Consolidation of the US property and casualty insurance industry: Is climate risk a causal factor for mergers and acquisitions?*

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Abstract

This report analyzes the difference between mergers and acquisitions (M&As) of target insurers in the US life and non-life insurance sectors. We first document M&A transactions in the US insurance market between 1990 and 2022 and select the M&A transactions related to US target insurers. We then study the evolution of the life and non-life insurance sectors over time in order to determine whether there are parallel trends between the evolution of M&As of target insurers in these two sectors over time. We empirically test the difference between the M&As of the life and non-life insurance sectors by employing a natural experiment method and verify whether climate risk has been a causal factor in the observed difference in mergers and acquisitions between the two sectors after 2012. Our results do not support a causal link between climate risk and M&As during the period of analysis. Insurers choose other diversification sources of capital, including reinsurance, premium management, CAT bonds, and better capital management under stronger risk regulation.

Keywords: Mergers and acquisition, US insurance industry, property and casualty insurance, life insurance, health insurance, climate risk, capital management, reinsurance, ILS, CAT bonds, premium management, risk regulation.

JEL codes: C10, C22, C23, C58, G22, G28, G52, H12.

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1. Introduction

The main objective of this study is to measure a causality effect of climate risk on property and casualty (P&C) insurance industry consolidation. More generally, we examine how catastrophic events may have affected industry resilience by focusing on M&As in the US insurance industry.

The proponents of diversifying risk portfolios via M&A argue that acquisitions between different industries allow the acquiring insurer to benefit from economies of scope and scale through the joint use of customer databases, managerial expertise, and brand name. In addition, diversified transactions are expected to reduce acquirers' risk because this allows them to operate in a broader range of insurance lines and to better diversify extreme risks. By contrast, the proponents of focusing transactions within the same industry (or business line) argue that insurers are better off when they concentrate on their core business. It is not clear that such concentration is always beneficial in presence of climate risk.

In both cases transactions are also likely to be initiated by managers wishing to protect their human capital or increase their private benefits (Amihud and Lev, 1981; Jensen, 1986). Such behavior could be very risky for poorly diversified acquirers.

We have not found studies linking catastrophic risks to M&As in the insurance industry. Cummins and Weiss (2004), Cummins and Xie (2008) and Boubakri et al. (2008) analyze M&As in the insurance industry. They do not focus on catastrophic or climate risks, and their methodology is not up-to-date because they do not perform a causality analysis on the effect of different factors on M&As. One way to extend this literature is to investigate how climate risk events might be causal variables in explaining M&As. Difference-in-differences analysis is a methodology that can be applied by using insurers in activities less exposed to climate risk events as a control group and insurers in more climate-exposed activities as a treatment group. For example, insurers in the life insurance industry can be considered less exposed to climate risks than P&C insurers.

There are two major difficulties associated with isolating climate risk events as a causal effect on M&As during our period of analysis (1990 to 2022). The first is separating M&As from the varied alternative sources of capital consolidation that the insurers can use to protect themselves from natural catastrophes. Dionne and Desjardins (2022) show that US property and casualty insurers significantly increased their capital over recent years. They also identify various potential sources of capital, such as reinsurance, M&As, premium management, capital regulation, and insurance-linked securities (ILS).

The second difficulty is identifying factors other than climate risk events that may have affected M&As during the period of analysis. Notably, our period of analysis contains the 2007–2009 financial crisis. The US insurance industry was affected by this crisis, albeit less significantly than banks. Market conditions were difficult after the crisis, particularly for the life insurance industry. Premium growth was low, as were interest rates. Moreover, new federal regulations for capital were introduced, particularly in and after 2012. These new regulations have affected the level of capital and introduced some uncertainty in the markets regarding M&As.

Our results do not support a causal link between climate risk and M&As during the period of analysis. Insurers choose other diversification activities, including reinsurance, premium management, catastrophe bonds, and better capital management under stronger risk regulation.

The rest of the report is organized as follows. Section 2 presents a literature review on M&As in the insurance industry. Section 3 describes the evolution of M&As in the US insurance industry from 1990 to 2022. Section 4 documents natural weather disasters during the same period. Section 5 analyzes the impact of markets conditions and regulation on M&A after 2012. Section 6 proposes an analysis of the parameters for a DID analysis, while Section 7 describes the DID analysis. Section 8 discusses the results. Section 9 concludes. A robustness analysis is presented in the appendices along with additional results.

2. Literature review

2.1. Rationale for M&As

Usually, bidders initiate M&A transactions only when they anticipate that these activities will create value for their shareholders. Thus, studying the impact of such deals on bidders' performance is of particular interest, especially for intra-industry transactions, because these are most likely to be driven by synergies, and hence, create value. The empirical literature shows that acquiring insurers in the US insurance industry experience greater efficiency and higher profitability three years after the M&A (Cummins et al., 1999; Cummins and Xie, 2008; Boubakri et al. 2008).

Among insurers' economic rationales for these operations are a desire to increase their geographical reach and product range (Amel et al., 2004) and to benefit from economies of scale and scope (Cummins et al., 1999). Further, insurers may initiate these transactions to benefit from financial synergies (Chamberlain and Tennyson, 1998) or to reduce their riskiness and/or improve the amount/timing of their cash flow streams (Cummins and Weiss, 2004). Estrella's (2001) findings refute the risk-reduction argument from transactions between different industries. Indeed, the article shows that the median failure probability resulting from combinations of two property-casualty firms is lower than that resulting from a combination of a property-casualty firm and a bank holding company.

The financial literature also suggests that M&A transactions may destroy rather than create value, especially if these transactions are motivated by managerial hubris, that is, where managers are more interested in maximizing the size of their business empires than in returning cash to shareholders (Roll, 1986; Denis and McConnell, 2003). Hence a negative impact on the bidders' firm value could be observed. For such behavior to be constrained, effective governance mechanisms must be put in place, such as 1) a strong board with competent independent directors, and 2) a legal environment that offers strong protection to minority shareholders. The legal environment relates not only to investor protection but also to transparency and overall quality of accounting standards, which were all recently shown by Rossi and Volpin (2004) and Moeller and Schlingemann (2005) to be significant determinants of M&A (see also Boubakri et al., 2008). Asymmetric information between

acquiring firms on particular targets can also affect M&A activities by modifying the premiums of different deals (Dionne et al., 2015; Betton et al., 2009; Brockman and Yan, 2009).

Akhigbe and Madura (2001) report a positive and significant abnormal return for acquiring insurers and conclude that this favorable valuation effect is driven by the similarity of services provided by both the acquirer and the acquired. In other words, standardization in their products makes the merger of operations easier for both parties. Interestingly, Akhigbe and Madura (2001) document a higher positive and significant market effect for acquirers that are non-life insurers. Floreani and Rigamonti (2001) also report a positive and significant valuation effect for the bidder, following M&A transactions involving pure insurance partners. This market valuation is positive but slightly lower when the target firm is publicly traded. However, only transactions involving insurers buying insurers seem to create value for the bidder. Indeed, Cummins and Weiss (2004) report a small negative valuation effect on the bidder's shares following transactions that do not involve pure insurance partners.

Additionally, cross-border transactions may generate a higher positive valuation effect for the bidder because they are perceived to lead to a geographic expansion of its market. The results of Floreani and Rigamonti (2001) support this argument. Specifically, they demonstrate that transactions involving insurance partners that are both located in the European Union countries are not welcomed by the financial market. On the other hand, cross-border transactions may also destroy value for the bidder because they are more difficult to manage (Cummins and Weiss, 2004)—a result not supported by Floreani and Rigamonti (2001). In the next section, we present a detailed analysis of various contributions on the insurance industry.

2.2. Detailed analysis of some contributions on the insurance industry

- Chamberlain and Tennyson (1998)

The empirical literature on M&As in the insurance industry focuses primarily on examining the motivations for M&As, and the financial characteristics and operational

efficiency of acquirers and targets pre- and post-consolidation. In this section we review some articles in chronological order.

Chamberlain and Tennyson (1998) examine the empirical relevance of two hypotheses based on theories of information asymmetries and firm financing decisions: i) financial synergies are a primary motive for insurance mergers and acquisition activity in general, and ii) mergers motivated by financial synergies will be more prevalent in periods following negative industry capital shocks. The two hypotheses are investigated through an analysis of accounting ratios of acquisitions targets during the period from 1980 to 1990 and an analysis of acquisition characteristics. The empirical results strongly support the hypothesis that financial synergies are a major motivation for M&As in the property-liability insurance industry following negative industry capital shocks.

Chamberlain and Tennyson (1998) base their two hypotheses on the theoretical foundations about how information asymmetries between firms and the capital market drive the firm's capital structure and financing decisions. Informational asymmetries appear to be a severe problem for insurance companies. In fact, many insurer assets are intangible and thus difficult for outsiders to observe and evaluate. In addition, insurer liabilities comprise mainly loss reserves, which are subject to both errors and discretion in the estimation of their value.

Information asymmetries lead to a lower valuation of firms with better than average future earnings, due to adverse selection. Therefore, firms with the best prospects will be more reluctant to obtain capital from more costly external sources and tend to use more internal generated funds. Moreover, the high cost of external funding caused by asymmetric information leads to a very harmful problem for the firm, namely the underinvestment problem by bypassing projects with positive net present value.

Firms can overcome this funding problem through mergers and acquisitions between well-capitalized firms and poorly capitalized firms if information asymmetries are lower between targets and potential acquirers than they are between targets and the capital market. In this context, the capital infusion to the target, which is expected to be undervalued in the market due to the information asymmetries, will yield a high return

relative to its low purchase price. Chamberlain and Tennyson (1998) referred to these mergers as being driven by financial synergies and formulate their first hypothesis related to the prevalence of financial synergies as a merger motive in the property-liability insurance industry.

H1: Financial synergies are a primary motive for insurance mergers and acquisition activity in general

The property-liability insurance industry is prone to capital shocks due to events such as natural disasters, changes in loss distributions, unexpected inflation or lower than expected investment returns, which affect many insurers simultaneously. Particularly, negative capital shocks will put many insurers in financial troubles, creating more opportunities for mergers based on financial synergies. The mergers motivated by financial synergies will be intensified after periods of negative capital shocks because of the increased information asymmetries due to the increased uncertainty about firm's values. These considerations lend foundation to the second hypothesis by Chamberlain and Tennyson (1998), namely financial synergies are an especially important motive for merger in periods following a negative capital shock.

H2: Mergers motivated by financial synergies will be more prevalent in periods following negative industry capital shocks

The sample for this study was restricted to acquisitions of US property-liability insurance companies completed during 1980 through 1990. Chamberlain and Tennyson (1998) focused their sample on acquisitions of ongoing concerns and exclude M&A transactions in which the target was retired or merged into the new parent entity. Authors use two additional requirements: that the acquired company report annual statements to A.M. Best Company three years prior to the merger and that it writes at least one million dollars in premiums per year.

The final sample consist of 84 transactions. A subsample of 72 of these transactions is used in the analysis of pre-merger characteristics, and 62 transactions are used in the analysis of the performance effects of mergers.

Pertaining to the methodology, Chamberlain and Tennyson (1998) used a matched-pair research design to analyze the pre-merger performance, and the effects of merger on performance of the acquired firms. Each acquired company's performance is evaluated relative to the average performance of non-acquired subsidiaries which are of approximately the same size, and which operate in the same line of business as the acquired subsidiaries.

Next, authors calculate a benchmarked performance measure by subtracting the three-year averaged benchmark of the matched firms from the three-year average performance for the acquired company. They do that for the two sub-period of three years before the merger (pre-merger period) and the three years after the merger (post-merger period). To detect the effect of merger on the target performance, Chamberlain and Tennyson (1998) subtracted the pre-merger benchmarked performance from the post-merger benchmarked performance. If the merger has no effect on the performance of the target, it is expected that the change in benchmarked performance will be zero. The statistical significance of the benchmarked performance is assessed using a sign test which examines whether there are equal numbers of positive and negative paired differences.

Chamberlain and Tennyson (1998) used two broad categories of performance measures: i) those intended to measure financial synergies and ii) those intended to measure operating synergies, to distinguish financial and operational motivations for mergers and acquisitions and to examine whether these motivations differ across different periods.

