illiquid assets than banks do. Insurers can increase their negative liquidity creation ratio (less negative) to improve their investment returns by buying costly reinsurance. They face a trade-off between liquidity creation and reinsurance demand. This trade-off is affected by insurers' risk diversification possibilities in managing claims and by the relative benefits of long-term investments as compared to reinsurance costs. So, insurers with a higher liquidity risk should buy more reinsurance when they create liquidity in the economy. In Online Appendix A6, we present a comparison between a sample of insurance firms and banks of the same size, to emphasize the similarities and differences between the two industries in terms of liquidity creation.

3.2 *Liquidity creation measurement*

Insurers' liquidity creation framework is analyzed in three steps. First, we categorize assets, liabilities, and surplus into liquid and illiquid items. This classification is based on the cost and time needed to meet contractual obligations. A financial institution will create one dollar of liquidity in the economy by transforming one dollar of liquid liabilities into one dollar of illiquid assets, or it will reduce one dollar of liquidity creation in the economy by transforming one dollar of illiquid liability or surplus into one dollar of liquid assets. Transforming one dollar of liquid (illiquid) assets into one dollar of liquid (illiquid) liabilities (or the converse) is considered neutral with respect to liquidity creation. Consistent with Berger and Bouwman (2009), we distinguish between categories of assets and liabilities as opposed to their corresponding maturities. This approach, identified as the "cat fat" approach, takes care of all financial institutions' balance-sheet information in creating liquidity in the economy and measuring financial institutions' output, contrary to other liquidity measures (Berger and Bouwman, 2016).

We assign weights to the different assets, liabilities, surplus, and off-balance sheet positions according to their degree of relative liquidity creation. We then add up the different relative measures to obtain an index of liquidity creation for a particular financial institution in a given period. We allocate positive weights to both illiquid assets and liquid liabilities. These weights are presented in Table 1 for an insurer's balance sheet. Accordingly, when one dollar of tax (liquid liability) is used to finance one dollar of real estate (illiquid asset), positive liquidity is created in the economy. Following the same reasoning, we give negative weights to liquid assets, illiquid liabilities, and surplus, so that when illiquid liabilities or surplus are used to buy liquid assets (stocks and bonds), negative liquidity is created in the economy.

Let us consider in detail two examples of transformation applied to insurance. Based on the above rules, as shown in Table 1, we can assign a weight of ½ to both illiquid assets and liquid liabilities, and a weight of −½ to both liquid assets and illiquid liabilities.[3] Thus, when one dollar of liquid liabilities (such as unearned premiums) is used to finance one dollar of illiquid assets (such as real estate), liquidity creation equals ½ × \$1 + ½ × \$1 = \$1. In this case, maximum liquidity (\$1) is created in the economy. Intuitively, the weight of ½ applies to both illiquid assets and liquid liabilities because the amount of liquidity created is only determined by ½ of the source of the funds, so that both entries are needed to create maximum liquidity. Similarly, when one dollar of illiquid liabilities or surplus is used to finance one dollar of liquid assets (such as treasury securities), negative liquidity creation in the economy equals −½ × \$1 −½ × \$1 = −\$1 and maximum liquidity is created in the balance sheet.

[Table 1 about here]

3.3 *Hypotheses to be tested*

In this study, we add the reinsurance demand from insurers to the framework of liquidity creation. The main goal is to verify whether there is a reciprocal link between reinsurance demand and liquidity creation in the economy. We test the following two hypotheses.

[3] As a robustness check, we show, in Table A1.1 of Online Appendix A1, that choosing different weights does not affect the results of our contribution. See also Online Appendix A6 for a comparison between banks and insurers with different weights.

H1: Reinsurance demand from insurers has a positive causal effect on their liquidity creation in the economy.

A positive statistical link can be interpreted as follows. If the demand for reinsurance positively affects liquidity creation (even when it is negative), this means that reinsurance enables insurers to use more liquidity in their balance sheet to invest in illiquid assets (or to increase liquidity creation in the economy). The reciprocal hypothesis reads as follows:

H2: Liquidity creation in the economy by insurers has a positive causal effect on their reinsurance demand.

If liquidity creation (even negative) positively affects reinsurance demand, this means that insurers, seeking more investment returns by creating liquidity in the economy, require more reinsurance to pay back unexpected claims when they do not have enough residual liquidity in their balance sheet.

Nonsignificant statistical relationships between the two activities will mean that insurers do not use reinsurance demand to protect their internal illiquidity when investing in the economy because they are well diversified, and that insurers that are well protected by reinsurance do not necessarily invest more in illiquid assets.

4. Data and variables

We focus on the demand for reinsurance and on liquidity creation in the US property-liability insurance industry. We use the National Association of Insurance Commissioners' (NAIC) annual financial statement data for US property-liability insurance companies. Our period of data ranges from 1993 to 2014, which gives us coverage of the 2007–2008 financial crisis and the 2001 recession.

Several data exclusion criteria are applied. We first remove insurers that report nonpositive total admissible assets and premiums. We exclude insurers reporting a value outside the 0 and 1 range for the ratio of reinsurance demand. The observations are winsorized at the 1% and 99% levels to remove the potential effects of outliers. In order to estimate fixed-effect regressions with lagged variables, firms with only one year of observations are also removed from the sample. The resulting sample consists of 34,376 firm-year observations, from 2,792 non–life insurers. The sample includes insurers that entered or left the market during the study period. We thus have an unbalanced panel to permit a comprehensive evaluation of liquidity creation by the US property-liability insurance industry.

4.1 *Dependent variables*

We use *Reins* to measure an insurer's demand for reinsurance. It is defined as (affiliated reinsurance ceded + nonaffiliated reinsurance ceded) / (direct business written plus reinsurance assumed). We use *Liquid* to measure an insurer's liquidity creation ratio. It is defined as LC / total admitted assets, where LC is defined in Table 1 (step 3).

4.2 *Endogenous variables*

Insurers' liquidity creation may represent an endogenous influence on demand for reinsurance. An insurer's liquidity creation activity may influence its demand for reinsurance. And the reverse causality, from reinsurance purchase to liquidity creation, may also exist. We want to identify the true causal relationships between the two activities.

We treat liquidity creation as an endogenous variable in the reinsurance demand equation. An insurer choosing a high level of liquidity creation in the economy may buy more reinsurance to better protect its policyholders because it has a higher amount of illiquid assets. We also consider the variable *Reins* as an endogenous variable in the liquidity creation equation in order to test for simultaneous causality between the two activities. An insurer buying more reinsurance can make more investments with higher returns in the economy and increase liquidity creation.

4.3 *Control variables*

Control variables include standard variables analyzed in the literatures on both reinsurance demand and liquidity creation (Cole and McCullough, 2006; Mayers and Smith, 1990; Garven and Lamm-Tennant, 2003; Winter, 1994; Sommer, 1996; Weiss and Chung, 2004; Powell and Sommer, 2007; Choi et al, 2013; Alhassan and Biekpe, 2019). Table 2 summarizes the definition and construction of each control variable and presents their symbols. Their estimation results are discussed in Section 10.

[Table 2 about here]

5. Descriptive statistics

Summary statistics for all insurers are shown in Table 3. To capture the variation in demand for reinsurance and liquidity creation by insurer size, we first divide the sample of insurers into three classes, as in Choi et al (2013):[4]

1. Large insurers, whose total admitted assets are greater than $3 billion;
2. Medium insurers, whose total admitted assets are between $1 billion and $3 billion;
3. Small insurers, whose total admitted assets are less than $1 billion.

Summary statistics for all variables are shown in Tables A1.2, A1.3, and A1.4 in Online Appendix A1 for large, medium, and small insurers. Among the 34,376 insurer-year observations,

[4] Dividing insurers in this way enables us to obtain that large insurers account for about 3.5% of the population, as previous studies have verified for large banks and large insurers. Other divisions of the data by insurer size are discussed in Online Appendix A4.

large insurers account for 1,236 observations, medium insurers for 1,993 observations, and small insurers for 30,753 observations. The sum of the three groups is not equal to 34,376 because we need lagged observations for the estimations, and insurers may change size categories over time.

Table 3 indicates that the mean value of demand for reinsurance is 37.2%, with a 28.1% standard deviation. Small insurers seem to use larger amounts of reinsurance to mitigate risk. On average, the demand for reinsurance for large insurers is 30.6%, and is 37.6% for small insurers, as Tables A1.2 and A1.4 show. Large insurers control 60% of the premium earned in the industry, and medium and small insurers control 18% and 22% of the insurance activity, respectively.

[Table 3 about here]

The average ratio of liquidity creation divided by the total assets is −51.73% for all insurers, indicating that insurers generate negative liquidity creation normalized by total admitted assets. Choi et al (2013) and Alhassan and Biekpe (2019) obtained −47% and −45%, respectively. The average liquidity creation ratio (standard deviation) is −51.78% (21%) for small insurers ; whereas, for large and medium insurers, the ratios are −51.38% (14%) and −51.53% (15%), respectively, indicating that large and medium insurers generate slightly more liquidity creation in the economy than do small insurers. The respective standard deviations indicate, however, much more variability for small insurers. Large insurers control 65% of the liquidity creation, whereas medium and small insurers control 16% and 19%, respectively. In Choi et al (2013), large insurers controlled 65%, medium insurers 16%, and small insurers 19% of the liquidity creation in 2007, with the same definitions of insurer size as in this study. With a different division of insurer size, Alhassan and Biekpe (2019) verified that large insurers controlled 70% of the liquidity creation in South Africa during their period of analysis (2007–2014), while medium insurers controlled 25%, and small insurers only 4%.

The mean value of the insurance leverage ratio is 1.94, and ranges from 0 to 33. This ratio is, on average, 2.05 for small insurers, which is more than double that of large insurers (0.74). The capital ratio variable also indicates variations among the different sizes of insurers. The capital ratio for large insurers is 0.37, and it is 0.44 for small insurers. Therefore, small insurers have to maintain a higher level of capital than large insurers do, which affects liquidity creation because the surplus is assigned to illiquid liabilities.

Concentration variables by insurance line, geographic area, or business mix indicate that larger insurers are, on average, more diversified than medium and small insurers. Medium insurers are more diversified than small insurers. Most large insurers are affiliated with a group (97%), as compared to 62% of small insurers. Small insurers bear more risk in relation to policyholders' surplus than do large insurers; 3.1% of small insurers have net premiums written to policyholders' surplus greater than 300%, as compared to 1.4 % for large insurers. For large insurers, 33.8% have a liability to liquid asset ratio greater than 100%, versus only 9.0% for small insurers, and 17.6% for medium insurers.

The mean for the two-year loss development ratio is equal to 9.39% and −2.70% for large insurers and small insurers, respectively. The usual range for the two-year loss development ratio includes results below 20%. Among the 34,376 observations, 7.35% have values greater than 20%; and, among large firms, 10.23% have values greater than 20%. Only 28.4% of small insurers held a New York State license, as compared to 81.3% of large insurers.

Figure A1 in the Online Appendix shows a potential positive dependence between reinsurance demand and liquidity creation over the population of all insurers after 1998. Figure A2 also indicates that liquidity creation seems positively correlated with reinsurance demand for small insurers after 1998. We should mention that, in our division by insurer size, the small insurers account for 89% of the total insurer population. For medium and large insurers, shown in Figures A3 and A4, the positive correlation does appear to be stronger before 2001. The 2007–2008 financial crisis seems to have more affected reinsurance demand, although liquidity creation increased during and after this period for almost all insurers. Liquidity creation was more affected, for all groups, after 1998, which is the middle of the dot-com bubble period (1995–2000). The bubble burst in 2000, affecting the financial markets during the 2001 recession and in the following years. Later, we will investigate separately how these two recessions affected reinsurance demand and liquidity creation and how they affected the relationship between them.

We may worry about a possible endogeneity between reinsurance demand and liquidity creation. In the next section, we present a test to verify the existence of potential endogeneity between these two key variables, before considering their causal relationships.

6. Endogeneity between liquidity creation and reinsurance demand

To test for the presence of potential endogeneity between liquidity creation and reinsurance demand in our dynamic panel data, we use the Hausman (1978) procedure. According to Arellano and Bond (1991), this procedure can be applied to dynamic panel data with the standard GMM to evaluate endogeneity issues in the data. The Hausman (1978) test is a specification test. The null hypothesis of the test is to assume there is no misspecification problem in the model, implying that there is no endogeneity issue. Let us denote by $\hat{\delta}_{\mathrm{GMM}}$ the estimated parameter of an independent variable obtained by a GMM estimation, and by $\hat{\delta}_{\mathrm{fe}}$ the corresponding estimated fixed-effect parameter.

The test statistic to implement the Hausman procedure is given by

$$H = \left(\hat{\delta}_{\mathrm{GMM}} - \hat{\delta}_{\mathrm{fe}}\right)' V\left(\hat{\delta}_{\mathrm{GMM}} - \hat{\delta}_{\mathrm{fe}}\right)^{-1}\left(\hat{\delta}_{\mathrm{GMM}} - \hat{\delta}_{\mathrm{fe}}\right)$$

We can look at the endogeneity between reinsurance demand and liquidity creation when reinsurance demand is the dependent variable. We could estimate the following equation to obtain the desired parameters for the test:

$$y_{i,t} = \beta_y + \delta_{\text{GMM}} x_{i,t-1} + \delta y_{i,t-1} + \delta_{\text{fe}} + \varepsilon_{i,t} \ , \tag{1}$$

where $y_{i,t}$ is for the reinsurance demand, and $x_{i,t-1}$ is for the lagged liquidity creation variable. The endogeneity problem comes from two sources. First, the presence of $y_{i,t-1}$ combined with the individual fixed effect in the model creates a correlation between this lagged variable and the error terms in such a way that the standard fixed-effect estimate may be inconsistent. Moreover, due to a potential endogeneity problem between the reinsurance demand ($y_{i,t}$) and liquidity creation ($x_{i,t-1}$), there is an additional correlation between $x_{i,t-1}$ and the model's error term. We can also apply the test without the $y_{i,t-1}$ variable in (1), as shown in Tables 4 and 5.

[Table 4 about here]

The test is implemented with the data from 1992 to 2014 and with all observations. The results in Table 4 Panel A come from the standard GMM method to estimate the parameters in equation (1). According to the *p*-values, we do not reject an endogeneity problem between reinsurance demand and liquidity creation. We can also use the random effect estimates (model not presented here) instead of the fixed effect estimates to compute the test statistic. In this case, the asymptotic distribution is a chi-square with K degrees of freedom. Results, presented in Panel B of Table 4, are very similar to those of Panel A.

The same results are obtained in Table 5 when liquidity creation is the dependent variable. The results are also confirmed when using regularization techniques for the GMM estimation (Panel C in both tables). The details about regularized GMM estimations are presented in the next section.

To account for this endogeneity conclusion in the coming analyses, a convenient way is to use GMM methods of estimation with the lagged values of all the explanatory variables as instruments. We could also use the maximum likelihood method**.**

[Table 5 about here]

7. Causality analysis based on the generalized method of moments

7.1 *Econometric model*

One objective of our research is to look at the reciprocal relationship between reinsurers' liquidity creation and their demand for reinsurance. One of the most efficient models that can be used to evaluate this reciprocal relation is the structural equations model (Low and Meghir, 2017). In our analysis, to evaluate the reciprocal relation between reinsurance demand and liquidity creation with a structural equations model, we specify a dynamic data panel incorporating unobserved heterogeneity. In this model, the lagged value of liquidity creation is added in the equation of reinsurance demand as one of the key explanatory variables, and the lagged reinsurance demand variable is added in the equation of liquidity creation also as an explanatory variable. This specification of the model, where the parameters associated with lagged variables reflect a causal link that takes some time to become effective, seems more appropriate in our framework. In fact, most of insurers' strategic decisions, such as investments (liquidity creation) and reinsurance demand (risk management), are generally made by the board of directors once a year and may take several months to materialize. The decisions are very unlikely to obtain causal effects during the same year. Therefore, we focus on lagged values of the key variables to analyze our causal relationships. Moreover, this specification of the model fits well with the notion of causality we are interested in (the Granger causality).

In this research, we analyze the causality between reinsurance demand and liquidity creation by applying a robust GMM procedure to estimate our parameters. More precisely, we use the regularized GMM procedure proposed by Carrasco and Nayihouba (2020) for dynamic panel data. An interesting property of the regularized GMM procedure is that there is no convergence problem even when *T* is large. In order words, this procedure can also be implemented if the time dimension of the panel data is moderately large, as in our application. Moreover, we do not need any distributional assumptions. We are going to estimate equation (2) where $y_{i,t}$ is for reinsurance demand and $x_{i,t}$ is for the liquidity ratio:

$$\begin{cases} y_{i,t} = \beta_1 x_{i,t-1} + \beta_2 y_{i,t-1} + \delta_1 w_{i,t} + \alpha_i + \varepsilon_{i,t} \\ x_{i,t} = \beta_3 x_{i,t-1} + \beta_4 y_{i,t-1} + \delta_2 s_{i,t} + \eta_i + v_{i,t} \end{cases} \tag{2}$$

In equations (2), the liquidity creation ratio at time *t* is regressed on the control variables at time *t,* and the reinsurance demand at time *t* is regressed on the control variables at *t*. Each equation of the model is in fact a dynamic panel data relationship with a lagged dependent variable, a lagged endogenous variable, individual fixed effects (α_i, η_i), and vectors of covariates $(w_{i,t}, s_{i,t})$. The terms $\varepsilon_{i,t}$ and $v_{i,t}$ are error terms with zero mean and positive variance for $i = 1 \ldots N$ and $t = 1 \ldots T$, where *N* is the number of firms, and *T* the number of periods. There are fewer control variables in the liquidity creation regression because some variables described in Table 2 are included in the definition of the liquidity creation ratio, as shown in Table 1.

The estimation of (2) will be done equation by equation. Using the above specification of the model, we may face some severe endogeneity problems that need to be solved in the estimation process. The first endogeneity problem is due to the presence of individual fixed effects in the model, which creates a correlation between the error term and one of the explanatory variables, namely, the lagged value of the dependent variable. This implies that the lagged value of the dependent variable should be treated as an endogenous variable in the estimation process. Moreover, this problem is amplified by the fact that the lagged value of liquidity creation in the equation of reinsurance demand and the lagged value of the reinsurance demand in the equation of liquidity creation are also endogenous variables, as was shown empirically in the preceding section, using the Hausman (1978) test procedure. Therefore, the standard OLS method with fixed effects may yield bias estimates. To come up with these two endogeneity problems and to avoid the problem involved in finding valid instruments for the two-stage least square (2SLS) regression method, the GMM model will be employed to estimate parameters in (2), with lagged levels of the set of explanatory variables as instruments. This model has an important feature: if a variable at a certain period can be used as an instrument, then all the past realizations of that variable can also be used as instruments. Therefore, the number of moment conditions can be very large, even if the time duration of the panel T is finite.

To be more specific, the vectors of control of variables $\left(w_{i,t}, s_{i,t}\right)$ in (2) are considered exogenous variables, and the two lagged variables $\left(y_{i,t-1},\, x_{i,t-1}\right)$ are endogenous variables. These last two variables cannot be used as instrumental variables. Let us define the vector $R_{it} = \left(y_{i,\,t-1},\, x_{i,\,t-1},\, r_{it}\right)$ where r_{it} is the vector of control variables in t in a given equation, and R_{it} contains all the explanatory variables in each equation. Therefore, when implementing the GMM estimation method, the lagged values of all explanatory variables become our instruments $R_{it-1},\, R_{it-2},\, \ldots$

The presence of this large set of moment conditions may create a variance bias that is also referred to as the many instruments problem. Moreover, the lagged levels of the dependent variable, which appear in the explanatory variables, can become weak instruments when the autoregressive parameter is close to unity (Blundell and Bond, 1998). As a solution to these problems (many instruments and weak instruments), we add some regularization methods to the standard GMM method, as in Carrasco and Nayihouba (2020), to evaluate the relationship between liquidity creation and reinsurance demand.