Financial synergies for M&A deals are measured using solvency, liquidity, and leverage. Solvency is measured by the ratio of policyholder's surplus to admitted assets. Policyholder's surplus to admitted assets represents the firm's net worth. The liquidity measure is calculated by dividing the liquid assets (cash and marketable securities) by total reserves. Two measures of leverage are used: i) Underwriting leverage is measured as premium revenues net of reinsurance transactions relative to policyholders' surplus. This ratio is inversely related to the capacity of a firm to write additional new policies. ii) Reserve leverage is measured as total loss and loss adjustment expense reserves relative to policyholders' surplus. This ratio measures the insurer's unpaid obligations and is

inversely related to the firm's ability to bear loss shocks. The percentage change in premium volume is also analyzed.

Operational synergies for M&A deals are measured using the ratios of net income scaled by total assets and net income scaled by premiums. To get more insights into the sources of any operational improvements due to the economies of scale and better expense management, the loss ratio, measured by the ratio of losses and loss adjustment expenses divided by earned premiums, and the expense ratio, measured by the ratio of underwriting expenses scaled by written premiums, are included. The ratio of investment gains (losses) to premiums earned is also used.

To test whether mergers provide a source of external capital for the target, the annual change in surplus is included. The annual change in surplus results from net income, equity capital paid, dividends paid and other adjustments including items such as foreign currency translations, changes in admitted assets, unrealized capital gains and losses and treasury stock issues and repurchases. Specifically, Chamberlain and Tennyson (1998) focused on the net income and paid-in-capital components of surplus changes.

Based on the sign test, the results indicate that the pre-merger financial characteristics of the target was worse than that of the benchmark groups. Solvency and liquidity are significantly lower for the target sample, and underwriting leverage is significantly higher during the pre-merger period. On the contrary, the results show that targets have higher premium growth in the pre- and post-merger periods. Pertaining to profitability ratios, the results reveal the ratio of net income to premiums for acquired firms was lower than that of the benchmark firms during the pre-merger period. However, the ratio of the net income to assets suggests that the acquired firms have similar return on assets as their non-acquired counterparts prior to the merger. In addition, targets exhibit a better (lower) loss ratio compared to the benchmark group in the pre-merger period. In contrast, targets have higher expense ratio, indicating higher selling and administrative costs. The acquired firms realize a significantly lower investment income relative to invested assets in the pre-merger period.

For the impact of the merger on financial characteristics, results show no statistically significant differences in the changes in the ratios of solvency and liquidity relative to

changes for the benchmark groups for the pre- and post-merger periods. In contrast, the underwriting leverage for acquired firms decreases after the merger compared the non-acquired firms. The improvement in the underwriting leverage after the merger combined with the high premium growth indicate that targets are firms with high growth opportunities who pursued merger to sustain growth. Pertaining to operational performance measures, the results indicate significant enhancements in the expense ratio and the investment income ratio after the merger, however there is no significant improvement in the loss ratio. Interestingly, the ratios of net income improved after merger. Overall, these results reveal improvements in the targets profits, suggesting that operating synergies were achieved in the mergers.

Generally, these conclusions are mixed about the drivers of M&A deals. The results give weak support to the first hypothesis (H1) related to financial synergies and show that only underwriting leverage enhanced following the merger. In contrast, there are strong evidence for operating synergies materialized by improvements in both expenses' ratio and investment income.

Then, Chamberlain and Tennyson (1998) tested the relevance of their second hypothesis, namely financial synergies are an especially important motive for merger in periods following a negative capital shock (H2). To be done, the authors compare the financial and operational characteristics of target acquired in 1985 and 1986 to those acquired in all other years of the studied period form 1980-1990. Chamberlain and Tennyson (1998) choose the two years 1985 and 1986 following the negative capital shocks of the mid-1980s due to astonishing increase in incurred losses.

Comparing post-merger and pre-merger financial ratios for the two subsamples based on the sign test, Wilcoxon tests and Median test, indicates that both the solvency and underwriting leverage of firms acquired in 1985 and 1986 improved significantly relative to their benchmark groups, but this was not true of firms acquired in the other years. The reserve leverage also decreased after the merger for targets acquired in 1985 and 1986, but not for the acquired firms in other years. Moreover, premium volume increased significantly for the 1985 to 1986 targets relative to their benchmarks, but not for targets

in other years. Overall, these findings indicate that the financial performance of firms acquired in 1985 and 1986 improved more, relative to their benchmarks, than that of the other subsample of firms. These results lend strong support to the hypothesis that financial synergies are an important motive for the merger transactions following the mid-1980s capital shock. Results also suggest the potential for operating synergies from merger in both sub-samples of firms.

Finally, Chamberlain and Tennyson (1998) investigate the incidence of capital transfers from the acquiring firm to the target in the year of the merger. Results of the logistic regression strongly reveal that firms with greater capital needs are more likely to receive a capital infusion at acquisition. Estimation results also show that capital infusions are more likely in the post- capital shock years 1985 and 1986 where targets were poorly capitalized and information asymmetries were more severe, suggesting more tough financial constraints. This finding confirms the hypothesis that acquisitions for financial synergies are more prevalent in this time of capital shocks.

- Cummins et al. (1999)

Cummins et al. (1999) empirically examine whether the scale economies and potential efficiency gains are a major driver for the mergers and acquisition in the insurance industry using a final sample of 106 acquired life insurers during the period 1988-1994 that continued to operate as viable decision-making units following the acquisition. The authors study this question by measuring several types of efficiency scores in the US life insurers, using data envelopment analysis (DEA). They also used the Malmquist index to measure the productivity changes over time. Cummins et al. (1999) focuses their analysis on targets involved in the M&As by comparing the efficiency of these acquisition targets with firms that have not been targets of acquisition activity.

They tested the empirical relevance of the following hypotheses.

H1: Operating performance: the M&A is expected to improve the operational efficiency of the target and/or the combined post-merger entity. Thus, life insurance targets should exhibit lower efficiency prior to their acquisition, and/or that less efficient firms are more

likely to be acquired. Both cost and revenue efficiency are used. Cost efficiency for a given firm is defined as the ratio of the costs of a fully efficient firm with the same output quantities and input prices to the given firm's actual costs. Revenue efficiency is defined as the ratio of a given firm's revenues to the revenues of a fully efficient firm.

H2: Earnings diversification: a large and diversified policyholder pool will reduce the volatility the underwriting earnings. This motivates the insurer to take on more risky, higher yielding investments, thus increasing revenues for a given level of overall risk.

H3: Scale economies: firms operating with non-decreasing returns to scale (NDRS) are more likely to be acquired because they could become more efficient through growth. Thus, authors hypothesize that acquisition targets are more likely to be to be characterized by NDRS.

The NAIC adopted a Risk-Based Capital (RBC) system in 1993 designed to raise capital standards in the insurance industry due to the sharp increase in insolvencies during the 1980s. Insurers that face regulatory costs and capital constraints due to information asymmetry are likely to be attractive acquisition targets for stronger firms, particularly if they are efficient and/or operating with favorable returns to scale.

Cummins et al. (1999) conduct a regression analysis where the dependent variables represent changes in various types of efficiency over a period ranging from two years prior to the year of acquisition to two years after the year of acquisition to test whether acquisitions lead to improvements in efficiency after controlling for firm's characteristics and time.

The independent variables include size (log of assets), organizational form (a dummy variable equal to 1 for mutuals and zero for stocks), ownership type (a dummy variable equal to 1 if the firm is an unaffiliated company and zero otherwise), and business mix (the proportions of the firm's premiums in group life, group annuities, individual annuities, and accident and health insurance, with individual life insurance as the excluded category). To control for geographical concentration, they include the firm's geographical Herfindahl index, based on the proportions of premium revenues by state. A firm with a high

geographical Herfindahl index has a substantial share of its business concentrated in one or a few states, while firms with lower Herfindahl indices tend to be more geographically diversified. To determine whether acquisitions improve firm efficiency, the authors include a dummy variable equal to 1 if the firm was acquired during the period and zero otherwise.

Overall, the regression results provide strong empirical evidence that target firms experienced significantly larger gains in efficiency than firms that were not implicated in M&A deals. This finding gives support to the evidence that acquisitions has improved the efficiency in the life insurance industry due to improvements in both revenue and cost efficiency and leading to a strong positive effect on profits for target firms.

In addition, Cummins et al. (1999) estimated probit models of the probability of acquisition in any given year where the dependent variable is set equal to 1 for target firms and to 0 for firms with no M&A activity. Acquired firms are included in the probit analysis only in the year of their acquisition. This analysis is aimed to test the relevance of the M&As motivations discussed above and to identify the predictor variables characterizing target firms.

The probit estimation contains explanatory variables to test the hypotheses discussed above along with control variables. To test the hypothesis that firms with non-decreasing returns to scale are more attractive acquisition targets than firms showing decreasing returns to scale, authors include a dummy variable equal to 1 if the firm has non-decreasing returns to scale and to 0 otherwise. A positive coefficient for this variable is expected. For efficiency hypothesis saying that more efficient firms are more likely to be targeted by an acquisition, authors include one type of efficiency ratio in each regression. A positive coefficient for this variable is expected.

To test the hypothesis that financially vulnerable firms are likely to be acquisition targets, many measures are used: 1) The ratio of equity capital to assets to measure the adequacy of the firm's capitalization, 2) The ratio of Net operating cash flow to assets, 3) The one-year growth rate in premiums to measure growth opportunities, 4) The ratio of cash and invested assets to liabilities to proxy for the liquidity ratio. Negative coefficients are expected for all these variables. A dummy variable equal to 1 for unaffiliated firms zero

otherwise to test the hypothesis related to managerial resistance to acquisition activity to protect job security. Negative coefficient is expected for this variable. Authors also include the log of assets to capture firm size, and a dummy variable equal to 1 if the firm is a mutual and equal to 0 otherwise. Negative coefficients are expected for these two variables. The geographical Herfindahl index is included to control for the degree of geographical diversification. No clear prediction is made for this variable. The final control variables consist of business mix percentages. The independent variables in the regression are lagged one year and year dummies are included.

Overall, the probit results provide strong support for the hypothesis that firms with non-decreasing returns to scale are more likely to be acquisition target. The results also lend some support for the hypothesis that more efficient firms are attractive merger targets. All efficiency variables have the predicted positive sign, however only the coefficient for revenue efficiency is statistically significant. Proxies for the financial vulnerability of the firm have the predicted negative sign with statistical significance at 5%, however, the liquidity ratio which has a positive and insignificant coefficient. This finding corroborates the hypothesis that financially vulnerable firms are more likely than stronger firms to be acquisition targets. The unaffiliated firm dummy and the mutual dummy have the predicted negative signs, indicating that managers of unaffiliated firm resist more the takeover activities and that mutuals are less likely to be acquired. Finally, the geographically diversified firms are more likely to be acquired which corroborates the earnings diversification hypothesis.

Like in Cummins et al. (1999), Cummins and Xie (2008) analyze the productivity and efficiency effects of mergers and acquisitions in the US property-liability insurance industry using data envelopment analysis (DEA) and Malmquist productivity indices. Their final sample consists of 241 target companies that continued as viable operating entities following the acquisitions during the 1994-2003 period. The work of Cummins and Xie (2008) aims to determine the value implications of M&A activity for acquirers and targets using efficiency and productivity change measures. Authors also examine the firm characteristics associated with becoming an acquirer or target through probit regressions.

For insurers, the “law of large numbers” makes expected losses more predictable as the size of the insured pool increases. Thus, large insurers, with diversified earnings, have less volatile earnings and need to hold less equity capital per policy underwritten which frees the insurers capital and provides a powerful source of cost reduction. In addition, increasing underwriting diversification allows insurers to engage in higher return/risk investment strategies without increasing their costs of capital. Thus, M&As provides a valuable source of earning diversification by expanding their pool of policyholders more rapidly than is usually possible through organic growth.

Thus, authors hypothesize that that firms operating with increasing or constant returns to scale are more likely to be takeover targets than firms operating with decreasing returns to scale. on the contrary, However, acquirers do not need to be scale efficient.

Economies of scope is an additional motivation for M&A transactions. And insurer could realize cost scope economies by reducing overall production costs by providing different types of products, rather than specializing. Also, an insurer could realize revenue economies of scope by providing several types of financial services. Then, Cummins et al. (2008) conjecture that insurers involved in M&A transactions should achieve economies of scope by increasing geographical or product line diversification, and hence improvement in the efficiency of the firm.

This theory predicts that poorly performing firms due to inefficient managers are more likely to be acquired and that the performance of targets will improve after the takeover. Acquiring firms are also expected to gain from the takeover activity if they could bring operating synergy to the post-takeover entity. On the contrary, empirical evidence in the insurance industry shows that acquirers prefer efficient targets. Thus, Cummins et al. (2008) do not have a clear prediction on whether the targets are relatively more or less efficient than non-targets.

M&A transaction can be motivated by financial synergies. Financially constrained firms with valuable investment opportunities may suffer from the underinvestment problem due to the asymmetric information in the financial market. In this case, M&A could alleviate the underinvestment problem by allowing the financially constrained firm to merge with

slack-rich firm when the information asymmetry between the two firms is smaller than with outside investors.

Thus, the authors conjecture that firms in financial distress but with good investment opportunities are more likely to be involved in M&A deals, either as targets or as acquirers. In addition, financial synergy should improve the efficiency of firms involved in the M&A deals.

M&A can be motivated by the empire building behavior by a self-serving manager increasing his personal wealth to the detriment of the firm's owners. In addition, the manager of an unaffiliated company faces employment insecurity if his firm is acquired and thus, he is more likely to be resistant to takeover offers. Cummins et al. (2008) hypothesize that unaffiliated firms are less likely to be targets of successful takeover attempts than companies that are part of insurance groups.

Managerial hubris theory argues that managers might overestimate the value of what they buy because of hubris, or they could underestimate the cost of post-merger integration, even if they are acting in the interests of the firm's owners. Consequently, M&A deals may appear to be poor strategic decision where benefits are overestimated, or costs are underestimated.

Industry shock theory argues that M&A activities within an industry could be driven by a changing economic environment or industry shocks such as changes in regulation (i.e., the adoption of the regulatory risk-based capital (RBC) system in 1994), changes in input costs, increased foreign or domestic competition, or innovations in technology.

For their sample period, Cummins et al. (2008) claim that it is unlikely that industry shock theory provides an explanation for most of the M&A because the US property-liability insurance industry in general was in excellent financial shape during most of their sample period.

Cummins et al. (2008) perform two set of multivariate regression models with productivity and efficiency changes as dependent variables proxied using six different measures and firm characteristics as independent variables. The first set of regressions tests the

hypotheses about acquirers and non-acquirers; and the second set of regressions tests the hypotheses about targets and non-targets. The regressions are estimated using ordinary least squares.

Several independent variables are included in the regressions to control for firm characteristics. The log of assets is included to control for firm size. A dummy variable equal to 1 for mutuals and zero for stock insurers is included to control for organizational form, and a dummy variable equal to 1 for unaffiliated companies and equal to zero for groups is included to control for differences in corporate structure. Dummy variables equal to the proportion of a firm's premiums in personal short-tail lines, personal long-tail lines, and commercial long-tail lines, with commercial short-tail lines as the omitted category to control for the business mix of insurers. The firm's geographical Herfindahl index based on the proportion of net premiums written by state and its product line Herfindahl index based on the proportion of net premiums written by product lines are included to control for diversification. The premium/surplus ratio is used to control for the effects of underwriting leverage. The independent variables are lagged by one year and acquisition year dummies are also included to control for time effects, with 1994 as the omitted year.

The first set of regressions includes a dummy variable equal to 1 for acquirers and zero for non-acquirers is used to test for differences between these two categories of firms. Overall, these regressions reveal that acquirers realize 8.4% higher revenue efficiency gains than non-acquirers. Hence, M&As are value-enhancing for acquirers in terms of the revenue efficiency suggesting that economies of scope may be a motivation for the M&A deals. On the contrary, acquirers are not significantly different from non-acquirers in terms of changes in cost efficiency.

The second set of regressions is used to test for efficiency improvements of M&A targets versus non-targets. The main finding is that targets achieve higher cost and allocative efficiency gains in comparison with non-targets. Thus, being acquired is value-enhancing in terms of cost and allocative efficiency. Nevertheless, the results are not as strong as in the Cummins et al. (1999) for US life insurers, where targets did significantly better than non-targets in terms of cost efficiency, revenue efficiency, and total factor

Cummins et al. (2008) perform two set of probit regressions to determine firm characteristics associated with becoming acquirers and targets. The dependent variable for the first set of probit regressions is a dummy variable for being an acquirer. The dependent variable for the second set of probit regressions is a dummy variable for being a target. The objective is to identify the predictor variables characterizing acquiring firms and target firms in the US property-liability insurance industry. Estimation is conducted using maximum likelihood probit analysis.

The independent variables in the probit model are firm characteristics lagged one year. A dummy variable equal to 1 for non-decreasing returns to scale firms and 0 for decreasing returns to scale firms. A positive coefficient of this variable is expected in the target probit models. the pre-acquisition performance is proxied by several efficiency scores, the loss ratio, the underwriting expense ratio, and pre-tax return on equity. For the acquirer regressions, a positive coefficient is expected for the pre-tax ROE, however, no clear predictions are made for efficiency scores or for the loss and expense ratios. For the target probit regressions, a negative coefficient is expected for the efficiency variables and positive coefficients for the loss and expense ratio variables, suggesting that poorly performing firms are likely to become targets because of the potential for efficiency gains (corporate control theory). However, positive signs for the efficiency scores could indicate that acquirers are seeking to enter new lines of businesses or geographical areas by acquiring more efficient targets.

The capital-to-asset ratio is included in the regressions to proxy for the financial strength of a firm. A positive coefficient is expected for this variable in the acquirer probit regressions and no clear prediction is made for the target regression. The geographical and product line Herfindahl indices are included to proxy for diversification, however, without a clear prediction about the expected signs. Asset portfolio risk is the measured by the proportion of invested assets in stocks with expected positive coefficient in the acquirer and target regressions. Firm size is measured by the log of assets with an expected positive coefficient in the acquiring probit and a negative coefficient in the target probit. A mutual dummy for organizational form is included with an expected negative sign in both acquirer and target regressions because mutuals have limited access to capital and are more difficult

to acquire. An unaffiliated dummy for corporate structure with a predicted negative sign in both probits. The growth rate (percent change in premiums) is included with ambiguous predicted sign in both the acquirer and target probits. Business mix is proxied by personal (commercial) lines short (long)-tail. Year dummies are included.

The principal finding from the target probit regression, is that poorly performing firms with low capitalization and poor underwriting performance (i.e., loss ratio and the expense ratio) are more likely to be takeover targets. Efficiency factors appear to have no significant impact on being target. These findings reveal that financial performance is a stronger predictor of being target in takeover deals. Targets tend to have higher geographical diversification. The product line Herfindahl is not significant in the target probit regressions. Mutuals and unaffiliated firm are less likely to be targeted by M&A transactions. the catastrophic risk exposure of personal short-tail coverages is positively related to the probability of being a target.

The principal finding from the acquirer probit regression, is that large and rapidly growing profitable firms are more likely to be acquirers, suggesting that more large and profitable firms have more resources to engage in M&As and/or have stronger tax incentives to make acquisitions.

The efficiency variables in the acquirer probit regressions are mostly insignificant, however, the coefficient of technical efficiency is significant and negative, indicating that technically efficient firms are less likely be acquirers. Results also indicate that unaffiliated single firms and mutuals are less likely to be acquirers, indicating that groups are more likely to be acquirers. Finally, acquirers appear to have more exposure in the commercial long-tail business lines.

- Boubakri et al. (2008)

Boubakri et al. (2008) investigate whether M&A transactions create value for acquirers' shareholders and explore the different channels of how firm-level corporate governance mechanisms and cross-country differences in the legal environment and investor protection affect the long-run performance for acquirers. The sample consists of 177 M&A

transactions over the sample period 1995-2000 where acquirers are US property–liability insurers and where targets could be U.S or foreign insurers.

Boubakri et al. (2008) assessed the empirical relevance of the different hypotheses related to value creation as measured by the long run stock price performance of bidders in M&A transactions.

For this first category, the authors postulated that:

H1: Diversifying M&A transactions, involving acquirers and targets with different four-digits SIC Code, could create higher value for bidders because of the created synergies and economies of scope and scale driven by the similarity of services provided by both the acquirers and the targets.

H2: Focusing M&A transactions, where acquirers and targets are in the property–liability insurance, should create more value for the bidders than diversifying transactions.

H3: Cross-border transactions could be value enhancing for bidders due to the perceived geographic expansion of its market.

This second category of hypothesis is related to the potential effects of the M&A deal characteristics, the firm-level corporate governance, and the country institutional environment on the long run stock price performance of bidders.

Boubakri et al. (2008) hypothesize that:

H4: M&A deal will be more value enhancing and less costly to acquirers when targets operate in environments where investor protection is weaker.

H5: The long run performance of the acquirers is positively related to the percentage of shares held by institutional investors, block-holders and the CEO, in the absence of entrenchment problems.

H6: The proportion of independent directors within the board and the percentage of new nominees on the board are positively related to the long run stock price appreciations due to a better monitoring on the firm's top management.

H7: CEO tenure and independence is positively related to the long run performance of bidders.

Moreover, the authors conjecture that the percentage of shares acquired, and the size of the target have respectively positive and negative effect on the bidders' long run performance, however the mode of acquisition and the origin of the target (i.e., foreign) have no clear effects on the value creation for acquirers. Lastly, frequent acquirers are more likely to be rewarded by the market.

Boubakri et al. (2008) measure the long run performance of acquirers by the 3-year buy and hold adjusted abnormal returns based on the market model. The results confirm a significant average positive abnormal return of 0.572 on the long run for acquirers, which is consistent with the evidence of a greater operating efficiency and a higher profitability during the post-acquisition three years. Results also suggest that M&A transactions involving a no U.S targets, yield lower mean adjusted long run returns than domestic targets (0.247 and 0.636, respectively). The results reveal that property-liability acquirers are better off when buying other property-liability insurers, namely focusing M&A transactions are more value enhancing for acquirers than diversifying M&A deals. Overall, these findings suggest that the diversification at the level of business lines and geographical locations are lower value enhancing channels for US property-liability acquirers.

As robustness check, the authors constructed, for each calendar month, a portfolio of acquirers that were involved in a M&A in the previous 3 years and regress the portfolio excess return on the Fama-French four-factor model (1993). Robustness results confirm a significant positive abnormal performance for acquirers.

Next, Boubakri et al. (2008) examine the potential determinants of the long run performance of acquirers by regression the adjusted buy and hold abnormal return on the

M&A deal characteristics, firm-level corporate governance, and country level institutional environment.

Deal characteristics refers to the percentage of shares acquired, the mode of acquisition proxied by a dummy variable that equals one if the transaction is a merger, zero otherwise, the target's origin a dummy variable equal to one when the target is a non US company, the type of bidder measured by the number of M&A transactions conducted by the bidder during the year of acquisition, the type of transaction measured by a dummy equals one if the target and the bidder have identical four digits SIC codes, zero otherwise, and the target's relative size proxied by a dummy variable that equals one if the target is an insurance agency or broker, and zero otherwise.

Internal Corporate Governance refers to the ownership structure of the acquirer measured by the share ownership by block-holders or by institutional investors, the BOD characteristics measured by the percentage of independent directors sitting on the board and the percentage of new members elected on the board, and the CEO characteristics proxied by percentage of share ownership by the CEO, a dummy that is equal to one if the CEO is also the chief of the board, and Tenure of the CEO as the CEO.

Institutional Environment refers to the level of investor protection in the country measured by an index calculated by the authors based on i) the strength and impartiality of the legal system and the popular observance of the law in the year of the announcement, ii) the perceived corruption within the political system in the year of the announcement, and iii) the extent of respect of contractual agreements in the year of the announcement.

Pertaining to the deal characteristics, results indicate that mergers are less beneficial to acquirers and that a tender offer are more value enhancing. Frequent acquirers are more likely to have higher returns in the long run due to the acquired experience to successfully integrate the target's activities into their own businesses. Moreover, results show that M&A transactions involving small size targets are more likely to enhance performance in the long run. On the contrary, the percentage acquired, the origin of the target and the focus of the M&A appear to be insignificant. Interestingly, the composite index of investor protection is negatively associated to the long run performance. Regarding the firm-level corporate

governance, the results show that the board independence and block-holders' ownership yield unexpectedly negative and significant coefficients in relation to performance. Results related to the CEO characteristics indicate that the percentage of shares held by the CEO and the CEO duality are significantly and negatively related to the bidder's long run performance which is consistent with managerial entrenchment theory related to CEO ownership. The CEO tenure, the institutional ownership and the percentage of new members elected on the board seem to be insignificant determinants of the long run performance of the acquirers.