7.2 *Regularization procedures for estimation*

Several methods have been proposed in the context of cross-sectional data models to deal with these problems of instruments. For instance, Carrasco (2012) and Carrasco and Tchuente (2015) propose to solve this problem with different regularization procedures based on efficient ways to stabilize the inverse of the covariance matrix of instruments. To manage this problem in a dynamic setting, Okui (2009) recommends choosing the optimal number of moment conditions to minimize the mean square error of the estimation in order to improve the finite sample properties. However, the finite sample problem is not completely solved since there may be a large bias in estimated cross-lagged parameters when the autoregressive coefficient in the dynamic panel is close to unity. Carrasco and Nayihouba (2020) propose a more general method based on different ways of inverting the covariance matrix of instruments. They show that this method improves the properties of the GMM estimation even if the autoregressive coefficient is close to unity. To analyze the causality relationships in (2), we focus on two of the regularization procedures proposed by Carrasco and Nayihouba (2020) in the context of our dynamic panel data.

The system of equations in (2) will be estimated separately, equation by equation, using regularization. Alternatively, this system could have been estimated simultaneously by GMM, as in Mitze (2012) and Hsiao and Zhou (2018). In comparison to the single-equation model, the covariance matrix of instruments would have a larger dimension because of the use of instruments from two equations. Inverting the covariance matrix of instruments may become much more complex in such a situation, particularly when we have many control variables as in our setting. In applying regularization to estimate each equation, we considerably improve the finite sample properties by solving most of the problems faced by the standard GMM method. It is not clear that a simultaneous GMM estimation of the system would do any better and making such a comparison is beyond the scope of this paper. The different GMM models are described in the Online Appendix A2.1.

When the number of moment conditions exceeds the number of unknown parameters to be estimated by GMM, the model validity must be verified, by testing the overidentifying restriction, before making any inference in the resulting estimation. A common test for this purpose is the J-test proposed by Sargan (1958) and Hansen (1982). To test if our models are well specified, we apply the modified version of the J-test to the context of dynamic panel data models (Arellano and Bond, 1991).

7.3 *Econometric results with the GMM model*

We now present the estimation results of (2) using the GMM fixed effects model.[5] Table 6 shows very important findings for all insurers together. For large, medium, and small firms, the results are presented in Tables A1.6, A1.7, and A1.8 in Online Appendix A1. Robust standard errors are used for obtaining confidence intervals. Quantities in brackets are the associated p-values for each coefficient. We observe, in the four tables, that the standard GMM estimation is rejected by the J-test where the number of periods is moderately large and regardless of the number

[5] For the purpose of comparison with the literature, we present estimation results obtained with the fixed-effects OLS model in Online Appendix A3.

of observations. We also observe that the cross effects between reinsurance demand and liquidity ratio are underevaluated with the standard GMM model, as compared to the two other regularized methods of estimation, which confirms the potential bias for the estimators obtained from the standard GMM methodology.

The results in Table 6 show a highly significant relationship between the liquidity creation ratio and the demand for reinsurance. An increase in the liquidity creation ratio increases the demand for reinsurance, as we predicted. In addition, the coefficient is positively significant for small and medium insurers, as shown in Online Appendix A1. It is not significant for large firms. The results in Tables A1.7 and A1.8 indicate that the impact of the liquidity creation ratio on the reinsurance demand is about the same for small insurers and medium insurers.

Demand for reinsurance positively affects the liquidity creation ratio only for small insurers in Tables A1.6 to A1.8, which seems to explain the overall result in Table 6, because small insurers represent a large fraction of the overall insurer population (89%), in our division by insurer size. The robustness of these results will be presented in Appendix A4, where alternative size divisions for the insurers will be considered.

Two results in the literature may explain why large insurance companies do not get significant results. In their seminal article on reinsurance demand, Mayers and Smith (1990) describe the demand for reinsurance as a form of risk management activity undertaken by insurers. They mention that the underinvestment problem following large and unexpected losses can be reduced through reinsurance coverage. They also predict that this underinvestment problem should be more severe for less-capitalized firms with more volatile cashflows. Moreover, small insurers should have less-specialized internal human capital for internal risk management. For all these reasons, they predict that larger insurers should have a lower demand for reinsurance because they are well diversified and usually have internal risk management activities other than reinsurance coverage. They verify empirically that large insurers have less demand for reinsurance than small insurers, using a continuous size variable (negative significant parameter). More recently, in line with the above contribution, Cummins et al (2021) identifies the reduction in loss-ratio volatility as a benefit of reinsurance purchases for insurers. They also show that this benefit from reinsurance purchases decreases with insurer size. Finally, 97% of large insurers are affiliated with a group, as compared to 61% for small insurers. Group affiliation is another way to diversify insurance risks. Descriptive statistics in Online Appendix 1 (Tables A1.2 to A1.4) also document that large insurers are more diversified than small insurers with respect to business lines, geographic areas, and business mix.

We can compare the estimation results for the liquidity creation ratio variable in Table 6 with those of Choi et al (2013, Table III), who use the same dependent variable with 17,174 observations from the period 1998–2007. The model specifications are different, however, because these authors do not estimate a dynamic panel regression model with lagged dependent variables, and they do not consider reinsurance demand with a lag of one period in their liquidity creation ratio equation.[6] They obtain similar results for Geographical concentration (-) and Line concentration (-) variables. We did not use Leverage and Surplus ratio (Capital) in the regression component as they did because these variables are part of the definition of the liquidity creation ratio dependent variable. Our results differ for two variables. They obtain a negative effect for Log of asset while we have a positive sign, and they obtain a negative sign for group affiliation while this variable is not significant in Table 6.

[6] A comparison can also be made with the OLS results in Appendix A3. We can see that the effects remain about the same, but these relationships cannot be interpreted as causal effects.

Another difference is related to the effect of current reinsurance utilization on liquidity creation by size of insurer. They obtain a positive sign on liquidity creation for large insurers and a nonsignificant effect for small insurers, while we have a positive sign for small insurers and a nonsignificant effect for large insurers. These differences could be explained by the modelization of reinsurance utilization. In their analysis, they use reinsurance at period *t* while we use a lagged variable to take risk management decision delays into account.

Alhassan and Biekpe (2019) also verify that reinsurance demand positively affects liquidity creation when they consider all insurers together. They obtain an interesting result, in line with our contribution, from their quantile regression model. The variable reinsurance ratio positively affects the liquidity creation ratio for all quantiles, with one exception: the Q 90 quantile (larger firms), where the coefficient is not statistically significant. Notice that our group of large insurers is in the Q 90 quantile of insurers size distribution.

[Table 6 about here]

8. Causality analysis based on the maximum likelihood method

8.1 *Econometric model*

The regularized GMM estimation procedure shows that the causal relationship between reinsurance demand and liquidity creation is bidirectional for small insurers and for all insurers together. We also verify that the standard GMM model underestimates the cross effects between liquidity creation and reinsurance demand. As a robustness test, we apply another estimation procedure to confirm these important results. The maximum likelihood (ML) model can also estimate reciprocal causal effects between two variables in a structural equations model. This model is presented in Online Appendix A2.2.

This method tends to work best when panels are strongly balanced, T is not too large, and there are no missing values. Only 16% of the firms studied (i.e., 489) are observed every year over the 23 years. To keep more observations while applying these conditions to our data set, we also separated our data into three periods: 1992–1999 (8 years); 2000–2007 (8 years); and 2008–2014 (7 years). From 1992 to 1999, we observe, in Table A1.5 of Online Appendix A1, that there are 1,072 firms present for all 8 years. There are 1,063 firms in 2000–2007 that are observed in all 8 years, and 1,108 firms observed in all 7 available years from 2008 to 2014.

The rationale for the estimation method is described in the works of Teachman et al (2001) and Allison and Bollen (1997). The assumption of sequential endogeneity is modeled by allowing the error term at each point in time to be correlated with the future values of the time-dependent covariates, but not with past values (Wooldridge, 2010). ML-SEM assumes that observed endogenous variables have a multivariate normal distribution conditional on the exogenous variables. However, ML-SEM produces consistent estimators even when the normality assumption is violated (Moral-Benito, 2013; Allison et al, 2017). In our applications, we used the Satorra-Bentler (2001) approach for adjusting standard errors to obtain the corresponding p-values, whatever the distributional assumption.

8.2 *Estimation results with the ML-SEM model*

Maximum likelihood estimations of structural equation modeling (ML-SEM) sometimes fail to converge. We therefore include in the model only the variables that improve the fit. A wide array of fit indices was developed.[7] These indices and their critical values are described in Online Appendix A2.3.

[7] See, for example, Schermelleh-Engel et al. (2003); Ding et al. (1995); Sugawara and MacCallum (1993): Root Mean Square Error of Approximation; Comparative Fit Index; Tucker-Lewis Index; and Standardized Root Mean Square Residual.

The strict exogeneity in the linear panel model for y_{it} with fixed effects can be established by verifying that $E\left(\varepsilon_{it}|\mathrm{w}_i,\alpha_i\right)=0$ (Wooldridge, 2010). An equivalent condition exists for x_{it}. A test of strict exogeneity fixed effects, when $T > 2$, is obtained by estimating equation (3):

$$\mathrm{y}_{it} = \delta_1 w_{it} + \phi_1 z_{it+1} + \alpha_i + \varepsilon_{it}, \qquad t = 1,2,\cdots,T-1 \tag{3}$$

where w_{it} is a vector of predetermined variables and z_{it+1} is a vector of exogenous variables. An equivalent equation can be estimated for x_{it}. The test for the strict exogeneity of each variable in each equation can be written as, $H_0:\phi_{jk}=0$, where $j = 1, 2$ is for reinsurance demand and liquidity creation, respectively, and $k = 1, 2 \ldots K$ is for variable k. Table 7 presents p-values for the test $H_0:\phi_{jk}=0$. We consider a variable to be strictly exogenous when the p-value is greater than 0.10. Otherwise, the independent variables will be considered predetermined variables.

[Table 7 about here]

We observe in Table 7 that reinsurance price, tax exemption, and capital are strictly exogenous variables for the estimation of reinsurance demand, and that regulatory pressure, tax exemption, and cost of capital are strictly exogenous for the estimation of the liquidity ratio variable. All other variables are considered predetermined variables in the two equations (p-value < 0.10) for all periods.

Table 8 presents the estimation results for all insurers, with control variables included in the model following the selection results in Table 7. We observe that the cross effects between reinsurance demand and liquidity ratio are significant, with parameters similar to those obtained with the regularized GMM estimations in Table 6. These findings support the reciprocal causal effects model in which each cross-effect variable exerts a causal influence on the other over time. The coefficients of the control variables are not significantly affected when compared with previous GMM estimations, except for tax exemption and information asymmetry. These differences can be explained by different model specifications and number of observations.

[Tables 8 about here]

To confirm our results in Table 8, we re-estimate the GMM model with the same specifications and number of observations as in Table 8. The results in Table 9 seem to confirm that the ML-SEM model is another way to overcome the standard GMM estimation problems (Moral-Benito, 2013). We observe that the ML-SEM results in Table 8 are very similar to the regularized GMM methods in Table 9. Almost the same control variables are significant, and the standard GMM is still rejected and continues to underevaluate the cross effects between reinsurance demand and liquidity creation, albeit to a lower extend. This can be explained by the use of fewer control variables and observations in Table 9 than in Table 6.

We now focus on the coefficient estimates of β_1, the cross-lagged effect of liquidity creation on reinsurance demand, and β_4, the cross-lagged effect of reinsurance demand on liquidity creation. The coefficient estimates of β_1 vary from 0.05 (standard GMM, Table 6) to 0.08 (Tikhonov regularized GMM, Table 6), 0.08 (Landweber-Fridman regularized GMM, Table 6), and 0.07 (ML-SEM, Table 8). The coefficient estimates of β_4 vary from 0.008 (standard GMM, Table 6) to 0.02 (Tikhonov regularized GMM, Table 6), 0.02 (Landweber-Fridman regularized GMM, Table 9), and 0.07 (ML-SEM, Table 8). This confirms the lower estimates of the standard GMM method, compared with the other estimation methods.

[Table 9 about here]

We obtain similar results over the entire period for small insurers. The conclusions remain about the same as those obtained from Tables 7 and 8, respectively. Results are presented in Tables A1.10 and A1.11 in Online Appendix A1. As shown in Tables A1.13 to A1.16, the results do not differ significantly with more observations and shorter periods, for both estimation methods. The results in Table A1.14 still show that the standard GMM is rejected and underestimates the effects of liquidity creation on reinsurance demand, when compared with regularized estimations in Tables A1.15 and A1.16, and with the ML-SEM results in Table A1.13. With fewer observations, the differences in the cross-effect parameters are less significant, however.

9. 2007–2008 global financial crisis and 2001 dot-com recession

Our goal in this section is to verify how the two recessions (2001 and 2007–2008) affected the links between reinsurance demand and liquidity creation. To our knowledge, there are no studies in the literature that document systemic risk during the 2007–2008 financial crisis in the insurance industry, even if AIG (American International Group) had financial difficulties with its structured financial products during this time. This is mainly because almost all insurers were not as involved in off-balance-sheet transactions and in structured finance as banks were (Kessler, 2014; Cummins and Weiss, 2014). The 2001 dot-com recession may have affected insurers that were also involved in the tech bubble of 1995–2000 through their investments.

Finding some statistical links between the two recessions and both liquidity creation and reinsurance demand will be important for regulatory purposes, because new insurer regulations are now putting more emphasis on liquidity risk management (Thimann, 2014).

If a significant effect is found between one recession and either reinsurance demand or liquidity creation (and their relationships), this may explain, in part, the persistent lack of investments during the years following the two crises, which postponed the economy’s recovery, as observed after the dot-com recession of 2001 and after the 2007–2008 global financial crisis.

Our econometric results in Table 10 show mixed effects. For the entire industry, the last financial crisis increased the demand for reinsurance for all insurers at a significance level of 5%. By contrast, the 2001 recession positively affected liquidity creation at 5%, but it did not affect reinsurance demand for all firms. It positively affected liquidity creation for all types of insurers. It seems that the nature of the recession and the firm size matter, which is an important conclusion that has policy implications. See Online Appendix A5 for more results.

We also still observe a stable positive link between liquidity creation and reinsurance demand for all insurers in Table 10 and in Tables A5.1 and A5.2, where, in the two last cases, the regressions are limited to shorter periods around both recessions.

[Table 10 about here]

10. Detailed analysis of the control variable results

The results are summarized in Tables A1.17 to A1.20 in Online Appendix A1 for all observations and for different insurer sizes. We kept the OLS for comparison with the literature on reinsurance demand and liquidity creation. We observe that the estimation results are stable between different estimation methods. We do not discuss the ML-SEM results with fewer observations and different specifications, but we have already shown that the results in Tables 8 and 9 are very similar for the control variables when comparing the two estimation methods.

Insurance leverage ratio. The coefficient of the insurance leverage ratio is positively and significantly related to the demand for reinsurance, suggesting that firms that have more debt have a greater need for reinsurance because they have a higher probability of insolvency. This result is robust, regardless of insurer size and estimation method. The variable is not present in the liquidity ratio estimation because it was used for the definition of the dependent variable.

Line of business, and geographic and business-mix concentrations. As discussed previously, the prediction for the signs of these coefficients is quite uncertain, and the results are rather mixed. Both the line of business and the geographic concentration coefficients are negative or not significantly related to reinsurance demand and liquidity creation. Business-mix concentration is almost nonsignificant in both equations, with all estimation methods and firm sizes.

Regulatory pressure. Regulatory pressure is significantly and negatively related to demand for reinsurance and positively related to the liquidity creation ratio for all insurers and for small insurers. Accordingly, firms whose net premiums-to-surplus ratio is higher than 300% require less reinsurance and are more active in liquidity creation, as predicted.

Liabilities to liquid assets ratio. Firms whose liabilities exceed their liquid assets are expected to purchase more reinsurance. We find this result for small insurers and for all insurers, with the exception of the standard GMM model. This variable was not used in the liquidity creation equation.

Reinsurance price. Reinsurance price measured by the inverse of the economic loss ratio is significantly and negatively related to the reinsurance demand, and significantly and positively related to the liquidity creation ratio for all insurers and for small insurers (same results sometimes for medium insurers). For large insurers, this price is significantly and negatively related to the demand for reinsurance (with the exception of the standard GMM) and not significantly related to the liquidity creation ratio.

Tax exemption. In examining the effect of tax-exemption income on the demand for reinsurance and on the liquidity creation ratio, we find insignificant results for the reinsurance demand and, for all insurers and for small insurers, a significant negative relationship for liquidity creation, indicating that insurers that invest more in tax-favored assets do not purchase more reinsurance, but they create less liquidity in the economy.

Information asymmetry. Information asymmetry is not significantly related to the liquidity creation ratio for all insurers and for small insurers. It affects the demand for reinsurance positively for the same insurers, and it positively affects liquidity creation for large insurers. It is never significant for medium insurers.

Two-year loss development. We use the two-year loss development variable to determine if variation in loss reserves affects the demand for reinsurance and the liquidity creation ratio. The variable is not significant, with the exception of a positive effect for reinsurance demand by all insurers with the OLS model. Loss development is not significant for liquidity creation, with few exceptions.

New York license. Insurers that have a license in New York State purchase more reinsurance and are not significantly related to the liquidity creation ratio. We find the same results among all insurers, and for small and medium insurers. For large insurers, we also find no relationship with the liquidity creation ratio but a significant negative relationship with the demand for reinsurance.

Cost of capital. The coefficient for the cost of capital is negatively and significantly related to the demand for reinsurance and is also negatively and significantly related to the liquidity creation ratio for small insurers and all insurers. It is not significant for large and medium insurers.

Firm size. We find a negative relationship between firm size and insurers' demand for reinsurance for all insurers and for small insurers, implying that, when firm size decreases, insurers are more likely to purchase reinsurance as a way to manage unexpected losses (Mayers and Smith, 1990). The firm-size variable is positively and significantly related to the liquidity creation ratio for all insurers, small insurers, and medium insurers. So, in terms of the logarithm of total admitted assets, smaller insurers are more likely to purchase reinsurance and less likely to create liquidity.

Group affiliation. The firm affiliation variable is positive for the demand for reinsurance for small insurers and for all insurers, indicating that insurers affiliated with a group require more reinsurance. This variable is not significantly related to the liquidity creation ratio, except for medium firms affiliated with a group, which tend to create more liquidity.

Capital. The demand for reinsurance is significant and positively associated with capital. This surprising result does not vary by size of insurer or by method of estimation. The variable was not used in the liquidity ratio estimation.