- Cummins et al. (2015)

The objective of Cummins et al. (2015) is to examine the market value implication of M&A transaction in the global insurance industry on both target and acquiring firms. Cummins et al (2015) conduct an event study analysis to determine the market value effects of M&A deals where either the target or the acquirer is an insurance company and where the merger partner can be from any part of the financial industry.

Cummins et al. (2015) tested the empirical relevance of the following hypotheses.

H1: Mergers and acquisitions are value-creating for acquirers and targets.

Based on the empirical finding of the prior literature, Cummins et al. (2015) conjecture that M&A deals are value enhancing for acquirers and targets. M&As allow acquirers to achieve economies of scale and scope, improve efficiency, and diversify earnings. In addition, empirical evidence show that poorly performing firms are more likely to be acquired and that the performance of targets will improve after the takeover. Overall, the beneficial valuation effect of M&A transactions for acquirers and target is driven by the created operational and financial synergies.

H2: Cross-border M&A transactions are value creating for acquirers and targets.

Cross-border M&As provide the acquirer and the target with higher diversification gains due to the low correlation between the underwriting return between their respective domestic markets. In addition, cross-border M&As is a less costly strategy to achieve

diversification than buying reinsurance. Thus, it is expected that geographic diversification through cross border M&As is value enhancing for both the acquirer and the target.

H3: Focusing M&As are more likely to create value for acquirers and targets than diversifying M&As.

Although, conglomeration can be value enhancing by generating costs and revenues' scales of economies and improving services, it could be value destroying due to managerial incentive conflicts and agency cost. On the contrary, strategic focus hypothesis stipulates that firms can maximize value by focusing on core businesses and core competencies. Recent empirical studies show that focusing M&A deals, within the same industry segment, are more value creating than diversifying M&As.

H4: The gains from M&A transactions are larger for transactions where at least one merger partner is headquartered in the US.

It is expected that the number of M&A transactions will be larger for countries that have a well-developed financial market and a large insurance market with numerous companies. Thus, the number of transactions is expected to be large in the US, the U.K. and in continental Europe. In addition, the value effects of M&A transactions are expected to be higher for countries with high insurance penetration (premiums as percentage of gross domestic product) and insurance density (premiums per capita). markets. Hence, M&A gains will be larger in well-developed insurance markets. Moreover, regulations about privacy and the sharing of consumer information may impact the efficacy of M&A and limit gains from M&As. strategies. Such legal restrictions are relatively weak in the US compared to various EU countries. Lastly, the presence of cultural and language barriers within the EU are also likely to reduce gains from M&As in comparison with US domestic transactions. All these arguments suggest that M&As with at least one partner domiciliated in the U.S are more value enhancing.

This study is based on M&A transactions over the period 1990-2006, as reported in the Thomson Financial SDC Platinum database, where either the acquirer or target was an insurance company. Insurance companies were defined as all firms with four-digit

Standard Industrial Classification (SIC) codes in the insurance industry: 6311, life insurance: 6321, accident & health insurance; 6331, fire, marine & casualty insurance; 6399, insurance companies NEC; and 6411, insurance agents, brokers, & service.

The empirical methodology is based on event study to capture the market reaction to the M&A transactions on both target and acquiring firms in a series of event windows surrounding the transaction dates. For each M&A transaction, the event study methodology computes the daily abnormal return using stock price data by subtracting the expected return from the actual return on each day during the event window. The predicted return on the stock is estimated by the standard market model using the stock's returns over the 250 trading-day period ending 30 days prior to the M&A event. The statistical significance of CAARs is verified using three significance tests: the Patell Z-score, the standardized cross-sectional Z-score, and the generalized sign Z-score.

Tests are conducted for differences in market value effects of mergers by country/ region, by whether the transaction is focusing vs diversifying, and by whether the transaction is cross-border or domestic.

There is a total of 4,068 M&A deals over the entire sample period from 1990 to 2006. There are at least 150 deals in each year of the sample period. The number of deals peaked during the period from 1996 to 2000 with more than 300 transactions each year. Total deal value for the entire period covered by the study is more USD1.3tn. The US dominates with 52.6% of total worldwide deal value, measured by target transactions.

The largest number of transactions in terms of targets was within North America, 1,073 in the US and 127 in Canada. The US thus accounts for 54.5% of all M&A transactions. There are 668 transactions involving European targets with largest number of targets in the UK and France. There are only 57 target transactions in Asia. There are 1,628 within-border and 340 cross-border transactions.

Statistics also reveal that there is considerable cross-industry M&A activity during the sample period, evidence of financial sector convergence. 70.0% of deals and 65.3% of deal volume are cross-industry, where each segment of the insurance industry is considered as

a separate industry. Interestingly, statistics show that 39.2% of all deals by number and 55.2% by value involve life insurance targets, and 36% by number and 44.8% by deal value involve life insurance acquirers.

Due to incomplete stock return information, the event study sample consists of 1,790 acquirers and 309 targets. The authors investigate several event windows (–1, +1), (–2, +2) and (–5, +5). To test the different hypothesis, the results are broken down in terms of cross versus within-border transactions, cross versus within-industry.

Overall, the event study reveals that M&A transactions are value enhancing for both acquirers and targets as expected, however the value effect for targets is larger. For example, the value gain measure by the average cumulative abnormal return is 10.8% for the targets and 0.52% for acquirers for the event window (–1,+1).

Next, Cummins et al. (2015) analyze the value effect of M&A deals by country/region: U.S, Europe (including the U.K) and Asia (including Australia and New Zealand). Overall, the results show that Acquirers headquartered in the U.S or Europe have statistically similar market value gains for the event window (–1,+1), with a men CAAR of around 0.43% for the USA and 0.50% for Europe. Surprisingly, there is no significant market gains for Asian acquirers. Thus, the results provide only weak support for the hypothesis that gains from M&A transactions are larger for transactions where at least one merger partner is headquartered in the US.

For targets, results reveal significant market value gains for targets in the US, Europe, and Asia, which lands support to the hypothesis that M&A are value enhancing for targets. Interestingly, U.S targets have a statistically significant the market value creation compared to European and Asian targets. For example, the mean CAAR for the event window (–2,+2) is 16.8% for US targets, 8.8% for Asian targets, and 7.4% for European targets.

To test the hypothesis that cross-border M&A transactions are value creating for acquirers and targets, Cummins et al. (2015) breaks down M&A transaction into cross border and within-border deals. For acquirers, the results show that cross-border M&A deals provide larger value enhancing than domestic transactions. For targets, results indicate a

statistically similar market value gains for cross border and within border M&A transactions.

Cummins et al. (2015) also test the hypothesis stipulating that focusing M&As are more likely to create value for acquirers and targets than diversifying M&As by breaking down the M&A transactions into cross-industry and within-industry deals. Overall, the results show a larger market value gains for acquirers for M&A deals where both acquirers and targets are insurance compagnies, with a mean CAAR of 0.66% and 0.48% for event windows (–1,+1) and (–2,+2). On the contrary, the mean CAAR is statistically insignificant when the acquirer is an insurance company, and the target is not an insurance company. It appears then that focusing M&As are more value enhancing for an acquiring insurance company than diversifying M&As. Same conclusions are drawn for insurance targets compared to non-insurance targets. In fact, insurance targets have significantly higher market value gains when the involved acquirer is also and insurance company than when the acquirer is operating in another industry. These latter results provide evidence that focusing M&A deals create more value for acquirers and targets in the insurance industry than diversifying transactions.

- Klumpes (2022)

This study aims to i) investigate the consolidation effects of M&A in the European insurance markets, ii) explicitly incorporate the effect of a fragmented regulatory and monetary environment to estimate the technical efficiency of European insurance, and iii) verify the relevance of the survivorship principle in explaining the insurance industry consolidation. The survivorship principle posits that likelihood of firms surviving over time is associated with their degree of business diversification.

Klumpes (2022) tested the empirical relevance of the following hypotheses.

H1: Incentives for M&A in the European insurance industry in the pre-financial crisis consolidation period (1997-2007) are primarily associated with the desire for technical efficiency improvements.

This first hypothesis finds support in the argument that M&A enhance shareholder value by exploiting opportunities to improve firm operating performance. The operational performance car be improved by i) higher technical efficiency due to the adoption of best practice technology, and ii) lower operating costs due to scale economies.

This hypothesis has also a diversification motivation leading to more predictable losses and lower earnings volatility due to the extended breadth of the policyholder pool. The more stable underwriting income gives the insurer an opportunity to take on more risky, higher yielding investments, thus increasing revenues.

H2: Surviving European insurance firms in the subsequent, post financial crisis consolidation period (2008-2016) are more likely to be those which engage in M&A activity, have similar or different business lines from their competitors, or engage in cross-border activity.

The second survivorship hypothesis tests the argument that inter-industry relatedness can predict insurance firm's survival probability in the longer-term, post-consolidation period. The survivor principle holds that the competitive process weeds out inefficient firms, so that surviving insurers are more efficient insurers with higher operational diversification.

The data comes from the Standards & Poor's Eurothesys database of annual account information relating to specialist life, composite and non-life insurance firms licensed in the seven major European markets: France, Germany, Italy, Netherlands, Spain, and Switzerland. Only general insurance business specialists are included in the sample. Non specialists, such as captive insurance firms or specialist reinsurance firms are excluded.

The sample period is 1997-2016 divided into two sub-periods: i) a pre-crisis period for 1997 to 2007 and a post-crisis surviving period for 2008 to 2016. For the pre-crisis period, there are 93 acquiring insurers and 379 non acquiring insurers. For the post-crisis period, there are 9 acquiring insurers and 19 non acquiring insurers.

As in Cummins and Xie (2008), M&A deals were excluded if they did not involve a change in the ownership of a firm, or were pending, terminated, non-binding or involved acquisition of a minority interest only. To examine the survivorship hypothesis, Klumpes

(2022) used a sub-sample of firms being in continuous existence during the post-crisis period from 2008 to 2016 and were not subject to major restructuring or business model changes.

Following prior research, Klumpes (2022) used the data envelopment analysis (DEA) to estimate the best practice production frontiers for each year of the sample period. A production frontier gives the minimum inputs, required to produce any given output vector. Efficiency measure ranges from 0 to 1, with firms operating on the frontier measured as fully efficient (efficiency of 1), and firms not operating on the frontier measured as inefficient (efficiency less than 1). Klumpes (2022) focused on the change in efficiency for firms that are acquirers or targets between during the period of two years before to two years after the M&A deal.

To test the empirical relevance of the first hypothesis, namely acquiring insurers are motivated by the desire for technical efficiency improvements, Klumpes (2022) runs OLS regressions with efficiency changes as dependent variables and firm characteristics as independent variables. The dependent variables are technical efficiency change and total factor productivity change. The independent variables include size (log of assets), and organizational form (a dummy variable equal to 1 for general insurance and zero for life insurance firms), the ratio equity capital to total invested capital, the ratio of invested capital to total assets, the ratio of earned premiums to surplus capital, and a UK dummy for UK domiciled firms. More importantly, Klumpes (2022) includes a dummy variable, equal to 1 if the firm was not an acquirer during the period and zero otherwise, to determine whether acquisitions improve firm efficiency. OLS regressions are estimated for the two sub-periods separately.

Interestingly, the results support the predictions of the first hypothesis and show that technical efficiency gains are significantly higher for acquiring insurers than for non-acquiring insurers in the pre-crisis period. Results also indicate that larger insurers, with higher premium/surplus ratio, realize the highest efficiency gains. Interestingly, well capitalized insurers, with high ratios of equity/invested capital and capital/total asset,

realize efficiency deterioration for the sub-period 1997-2007. Life insurers and UK domiciliated insurers appear to realize lower efficiency gains form M&A deals.