11. Conclusion

This study analyzes how liquidity creation and reinsurance demand are reciprocal, a structural relationship that has not been studied previously in the literature. Our statistical analysis indicates that liquidity creation has a positive causal effect on reinsurance demand for all insurers together, meaning that those with an active participation in investments that are more risky or less liquid buy more reinsurance protection. Only larger reinsurers that create more liquidity in the economy are not likely to purchase more reinsurance when they increase their investments in less-liquid assets. One possible explanation is that large insurers are more involved in other types of risk management activities than smaller insurers. Conversely small insurers that buy more reinsurance create more liquidity in the economy. Because they feel more protected, they become more active in riskier investments. Again, the relationship is not significant for large insurers. The 2007–2008 financial crisis increased the demand for reinsurance but did not affect liquidity creation, for all insurers and for small insurers. Insurers increased their protection to maintain their investments. Conversely, the 2001 dot-com recession increased liquidity creation for all insurers, which may be related to the resiliency role the insurance industry has during recessions. Neither recession affected the causality links between liquidity creation and reinsurance demand.

We performed our causality analysis by applying two complementary methodologies that yield comparable results with the same econometric specifications and the same data. One important result from our analysis is that we reject the standard GMM method in all estimations. We also show that the standard GMM underestimates the cross effects between liquidity creation and reinsurance demand when the estimation period is relatively large and when the autoregressive parameters of the two dependent variables are important or close to one. These results justify the use of more sophisticated estimation methods that regularize the GMM procedure by including ways to stabilize the inverse of the covariance matrix of instruments with dynamic panel data (Carrasco and Nayihouba, 2020). For robustness, we also estimated the ML-SEM model. When we use the same econometric specification, with the same data, the regularized GMM and the ML-SEM estimation methods yield the same results. To our knowledge, this is the first time that such a comparison between the regularized GMM and ML-SEM methods is made in the applied econometrics literature.

Many extensions to our research are possible. A first important one would be to apply our methodologies to the relationship between liquidity creation and bank capital, to test for bidirectional causality. The results of these estimations would be important for the new international regulation of banks' liquidity risk. Another extension would be to estimate the two equations in the structural model simultaneously.

As suggested by a referee, an interesting question arises from our research: given that the business activities of property-liability insurance companies are mainly short-term contracts, these insurers usually need to maintain high liquidity to compensate their clients. Compared with life insurers, the liquidity created by property-liability insurers should be smaller. Since the cash flow of life insurers is relatively stable, they can invest in more illiquid assets to create more liquidity in the economy than property-liability insurers. It would be interesting to investigate the liquidity creation activities of life insurers. However, their demand for reinsurance should be relatively lower, which may weaken the role of reinsurance in creating liquidity.

It is well known from the insurance literature that some other firms' specific characteristics than liquidity creation and reinsurance demand, such as capital adequacy and liquidity, may be endogenous variables that may affect the conclusions of this research. (Cummins and Sommer, 1996; Baranoff and Sager, 2002; Shiu, 2011; Mankai and Belgacem, 2016; Liu et al, 2016). Taking care explicitly of the interactions between these potentially endogenous variables with liquidity creation and reinsurance demand may have a significant effect on the conclusions of this article.

Finally, we could consider the roles of insurers' risk management and financial intermediary activities as complements or substitutes to liquidity creation and demand for reinsurance. Insurers, as financial intermediaries, obtain money from their policyholders in the form of premium payments and invest the funds raised in financial assets, which is related to liquidity creation but not identical. Another important economic function of property-liability insurers is to provide risk pooling to their policyholders, and these services are a primary driver of the need for risk management as a complementary activity to reinsurance demand. Cummins et al (2009) show that risk management and financial intermediation improve insurers' financial performance. But they do not consider liquidity creation activities.

Acknowledgements

We received very useful comments, which improved the paper, from the participants of the following conferences: 2017 Annual Meeting of the American Risk and Insurance Association, 2018 Annual Seminar of the European Group of Risk and Insurance Economists, the 2021 Annual Conference of the International Association for Applied Econometrics (IAAE), the 2021 Annual Meeting of the Canadian Economics Association, the 2021 Annual Meeting of the Société canadienne de science économique, and, more particularly, from James Garven, Pierre Picard, Pierre-Carl Michaud, and Philippe d'Astous. A referee and an associate editor made substantial comments that improved the earlier versions of the article, and Akouete-Tognikin Fenou and Claire Boisvert were very competent in the preparation of the final version.

References

Alhassan, A.L., Biekpe, N., 2019. Why do property-liability insurers destroy liquidity? Evidence from South Africa. *South African Journal of Economics* 87, 1, 22-45.

Allison, P., Bollen, K.A., 1997. Change score, fixed effects, and random component models: A structural equation approach. Paper presented in the *Annual Meeting of the American Sociological Association*.

Allison, P.D., Williams, R., Moral-Benito, E., 2017. Maximum likelihood for cross-lagged panel models with fixed effects. *Socius: Sociological Research for a Dynamic World* 3, 1-17.

Arellano, M., Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies* 58, 2, 277-297.

Arellano, M., Bover, O., 1995. Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics* 68, 29-51.

Bai, J., Krishnamurthy, A., Weymuller, C.H., 2018. Measuring liquidity mismatch in the banking sector. *The Journal of Finance* 73, 1, 51-93.

Baranoff, E.G., Sager, T.W., 2002. The relationship among asset risk, product risk, and capital in the life insurance industry. *Journal of Banking and Finance* 26, 1181-1197.

Berger, A. N., Bouwman C.H.S., 2009. Bank liquidity creation. *The Review of Financial Studies* 22, 9, 3779-3837.

Berger, A. N., Bouwman C.H.S., 2016. *Bank Liquidity Creation and Financial Crises*. Academic Press, San Diego, CA, 274 p.

Blundell, R., Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics* 87, 115–143.

Bouwman, C.H.S., 2014. Liquidity: How banks create it and how it should be regulated? In: Berger, N., Molyneux, P., and Wilson, J.O. (Eds), *The Oxford Handbook Banking* (2nd Edition), Oxford University Press, NY, USA.

Browne, M.W., Cudeck, R., 1992. Alternative ways of assessing model fit. *Sociological Methods & Research* 21, 230-258.

Bryant, J., 1980. A model of reserves, bank runs, and deposit insurance. *Journal of Banking and Finance* 4, 335-344.

Carrasco, M., 2012. A regularization approach to the many instruments problem. *Journal of Econometrics* 170, 383–398.

Carrasco, M., Florens, J.P., Renault, E., 2007. Linear inverse problems in structural econometrics estimation based on spectral decomposition and regularization. In: Heckman, J.J. and Leamer, E.E. (Eds.) *Handbook of Econometrics* 6b, Elsevier, p.5633–5751.

Carrasco, M., Nayihouba, A., 2020. A regularization approach to the dynamic panel data model estimation. Mimeo, University of Montreal.

Carrasco, M., Tchuente, G., 2015. Regularized LIML for many instruments. *Journal of Econometrics* 186, 427-442.

Center for Capital Markets Competitiveness, 2019. The Role of insurance Investments in the U.S. Economy. Report, 41 p.

Choi, B.P., Park, J., Ho, C.L., 2013. Liquidity creation or de-creation evidence from US property and liability insurance industry. *Managerial Finance* 39, 10, 938-962.

Cole, C.R., McCullough, K.A., 2006. A reexamination of the corporate demand for reinsurance. *The Journal of Risk and Insurance* 73, 1, 169-192.

Cummins, D., Dionne, G., Gagné, R., Nouira, A., 2009. Efficiency of insurance firms with endogenous risk management and financial intermediation activities. *Journal of Productivity Analysis* 32, 2, 145-159.

Cummins, J.D., Dionne, G., Gagné, R., Nouira, A., 2021. The costs and benefits of reinsurance. *Geneva Papers on Risk and Insurance – Issues and Practice* 46, 177-199.

Cummins, J.D., Sommer, D.W., 1996. Capital and risk in property-liability insurance markets. *Journal of Banking and Finance* 20, 1069-1092.

Cummins, J.D., Weiss, M., 2014. Systemic risk and the U.S. insurance sector. *Journal of Risk and Insurance* 81, 3, 489-528.

Cummins, J.D., Weiss, M., 1993. Measuring cost efficiency in the property-liability insurance industry. *Journal of Banking & Finance* 17, 2-3, 463-481.

Deloitte, 2020. Climate change and insurance: How boards can respond to emerging supervisory expectations. Research document, 42 p.

Diamond, D.W., Dybvig, P.H., 1983. Bank runs, deposit insurance and liquidity. *Journal of Political Economy* 91, 401-419.

Ding, L., Velice, W.F., Harlow, L.L., 1995. The effects of estimation methods, number of indicators per factor and improper solutions on structural equation modeling fit indices. *Structural Equation Modeling* 2, 119-144.

Dionne, G., Harrington, S.E., 2014. Insurance and Insurance Markets. In W.K. Viscusi and M. Machina (Eds.), *Handbook of the Economics of Risk and Uncertainty*, 1st Edition, North Holland, Amsterdam, p. 203-261.

Doran, H.E., Schmidt, P., 2006. GMM estimators with improved finite sample properties using principal components of the weighting matrix, with an application to the dynamic panel data model. *Journal of Econometrics* 133, 387-409.

Fungacova, Z., Weill, L., Zhou, M., 2010. Bank capital, liquidity creation and deposit insurance. BOFIT Discussion Papers, No. 17/2010, ISBN 978-952-462-692-7.

Garven, J.R., Lamm-Tennant, J., 2003. The demand for reinsurance: Theory and empirical tests. *Insurance and Risk Management* 7, 3, 217-237.

Hansen, L.P., 1982. Large sample properties of generalized method of moments estimators. *Econometrica* 50, 4, 1029-1054.

Hausman, J.A., 1978. Specification Tests in Econometrics. *Econometrica* 46, 1251-1272.

Holmstrom, B., Tirole, J., 1998. Public and private supply of liquidity. *Journal of Political Economy* 106, 1-40.

Horváth, R., Seidler, J., Weill, L., 2012. Bank capital and liquidity creation: Granger causality evidence. IOS Working Papers no 318. Institut für Ostund, Südosteuropaforschung (IOS), Regensburg. http://nbn-resolving.de/urn:nbn:de:101:1-201207106474.

Hsiao, C., Zhou, Q., 2018. Jive for panel dynamic simultaneous equations models. *EconometricTheory* 34, 6, 1325-1369.

Hu, L.T., Bentler, P.M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal* 6, 1-55.

Judge, G., Griffiths, W., Hill, R.C., Lutkepohl, H., Lee, T.C., 1980. *The Theory and Practice of Econometrics*, John Wiley and Sons, New York.

Kashyap, A.K., Rajan, R.G., Stein, C.C., 2002. Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking. *Journal of Finance* 57, 33-73.

Kessler, D., 2014. Why insurance is not systemic. *Journal of Risk and Insurance* 81, 477-488.

Kress, R., 1999. *Linear Integral Equations.* Springer, Applied Mathematical Sciences, NewYork.

Li, X., Shiu Y.M. 2021 Reinsurance, debt capacity and financial flexibility. *The Geneva Papers on Risk and Insurance* 46, 664-687.

Liu, H.H., Shiu, Y.M., Liu, T.C., 2016. Reinsurance and liquidity: Evidence from the United Kingdom general insurance industry. The Geneva Papers on Risk and Insurance-Issues and Practice 41, 307-324.

Low, H., Meghir, C., 2017. The use of structural models in econometrics. *Journal of Economic Perspectives* 31, 2, 33-58.

Mankai, S., Belgacem, A., 2016. Interactions between risk-taking, capital, and reinsurance for property-liability insurance firms. *Journal of Risk and Insurance* 83, 1007-1043.

Mayers, D., Smith, C.W. Jr., 1990. On the corporate demand for insurance: Evidence from the reinsurance market. *The Journal of Business* 63, 1, 19-40.

Mitze, T., 2012. Empirical Modelling in Regional Science. In: T. Mitze (Ed.) *Lecture Notes in Economics and Mathematical Systems,* Springer.

Moral-Benito, E., 2013. Likelihood-based estimation of dynamic panels with predetermined regressors. *Journal of Business & Economic Statistics* 31, 451-472.

Munich Re, 2020. Pandemics, climate change, Cyber: Major risks of our time: Better preparation needed. Media release, 4 p. Rethink complexity – Be better prepared for systemic risks, 17 p.

Okui, R., 2009. The optimal choice of moments in dynamic panel data models. *Journal of Econometrics* 151, 1-16.

Powell, L.S., D.W. Sommer, 2007. Internal versus external capital markets in the insurance industry: The role of reinsurance. *Journal of Financial Services Research* 31, 3, 173-188.

Sargan, J.D., 1958. The estimation of economic relationships using instrumental variables. *Econometrica* 26, 393-415.

Satorra, A., Bentler, P.M., 2001. A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika* 66, 4, 507–514. https://doi.org/10.1007/BF02296192.

Schermelleh-Engel K., Moosbrugge H., Müller H., 2003. Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of fit measures. *Methods of Psychological Research Online* 8, 2, 23-74.

Shiu, Y.M., 2011. Reinsurance and capital structure: Evidence from the United Kingdom non-life Insurance Industry. *Journal of Risk and Insurance* 78, 475-494.

Sommer, D.W, 1996. The impact of firm risk on property-liability insurance prices. *Journal Risk of Insurance* 63, 3, 501-514.

Sugawara, H.M., McCallum, R.C., 1993. Effect of equation method on incremental fit indices for covariance structure models. *Applied Psychological Measurement* 17, 365-377.

Teachman, J., Duncan, G.J., Yeung W.J., Levy D., 2001. Covariance structure models for fixed random effects. *Sociological Methods and Research* 30, 271-288.

Thimann, C., 2014. How insurers differ from banks. Working paper no 2014-32, Paris School of Economics, 26 p.

Weiss, M.A., Chung, J.H., 2004. U.S. reinsurance prices, financial quality, and global capacity. *The Journal of Risk and Insurance* 71, 3, 437-467.

Winter, R.A., 1994. The Dynamics of competitive insurance markets. *Journal of Financial Intermediation* 3, 379-415.

Wooldridge, J.M., 2010. *Econometric Analysis of Cross Section and Panel Data*, Second edition. MIT Press, Boston.

Table 1: Liquidity creation measure for an insurer

Step 1: We classify all items in assets, liabilities, and surplus as liquid and illiquid
Step 2: Assign weights to the activities
Step 3: Combine insurance activities as classified in step 1 and as weighted in step 2 to construct the liquidity creation (LC) measure

$$
\begin{aligned}
LC = \; & + \tfrac{1}{2} \times \text{illiquid assets} && - \tfrac{1}{2} \times \text{liquid assets} \\
& + \tfrac{1}{2} \times \text{liquid liabilities} && - \tfrac{1}{2} \times \text{illiquid liabilities} \\
& && - \tfrac{1}{2} \times \text{surplus}
\end{aligned}
$$

Assets	
Illiquid assets (weight = ½)	Liquid assets (weight = – ½)
Mortgage loan	Cash, cash equivalents, and short-term investments
Real estate	Investments in stock and bonds
Other invested assets	
Uncollected premiums and agents' balances	
Electronic data processing equipment and software	
Furniture and equipment	
Liabilities plus surplus	
Liquid liabilities (weight = ½)	Illiquid liabilities plus surplus (weight = –½)
Loss reserves within one year (Net losses and unpaid expenses)	Loss reserves with more than one year
Reinsurance payable on paid losses and loss adjustment expenses	Funds held by company under reinsurance treaties
Other expenses	Provision for reinsurance
Taxes, licenses, and fees	Amounts withheld or retained by company on others' behalf
Current federal and foreign income taxes	Draft outstanding
Net deferred tax liability	Liability for amounts held under uninsured accident and health plans
Unearned premiums	Surplus
Dividends declared unpaid	

Table 2: Control variables: definition, symbol, and construction

Variable name	Symbol	Variable definition and construction
Insurance leverage ratio	Insurance leverage	Direct business written to surplus
Geographical concentration in direct premiums written	Geographical concentration	Herfindahl index defined as $\sum_{l=1}^{55}\left(\frac{PW_l}{TPW}\right)^2$ where PW_l is the value of direct premiums written in each state and TPW represents the insurer's total direct premiums written
Line of business concentration in direct premium written	Line concentration	Herfindahl index defined as $\sum_{l=1}^{22}\left(\frac{PW_l}{TPW}\right)^2$ where PW_l is the value of direct premiums written in each line of business in the insurers' annual statement and TPW represents the insurer's total direct premiums written
Business mix concentration	Mix concentration	Herfindahl index of commercial lines: short and long tails or personal and commercial lines
Regulatory pressure	Regulatory pressure	Dummy variable equal to 1 if firm's net premium to surplus ratio ≥ 300%, 0 otherwise
Liabilities to liquid assets ratio	Liabilities	Dummy variable equal to 1 if firm's adjusted liabilities to liquid assets ratio ≥ 100%, 0 otherwise
Reinsurance price	Reinsurance price	$\frac{Net\,premium\ written - \exp - divp}{D \times losses\ incurred}$ where exp = Commissions, expenses paid and aggregate write-ins for deduction; divp = Dividend paid D is the Discount factor used in Winter (1994) to calculate the economic loss ratio. Losses incurred is losses incurred in current year.
Tax-exemption investment income	Tax exemption	Bond interests exempt from federal taxes plus 70% of dividends received from common and preferred stock to total investment
Information asymmetry	Information asymmetry	Standard deviation of the firm's ROE over the last 5 years
2-yr loss development	Loss development	Estimated losses and loss expense incurred 2 years before current year and prior year scaled by policyholder's surplus ×100
New York license	New York license	Dummy variable equal to 1 if firm is licensed in New York State, 0 otherwise
Cost of capital	Cost of capital	Average of positive ROE over the last 5 years
Firm size	Firm size	Logarithm of total admitted assets
Firm affiliated with a group	Group affiliation	Dummy variable equal to 1 if the insurer is affiliated with a group, 0 otherwise
Capital	Capital	Ratio of surplus to total admitted assets

Table 3: Summary statistics for all insurers

This table provides summary statistics for the 2,792 firms, for the period 1993–2014. Variables are defined in Table 2.

Variable	Obs	Mean	Median	Std	Min	Max
Reins	34,376	0.3723	0.3205	0.2809	0.0000	0.9992
Liquid	34,376	-0.5173	-0.5171	0.2054	-3.2730	0.6358
Insurance leverage	34,376	1.9399	1.2196	2.8694	0.0000	33.0000
Geographical concentration	34,376	0.5792	0.5717	0.3850	0.0303	1.0000
Regulatory pressure	34,376	0.0290	0.0000	0.1678	0.0000	1.0000
Liabilities	34,376	0.1052	0.0000	0.3069	0.0000	1.0000
Line concentration	34,376	0.5512	0.4997	0.2862	0.0991	1.0000
Reinsurance price	34,376	1.3967	1.1854	1.2570	0.0000	12.0000
Tax exemption	34,376	0.2549	0.1912	0.2443	0.0000	1.0000
Information asymmetry	34,376	0.1189	0.0798	0.1393	0.0020	1.1110
Loss development	34,376	-2.5469	-2.2879	19.2171	-73.7500	80.6200
New York license	34,376	0.3275	0.0000	0.4693	0.0000	1.0000
Cost of capital	34,376	0.0805	0.0801	0.1315	-0.4648	0.5280
Firm size	34,376	18.1683	18.1054	1.9889	11.1758	25.8412
Group affiliation	34,376	0.6526	1.0000	0.4761	0.0000	1.0000
Mix concentration	34,376	0.6699	0.5988	0.2480	0.2505	1.0000
Capital	34,376	0.4335	0.3921	0.1880	0.0000	1.0000

Table 4: Endogeneity test using reinsurance demand as dependent variable

	Statistic	Degree of freedom	*p*-value of the test	Decision about endogeneity
Panel A: Estimation using fixed effects estimate				
Reins and liquid endogenous	322.21	2	0.0000	Yes
Liquid endogenous[1]	469.67	2	0.0000	Yes
Panel B: Estimation using random effects estimate				
Reins and liquid endogenous	459.45	2	0.0000	Yes
Liquid endogenous[1]	472.05	2	0.0000	Yes

Panel C: Estimation using GMM regularization[2]

TH GMM			LF GMM		
Statistic	*p*-value	Decision	Statistic	*p* -value	Decision
120.487	0.000	Yes	102.08	0.000	Yes

[1] Same test with only liquidity creation as endogenous variable.
[2] TH GMM is for Tikhonov regularized GMM, and LF GMM is for Landweber-Fridman regularized GMM.

Table 5: Endogeneity test using liquidity creation as dependent variable

	Statistic	Degree of freedom	*p*-value of the test	Decision about endogeneity
Panel A: Estimation using fixed effects estimate				
Reins and liquid endogenous	262.47	2	0.0000	Yes
Liquid endogenous[1]	270.97	2	0.0000	Yes
Panel B: Estimation using random effects estimate				
Reins and liquid endogenous	234.54	2	0.0000	Yes
Liquid endogenous[1]	223.12	2	0.0000	Yes

Panel C: Estimation using GMM regularization[2]

TH GMM			LF GMM		
Statistic	*p*-value	Decision	Statistic	*p* -value	Decision
150.897	0.000	Yes	197.57	0.000	Yes

[1] Same test with only reinsurance demand as endogenous variable.
[2] TH GMM is for Tikhonov regularized GMM, and LF GMM is for Landweber-Fridman regularized GMM.

Table 6: Demand for reinsurance and liquidity creation for all firms during the 1993–2014 period, with generalized method of moments

This table presents the coefficients and *p*-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals, and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at all significance levels. Control variables are defined in Table 2.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
Variable	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.8380	0.0078	0.7869	0.0242	0.7672	0.0218
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0510	0.8035	0.0801	0.6371	0.0781	0.6052
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Insurance leverage $_t$	0.0078		0.0081		0.0089	
	(0.000)		(0.000)		(0.000)	
Geographical concentration $_t$	-0.0210	-0.0118	-0.0298	-0.0251	-0.0358	-0.02104
	(0.1781)	(0.205)	(0.000)	(0.2871)	(0.000)	(0.3038)
Regulatory pressure $_t$	-0.0287	0.0248	-0.0970	0.0510	-0.0887	0.0463
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Liabilities $_t$	0.0089		0.0204		0.0191	
	(0.1081)		(0.004)		(0.0407)	
Line concentration $_t$	-0.0148	-0.0061	-0.0610	-0.0321	-0.0708	-0.0258
	(0.000)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Reinsurance price $_t$	-0.0018	0.0029	-0.0185	0.0109	-0.0147	0.0120
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)
Tax exemption $_t$	0.0072	-0.0038	0.0107	-0.0087	0.0098	-0.0069
	(0.105)	(0.000)	(0.0981)	(0.000)	(0.1520)	(0.000)
Information asymmetry $_t$	0.0174	0.0136	0.0198	-0.0093	0.0230	-0.0021
	(0.024)	(0.247)	(0.005)	(0.1289)	(0.0120)	(0.1480)
Loss development $_t$	1.7E-5	0.008	2.05E-5	0.0082	2.01E-5	0.0089
	(0.102)	(0.3204)	(0.1782)	(0.4081)	(0.2587)	(0.4370)
New York license $_t$	0.0102	4.90E-4	0.0380	-2.1E-4	0.0481	-1.4E-4
	(0.000)	(0.2501)	(0.000)	(0.2428)	(0.000)	(0.3480)
Cost of capital $_t$	-0.0201	-0.0108	-0.0745	-0.0307	-0.0673	-0.0274
	(0.008)	(0.000)	(0.0427)	(0.000)	(0.019)	(0.000)
Firm size $_t$	-0.0028	0.0201	-0.0154	0.0131	-0.0187	0.0214
	(0.0689)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Group affiliation $_t$	0.0201	-0.0102	0.0408	-0.0047	0.0378	-0.0066
	(0.000)	(0.245)	(0.000)	(0.4241)	(0.000)	(0.2648)
Mix concentration $_t$	0.0180	-0.0057	0.0440	-0.0181	0.0345	-0.0207
	(0.2810)	(0.1089)	(0.2078)	(0.3280)	(0.2489)	(0.4483)
Capital $_t$	0.0271		0.0917		0.0987	
	(0.000)		(0.000)		(0.000)	
p-value of the J-test	0.0041	0.0008	0.2187	0.2871	0.5297	0.4786
Number of observations			34,376			
Number of firms			2,792			

Table 7: Test of variable exogeneity for the ML-SEM model

All insurers present each year during the 1992–2014 period. Robust standard errors are used to obtain reported *p*-values for the test: $H_0 : \phi_{jk} = 0$. Variables are defined in Table 2. Those with a *p*-value greater than 0.10 are exogenous variables.

Variable	$Reins_t$	$Liquid_t$
Insurance leverage $_{t+1}$	0.015	
Regulatory pressure $_{t+1}$	0.050	0.101
Reinsurance price $_{t+1}$	0.129	0.015
Cost of capital $_{t+1}$		0.494
Tax exemption $_{t+1}$	0.103	0.602
Information asymmetry $_{t+1}$		0.000
Capital $_{t+1}$	0.560	
Number of observations	10,269	
Number of firms	489	

Table 8: Estimates with ML-SME model for all insurers present each year during the 1992–2014 period with standardized control variables

All goodness of fit measures have acceptable values. Robust standard errors are used to obtain confidence intervals, and the corresponding *p*-values are reported in parentheses. Control variables are defined in Table 2 and their tests of exogeneity are documented in Table 7.

Variable	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.8725	0.0695
	(0.000)	(0.000)
$Liquid_{t-1}$	0.0705	0.8912
	(0.000)	(0.000)
Insurance leverage $_t$	0.0578	
	(0.000)	
Regulatory pressure $_t$	-0.0193	0.0220
	(0.000)	(0.000)
Reinsurance price $_t$	-0.0428	0.0181
	(0.000)	(0.002)
Cost of capital $_t$		-0.0318
		(0.000)
Tax exemption $_t$	0.0053	0.0025
	(0.298)	(0.657)
Information asymmetry $_t$		-0.0202
		(0.001)
Capital $_t$	0.0872	
	(0.000)	
Number of observations	10,269	
Number of firms	489	
Goodness of fit measure		
RMSEA_SB	0.033	0.035
CFI_SB	0.944	0.931
TLI_SB	0.924	0.907
SRMR	0.017	0.026

Note: According to Hu and Bentler (1999) and Browne and Cudeck (1992) a value for the Root Mean Square Error of Approximation (RMSEA_SB) less than 0.08 and 0.06, respectively, is a good fit. The Satorra-Bentler (2001, SB) scaled test is robust to nonnormality. See Online Appendix A2.3 for more details on goodness of fit measures.

Table 9: Estimation of Table 8 model with GMM from 1992 to 2014

This table presents the coefficients and *p*-values obtained from the GMM method of estimation with the same specifications and number of observations as in Table 8. Robust standard errors are used to obtain confidence intervals, and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at all significance levels. Variables are defined in Table 2.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
Variable	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.9040 (0.000)	0.047 (0.000)	0.8140 (0.000)	0.0541 (0.000)	0.7981 (0.000)	0.0621 (0.000)
$Liquid_{t-1}$	0.0389 (0.000)	0.9420 (0.000)	0.0647 (0.000)	0.8758 (0.000)	0.0710 (0.000)	0.8691 (0.000)
Insurance leverage $_t$	0.0281 (0.000)		0.0534 (0.000)		0.0487 (0.000)	
Regulatory pressure $_t$	-0.023 (0.0560)	0.024 (0.000)	-0.0381 (0.000)	0.0451 (0.000)	-0.0359 (0.000)	0.0385 (0.000)
Reinsurance price $_t$	-0.013 (0.000)	0.002 (0.080)	-0.045 (0.000)	0.0064 (0.0937)	-0.047 (0.000)	0.0044 (0.162)
Cost of capital $_t$		-0.037 (0.000)		-0.0720 (0.000)		-0.068 (0.000)
Tax exemption $_t$	0.0077 (0.390)	0.0031 (0.286)	0.0021 (0.524)	0.0134 (0.308)	0.0028 (0.598)	0.0159 (0.387)
Information asymmetry $_t$		-0.0431 (0.000)		-0.0246 (0.000)		-0.024 (0.000)
Capital $_t$	0.1624 (0.000)		0.198 (0.000)		0.186 (0.000)	
p-value of the J-test	0.0066	0.0048	0.8420	0.7851	0.8657	0.7731
Number of observations	10,269					
Number of firms	489					

Table 10: Estimation of demand for reinsurance and liquidity creation for all firms with recession variables during the 1993–2014 period, with generalized method of moments

This table presents the coefficients and *p*-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals, and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at all significance levels. Control variable coefficients are not reported, and dummy variables are added to control for the 2001 and the 2007–2008 recessions.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
Variable	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.8091	0.0146	0.7431	0.0108	0.7314	0.0128
	(0.000)	(0.044)	(0.000)	(0.046)	(0.000)	(0.032)
$Liquid_{t-1}$	0.0213	0.7981	0.084	0.6821	0.0867	0.6891
	(0.008)	(0.000)	(0.005)	(0.000)	(0.000)	(0.000)
2007-2008	0.007	0.0045	0.0052	0.008	0.0050	0.0067
	(0.0471)	(0.184)	(0.0354)	(0.1840)	(0.0387)	(0.1262)
2001	0.0044	0.017	0.0073	0.0424	0.0072	0.0536
	(0.0974)	(0.027)	(0.318)	(0.021)	(0.183)	(0.004)
p-value of the J-test	0.0083	0.0016	0.2389	0.2367	0.5939	0.4584
Number of observations	34,376					
Number of firms	2,792					

Reinsurance demand and liquidity creation: A search for bi-causality*

Denise Desjardins[†], Georges Dionne[†], and N'Golo Koné[‡]

20 January 2022

Online Appendix

[†] Canada Research Chair in Risk Management, HEC Montréal. Corresponding author: Georges Dionne, Canada Research Chair in Risk Management, HEC Montréal, 3000, Côte-Ste-Catherine, room 4.454. Phone: 1-514-340-6596. Email: georges.dionne@hec.ca.

[‡]Departments of Economics, Université de Montréal and Queen's University.

A1. Additional tables

Table A1.1: Correlations between liquidity creation ratio and reinsurance demand with different weights in creating the liquidity creation ratio.

	Liquid.50	Liquid.25	Reins
Liquid .50	1.00000	1.00000 (<0.0001)	-0.01201 (0.00230)
Liquid .25		1.00000	-0.01201 (0.00230)
Reins			1.00000

Note: We observe that using .50 or .25 as weight in creating the liquidity creation ratio does not affect the correlation between current liquidity creation and current reinsurance demand since the two liquidity ratio variables have a correlation equal to one. We did also the analysis with .33 and the results are the same.

Table A1.2: Summary statistics – Large insurers

This table provides summary statistics for the 100 large firms during the period 1993-2014. Variables are defined in Table 2.

Variable	Obs	Mean	Median	Std	Min	Max
Reins	1,236	0.3055	0.2472	0.2549	0.0000	0.9486
Liquid	1,236	-0.5138	-0.5090	0.1409	-0.9949	0.2610
Insurance leverage	1,236	0.7385	0.5610	0.7832	0.0000	7.1079
Geographical concentration	1,236	0.1824	0.0716	0.2618	0.0331	1.0000
Regulatory pressure	1,236	0.0138	0.0000	0.1165	0.0000	1.0000
Liabilities	1,236	0.3277	0.0000	0.4696	0.0000	1.0000
Line concentration	1,236	0.3752	0.3053	0.2348	0.1038	1.0000
Reinsurance price	1,236	1.3470	1.1484	1.4292	0.0000	12.0000
Tax exemption	1,236	0.3827	0.3741	0.2062	0.0000	0.9753
Information asymmetry	1,236	0.0966	0.0693	0.0960	0.0045	1.1110
Loss development	1,236	0.0939	-1.9743	16.6341	-73.7500	80.6200
New York license	1,236	0.8131	1.0000	0.3900	0.0000	1.0000
Cost of capital	1,236	0.1156	0.1131	0.1002	-0.4648	0.4745
Firm size	1,236	22.8221	22.6129	0.7802	21.8226	25.8412
Group affiliation	1,236	0.9693	1.0000	0.1727	0.0000	1.0000
Mix concentration	1,236	0.5526	0.4969	0.2016	0.2567	1.0000
Capital	1,236	0.3715	0.3401	0.1463	0.0521	0.9893

Table A1.3: Summary statistics – Medium insurers

This table provides summary statistics for the 235 medium firms during the period 1993-2014. Variables are defined in Table 2.

Variable at time t	Obs	Mean	Median	Std	Min	Max
Reins	1,993	0.3603	0.3291	0.2578	0.0000	0.9958
Liquid	1,993	-0.5153	-0.5201	0.1545	-0.9503	0.2079
Insurance leverage	1,993	1.1799	0.9179	1.1267	0.0000	13.2395
Geographical concentration	1,993	0.3337	0.1324	0.3585	0.0320	1.0000
Regulatory pressure	1,993	0.0166	0.0000	0.1276	0.0000	1.0000
Liabilities	1,993	0.1761	0.0000	0.3810	0.0000	1.0000
Line concentration	1,993	0.4302	0.3355	0.2661	0.0991	1.0000
Reinsurance price	1,993	1.2764	1.1555	0.8381	0.0000	12.0000
Tax exemption	1,993	0.3644	0.3423	0.2351	0.0000	0.9922
Information asymmetry	1,993	0.1018	0.0735	0.1198	0.0024	1.1110
Loss development	1,993	-2.8312	-3.3556	16.2145	-73.7500	80.6200
New York license	1,993	0.6342	1.0000	0.4818	0.0000	1.0000
Cost of capital	1,993	0.1101	0.1047	0.1184	-0.4648	0.5280
Firm size	1,993	21.2338	21.2088	0.2912	20.7238	21.8210
Group affiliation	1,993	0.9498	1.0000	0.2184	0.0000	1.0000
Mix concentration	1,993	0.6044	0.5219	0.2303	0.2521	1.0000
Capital	1,993	0.3642	0.3356	0.1359	0.0469	0.9986

Table A1.4: Summary statistics – Small insurers

This table provides summary statistics for the 2,658 small firms during the period 1993-2014. Variables are defined in Table 2.

Variable	Obs	Mean	Median	Std	Min	Max
Reins	30,753	0.3758	0.3229	0.2832	0.0000	0.9992
Liquid	30,753	-0.5178	-0.5171	0.2108	-3.2730	0.6358
Insurance leverage	30,753	2.0463	1.3004	2.9933	0.0000	33.0000
Geographical concentration	30,753	0.6145	0.6654	0.3751	0.0303	1.0000
Regulatory pressure	30,753	0.0305	0.0000	0.1721	0.0000	1.0000
Liabilities	30,753	0.0898	0.0000	0.2860	0.0000	1.0000
Line concentration	30,753	0.5670	0.5083	0.2849	0.1139	1.0000
Reinsurance price	30,753	1.4078	1.1903	1.2727	0.0000	12.0000
Tax exemption	30,753	0.2415	0.1709	0.2428	0.0000	1.0000
Information asymmetry	30,753	0.1207	0.0808	0.1414	0.0020	1.1110
Loss development	30,753	-2.6989	-2.2443	19.4673	-73.7500	80.6200
New York license	30,753	0.2835	0.0000	0.4507	0.0000	1.0000
Cost of capital	30,753	0.0771	0.0772	0.1328	-0.4648	0.5280
Firm size	30,753	17.7449	17.8334	1.6180	11.1758	20.7224
Group affiliation	30,753	0.6169	1.0000	0.4862	0.0000	1.0000
Mix concentration	30,753	0.6790	0.6136	0.2490	0.2505	1.0000
Capital	30,753	0.4416	0.4008	0.1912	0.0000	1.0000

Table A1.5: Number of years of observations for each firm by period

Number of years of observations	1992-1999		2000-2007		2008-2014	
	N	%	N	%	N	%
4	156	8.30	169	9.84	191	11.29
5	218	11.60	167	9.73	192	11.35
6	152	8.09	163	9.49	201	11.88
7	281	14.95	155	9.03	1,108	65.48
8	1,072	57.05	1,063	61.91	--------	--------
Number of firms	1,879	100.00	1,717	100.00	1,692	100.00

Table A1.6: Demand for reinsurance and liquidity creation by size of firms
during the 1993-2014 period with standard GMM

This table presents the coefficients and *p*-values obtained from the standard GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at all significance levels. Control variables results are not reported.

Variable	Large firms		Medium firms		Small firms	
	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance $_{t-1}$	0.9074	0.0061	0.8171	0.0204	0.8014	0.0214
	(0.000)	(0.624)	(0.000)	(0.6528)	(0.000)	(0.000)
Liquidity creation ratio $_{t-1}$	0.0531	0.7341	0.0321	0.8104	0.0240	0.8014
	(0.2100)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0081	0.0051	0.0000	0.0000	0.004	0.0045
Number of observations	1,236		1,993		30,753	
Number of firms	100		235		2,658	

Table A1.7: Demand for reinsurance and liquidity creation by size of firms during the 1993-2014 period with Tikhonov regularized GMM

This table presents the coefficients and *p*-values obtained from the Tikhonov regularized GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The Tikhonov regularized GMM is not rejected. Control variables results are not reported.

	Large firms		Medium firms		Small firms	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance $_{t-1}$	0.8241	-0.0341	0.7781	0.0140	0.7201	0.0471
	(0.000)	(0.6814)	(0.000)	(0.837)	(0.000)	(0.000)
Liquidity creation ratio $_{t-1}$	0.0320	0.6687	0.091	0.6914	0.0651	0.7810
	(0.2731)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.1687	0.1693	0.2312	0.1258	0.2481	0.1810
Number of observations	1,236		1,993		30,753	
Number of firms	100		235		2,658	

Table A1.8: Demand for reinsurance and liquidity creation by size of firms during the 1993-2014 period with Landweber-Fridman regularized GMM

This table presents the coefficients and *p*-values obtained from the Landweber-Fridman GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The Landweber-Fridman regularized GMM is not rejected. Control variables results are not reported.

	Large firms		Medium firms		Small firms	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance $_{t-1}$	0.8041	-0.0291	0.7541	0.0154	0.7021	0.0441
	(0.000)	(0.427)	(0.000)	(0.548)	(0.000)	(0.000)
Liquidity creation ratio $_{t-1}$	0.0314	0.6587	0.084	0.7104	0.0642	0.7714
	(0.4236)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.2890	0.3435	0.2425	0.2574	0.4574	0.3281
Number of observations	1,236		1,993		30,753	
Number of firms	100		235		2,658	

Table A1.9: Test of variable exogeneity for small firms using the ML-SEM model

Small insurers that are present each year during the 1992-2014 period. *p*-values for the test: $H_0 : \phi_{jk} = 0$ are reported. Variables are defined in Table 2. Those with *p*-value greater than 0.10 are exogenous variables.

Variable	$Reins_t$	$Liquid_t$
Insurance leverage $_{t+1}$	0.015	
Regulatory pressure $_{t+1}$	0.164	0.042
Reinsurance price $_{t+1}$	0.046	0.046
Cost of capital $_{t+1}$		0.497
Tax exemption $_{t+1}$	0.118	0.755
Information asymmetry $_{t+1}$		0.000
Capital $_{t+1}$	0.365	
Number of observations	7,750	
Number of firms	360	

Table A1.10: Estimates with ML-SME model for small insurers present each year during the 1992-2014 period with standardized control variables

All goodness of fit measures have acceptable values. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Control variables are defined in Table 2 and their tests of exogeneity is documented in Table A1.9.