Klumpes (2022) undertakes a logistic regression of the probability that an insurer becomes an acquiring firm using a dummy dependent variable taking zero for non-acquiring insurers and equal to 1 for acquiring insurers. Acquiring firms are included in the logistic regression analysis only in the year of their acquisition deal and non-M&A firms are included for all sample years for the two pre-crisis and post-crisis sub-periods. Several control variables related to the firm characteristics are included in the regressions. The efficiency ratio is included, and it is expected to be positively related to being an acquirer. Proxies for the financial strength of the firm are also included: the ratio of equity capital to assets to measure the adequacy of the firm's capitalization, the ratio of loss reserve as a proportion of premiums, and the percentage of equity investments. All these variables are expected to be positively related to being an acquirer. The log of assets is used to capture size effects. UK dummy for UK domiciled firms and life insurance dummy are included.

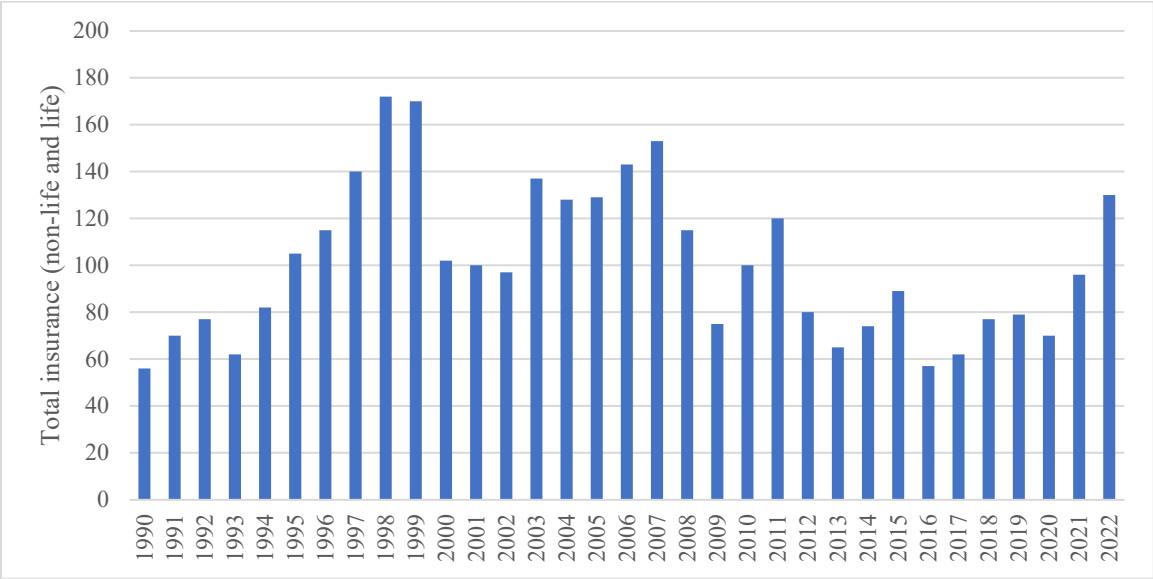
The logistic regression results show that more efficient insurers are more likely to be acquirers, which lends support to the first hypothesis related to the technical efficiency improvements for M&A transactions. Results also indicate that the log of assets, the life insurance dummy, the percentage of equity investments and the UK dummy are significantly positively related to the probability of being an acquirer in both pre and post-crisis periods.

3. M&A transactions related to US target insurers from 1990 to 2022

From the SDC database, we identify 3,328 M&A transactions related to US target insurers from 1990 to 2022. Data are annual observations as of December 31 of each year.

Figure 1 identifies the two main waves of target insurer M&As recorded in the US insurance industry over the past 33 years. There was strong M&A growth until the years 1997 to 1999, when the market reached its first peak since 1990.

Figure 1: Histogram of the annual number of M&A transactions related to US target insurers from 1990 to 2022

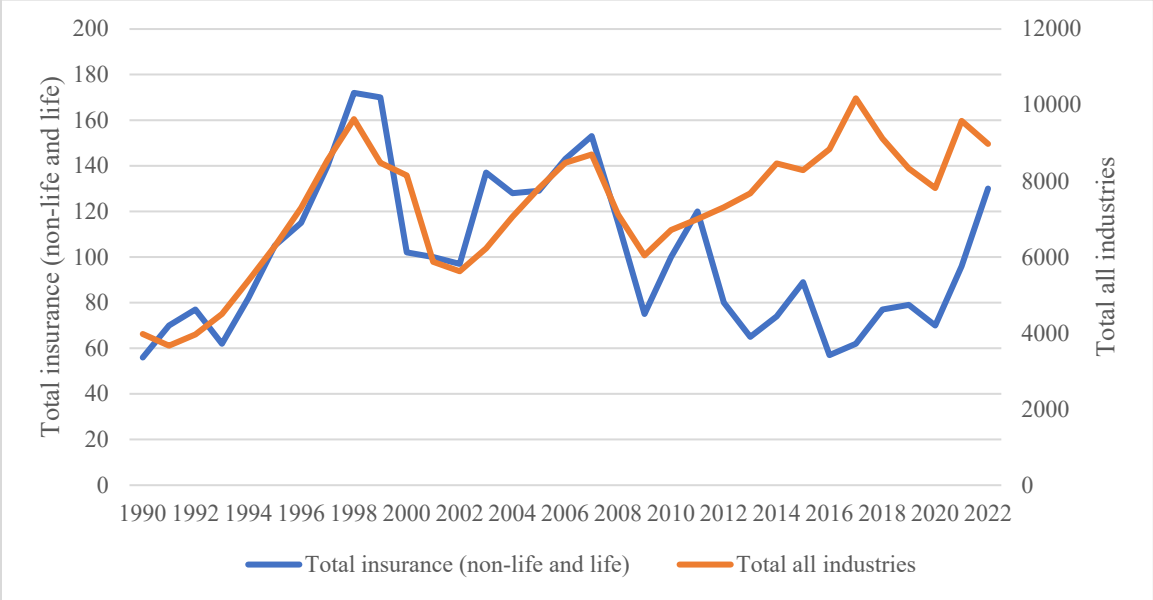


Data source: SDC database.

After a sharp decline in 2000, the M&A market resumed growth in 2003, and reached its second peak in 2007. Each of these wave years has more than 120 annual transactions. The two peaks correspond to periods of economic expansion. The wave recorded around 1997-1999 represents the largest of the US insurance industry during the period of analysis. The record years of 1998 and 1999 have not been broken since then. In fact, this period corresponds to the internet and new technologies growth of the years 1998-2000. The years of the second largest wave of M&As correspond to the economic expansion period before the financial crisis that began in August 2007.

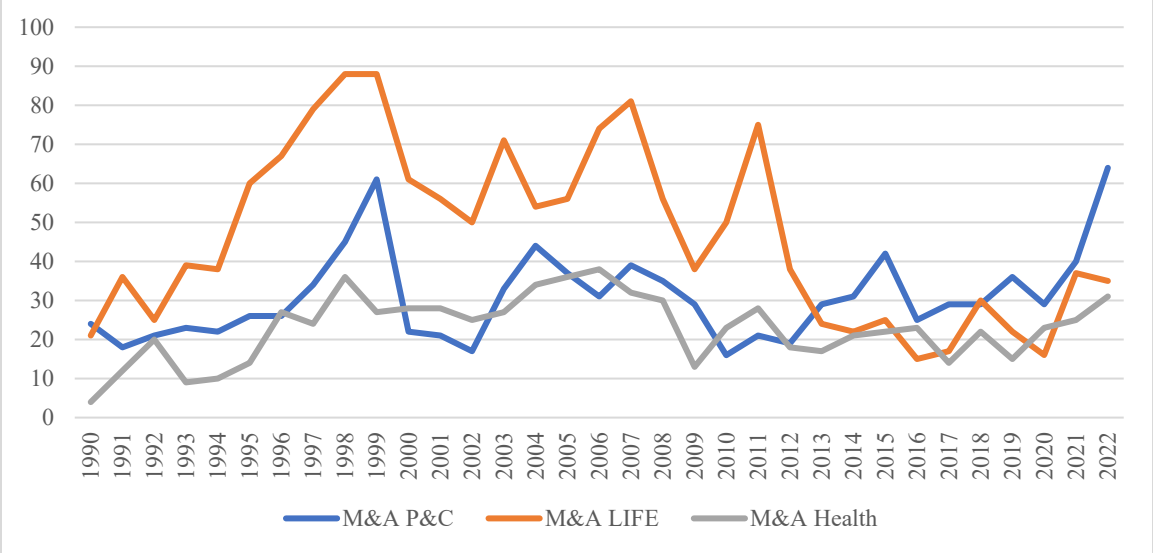
Figure 2 depicts three peaks of M&As across all industries in the US (1998, 2007, and 2017) during the same period. As documented above, only two waves of M&As occurred in the US insurance industry during that period. Since the 2007 peak, the M&A market has exhibited an overall downward trend throughout the US insurance industry (life and non-life combined). By comparison, the all-industry M&A market resumed its overall upward trend after a short decline during the financial crisis, from 2007 to 2009, and reached a new peak in 2017. Figure 2 suggests that the post-2007 period is marked by a shift behavior of insurers across the US insurance industry, which may be explained by changes in industry regulation after the 2007-2009 financial crisis, market conditions, and climate risk.

Figure 2: M&A trends in the US insurance industry (total M&A for non-life and life targets, left) and for all industries in the US (right), 1990 to 2022



Data source: SDC database.

Figure 3: MA trends of target insurers by the three insurance sectors in the US, 1990 to 2022



Data source: SDC database.

Table 1: Mean and standard deviation of the M&A in each sector

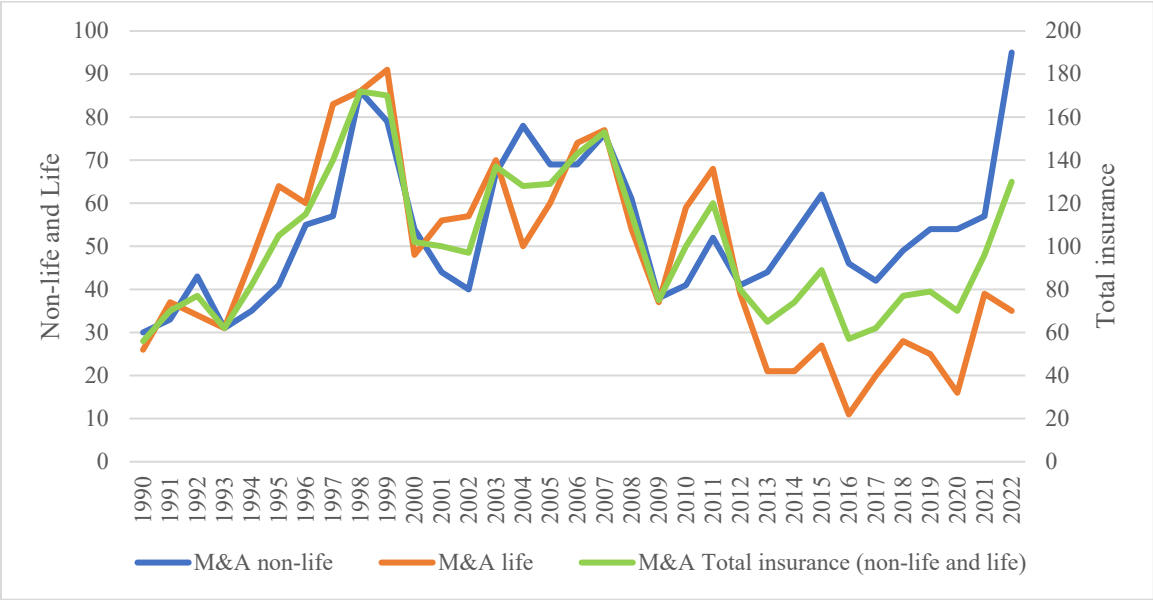
Period	1990-2022		1990-2012		2013-2022	
Annual number of MA	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
P&C sector	30.848	11.353	28.870	10.981	35.400	11.423
Life sector	46.788	22.342	56.565	19.294	24.300	7.660
Health sector	22.909	8.402	23.609	9.524	21.300	5.012

Figure 3 presents the evolution of the numbers of M&As in the three insurance lines and Table 1 summarizes their main statistics. Property and casualty insurers and health insurers appear to be more similar than with life insurers. We also observe the large reduction in M&As in the life sector after 2011. In this report, we consider that the US insurance industry consists of two main lines of business: life insurance, and non-life insurance that includes property and casualty insurance and health insurance.[1] Given that the two main lines of insurance can be affected differently by climate risk, market conditions, and insurance regulation, we have plotted the M&A transactions recorded in each of these two lines in order to analyze their behavior in relation to the target insurer M&A phenomenon. Figure 4 shows the evolution of M&As in each of the two main US insurance lines and that of the US insurance industry as a whole over the period of 1990 to 2022.

We observe, in Figure 4, that the evolution of M&As of target insurers in the life insurance sector seems to mirror the evolution of M&As of target insurers observed in the entire US insurance industry. More importantly, we confirm the strong decrease in mergers and acquisitions in the life insurance industry after 2012 while this activity seems more stable in the non-life insurance sector during the same period.

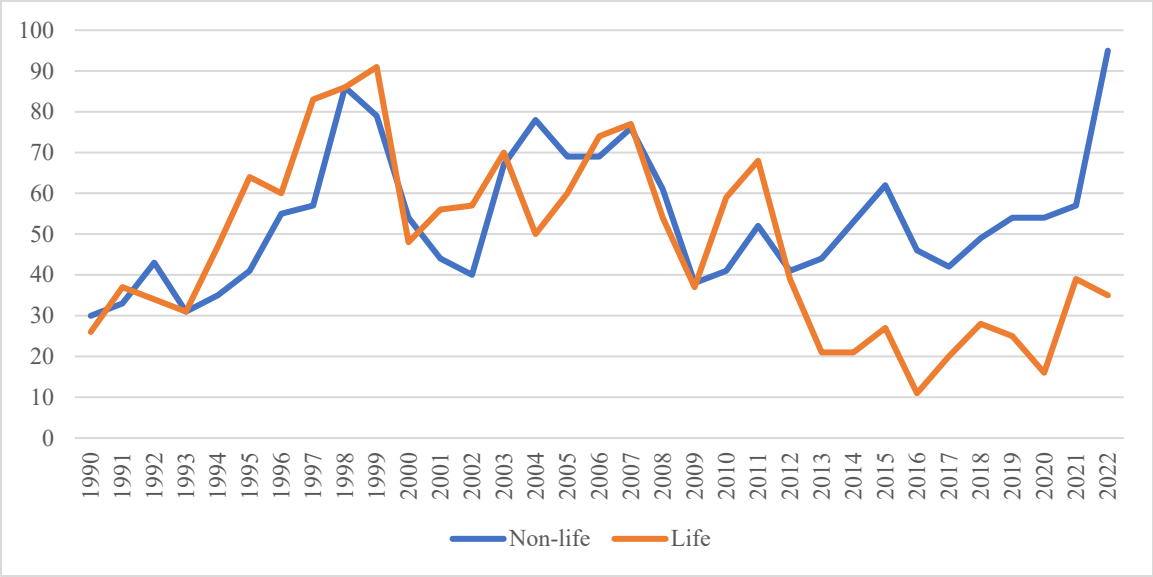
[1] We perform a robustness analysis in Appendix 1 by merging health insurers with life insurers.

Figure 4: M&A trends for target insurers by the two major insurance lines (life or non-life, left) and the overall US insurance industry (right), 1990 to 2022



Data source: SDC database.

Figure 5: M&A trends of target insurers by the two main insurance sectors (life and non-life) in the US, 1990 to 2022



Data source: SDC database.

Figure 5 shows a parallel time trend in the evolution of target insurer M&As for life and non-life insurance from 1990 until 2009 and even 2012 (see the corresponding Table A11 in Appendix 2). This result suggests that the evolution of target insurer M&As in the non-

life insurance sector is almost identical to that observed in the life insurance sector during this period. The parallel trends observed between the two groups started to disappear after 2009. The difference is more pronounced after 2012. Based on Figure 5, we retain the years 2009 and 2012 as potential candidates for the treatment date in our analysis with the difference-in-differences (DID) method. The choice of the treatment date for our DID method thus seems ambiguous. We will use a statistical approach, applied to time series, to validate the year that best suits our data.

It is worth trying to understand the divergence in the temporal trends in M&As observed between our two groups. It is possible that the temporal trends in M&As observed between our two groups cease being parallel in 2009 or 2012 owing to series of natural disaster events in the US or to the relative change in the regulation and market conditions of the two industries after the 2007-2009 financial crisis. To analyze these possible causes, we will first describe the evolution of the number and the severity of natural disaster events occurring in the US from 1990 to 2022.

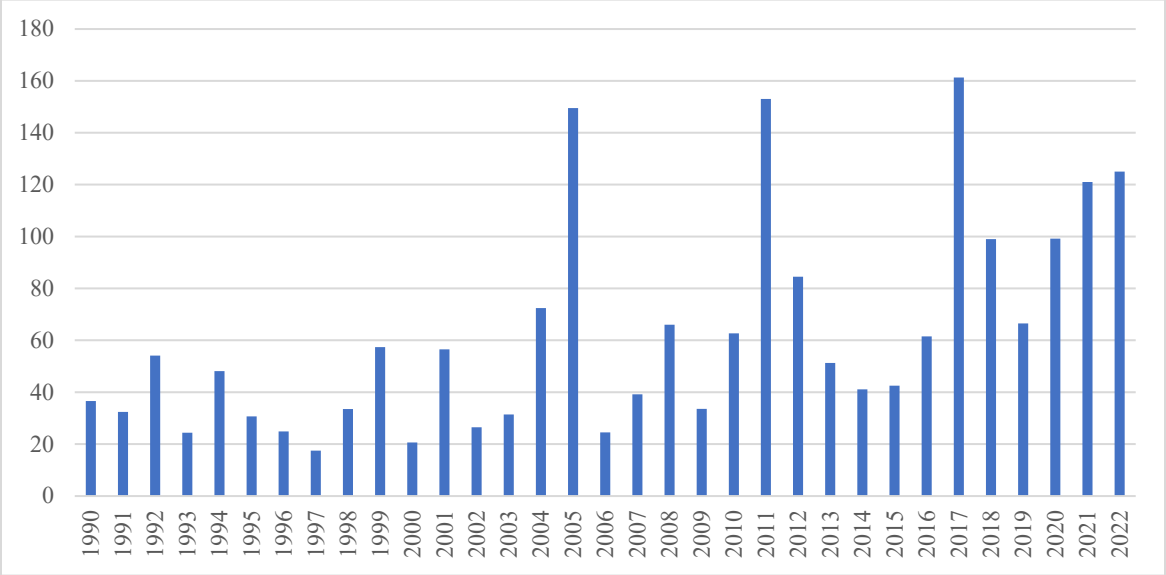
4. Analysis of the evolution of natural weather disasters events from 1990 to 2022

4.1. General statistics

The year 2011 will remain etched in the memory of insurers and reinsurers. It generated losses of exceptional magnitude, particularly in Japan, Thailand, New Zealand, Australia and the US. In other words, 2011 was a year of huge losses both globally and nationally (speaking of the US).

Globally, the last few decades have seen an increase in extreme weather-related events that have fueled the rise in the number of claims paid by insurers. Figure 6 shows three major peaks in the insured losses paid by insurers worldwide. The first largest peak in claims costs was in 2017. The year 2011 represents the second largest peak in the cost of claims borne by insurers worldwide. The year 2005 represents the third highest peak in insured losses. Looking only at the period prior to 2017, 2011 is the worst year for claims over the period of 1990 to 2017.

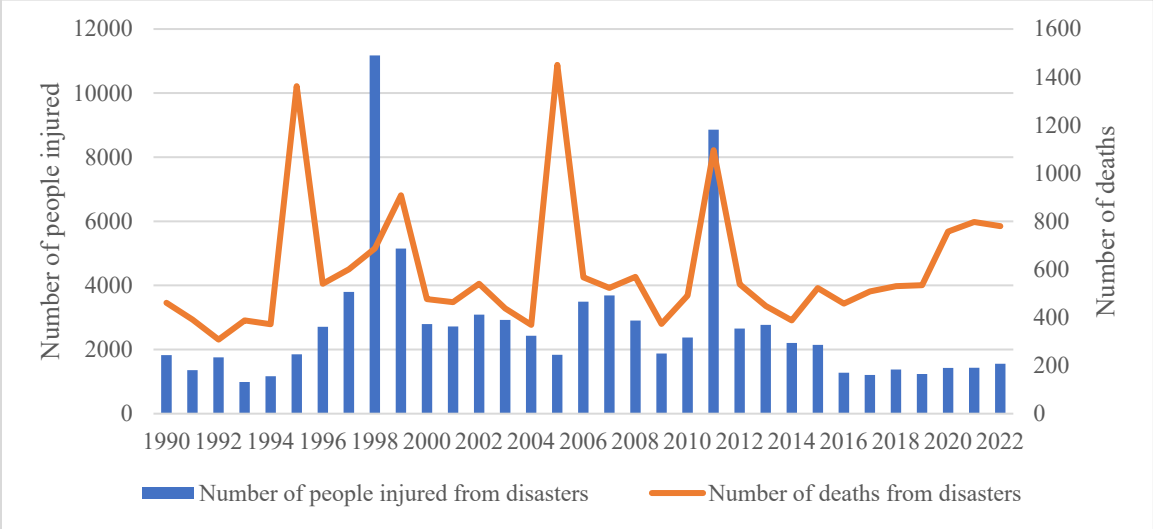
Figure 6: Insured losses (in billion $) from natural disaster events worldwide, 1990 to 2022



Data source: Swiss Re Institute.

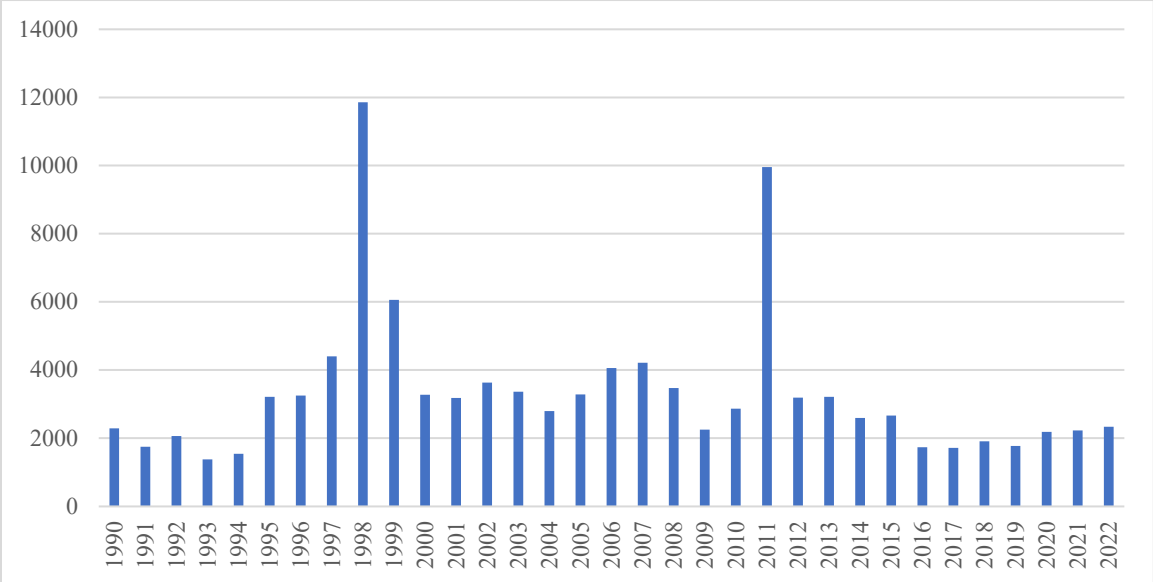
Figure 7 indicates that 2011 represents the third deadliest year due to natural disasters in the US. This 2011 record can be linked to the exceptional series of severe tornadoes that occurred that year in the Midwestern US. The most catastrophic year was 2005, the year Katrina struck. Figure 8 shows that 2011 is the year with the first highest number of injuries and deaths from natural disasters after 1998, the year of Hurricane Georges. Finally, the figure indicates a decrease in total casualties after 2011. Bear in mind that when a single natural catastrophe event affects a large number of policyholders, it increases claims costs on the one hand and management expenses (operating costs) on the other, putting upward pressure on the combined ratio and other financial ratios of insurers.

Figure 7: Numbers of injuries (left) and deaths (right)
from natural disasters observed in the US, 1990 to 2022



Data source: NOAA Weather Related Fatality and Injury Statistics. People injured or killed by natural disasters are not necessarily insured.