Variable	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.8853	0.0495
	(0.000)	(0.000)
$Liquid_{t-1}$	0.0739	0.8727
	(0.000)	(0.000)
Insurance leverage $_t$	0.0592	
	(0.000)	
Regulatory pressure $_t$	-0.0177	0.0273
	(0.000)	(0.000)
Reinsurance price $_t$	-0.0420	0.0125
	(0.000)	(0.052)
Cost of capital $_t$		-0.0412
		(0.000)
Tax exemption $_t$	0.0067	0.0041
	(0.226)	(0.501)
Information asymmetry $_t$		-0.0123
		(0.112)
Capital $_t$	0.0878	
	(0.000)	
Number of observations	7,560	
Number of firms	360	
Goodness of fit measure		
RMSEA_SB	0.041	0.042
CFI_SB	0.922	0.921
TLI_SB	0.895	0.882
SRMR	0.021	0.029

Table A1.11: Estimates by GMM for small insurers present each year during the 1992-2014 period.

This table presents the coefficients and *p*-values obtained from the GMM method of estimation with the same specifications and numbers of observations as in Table A1.10. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at 10%. Variables are defined in Table 2.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance	0.9204 (0.000)	0.0356 (0.000)	0.7210 (0.000)	0.0641 (0.000)	0.7178 (0.000)	0.0661 (0.000)
Liquidity creation ratio	0.0574 (0.000)	0.7891 (0.000)	0.0614 (0.000)	0.6981 (0.000)	0.0631 (0.000)	0.6841 (0.000)
Insurance leverage	0.0361 (0.000)		0.0318 (0.000)		0.0294 (0.000)	
Regulatory pressure	-0.0217 (0.000)	0.0235 (0.000)	-0.0361 (0.000)	0.041 (0.000)	-0.0378 (0.000)	0.043 (0.000)
Reinsurance price	-0.0321 (0.000)	0.0310 (0.000)	-0.042 (0.000)	0.046 (0.000)	-0.0461 (0.000)	0.0410 (0.000)
Cost of capital		-0.038 (0.000)		-0.0460 (0.000)		-0.0426 (0.000)
Tax exemption	0.0167 (0.686)	0.0051 (0.4361)	0.0371 (0.633)	0.0121 (0.591)	0.0351 (0.4721)	0.0201 (0.386)
Information asymmetry		-0.0216 (0.324)		-0.0461 (0.664)		-0.0394 (0.5313)
Capital	0.0614 (0.000)		0.0910 (0.000)		0.0861 (0.000)	
p-value of the J-test	0.0547	0.0439	0.9361	0.8814	0.9641	0.7427
Number of observations	7,560					
Number of firms	360					

Table A1.12: Test of exogeneity for ML-SEM model for shorter periods than 1992-2014

All firms in shorter sub-periods during the 1992-2014 period. Robust standard errors are used to obtain reported *p*-values for the test: $H_0 : \phi_{jk} = 0$. Variables are defined in Table 2. Those with a *p*-value greater than 0.10 are exogenous variables.

	1992-1999		2000-2007		2008-2014	
Variable	Reins $_t$	Liquid $_t$	Reins $_t$	Liquid $_t$	Reins $_t$	Liquid $_t$
At time $_{t+1}$						
Insurance leverage $_{t+1}$	0.007		0.001		0.168	
Regulatory pressure $_{t+1}$	0.201	0.000	0.012	0.017	0.009	0.135
Reinsurance price $_{t+1}$	0.093	0.000	0.036	0.001	0.013	0.023
Cost of capital $_{t+1}$		0.132		0.024		0.513
Tax exemption $_{t+1}$	0.069	0.009	0.838	0.844	0.883	0.013
Information asymmetry $_{t+1}$		0.006		0.002		0.001
Capital $_{t+1}$	0.066		0.316		0.847	
Number of observations	7,504		7,441		6,648	
Number of firms	1,072		1,063		1,108	

Table A1.13: Estimations for the ML-SEM model for shorter periods than 1992-2014

For all insurers during the 1992-2014 period with non-standardized control variables. All goodness of fit measures have acceptable values under the non-normality assumption. The Satorra-Bentler (SB) approach is used to compute standard error and the corresponding *p*-values are reported in parentheses. Control variables are defined in Table 2 and their tests of exogeneity is documented in Table A1.12.

Variable	1992-1999 Reins $_t$	1992-1999 Liquid $_t$	2000-2007 Reins $_t$	2000-2007 Liquid $_t$	2008-2014 Reins $_t$	2008-2014 Liquid $_t$
Reins $_{t-1}$	0.8068 (0.000)	0.2264 (0.000)	0.7971 (0.000)	0.0734 (0.009)	0.7990 (0.000)	0.1252 (0.000)
Liquid $_{t-1}$	0.2030 (0.000)	0.8846 (0.000)	0.0777 (0.000)	0.7557 (0.000)	0.0684 (0.000)	0.6973 (0.000)
Insurance leverage $_t$	0.1163 (0.002)		0.1331 (0.000)		0.0789 (0.001)	
Regulatory pressure $_t$	-0.0374 (0.000)	0.0646 (0.000)	-0.0442 (0.000)	0.0907 (0.000)	-0.0367 (0.010)	0.0412 (0.000)
Reinsurance price $_t$	-0.0363 (0.001)	0.0283 (0.045)	-0.0589 (0.000)	0.0341 (0.060)	-0.0386 (0.000)	-0.0114 (0.290)
Cost of capital $_t$		-0.0262 (0.096)		0.0226 (0.308)		-0.0156 (0.218)
Tax exemption $_t$	0.0207 (0.389)	0.0044 (0.862)	0.0075 (0.495)	0.0381 (0.010)	0.0183 (0.069)	-0.0164 (0.596)
Information asymmetry $_t$		-0.0322 (0.052)		0.0018 (0.926)		0.0008 (0.963)
Capital $_t$	0.1790 (0.000)		0.0888 (0.001)		0.0855 (0.000)	
Number of observations	7,504		7,441		6,648	
Number of firms	1,072		1,063		1,108	
Goodness of fit measure						
RMSEA_SB	0.035	0.029	0.024	0.033	0.024	0.036
CFI_SB	0.977	0.983	0.989	0.973	0.991	0.977
TLI_SB	0.957	0.967	0.982	0.950	0.986	0.960
SRMR	0.008	0.013	0.007	0.012	0.005	0.010

Table A1.14: Standard GMM Estimation for shorter periods than 1992-2014

This table presents the coefficients and *p*-values obtained for all firms from the standard GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at 5 %. Coefficients for control variables are not reported.

	1992-1999		2000-2007		2008-2014	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance	0.9148 (0.000)	0.0564 (0.000)	0.9351 (0.000)	0.0681 (0.000)	0.9552 (0.000)	0.0715 (0.000)
Liquidity creation ratio	0.0674 (0.000)	0.8104 (0.000)	0.0541 (0.008)	0.7678 (0.000)	0.0268 (0.000)	0.7814 (0.000)
p-value of the J-test	0.0410	0.0089	0.0389	0.0097	0.0440	0.0078
Number of observations	7,504		7,441		6,648	
Number of firms	1,072		1,063		1,108	

Table A1.15: GMM estimation with Tikhonov method for shorter periods than 1992-2014

This table presents the coefficients and *p*-values obtained for all firms from the Tikhonov GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The model is not rejected. Coefficients for control variables are not reported.

	1992-1999		2000-2007		2008-2014	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance	0.6758 (0.000)	0.0725 (0.000)	0.6897 (0.000)	0.0667 (0.000)	0.7104 (0.000)	0.0671 (0.000)
Liquidity creation ratio	0.0814 (0.000)	0.6894 (0.000)	0.078 (0.000)	0.6914 (0.000)	0.0614 (0.000)	0.7140 (0.000)
p-value of the J-test	0.9781	0.9614	0.9014	0.8813	0.9834	0.7324
Number of observations	7,504		7,441		6,648	
Number of firms	1,072		1,063		1,108	

Table A1.16: GMM estimation with Landweber-Fridman method
for shorter periods than 1992-2014

This table presents the coefficients and *p*-values obtained for all firms from the Landweber-Fridman GMM method. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The model is not rejected. Coefficients for control variables are not reported.

	1992-1999		2000-2007		2008-2014	
Variable	Reins	Liquid	Reins	Liquid	Reins	Liquid
Demand for reinsurance	0.6871 (0.000)	0.0681 (0.000)	0.6984 (0.000)	0.0671 (0.000)	0.7091 (0.000)	0.0681 (0.000)
Liquidity creation ratio	0.0741 (0.000)	0.6914 (0.000)	0.076 (0.000)	0.7061 (0.000)	0.0598 (0.000)	0.7104 (0.000)
p-value of the J-test	0.9624	0.8621	0.9777	0.8914	0.9715	0.7245
Number of observations	7,504		7,441		6,648	
Number of firms	1,072		1,063		1,108	

Table A1.17: OLS fixed effects summary results
Control variables are defined in Table 2.

Variable	All firms		Large firms		Medium firms		Small firms	
	R	L	R	L	R	L	R	L
Reins $_{t-1}$	+	+	+	NS	+	NS	+	+
Liquid $_{t-1}$	+	+	NS	+	+**	+	+	+
Insurance leverage $_{t}$	+	----	+	----	+	----	+	----
Geographical concentration $_{t}$	-	-**	-	-	NS	NS	-	-*
Regulatory pressure $_{t}$	-	+	NS	NS	NS	+	-	+
Liabilities $_{t}$	+	----	NS	----	NS	----	+	----
Line concentration $_{t}$	-	-	-	NS	NS	NS	-	-
Reinsurance price $_{t}$	-	+	-*	NS	-	+**	-	+
Tax exemption $_{t}$	NS	-	NS	NS	NS	NS	NS	-
Information asymmetry $_{t}$	+	NS	NS	+	NS	NS	+	NS
Loss development $_{t}$	NS	+	NS	NS	NS	NS	NS	-
New York license $_{t}$	+	NS	-**	NS	+**	NS	+	NS
Cost of capital $_{t}$	-*	-	NS	NS	NS	NS	-**	-
Firm size $_{t}$	-	+	NS	NS	NS	+	-	+
Group affiliation $_{t}$	+	NS	NS	NS	NS	+	+	NS
Mix concentration $_{t}$	NS	NS	+	NS	NS	NS	NS	NS
Capital $_{t}$	+	----	+	----	+	----	+	----
Number of observations	34,376		1,236		1,993		30,753	

R: Reinsurance demand L: Liquidity creation ratio;
NS: Not significance at 10%; ** Significant at 5%; * Significant at 10% ± Significant at 1%

Table A1.18: Standard GMM summary results
Control variables are defined in Table 2.

Variable	All firms R	All firms L	Large firms R	Large firms L	Medium firms R	Medium firms L	Small firms R	Small firms L
Reins $_{t-1}$	+	+	+	NS	+	NS	+	+
Liquid $_{t-1}$	+	+	NS	+	+	+	+	+
Insurance leverage $_t$	+	----	+	----	+	----	+*	----
Geographical concentration $_t$	NS	NS	-	-	-*	NS	-	NS
Regulatory pressure $_t$	-	+	NS	NS	NS	+	-	+
Liabilities $_t$	NS	----	NS	----	NS	----	+*	----
Line concentration $_t$	-	-	-	NS	NS	NS	-	-
Reinsurance price $_t$	-	+	NS	NS	-*	+	-	+
Tax exemption $_t$	NS	-	NS	NS	NS	NS	NS	-
Information asymmetry $_t$	+**	NS	NS	+	NS	NS	+	NS
Loss development $_t$	NS	NS	NS	NS	NS	NS	NS	NS
New York license $_t$	+	NS	-	NS	+	NS	+	NS
Cost of capital $_t$	-	-	NS	NS	NS	NS	-	-
Firm size $_t$	-	+	NS	NS	NS	+	-	+
Group affiliation $_t$	+	NS	NS	NS	+	NS	+	NS
Mix concentration $_t$	NS	NS	NS	NS	NS	NS	NS	NS
Capital $_t$	+	----	+	----	+	----	+	----
Number of observations	34,376		1,236		1,993		30,753	

R: Reinsurance demand L: Liquidity creation ratio;
NS: Not significance at 10%; ** Significant at 5%; * Significant at 10% ± Significant at 1%

Table A1.19: Landweber-Fridman regularized GMM summary results
Control variables are defined in Table 2.

Variable	All firms		Large firms		Medium firms		Small firms	
	R	L	R	L	R	L	R	L
Reins $_{t-1}$	+	+	+	NS	+	NS	+	+
Liquid $_{t-1}$	+	+	NS	+	+	+	+	+
Insurance leverage $_t$	+	----	+	----	+	----	+**	----
Geographical concentration $_t$	-	NS	-	-	NS	NS	-	NS
Regulatory pressure $_t$	-	+	NS	NS	NS	+	-	+
Liabilities $_t$	+**	----	NS	----	NS	----	+	----
Line concentration $_t$	-	-	-	NS	NS	NS	-	-
Reinsurance price $_t$	-	+	-	NS	-	+	-	+
Tax exemption $_t$	NS	-	NS	NS	NS	NS	NS	-
Information asymmetry $_t$	+**	NS	NS	+	NS	NS	+	NS
Loss development $_t$	NS	NS	NS	NS	NS	NS	NS	-*
New York license $_t$	+	NS	-	NS	+	NS	+	NS
Cost of capital $_t$	-**	-	NS	NS	NS	NS	-	-
Firm size $_t$	-	+	NS	NS	NS	+	-	+
Group affiliation $_t$	+	NS	NS	NS	NS	+	+	NS
Mix concentration $_t$	NS	NS	+	NS	NS	NS	NS	NS
Capital $_t$	+	----	+	----	+	----	+	----
Number of observations	34,376		1,236		1,993		30,753	

R: Reinsurance demand L: Liquidity creation ratio;
NS: Not significance at 10%; ** Significant at 5%; * Significant at 10% ± Significant at 1%

Table A1.20: Tikhonov regularized GMM summary results
Control variables are defined in Table 2.

Variable	All firms		Large firms		Medium firms		Small firms	
	R	L	R	L	R	L	R	L
Reins $_{t-1}$	+	+	+	NS	+	NS	+	+
Liquid $_{t-1}$	+	+	NS	+	+	+	+	+
Insurance leverage $_t$	+	----	+	----	+	----	+**	----
Geographical concentration $_t$	-	NS	-	-	NS	NS	-	NS
Regulatory pressure $_t$	-	+	NS	NS	NS	+	-	+
Liabilities $_t$	+	----	NS	----	NS	----	+	----
Line concentration $_t$	-	-	-	NS	NS	NS	-	-
Reinsurance price $_t$	-	+	-	NS	-	+	-	+
Tax exemption $_t$	+*	-	NS	NS	NS	NS	NS	-
Information asymmetry $_t$	+	NS	NS	+	NS	NS	+	NS
Loss development $_t$	NS	NS	NS	NS	NS	+*	NS	-*
New York license $_t$	+	NS	-	NS	+	NS	+	NS
Cost of capital $_t$	-**	-	NS	NS	NS	NS	-	-
Firm size $_t$	-	+	NS	NS	NS	+	-	+
Group affiliation $_t$	+	NS	NS	NS	NS	+	+	NS
Mix concentration $_t$	NS	NS	+	NS	NS	NS	NS	NS
Capital $_t$	+	----	+	----	+	----	+	----
Number of observations	34,376		1,236		1,993		30,753	

R: Reinsurance demand L: Liquidity creation ratio;
NS: Not significance at 10%; ** Significant at 5%; * Significant at 10% ± Significant at 1%

A2. Econometric models

A2.1 GMM models

We first consider the standard GMM method. Without loss of generality, we assume that each component of (2) can be written as follows:

$$y_{i,t} = \theta z_{i,t} + \alpha_i + \varepsilon_{i,t} \tag{A.1}$$

where $\theta = (\delta, \gamma')'$ is the vector of parameters of interest, with δ as the autoregressive coefficient in the dynamic panel associated with the lagged level of the dependent variable; and $z_{it} = \left(y_{i,t-1}, m_{i,t}^{'}\right)$ is the vector of explanatory variables including the lagged level of the dependent variable and other covariates at *t*. Let *A* denote the forward orthogonal deviation operator (Arellano and Bover, 1995). *A* is a matrix equal to $(T-1)\times T$. Multiplying the model by *A*, (A.1) becomes

$$y_{i,t}^{*} = \theta z_{i,t}^{*} + \varepsilon_{i,t}^{*} \tag{A.2}$$

with

$$E\left[z_{i,t-s}\varepsilon_{i,t}^{*}\right] = 0 \tag{A.3}$$

for $s = 0,...t-1$ and $t = 1,...T-1$, and where *s* is for periods before *t*. We also have

$$z_i^{*} = Az_i,\ y_i^{*} = Ay_i \text{ and } \varepsilon_i^{*} = A\varepsilon_i.$$

We first estimate θ by the standard GMM method, based on the following set of moment conditions:

$$E\left[Z_i\varepsilon_i^{*}\right] = 0, \tag{A.4}$$

for $i = 1,...,N$ with $\varepsilon_i^{*} = \left(\varepsilon_{i,1}^{*},...\varepsilon_{i,T-1}^{*}\right)'$. In a compact form, the standard GMM estimator of θ is given by

$$\hat{\theta} = \frac{(z^*)' M y^*}{(z^*)' M x^*} \tag{A.5}$$

with

$$M = Z(Z'Z)^{-1} Z' = \frac{Z}{\sqrt{NT}} \left(\frac{Z'Z}{NT} \right)^{-1} \frac{Z'}{\sqrt{NT}} = \frac{Z}{\sqrt{NT}} K_N^{-1} \frac{Z'}{\sqrt{NT}},$$

where $K_N = \frac{Z'Z}{NT}$ is the sample covariance matrix of the orthogonality conditions, $Z = \left(Z_1^{'}, ..., Z_N^{'} \right)$ is a $N(T-1) \times \overline{q}$ block diagonal matrix, and $\overline{q}$ is the number of moment conditions in the estimation process $T\frac{T-1}{2}$. According to Doran and Schmidt (2006), in applications with many instruments, the marginal contribution of some instruments can be small in the standard GMM framework. As a result, this GMM estimator may suffer from poor finite sample properties. Instead of estimating this standard GMM estimator, Carrasco and Nayihouba (2020) advocate computing the inverse of the sample covariance matrix of the orthogonality conditions K_N to obtain a more stable estimator of θ that is robust to the presence of many instruments. Because the dimension of K_N may be very large, some of the eigenvalues of this matrix can be too small, such that the condition number, which determines the degree of ill-posedness in this estimation problem, can be large. According to Carrasco et al (2007), to solve this problem, one can regularize the inversion of this sample covariance matrix by damping the explosive asymptotic effect of the inversion of the eigenvalues. More precisely, we replace the sequence $\left\{ 1/\lambda_j \right\}$ of the explosive inverse eigenvalues by the following sequence of elements $\left\{ q(\alpha, \lambda_j)/\lambda_j \right\}$ where the damping function $q(\alpha, \lambda)$ is chosen such that the following apply:

1. $q(\alpha,\lambda)/\lambda$ remains bounded when $\lambda \to 0$;

2. for any λ, $\lim_{\alpha\to 0} q(\alpha,\lambda)=1$,

where α is the regularization parameter, and the damping function is specific to each regularization procedure (Judge et al, 1980; Kress, 1999).