Figure 8: Total casualties (injuries and deaths)
from natural disasters in the US, 1990 to 2022

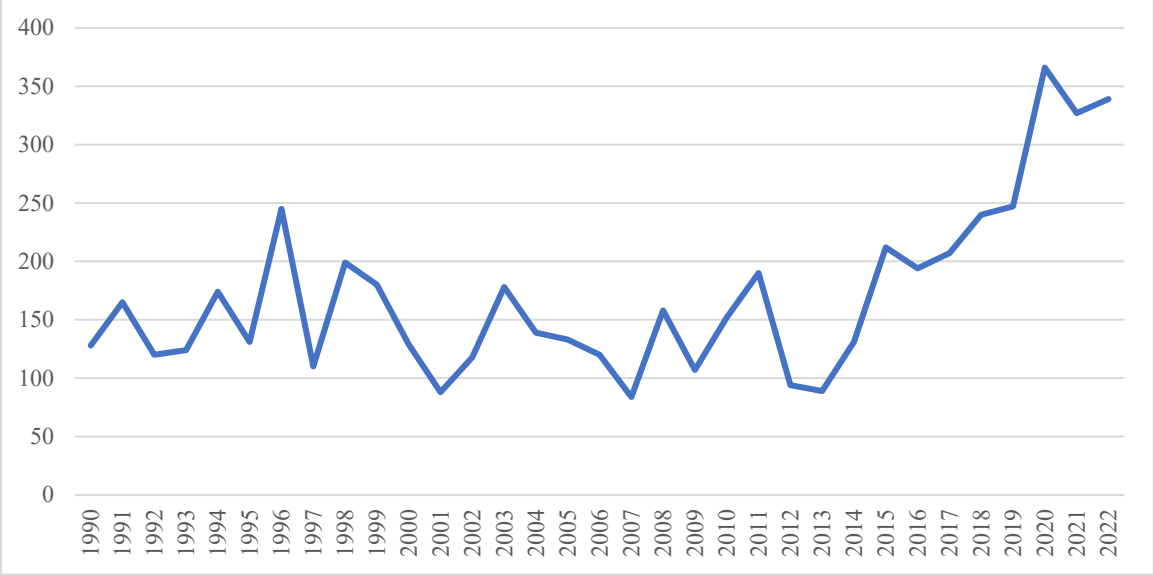


Data source: NOAA Weather Related Fatality and Injury Statistics. People injured or killed by natural disasters are not necessarily insured.

4.2. Our data

We now present the definition of the three main variables used in the following analysis of the US insurance industry. The data for the first two measures of weather disasters are from the VERISK database. Our first variable is the annual number of natural weather disaster events that cause insured losses to the insurance industry of $25 million or more which is the VERISK threshold to document a catastrophe. Events that meet or exceed this threshold are considered natural disasters, given the magnitude of the loss costs incurred by insurers. Our second variable measures the total annual insured losses from natural weather disaster events that cause losses of $25 million or more to the insurance industry. Finally, our third variable measures the number of natural disaster casualties. It represents the sum of the annual number of deaths and injuries caused by natural disaster events. The data for the number of natural disaster casualties were obtained from the National Oceanic and Atmospheric Administration (NOAA) website. Figure 9 shows the evolution of the number of natural weather disaster events occurring in the US from 1990 to 2022, as reported by VERISK. They cover hurricane, tropical storm, wildland fire, wind and thunderstorm, and winter storm.

Figure 9: Number of natural disaster events in the US, 1990 to 2022



Data source: VERISK database.

Note: An "ISOnet PCS Loss Event" means an event occurring within the Service Area to which ISO assigns a serial number, based on ISO's judgment that the event is likely to cause $25,000,000 or more in total insured property losses within such Service Area and is likely to affect a significant number of property and casualty insurance policy holders and property and casualty insurance companies.

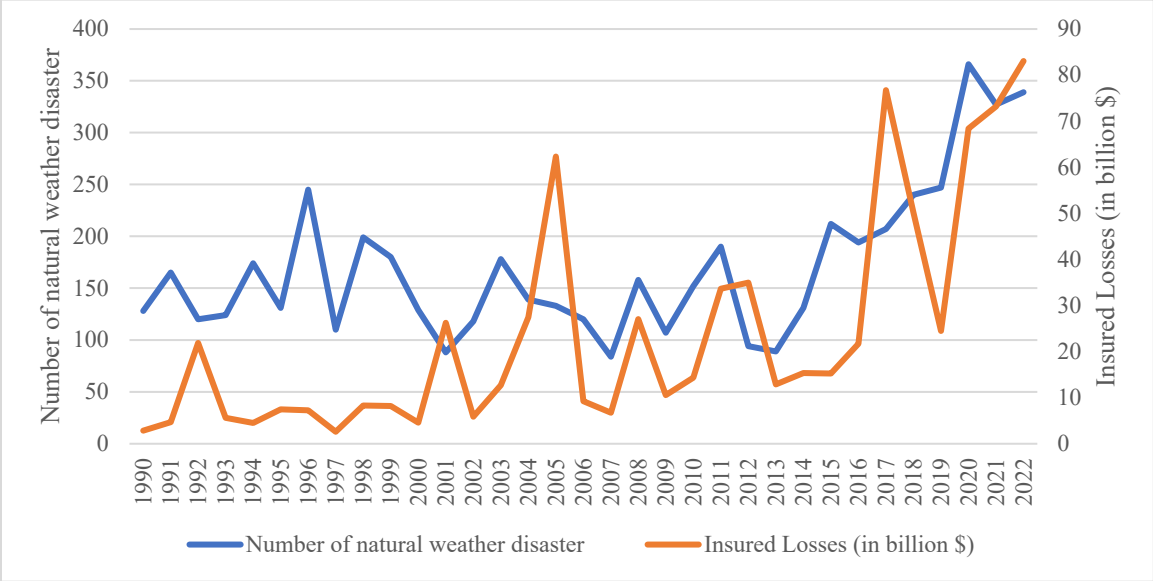
Figure 9 shows that there have been significant variations in the number of weather disaster events in recent years with an upward trend in the post-2013 period. The year 2013 is the turning starting point for this increase in the numbers. The increase in disaster weather events observed after 2013 could be attributed to variation in climate change.[2] This phenomenon may have posed a real threat to the American insurance market because of some extreme natural disaster events it has caused in the US. As can be seen in Figure 9, the number of natural disaster events has reached extremes over the last six years (2017 to 2022). Arguably, the insurance industry can be weakened by the increase in extreme natural disaster events because of the high claims costs they incur, particularly after 2017.

Our data indicates an average number of 251 natural disaster events per year during the post-2013 period, compared with 140 from 1990 to the end of 2013.[3] This analysis was limited to the number of events. It may be more appropriate to consider the losses in the insurance industry. Figure 10 relates annual numbers of natural disasters events and annual insured losses. See Appendix 2 for different correlation results. These results do not support any causality link.

[2] Many references consider weather and climate risks to be synonymous. In this study, as in Dionne and Desjardins (2022), we use the NASA (2005) definitions of climate and weather. The main difference between the two definitions is time. Weather is atmospheric conditions over a short period of time, while climate covers a long period of time. Climate change is related to changes in average daily weather.

[3] The corresponding numbers for the period post-2012 and before are respectively 235 and 142.

Figure 10: Number of natural disaster events (left) and insured losses (right) linked to these natural disaster events observed in the US, from 1990 to 2022



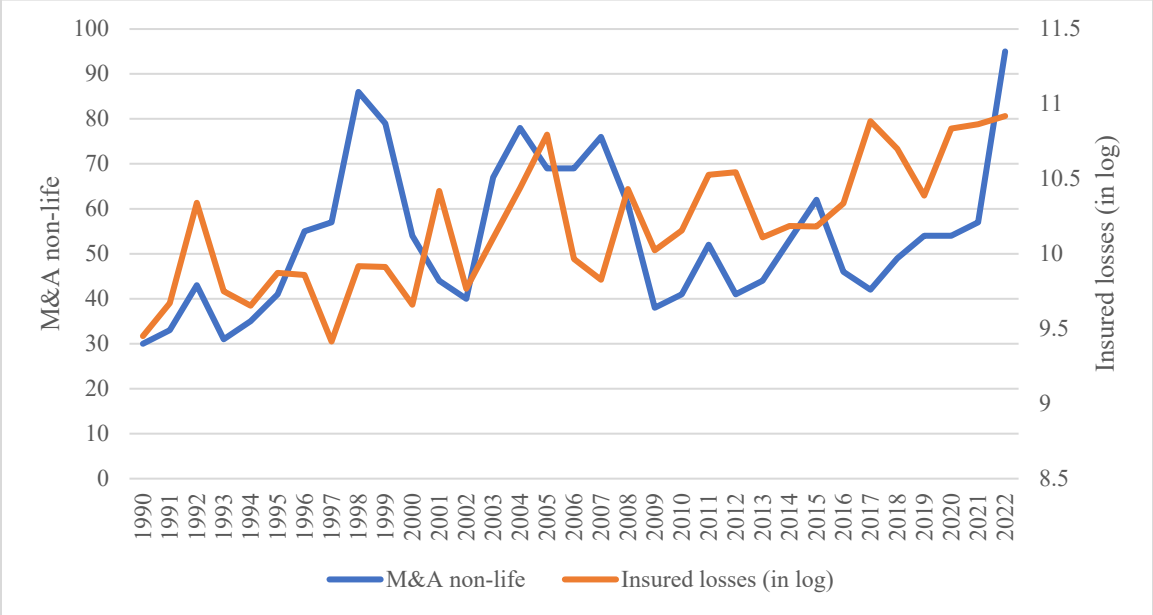
Data source: VERISK database.

4.3. Comparative analysis of the evolution of M&As and insured natural disaster losses

Figure 11 shows a link between insured losses from natural wealth disasters and the number of M&As per year in the non-life insurance sector. This link seems to confirm graphically the hypothesis that the number of target insurer M&As is an increasing function of the insured losses from natural disasters variable, particularly after 2012.

Given that the post-2012 period marked by the resurgence of natural disaster events coincides with the period of the loss of parallel trends observed between our two groups identified graphically (see Figure 5), we can assume that the upsurge in natural disaster weather events observed after the year 2012 may have caused the difference in the number of M&As of target insurers in the non-life insurance sector compared with the number of M&As of target insurers in the life insurance sector observed after 2012. We will consequently select target insurers in the non-life insurance sector as organizations affected by the increase in natural disaster events observed during the post-2012 period, as our potential treatment group for our DID analysis between the M&As of target insurers in the life and non-life insurance sectors in the US.

Figure 11: Comparison of M&A trends in the non-life insurance sector (left) and observed insured losses from weather events (right) during the period 1990 to 2022



Data sources: SDC database and VERISK database.

According to a study published by Atlas Magazine, the emergence of new hazard detection technologies and the generalization of anti-seismic construction standards, especially in developed countries, have significantly limited the number of natural disaster casualties in the world. This information seems relevant to explain the relatively stable level of casualties observed after the year 2012 (Figure 8) despite the upsurge in extreme natural events compared with the period of 1990 to 2012.

The capacity of new hazard detection technologies to warn residents of potential extreme natural events enables these individuals to leave their areas of residence when natural disasters occur, which limits the number of deaths and injuries. However, even if residents are warned about the possibility of an extreme natural disaster, they cannot take real estate such as houses and buildings with them when they evacuate the area. In other words, insured losses are still potentially present in the non-life insurance sector despite the advent of new hazard detection technologies. The direct consequence of this would be an increase in insured losses associated with extreme natural disasters, which would increase the claims costs paid by non-life insurers, thereby worsening their financial performance and potentially increasing the number of M&As.

We have shown above that the upsurge in natural disaster events observed after 2012 has led to increased growth in insured losses from natural disasters for non-life insurers (Figure 10). We have also shown that the number of natural disaster casualties remains relatively stable despite the upsurge in extreme natural events observed in the post-2012 period (Figure 8).

As to which event may have produced an exogenous change in treatment that further increased the number of M&As for target insurers in the non-life insurance sector relative to the life insurance sector, our analysis indicates that the upsurge in natural disaster events observed in the post-2012 period may represent a causal shock on M&As in the non-life sector.

After having motivated our first theoretical hypothesis graphically and statistically, we will analyze a second potential causal factor explaining the difference in M&As between life and non-life sectors after 2012.