In this paper, we focus on two forms of the damping function:

$$q(\alpha,\lambda)=\begin{cases}\dfrac{\lambda}{\lambda+\alpha} & \text{for Tikhonov regularization,}\\ 1-(1-c\lambda)^{1/\alpha} & \text{for Landweber-Fridman regularization.}\end{cases} \tag{A.6}$$

By spectral decomposition, we have that

$$K_N = P_N D_N P_N^{'} \tag{A.7}$$

with $P_N^{'} P_N = I_{\bar{q}}$, where P_N is the matrix of eigenvectors, and D_N the diagonal matrix with eigenvalues λ_j on the diagonal. Let K_N^{α} denote the regularized inverse of K_N given by

$$K_N^{\alpha} = P_N D_N^{\alpha} P_N^{'}$$

where D_N^{α} is the diagonal matrix with elements $q(\alpha,\lambda_j)/\lambda_j$. From the regularized inverse K_N^{α} of K_N one obtains that

$$M^{\alpha} = \frac{Z}{\sqrt{NT}} K_N^{\alpha} \frac{Z'}{\sqrt{NT}}.$$

Therefore, the regularized GMM estimator of θ is given by

$$\hat{\theta}^{\alpha} = \frac{(z^*)' M^{\alpha} y^*}{(z^*)' M^{\alpha} x^*} \tag{A.8}$$

Carrasco and Nayihouba (2020) derive the asymptotic properties of this estimator with the same assumptions as in Okui (2009). In particular, the consistency and the asymptotic-normality properties of the model are derived. Moreover, they propose a data-driven procedure based on the mean square error approximation to select the regularization parameter in an optimal way.

A2.2 ML-SEM model

Consider the following set of equations:

$$\begin{aligned} y_{it} &= \mu_t + \beta_1 x_{i,t-1} + \beta_2 y_{i,t-1} + \delta_1 w_{it} + \alpha_i + \varepsilon_{it} \\ x_{it} &= \tau_t + \beta_3 x_{i,t-1} + \beta_4 y_{i,t-1} + \delta_2 s_{it} + \eta_i + \nu_{it} \end{aligned}, \ t = 2, \cdots, T \tag{A.9}$$

where μ_t and τ_t are intercepts that vary with time; $\beta_1, \beta_2, \beta_3$, and β_4 are scalar coefficients; and $\varepsilon_{i,t}$ and $\nu_{i,t}$ are random disturbances. As previously, equations in (A.9) contain the fixed effects terms α_i and η_i, which vary across firms. They also contain vectors of control variables w_{it}, s_{it}, as in (2), which vary over firms as well as time. Their corresponding vectors of coefficients are δ_1 and δ_2.

The coefficients of lagged cross effects are constrained to equality across waves, making these parameters equivalent to the average effects over the duration of the panel. We use the maximum likelihood of structural equation modeling (ML-SEM) to estimate the parameters of the model.

A2.3 Fit indices for the ML-SEM model

*Root Mean Square Error of Approximation (*RMSEA-SB*) Index:* An index of the difference between the observed covariance matrix per degree of freedom and the hypothesized covariance matrix. A value less than .08 is generally considered a good fit (Hu and Bentler, 1999). For Browne and Cudeck (1992), RMSEA < 0.06 is a good fit. The Satorra–Bentler (SB) scaled test is robust to nonnormality.

The *Comparative Fit Index* (CFI-SB) is an incremental fit index that produces values between 0 – 1; high values are indicators of good fit. An acceptable fit is provided when the CFI value is larger than 0.95 (Schermelleh-Engel et al, 2003). This index is relatively independent from sample size and yields better performance when small samples are studied (Hu and Bentler, 1999). The Satorra–Bentler (SB) scaled test is robust to nonnormality.

The *Tucker-Lewis Index* (TLI-SB) is an incremental index that is not required to be between 0 and 1. A higher TLI value indicates better fit, and values larger than 0.95 are interpreted as acceptable fit. The Satorra–Bentler (SB) scaled test is robust to nonnormality.

The *Standardized Root Mean Square Residual* (SRMR) is a measure of the average difference between the observed and model implied correlations. It will be close to 0 when the model fits well. Hu and Bentler (1999) suggest values of about .08 or under.

A3. OLS model and results

A3.1 *Basic model: OLS fixed effects model*

We use the following least-squares regression model with lagged variables for demand for reinsurance and liquidity creation where $y_{i,t}$ stands for reinsurance demand and $x_{i,t}$ for the liquidity ratio:

$$\mathrm{y}_{i,t} = \beta_y + \beta_1 \mathrm{x}_{i,t-1} + \beta_2 \mathrm{y}_{i,t-1} + \delta_1 \mathrm{w}_{i,t} + \alpha_i + \varepsilon_{i,t} \tag{A9}$$

and

$$\mathrm{x}_{i,t} = \beta_x + \beta_3 \mathrm{x}_{i,t-1} + \beta_4 \mathrm{y}_{i,t-1} + \delta_2 \mathrm{s}_{i,t} + \eta_i + \nu_{i,t} \, . \tag{A10}$$

In equations (A9) and (A10), the liquidity creation ratio at time *t* is regressed on the control variables at time *t* and the reinsurance demand at time *t* is regressed on control variables at *t*. Both equations are estimated separately. Therefore, each equation of the model is in fact a dynamic panel data relationship with individual fixed effects (α_i, η_i) and vectors of covariates $(w_{i,t}, s_{i,t})$. $\varepsilon_{i,t}$ and $\nu_{i,t}$ are error terms with zero mean and positive variance for $i = 1...N$ and $t = 1...T$, where *N* is the number of firms and *T* the number of periods. Insurers with more liquidity creation should be riskier and demand more reinsurance, while those with more reinsurance should be less risky and more active in liquidity creation. Yet these effects can vary for different firm sizes and time periods. There are less control variables in the liquidity creation regression because some variables described in Table 2 are ratios included in the definition of the liquidity creation ratio, as shown in Table 1. We correct standard errors for within-firm correlation and heteroscedasticity using the Huber–White consistent estimator. Since we do not use instrumental variables, the relationships between liquidity creation and reinsurance demand cannot be interpreted as causal.

A3.2 *Econometric results*

We briefly present some estimation results of the two equations using an OLS fixed effects model in order to compare some results with the existing literature on liquidity creation in the insurance sector. Table A3.1 presents the results from the least-squares estimations. For large, medium and small firms, the results are presented in tables A3.2. The results are very similar to those of the regularized GMM estimations presented in Online Appendix A1. When we compare the results of OLS with those of the Landweber-Fridman regularized GMM models in Table 6, the significance and sign of most of the other coefficients are not affected, with the exceptions of Geographical concentration and Loss development in the liquidity creation equation.

Table A3.1: Demand for reinsurance and liquidity creation
for all firms during the 1993-2014 period with OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables are defined in Table 2. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.6922	0.0217
	(0.000)	(0.000)
$Liquid_{t-1}$	0.0787	0.6697
	(0.000)	(0.000)
Insurance leverage $_t$	0.0106	
	(0.000)	
Geographical concentration $_t$	-0.0353	-0.0132
	(0.000)	(0.047)
Regulatory pressure $_t$	-0.0749	0.0900
	(0.000)	(0.000)
Liabilities $_t$	0.0209	
	(0.000)	
Line concentration $_t$	-0.0695	-0.0293

	(0.000)	(0.001)
Reinsurance price $_t$	-0.0104	0.0067
	(0.000)	(0.000)
Tax exemption $_t$	0.0005	-0.0116
	(0.919)	(0.008)
Information asymmetry $_t$	0.0262	-0.0125
	(0.002)	(0.186)
Loss development $_t$	-0.0001	0.0002
	(0.179)	(0.000)
New York license $_t$	0.0282	-0.0033
	(0.000)	(0.461)
Cost of capital $_t$	-0.0176	-0.0656
	(0.061)	(0.000)
Firm size $_t$	-0.0092	0.0105
	(0.000)	(0.000)
Group affiliation $_t$	0.0213	-0.0025
	(0.000)	(0.547)
Mix concentration $_t$	0.0097	-0.0074
	(0.442)	(0.441)
Capital $_t$	0.1768	
	(0.000)	
Number of observations	34,376	34,376
Number of firms	2,792	2,792
R-Square (within)	0.5661	0.4999

Table A3.2: Demand for reinsurance and liquidity creation
for different sizes of insurers during the 1993-2014 period with OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables are not presented. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Large		Medium		Small	
	Reins_t	Liquid_t	Reins_t	Liquid_t	Reins_t	Liquid_t
Reins_{t-1}	0.7451	-0.0109	0.6263	0.0074	0.6893	0.0227
	(0.000)	(0.734)	(0.000)	(0.785)	(0.000)	(0.000)
Liquid_{t-1}	0.0209	0.7018	0.0823	0.7035	0.0820	0.6594
	(0.460)	(0.000)	(0.027)	(0.000)	(0.000)	(0.000)
Number of observations	1,236		1,993		30,753	
Number of firms	100		235		2,658	

Table A3.3: Demand for reinsurance and liquidity creation
for all firms during the 1993-2014 period with two recession periods and OLS

Dummy variables were added to models in Table A3.1 to take into account of the 2007-2008 financial crisis and the 2001 recession. The financial crisis has a positive impact on reinsurance demand and the 2001 recession has a positive impact on Liquidity creation. Both variables have not affected the relationships between liquidity creation and reinsurance demand.

Variable	Reins_t	Liquid_t	Reins_t	Liquid_t
Reins_{t-1}	0.6920	0.0217	0.6920	0.0216
	(0.000)	(0.000)	(0.000)	(0.000)
Liquid_{t-1}	0.0787	0.6697	0.0793	0.6737
	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	0.0041	-0.0010	0.0042	0.0010
	(0.028)	(0.544)	(0.022)	(0.556)
2001			0.0041	0.0507
			(0.134)	(0.000)
Number of observations	34,376	34,376	34,376	34,376
Number of firms	2,792	2,792	2,792	2,792
R-Square (within)	0.5662	0.4999	0.5662	0.5081

Table A3.4: Demand for reinsurance and liquidity creation for different sizes of insurers during the 1993-2014 period with two recession periods and OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables are not presented. Recession periods are added to Table A3.2. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Large				Medium				Small			
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7451	-0.0117	0.7437	-0.0147	0.6242	0.0051	0.6242	0.0045	0.6892	0.0228	0.6892	0.0227
	(0.000)	(0.719)	(0.000)	(0.646)	(0.000)	(0.848)	(0.000)	(0.864)	(0.000)	(0.000)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0209	0.7008	0.0262	0.7061	0.0841	0.7045	0.0839	0.7085	0.0819	0.6592	0.0826	0.6632
	(0.462)	(0.000)	(0.353)	(0.000)	(0.025)	(0.000)	(0.024)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	-0.0001	0.0184	0.0004	0.0196	0.0091	0.0108	0.0090	0.0119	0.0037	-0.0031	0.0038	-0.0011
	(0.981)	(0.000)	(0.954)	(0.000)	(0.090)	(0.020)	(0.089)	(0.010)	(0.075)	(0.089)	(0.062)	(0.538)
2001			0.0229	0.0627			-0.0014	0.0504			0.0045	0.0489
			(0.015)	(0.000)			(0.847)	(0.000)			(0.128)	(0.000)
Number of observations	1,236				1,993				30,753			
Number of firms	100				235				2,658			

Table A3.5: Demand for reinsurance and liquidity creation for firms ranked according to Cummins and Weiss (2013) during the 1993-2014 period with OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Large		Medium		Small	
	Reins_{t}	Liquid_{t}	Reins_{t}	Liquid_{t}	Reins_{t}	Liquid_{t}
Reins_{t-1}	0.6597	0.0382	0.6880	0.0246	0.6251	0.0301
	(0.000)	(0.167)	(0.000)	(0.001)	(0.000)	(0.000)
Liquid_{t-1}	0.0168	0.7260	0.0842	0.6799	0.0834	0.6075
	(0.631)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	1,468		15,112		17,550	
Number of firms	117		1,290		1,970	

Table A3.6: Demand for reinsurance and liquidity creation
for firms ranked according to Cummins and Weiss (2013) during the 1993-2014 period with OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Recession years are added to the specifications of table A3.5. Control variables results are not presented. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Large				Medium				Small			
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.6590	0.0376	0.6590	0.0341	0.6878	0.0245	0.6879	0.0252	0.6251	0.0301	0.6250	0.0291
	(0.000)	(0.179)	(0.000)	(0.208)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0174	0.7264	0.0190	0.7341	0.0841	0.6800	0.0846	0.6854	0.0834	0.6074	0.0841	0.6111
	(0.622)	(0.000)	(0.588)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	0.0092	0.0104	0.0094	0.0119	0.0032	0.0018	0.0032	0.0035	0.0014	-0.0021	0.0016	-0.0002
	(0.026)	(0.009)	(0.024)	(0.002)	(0.196)	(0.374)	(0.183)	(0.088)	(0.622)	(0.418)	(0.572)	(0.931)
2001			0.0055	0.0603			0.0034	0.0564			0.0048	0.0432
			(0.523)	(0.000)			(0.310)	(0.000)			(0.252)	(0.000)
Number of observations	1,468				15,112				17,550			
Number of firms	117				1,290				1,970			

Table A3.7: Demand for reinsurance and liquidity creation
for tiers of insurers (by year) during the 1993-2014 period with OLS

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation. Control variable results are not presented. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Tier 1		Tier 2		Tier 3	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.6096	0.0220	0.6454	0.0260	0.6954	0.0092
	(0.000)	(0.043)	(0.000)	(0.007)	(0.000)	(0.244)
$Liquid_{t-1}$	0.0669	0.5908	0.0918	0.6045	0.0786	0.7027
	(0.000)	(0.000)	(0.000)	(0.000)	(0.027)	(0.000)
Number of observations	11,204		11,597		11,291	
Number of firms	1,333		1,239		908	

Table A3.8: Demand for reinsurance and liquidity creation
for tiers of insurers (by year) during the 1993-2014 period with OLS and recession variables

This table provides the results of the OLS fixed effects regression model. The dependent variables are Demand for reinsurance and Liquidity creation. Recession years are added to the specifications of table A1.7. Control variable results are not presented. Heteroscedasticity-consistent standard errors clustered at the firm level are computed and the corresponding *p*-values are reported in parentheses.

Variable	Tier 1				Tier 2				Tier 3			
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.6096	0.0220	0.6097	0.0203	0.6451	0.0260	0.6454	0.0264	0.6951	0.0090	0.6952	0.0103
	(0.000)	(0.042)	(0.000)	(0.059)	(0.000)	(0.007)	(0.000)	(0.006)	(0.000)	(0.256)	(0.000)	(0.190)
$Liquid_{t-1}$	0.0669	0.5908	0.0667	0.5934	0.0917	0.6045	0.0936	0.6101	0.0785	0.7028	0.0787	0.7094
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	-0.0014	-0.0030	-0.0014	-0.0014	0.0069	0.0006	0.0073	0.0024	0.0037	0.0025	0.0038	0.0042
	(0.701)	(0.349)	(0.689)	(0.665)	(0.043)	(0.827)	(0.031)	(0.381)	(0.136)	(0.273)	(0.133)	(0.063)
2001			-0.0014	0.0370			0.0126	0.0533			0.0009	0.0603
			(0.775)	(0.000)			(0.021)	(0.000)			(0.808)	(0.000)
Number of observations	11,204				11,597				11,291			
Number of firms	1,333				1,239				908			

Appendix A4: Different divisions of firm size

For robustness analysis, we first ranked insurer sizes into three similar groups according to their numbers. We used the company size ranked at 33th quantile (Tier 1) and at 67th quantile (Tier 2) of total admitted assets to be the cut points in dividing our sample into three groups. The values of the 33th and 67th quantile vary by year according to inflation in Table A4.3 or are stable across years in Table A4.2. These divisions by quantile are neutral but they do not really take into account of the industry structure where many small insurers are active in different states and fewer very large companies are active in many states. Table A4.2 and A4.3 provides the numbers of observations, the means and standard deviations of reinsurance demand and liquidity creation ratio in each group. The results are very similar. We will then consider the divisions presented in Table A4.3 in the next steps. The divisions can be compared to those we used previously and documented in Table A4.1, where 89% of observations are small insurers. It is clear that small insurers in Table A4.1 are present in the three groups of Table A4.3 and that they represent all firms in the first two quantiles.

Second, we used premium written instead of assets by following Cummins and Weiss (1993) definition of size groups: small, medium, and large. In their methodology, large firms are identified as those with at least $500 million in real net premiums written in 1985, medium size firms are defined as those with premium written between $16 million and $500 million, while small firms are those with premium written between $1 and $16 million. When creating the three groups, inflation was taken into account for obtaining real net premiums each year as in Cummins and Weiss (1993). The results are presented in Table A4.4. The number of observations for large firms remains about the same as in Table A4.1, but the repartition between small and medium firms changes.

In tables A4.5, A4.6, and A4.7, we present the estimation results obtained from different sizes of insurance companies, following the classification method of Cummins and Weiss (1993) based on the volume of written premiums, as documented in Table A4.4. Small insurers account for 52% of observations instead of 89%, and we have about 10% more large insurers. Large insurers remain more active in liquidity creation and have a lower demand for reinsurance. The estimation results in Table A4.5, A4.6, and A4.7 are very similar to those in Tables A1.6, A1.7, and A1.8. We still obtain strong positive causal effects between liquidity creation and reinsurance demand for small insurers, no significant links for large insurers, and mixed results for medium insurers.

We now present our results when our total number of observations are separated into three groups, each having about the same number of observations. It is not clear however that this separation reflects the structure of the US insurance industry, which is made up of many small insurers, which do business in their own state, and some very large insurers, which are active in across state lines. According to the NAIC statistics, the ten biggest insurers managed more than 45% of P&C premiums in 2020. Results presented in Table A4.8, A4.9, and A4.10 show that the causalities between reinsurance demand and liquidity creation in the first two tier groups are very similar to those of small insurers in Table A1.8 because these two groups are entirely made up of small firms. Table A4.10 reports a stronger causal link than Table A1.6 between liquidity creation and reinsurance demand for larger firms, but reinsurance demand still does not affect liquidity creation. This group of larger firms still contains small firms, according to our initial classification groups. The robust conclusion of our analysis is that small insurers, which are active in liquidity creation, use reinsurance for protection against unanticipated claims, while large and more diversified insurers do not seem to need reinsurance for their diversification. The dual relationship also holds in the sense that small insurers that are well protected with reinsurance against unanticipated claims are more active in liquidity creation, which is not the case for large insurers.

Table A4.1 Original division: Three groups ranked by total admitted assets

Asset	N	Median Year		Mean	Std	Corr coef
Small firms			$Reins_t$	0.3758	0.2832	0.0228
Less than $1 billion	30,753	2003	$Liquid_t$	-0.5178	0.2108	(<.0001)
Medium firms			$Reins_t$	0.3603	0.2578	0.0771
Between $1 billion and $ 3 billion	1,993	2006	$Liquid_t$	-0.5153	0.1545	(0.0006)
Large firms			$Reins_t$	0.3056	0.2549	0.1594
At least $3 billion	1,236	2006	$Liquid_t$	-0.5138	0.1409	(<.0001)

Table A4.2 Three groups ranked by 33^{th} and 67^{th} quantile of total admitted assets

Total admitted assets	N	Median Year		Mean	Std	Corr coef
First tier insurers			$Reins_t$	0.3472	0.2842	-0.0049
Less than $30,155,303	11,224	2002	$Liquid_t$	-0.5517	0.2377	(0.6041)
Second tier insurers			$Reins_t$	0.3967	0.2858	0.0181
$30,155,303 – $179,947,192	11,599	2003	$Liquid_t$	-0.4886	0.1966	(0.0517)
Third tier insurers			$Reins_t$	0.3703	0.2693	0.0618
At least $179,947,192	11,298	2005	$Liquid_t$	-0.5125	0.1683	(<.0001)

Table A4.3 Three groups ranked by 33^{th} and 67^{th} quantile of total real admitted assets

Total admitted assets	N	Median Year		Mean	Std	Corr coef
			$Reins_t$	0.3447	0.2842	0.0187
First tier insurers	11,204	2003	$Liquid_t$	-0.5490	0.2393	(0.0474)
			$Reins_t$	0.4032	0.2877	-0.0035
Second tier insurers	11,597	2003	$Liquid_t$	-0.4911	0.1976	(0.7068)
			$Reins_t$	0.3654	0.2657	0.0504
Third tier insurers	11,291	2003	$Liquid_t$	-0.5127	0.1677	(<.0001)

Table A4.4 Three groups ranked by net premium written in real 1985 dollars

Net premium written measured in real 1985 dollars	N	Median Year		Mean	Std	Corr coef
Small firms Less than $16 million	17,750	2003	$Reins_t$ $Liquid_t$	0.3854 -0.5563	0.2958 0.2295	0.0267 (0.0004)
Medium firms Between $16 million and $500 million	15,112	2003	$Reins_t$ $Liquid_t$	0.3648 -0.4774	0.2630 0.1697	0.0595 (<.0001)
Large firms At least $500 million	1,468	2004	$Reins_t$ $Liquid_t$	0.2750 -0.4687	0.2394 0.1261	0.1146 (<.0001)

Table A4.5: Demand for reinsurance and liquidity creation
for firms ranked according to Cummins and Weiss (2013) during the 1993-2014 period with Standard GMM

This table provides the results of the Standard GMM regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Standard GMM is rejected at 5 %.

Variable	Large		Medium		Small	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.8204	0.0381	0.7620	0.0091	0.8024	0.0124
	(0.000)	(0.2814)	(0.000)	(0.0765)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0438	0.7921	0.0470	0.7862	0.058	0.8035
	(0.0789)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0088	0.0048	0.0082	0.0065	0.0307	0.0064
Number of observations	1,468		15,112		17,550	
Number of firms	117		1,290		1,970	

Table A4.6: Demand for reinsurance and liquidity creation
for firms ranked according to Cummins and Weiss (2013) during the 1993-2014 period with the Tikhonov regularized GMM

This table provides the results of the Tikhonov regularized GMM regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Tikhonov regularized GMM is not rejected according to J-test.

Variable	Large		Medium		Small	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7281	0.0821	0.7104	0.0476	0.7432	0.0487
	(0.000)	(0.837)	(0.000)	(0.349)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0720	0.624	0.0973	0.6170	0.0942	0.6213
	(0.481)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.2471	0.2961	0.2875	0.2961	0.5137	0.4845
Number of observations	1,468		15,112		17,550	
Number of firms	117		1,290		1,970	

Table A4.7: Demand for reinsurance and liquidity creation
for firms ranked according to Cummins and Weiss (2013) during the 1993-2014 period with Landweber-Fridman regularized GMM

This table provides the results of the Landweber-Fridman regularized GMM regression model. The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Landweber-Fridman regularized GMM is not rejected according to J-test.

Variable	Large		Medium		Small	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7328	0.0813	0.7247	0.04801	0.7534	0.051
	(0.000)	(0.327)	(0.000)	(0.467)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0675	0.6147	0.0967	0.6084	0.0927	0.6104
	(0.594)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.5137	0.4845	0.5978	0.4867	0.5630	0.4652
Number of observations	1,468		15,112		17,550	
Number of firms	117		1,290		1,970	

Table A4.8: Estimation by GMM and GMM regularization, first tier

The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Standard GMM is rejected at 5 %.

Variable	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7807	0.0524	0.7084	0.0434	0.7120	0.0528
	(0.000)	(0.0632)	(0.000)	(0.0464)	(0.000)	(0.0386)
$Liquid_{t-1}$	0.0704	0.8046	0.082	0.5862	0.0841	0.579
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0435	0.0487	0.2694	0.5878	0.6251	0.7786
Number of observations	11,204					
Number of firms	1,133					

Table A4.9: Estimation by GMM and GMM regularization, second tier

The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Standard GMM is rejected at 5 %.

Variable	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7621	0.0520	0.7380	0.0712	0.7207	0.0708
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Liquid_{t-1}$	0.0617	0.7620	0.098	0.6281	0.121	0.6020
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0435	0.0048	0.3567	0.2562	0.6258	0.4830
Number of observations	11,597					
Number of firms	1,239					

Table A4.10: Estimation by GMM and GMM regularization, third tier

The dependent variables are Demand for reinsurance and Liquidity creation ratio. Control variables results are not presented. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. Standard GMM is rejected at 5 %.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
Variable	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.7460	0.055	0.7240	0.0357	0.7280	0.0352
	(0.000)	(0.0871)	(0.000)	(0.184)	(0.000)	(0.248)
$Liquid_{t-1}$	0.062	0.7680	0.0975	0.6204	0.108	0.617
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0431	0.0072	0.2489	0.3576	0.5859	0.5887
Number of observations			11,291			
Number of firms			908			

Appendix A5: Different recession periods

Berger and Bouwman (2016) published a book on bank liquidity creation and financial crises. They were particularly interested in finding statistical links between liquidity creation and financial crises. When banks create liquidity in the economy by investing in illiquid assets, they reduce their own liquidity, which may cause a liquidity crisis in the banking industry when many banks simultaneously apply the same strategy. In fact, the 2007–2008 global financial crisis was mainly interpreted as a liquidity crisis for banks. Berger and Bouwman (2016) find that off-balance-sheet liquidity creation, normalized by detrended GDP, decreased during the global financial crisis and continued to decrease for years afterwards. This effect was particularly significant for large banks that were more involved in off-balance-sheet transactions and needed to restore their liquidity. They did not obtain significant results for the dot-com recession.

The results of Table 10 is also observed for small and medium insurers but is not statistically significant for large insurers (Tables A5.3, A5.4, A5.5). The last financial crisis had no impact on liquidity creation for all firms together or for small firms but had a positive impact on liquidity creation for large firms and for medium firms.

Table A5.1: Demand for reinsurance and liquidity creation for all insurers during the 1998-2002 period

This table presents the coefficients and *p*-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at 10%. Coefficients of control variables are not reported.

Variable	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.4201	0.0214	0.4064	0.0126	0.3920	0.021
	(0.000)	(0.0492)	(0.000)	(0.0420)	(0.000)	(0.0468)
$Liquid_{t-1}$	0.076	0.3648	0.0625	0.3562	0.0633	0.3462
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0769	0.07921	0.6771	0.8001	0.6871	0.7255
Number of observations	7,732					
Number of firms	1,792					

Table A5.2: Demand for reinsurance and liquidity creation for all insurers during the 2006-2010 period.

This table presents the coefficients and *p*-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding *p*-values are reported in parentheses. It also documents the *p*-value of the specification J-test. The standard GMM is rejected at 10%. Coefficients of control variables are not reported.

Variable	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$	$Reins_t$	$Liquid_t$
$Reins_{t-1}$	0.4620	0.0031	0.3450	0.008	0.326	0.006
	(0.000)	(0.178)	(0.000)	(0.064)	(0.000)	(0.0541)
$Liquid_{t-1}$	0.0781	0.3781	0.0814	0.324	0.0735	0.3061
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J-test	0.0894	0.0854	0.5891	0.6481	0.5836	0.6273
Number of observations	7,662					
Number of firms	1,783					

Table A5.3: Estimation by GMM for large insurers with dummy variables for recessions.

This table presents the coefficients and p-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding p-values are reported in parentheses. It also documents the p-value of the specification J-test. The standard GMM is rejected at 5% level. Coefficients of control variables are not reported.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	Reins	Liquid	Reins	Liquid	Reins	Liquid
Reins	0.8241	0.0181	0.7184	0.0124	0.7210	0.0122
	(0.000)	(0.386)	(0.000)	(0.578)	(0.000)	(0.627)
Liquid	0.0241	0.7681	0.0314	0.6914	0.0415	0.6871
	(0.381)	(0.000)	(0.524)	(0.000)	(0.468)	(0.000)
2007-2008	-0.0006	0.0238	-0.0034	0.0214	-0.0028	0.0148
	(0.960)	(0.000)	(0.884)	(0.000)	(0.385)	(0.000)
2001	0.024	0.0248	0.0314	0.0581	0.0381	0.0614
	(0.034)	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)
p-value of the J_test	0.0145	0.0125	0.4875	0.2541	0.52814	0.4814
Number of observations			1,236			
Number of firms			100			

Table A5.4: Estimation by GMM for medium insurers with dummy variables for recessions.

This table presents the coefficients and p-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding p-values are reported in parentheses. It also documents the p-value of the specification J-test. The standard GMM is rejected at 5% level. Coefficients of control variables are not reported.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	Reins	Liquid	Reins	Liquid	Reins	Liquid
Reins	0.8141	-0.0135	0.732	0.011	0.7284	0.0103
	(0.000)	(0.480)	(0.000)	(0.621)	(0.000)	(0.803)
Liquid	0.0621	0.7681	0.0481	0.6810	0.0581	0.6720
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	0.008	0.013	0.0071	0.021	0.0068	0.020
	(0.0997)	(0.000)	(0.0869)	(0.000)	(0.0968)	(0.001)
2001	0.0038	0.023	0.0048	0.046	0.0046	0.0420
	(0.681)	(0.000)	(0.567)	(0.000)	(0.480)	(0.003)
p-value of the J_test	0.0181	0.00420	0.2541	0.2284	0.5358	0.4358
Number of observations			1,993			
Number of firms			235			

Table A5.5: Estimation by GMM for small insurers with dummy variables for recessions.

This table presents the coefficients and p-values obtained from the GMM method of estimation. Robust standard errors are used to obtain confidence intervals and the corresponding p-values are reported in parentheses. It also documents the p-value of the specification J-test. The standard GMM is rejected at 1 % level. Coefficients of control variables are not reported.

	Standard GMM		Tikhonov regularized GMM		Landweber-Fridman regularized GMM	
	Reins	Liquid	Reins	Liquid	Reins	Liquid
Reins	0.7986	0.0314	0.7251	0.012	0.7184	0.0131
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Liquid	0.0420	0.7614	0.082	0.6621	0.084	0.6701
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2007-2008	0.006	-0.0031	0.0075	-0.0014	0.008	-0.002
	(0.043)	(0.680)	(0.038)	(0.633)	(0.046)	(0.258)
2001	0.0043	0.006	0.0046	0.0481	0.0052	0.052
	(0.214)	(0.000)	(0.620)	(0.000)	(0.499)	(0.000)
p-value of the J_test	0.00671	0.0084	0.2366	0.2614	0.5720	0.4841
Number of observations	30,753					
Number of firms	2,658					

Appendix A6: Liquidity creation: Differences between banks and insurers

In this study we use the following definition of liquidity creation. Financial institutions create liquidity in the economy when they invest in relatively illiquid assets with relatively liquid liabilities. Liquidity creation in the economy means a reduction in liquidity on the balance sheet of a financial institution. Insurers reduces liquidity in the economy when they use illiquid liabilities and surplus to create liquidity on the balance sheet. In other words, liquidity reduction in the economy means an increase in liquidity on the balance sheet with more liquid assets such as bonds and stocks. The average ratio of liquidity creation (LCR) is usually positive for banks and negative for insurers. In relative terms, banks invest more in illiquid assets to obtain higher investment returns while insurers maintain more liquidity on their balance sheet in investing in liquid assets to better payback claims when unexpected events happen. In this study we add reinsurance demand by insurers to improve their capacity to payback unexpected claims.

The goal of this appendix is to compare banks and insurers in liquidity creation activity during the period 2010-2012. We created a subsample of 163 insurers from our data set of insurers and a comparable sample of 163 banks of the same size (total assets) with the FDIC data. The mean liquidity creation ratio (LCR) is equal to 0.012 for banks and -0.42 for insurers. How these differences could be explained?

We use the four main sections of balance sheet to make the comparison. We should mention that our bank sample does not contain the very large investment banks; this explains in part the low positive LCR. For both groups of financial institutions, we compute the liquidity creation ratio as follows:

$$\text{Liquidity Creation Ratio (LCR)} = \frac{\text{liquidity creation}}{\text{assets}} \tag{A11}$$

$$\text{LCR} = \frac{0.5*(\text{illiquid asset} + \text{liquid liabilities}) - 0.5*(\text{liquid asset} + \text{illiquid liabilities} + \text{surplus})}{\text{assets}} \tag{A12}$$

Positive weights mean that the financial institution creates liquidity in the economy when financial institutions invest in relatively illiquid assets with relatively liquid liabilities. Negative weights mean that the financial institution creates liquidity in its balance sheet by using illiquid liabilities and surplus.

As we see in Figure A6.1, the financial structure of each group of firms is very different in proportions. Banks have more illiquid assets than insurers and more liquid liabilities, where both variables have a positive sign in the computation of LCR: illiquid investments are financed by liquid liabilities. Moreover, banks have fewer liquid assets (less inside liquidity) and less illiquid liabilities + surplus than insurers, where both have a negative sign in equation (A6.2). Note that the figure remains the same whatever the weights used in equation A6.2. Figures A6.2 and A6.3 show the differences in the composition of assets and liabilities. The main differences are in loans (illiquid assets) and investments in stocks and bonds (liquid assets).

To see differently how the differences in the main sections of the balance sheet could explain the difference in LRC, we estimated equation (A6.3) over 453 observations (some observations were missing) where the dependent variable is the difference of LCR between comparable firms (bank-insurer) in the two sectors and the independent variables are the differences in the main balance sheet sections of the same firms. Table A6.1 presents the estimation results of the following panel regression with fixed effects.

$$LCR_t{}^D = \alpha_D + \delta_1 \Delta IlliquidAss_{it} +$$

$$\delta_2 \Delta LiquidAss_{it} + \delta_3 \Delta LiquidLiab_{it} + \delta_4 \Delta IlliquidLiab_{it} \qquad \text{(A13)}$$

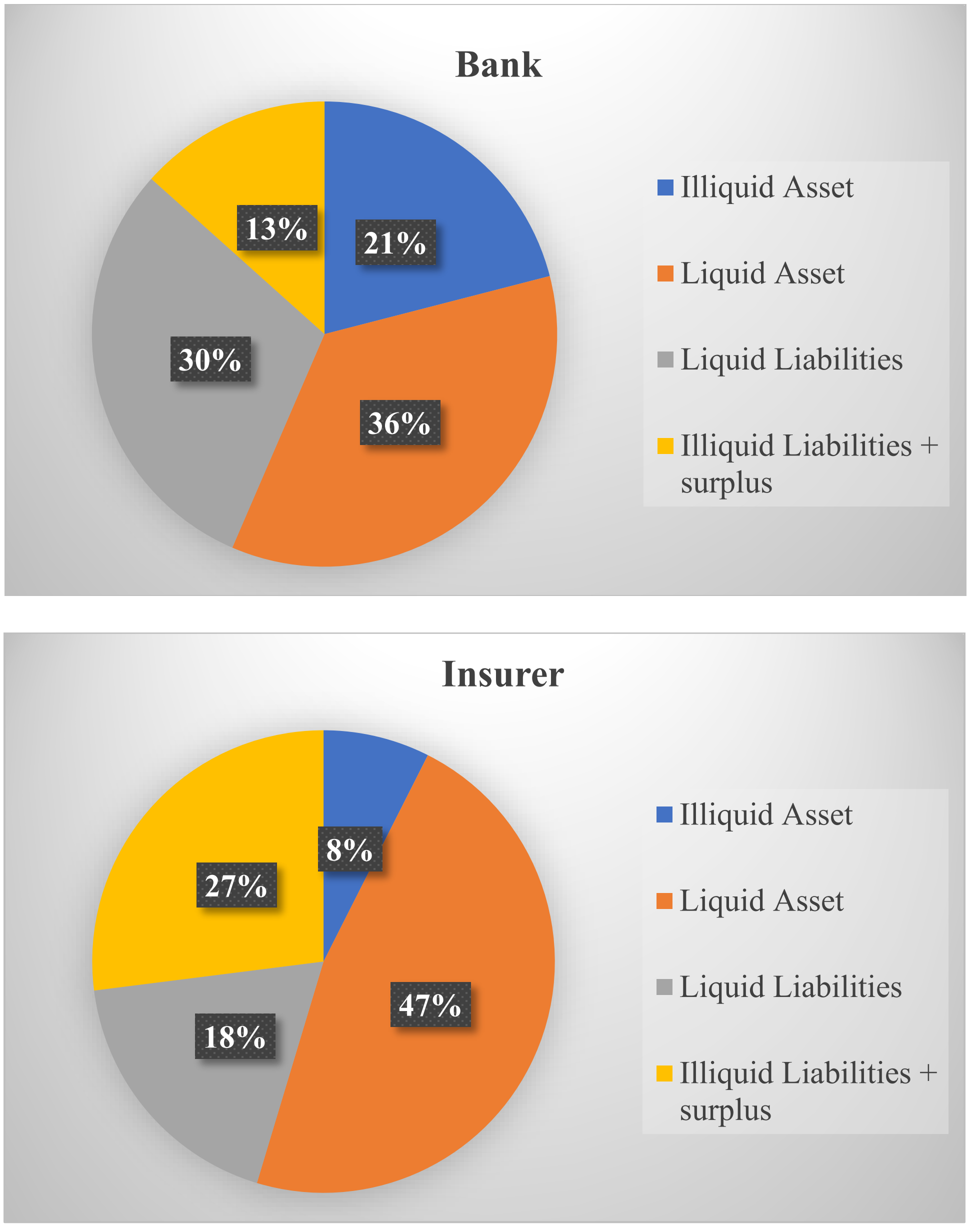


Figure A6.1: Comparison of financial structure in our sample of banks and insurers during the period 2010-2012 (in%)

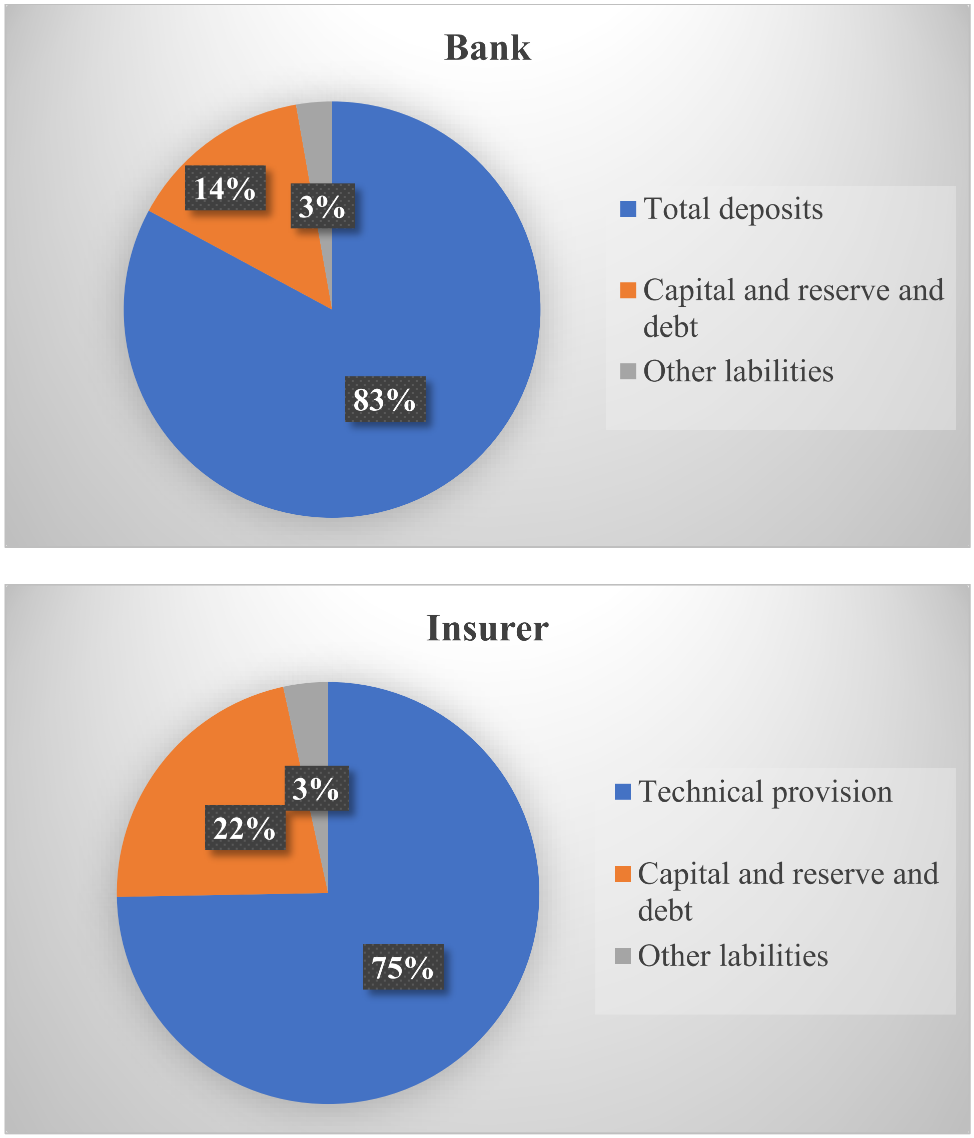
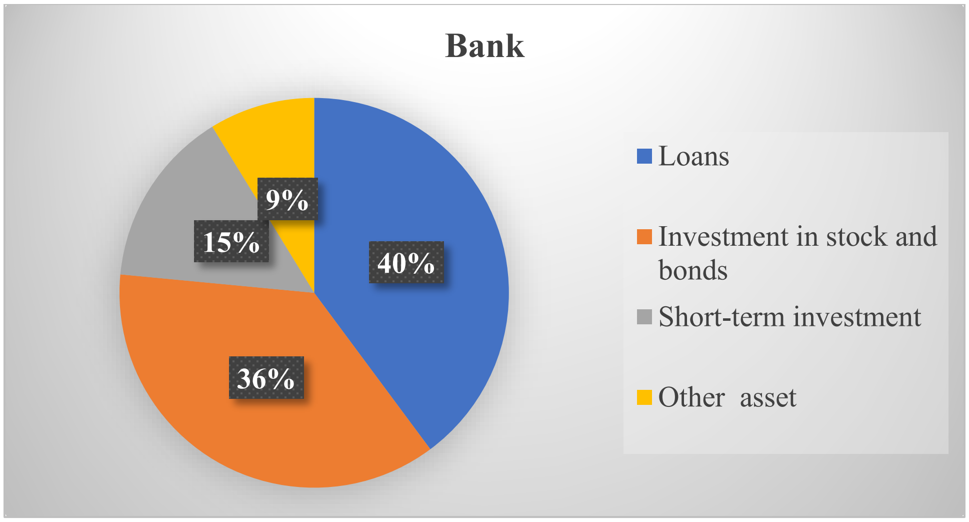


Figure A6.2: Comparison of liabilities during the period 2010-2012 (in %). The ratio equity to assets is 52% for insurers and 11% for banks.



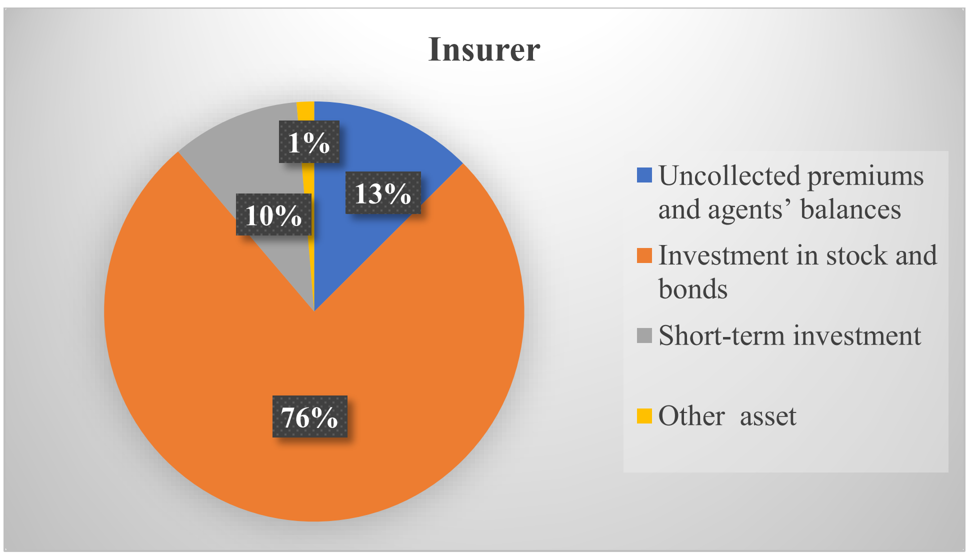


Figure A6.3: Comparison of assets during the period 2010-2012 (in %)

Table A6.1: Effect of different balance sheet sections on LCR with weight = 0.5

Dependent variable: Difference in liquidity creation ratio (Bank – Insurer)

Variable	Coefficient (Robust se)
Diff_Illiquid_Asset	5.77e-09*** (1.21e-09)
Diff_Liquid_Asset	-1.26e-09** (5.20e-10)
Diff_Liquid_Labilities	7.16e-10 (7.80e-10)
Diff_Illiquid_LiabilitiesEquity	-1.67e-09 (1.03e-09)
Constant	0.273*** (0.0268)
Observations	453
R-squared	0.203

Notes: Robust standard errors in parentheses
*** p<0.01, ** p<0

We observe in Table A6.1 that the difference in illiquid assets (more illiquid investments for banks or liquidity creation) and the difference in liquid assets (more inside liquidity for insurers) represent the main drivers of the difference in LCR between banks and insurers. When we estimate the model with different weights in equation (A6.2) only the constant changes in the regression. Detailed results are available.

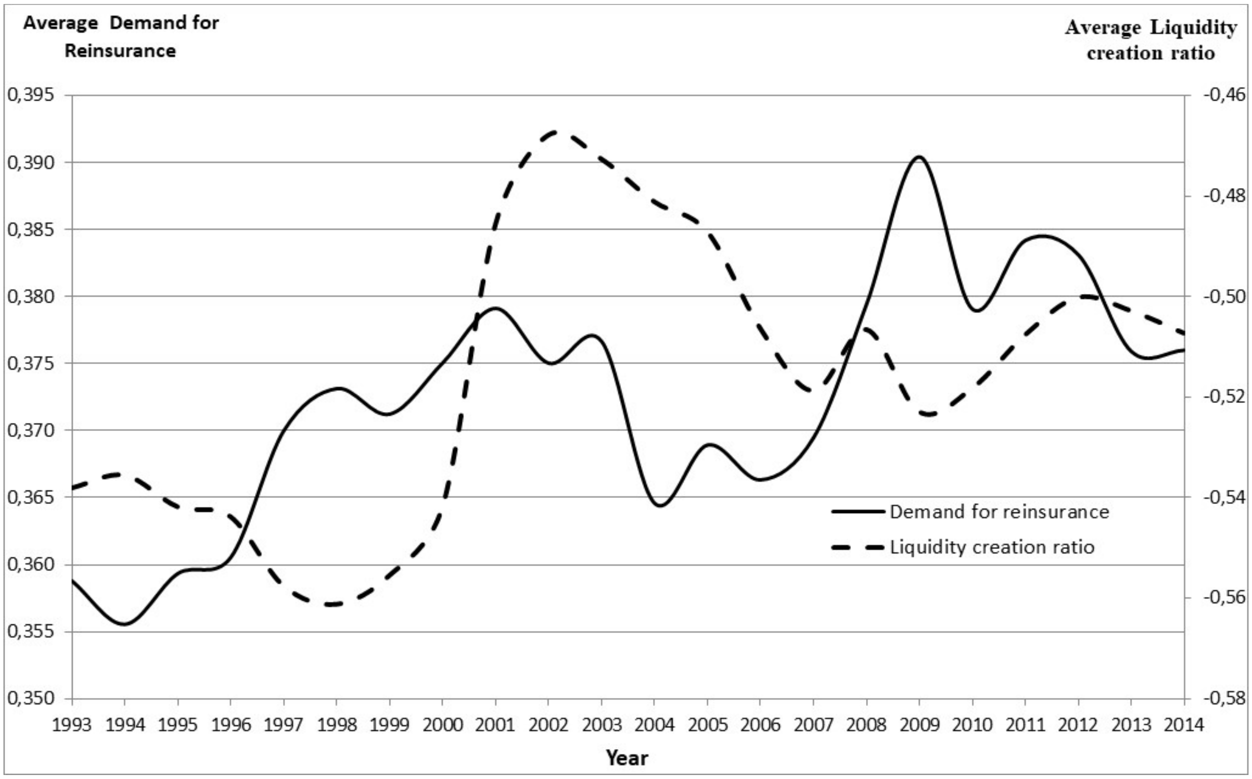


Figure A1: All insurers
Average demand for reinsurance and average liquidity creation ratio by year

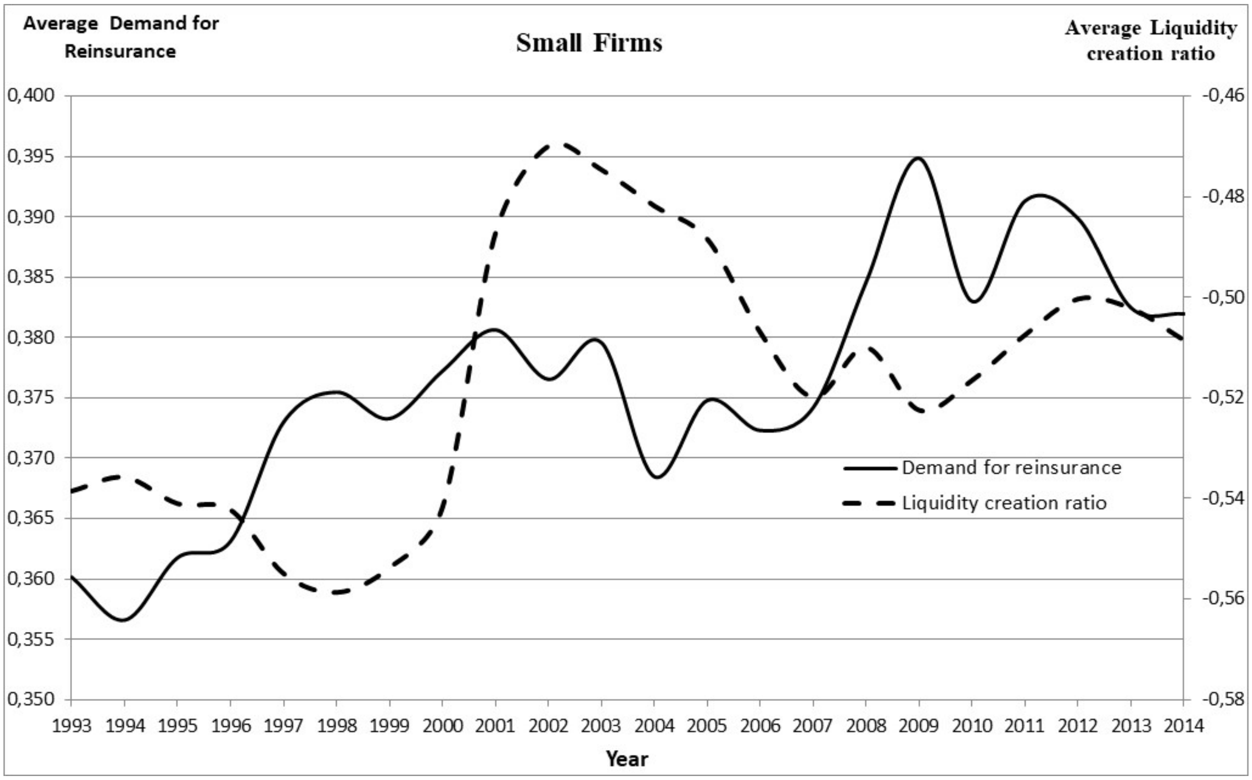


Figure A 2: Small insurers
Average demand for reinsurance and liquidity creation ratio by year

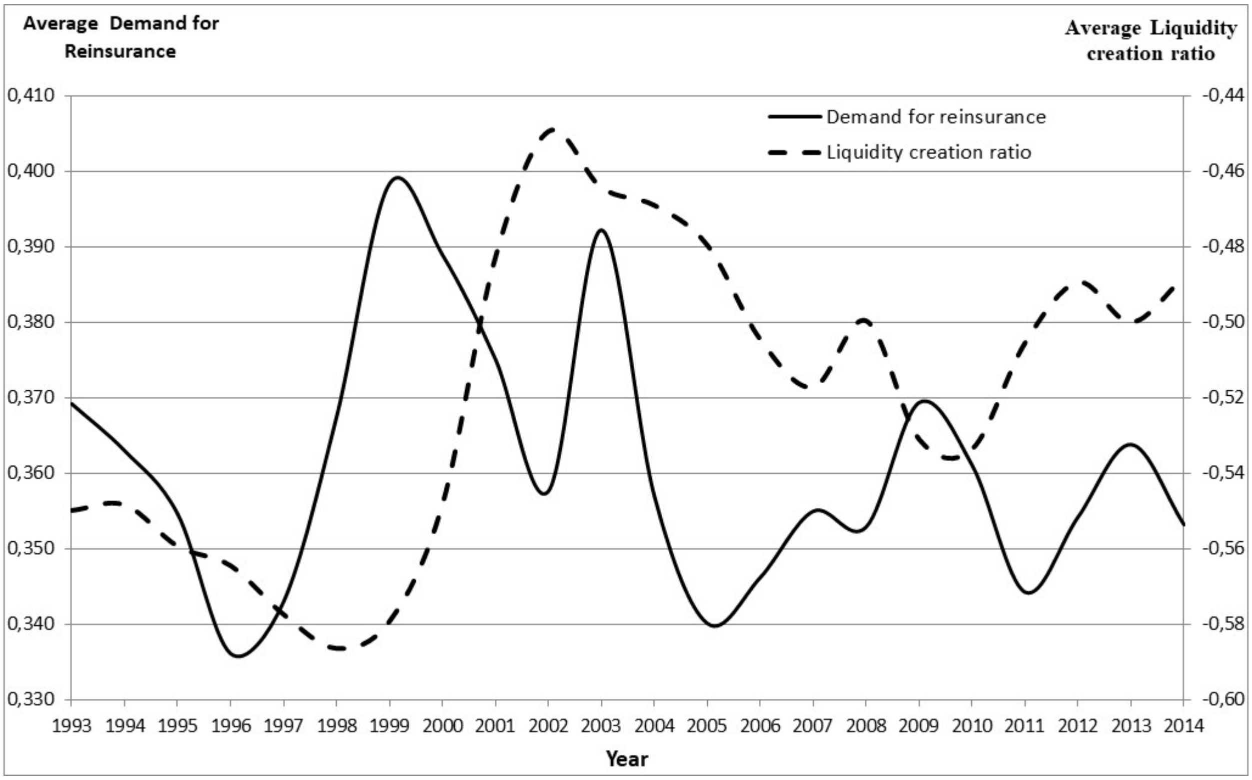


Figure A3: Medium insurers

Average demand for reinsurance and liquidity creation ratio by year

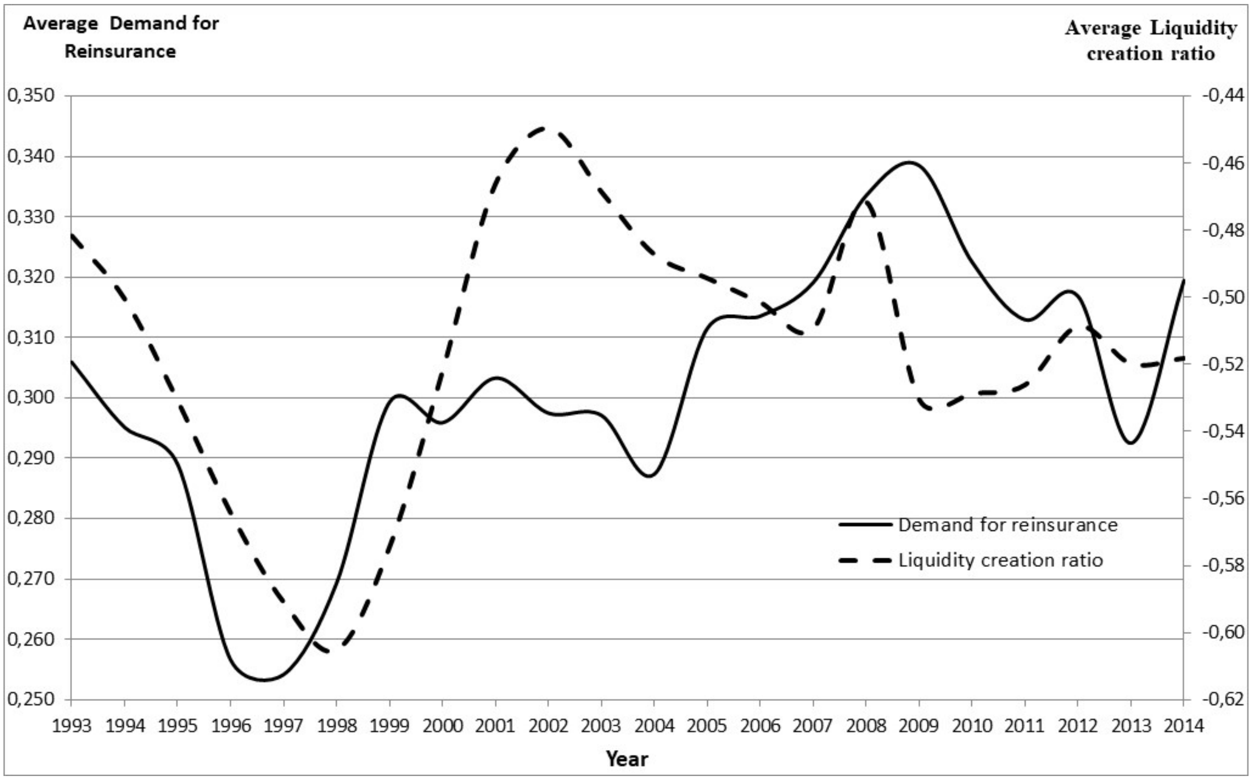


Figure A4: Large insurers
Average demand for reinsurance and liquidity creation ratio by year