5. Impact of market conditions and regulation on M&As after 2012[4]

5.1. Markets conditions and regulation

In the preceding sections, we emphasized climate risk as motivating the difference between the life and non-life insurance industries in the evolution of M&A after 2012. In this section, we document potential alternative economic explanations of this difference before proceeding to the formal DID analysis.

Another catastrophe in the US economy in recent years was the 2007–2009 financial crisis. Although this crisis affected banks more significantly, it also disrupted the insurance industry. It took many years for the US insurance industry to recover. Moreover, the insurance industry was subject to new federal regulations in the years following the crisis. In these years, economic growth was slow due to a lack of liquidity in the US economy, partly explained by the strong new banking regulation. In particular, the secondary market

[4] This section is based on many reports from industry, including the annual reports of Mayer Brown and documents from KPMG. The SDC database is also used to document the annual numbers of mergers and acquisitions.

for bond trading was out of liquidity. Interest rates were very low for investments, and the European economy was in distress. These facts seem to have affected the life insurance industry more strongly than the P&C insurance industry.

The year 2012 was an active one for life insurance M&As, with 39 transactions, as shown in Figure 5. The aggregate deal value involving US targets for the year was about $4.2 billion, which is higher than the $775 million in 2011, but significantly less than the $21.6 billion reported in 2010 (59).[5] This can be explained by AIG's activity of selling firms following the financial crisis (Mayer Brown, 2013). This decrease was mainly due to the need for acquirers to maintain capital under new regulatory capital requirements and to the uncertainty around the impact of Solvency II in Europe.

Acquisition activity in the non-life sector was significantly lower in 2012 than in 2011. The announced aggregate US deal value for 2012 (41) was approximately $6 billion, down from approximately $10 billion in 2011 (52). Moreover, 2012 was characterized by small and medium-sized deals under $500 million (Mayer Brown, 2013). P&C activity was driven primarily by geographic or product expansions, as well as by runoff transactions involving insurers deciding to exit some lines of business.

The year 2013 was characterized by the continued decline in deal activity in the US life insurance M&A market (transactions involving US targets), as compared to 2010, in terms of deal values and numbers (21 instead of 59). Deal value in the life sector was $3.2 billion, compared to $4.2 billion in 2012. Continued macroeconomic uncertainty presented challenges for product sales in this industry, and low interest rates continued to create challenges for long-term investment returns in bonds. Regulatory changes, such as the NAIC's Own Risk Solvency Assessment (ORSA, adopted in 2012, effective in January 2015) and the international accounting convergence project contributed to a climate of caution among buyers and sellers in the M&A markets. To increase shareholder value, insurers tended to use excess capital for share repurchases and dividend distributions rather than M&A activity. ORSA represented a major regulatory change in the insurance industry.

[5] Numbers in parentheses are observations on the number of mergers and acquisitions, as illustrated in Figure 5 and in the corresponding Table A11.

Insurers must now use market value information instead of accounting values to compute economic capital. It represented an additional source of uncertainty, because many insurers had to learn about capital computation with market information.

Acquisition activity in the P&C sector was stable in 2013 compared to 2012, despite generally favorable market valuations on companies' balance sheets in a year marked by few large catastrophe losses. Major runoff acquisition specialists continued to be active acquirers in the global P&C sector. Many P&C companies were still overcapitalized. Some companies were returning capital in the form of stock buybacks and dividends, but high stock prices made stock buybacks expensive.

At the NAIC's Summer 2013 National Meeting, the Solvency Modernization Initiative (SMI) Task Force adopted a white paper: the US National State-band System of Insurance Financial Regulation and the Solvency Modernization Initiative (NAIC, 2013). The white paper also highlighted the importance of the national state-based system of insurance regulation, instead of state only regulation as before the financial crisis.

In addition, regulatory scrutiny of M&As in the two areas may have had a slight negative effect on capital management, thus limiting M&As: the restrictive use of captives for reserve financing and additional requirements for approval of acquisitions raised difficulties in making acquisitions (Mayer Brown, 2014).

Acquisition activity in the non-life sector was moderate in 2013. This occurred despite generally favorable market valuations and significant cash balances on P&C companies' balance sheets in a year marked by few large catastrophe losses. Since catastrophe losses had been relatively modest, many P&C companies remained overcapitalized. M&A was not considered an important activity for consolidation during these years.

The number of US life insurance M&A deals in 2014 was down for the third straight year, but overall, the deal value on announced transactions was $8 billion in 2014, more than double the total for 2013 (Mayer Brown, 2015). There were 53 announced M&A deals involving non-life companies (Figure 5). The year was again characterized by small- and medium-sized deals.

Insured losses from natural catastrophes fell significantly in 2014, according to research from Swiss Re's Sigma (2015), as reported in Mayer Brown (2015). The global insured losses for 2014 fell by 24% to $34 billion, compared to $45 billion the previous year. The number of life insurance M&A transactions involving US targets was on the rise in 2015 after falling in each of the previous two years. The number of annual non-life insurance M&A transactions in 2015 was up for the third straight year, increasing from 44 to 62. The overall deal value on announced transactions was also up, from approximately $12 billion in 2014 to $48 billion in 2015. The year 2015 saw a number of very large transactions being announced, as buyers increasingly sought scale, diversification, and market access (Mayer Brown, 2016).

The number and size of life insurance M&A deals was very low in 2016 (only 11), compared to 2015 (27). The slowdown in activity was due to a number of obstacles facing the US life industry, including low life insurance policy sales, continued profit pressure in investments arising from the low interest-rate environment, and regulatory-change uncertainty.

The number of M&A transactions involving non-life insurance targets decreased in 2016 to 46, as compared to 62 in 2015, according to data compiled from the SDC database. The 2016 P&C insurance segment was again characterized by small and medium-sized transactions, with more than 75% of all announced deals valued below $200 million. The growing need for capital expenditure for investments, to support new digital and high-tech business models demanded that smaller and mid-sized companies look to M&As as an option for continued growth. Insurers worked to adapt to technological growth. For example. developments in insurtech continued to be important in 2016, with significant deals and expansion across product lines and markets. Moreover, in 2016, regulators took significant steps to enhance the regulation of insurers' data practices. Cybersecurity became a new priority for regulators (Mayer Brown, 2017).

In January 2017, the US and Europe announced an agreement regarding international insurance groups doing business in the US and the EU, to enhance regulatory certainty for insurers and reinsurers operating in both places. Meanwhile, the number of M&A

transactions involving non-life insurance targets continued to decrease in 2017, to about 42, as compared to 46 in 2016 (SDC database). Overall, the deal value on transactions in 2017 was down to $7.5 billion, compared to $12 billion in 2016 (Mayer Brown, 2017).

With excess capital, more insurers saw themselves as buyers rather than sellers, which pushed the valuation levels of target companies upwards. Insurers in the P&C market appeared more likely to allocate their excess capital to investments in technology and marketing. Consequently, instead of buying competitors, insurers were more likely to make acquisitions of insurtech enterprises to improve their diversification.

The number and size of life insurance M&A deals involving US targets were up in 2017 (20), compared to 2016 (11). According to the SDC database, 2017 saw several large deals take place. The continued low-interest-rate environment, combined with the significant amount of capital available for deployment into the life and annuity sector led to a number of large annuity transactions in 2017. The year 2017 was notable for the occurrence of a number of catastrophic events, including hurricanes Harvey and Irma and wildfires in California all of which caused losses for several outstanding catastrophe bonds. The availability of this financial market protection in a year with significant catastrophe losses illustrates the robust nature of the insurance market and its critical importance in providing the resources needed to pay claims (Dionne and Desjardins, 2022).

The number of M&A transactions in 2018 involving non-life insurance targets rose to 49, compared to 42 in 2017, according to data compiled by the SDC database. The $32 billion in aggregate transaction value ranks as the most active year for P&C M&As since 2015. It should be noted that approximately two-thirds of that amount is attributable to two very large acquisitions. As in the previous years, small and medium-sized transactions of deals valued below $500 million represented more than 70% of transactions (Mayer Brown, 2019).

Despite around $80 billion of catastrophe losses in 2018, which followed on record catastrophe losses in 2017, the P&C industry continued to be regarded as overcapitalized. Other key factors limiting the increase in P&C M&As included federal tax reform and continued inbound interest from international acquirers seeking a meaningful presence in

the US market (Mayer Brown, 2019). Established players were pursuing strategic investments in insurtech businesses.

Issuance of RWI policies continued to be important in the Americas, predominantly in the US. RWI is a form of insurance policy that is purchased in connection with an M&A transaction that protects the insured party (almost always the buyer) against financial loss arising from an unanticipated or unknown breach of certain conditions in the purchase agreement. While there are no market studies that provide reliable figures on the numbers of RWI policies written each year, data from several market studies suggest that numbers have doubled every two years since 2013. The year 2018 also saw the first transfer of pure wildfire risk to the capital markets. Two California utility providers sponsored a catastrophe bond covering third-party liability losses due to wildfires caused by their respective infrastructure. Demand for reinsurance remained high following the ongoing capital requirements of the Solvency II regime, which made reinsurance attractive.

One of the consequences of the 2007–2009 financial crisis was a decision by the federal government to revisit the regulatory system in the McCarran-Ferguson Act. The Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) gave increased systemic risk regulatory authority to the Federal Reserve. In addition, Dodd-Frank also created a Federal Insurance Office within the Department of the Treasury to establish greater uniformity among the states with regard to excess and surplus insurance and reinsurance lines.

The development of the COVID-19 pandemic in the first quarter of 2020 created uncertainty regarding all aspects of the insurance business. This resulted in a halt in insurance P&C transactions in the US, as insurers and investors reevaluated their strategic plans. Despite of this first quarter slowdown, an increase in industry M&As from the third quarter of 2020 resulted in deal-making in 2020 whose value exceeded that of 2019 (Mayer Brown, 2021).

The year 2020 has been described as the Year of the SPAC.[6] According to SPAC Insider, 248 special purpose acquisition corporations (SPACs) completed their initial public offerings (IPOs), raising over $83 billion. The recent rise of the SPAC has had an important effect on the US IPO market and, to a lesser extent, the US IPO market for insurance companies. In 2020, three SPACs completed IPOs, with a stated focus on the insurance (including insurtech) industry.

During 2020, US jurisdictions began revising their laws and regulations governing credit for reinsurance to implement the amendments to the NAIC Credit for Reinsurance Model Law and Model Regulation adopted in 2019. Those amendments were designed to satisfy the requirements of the bilateral agreement on insurance and reinsurance between the US and EU.

Climate risk and sustainability were established as a key theme of the IAIS (International Association of Insurance Supervisors) strategy for 2020–2024. Included in this strategy is its partnership with the United Nations Environmental Programme's Sustainable Insurance Forum. The IAIS is one of the first global standard-setting bodies to adopt policy to guide its performance in terms of environmental issues: incorporating risks from climate change into their governance frameworks, risk management processes, and business strategies.

The year 2022 represents a large increase in the non-life sector (95 instead of 57 in 2021) and a moderate decrease in the life sector (35 instead of 39 in 2021).

5.2. Use of ILS for catastrophes losses

The use by insurers and reinsurers of insurance-linked securities (ILS) as a supplemental source of capital for their protection continued after 2012. The capital markets have become a critical component of managing catastrophe risk for a growing number of insurers and reinsurers, although the relative magnitude is still low compared to the total capital available in the industry (Dionne and Desjardins, 2022).

[6] A SPAC is a new type of company with no assets or operations, also known as a blank check company.

The catastrophe bond market was quite strong in 2013, with a total of $7.5 billion of new catastrophe bonds issued, the second highest annual issuance volume in market history. As of December 31, 2013, there was $20.3 billion of catastrophe bonds outstanding. US catastrophe risks (particularly US wind) continued to dominate, representing approximately 51% of outstanding bonds (Mayer Brown, 2014).

In 2017, the ILS market solidified its importance as a critical component of the global reinsurance market, representing almost 20% of dedicated reinsurance capacity. There was a $31.0 billion total aggregate principal amount of risk-linked securities outstanding, almost 20% higher than the amount at the end of 2016 (Mayer Brown, 2018).

In 2020, the volume issued was the largest in market history, beating the record level of 2018. The total aggregate principal amount of risk-linked securities outstanding of $46.4 billion represented a yearly growth of approximately $5.7 billion. It should be mentioned that the total capital of the US insurance industry was about $1.1 trillion in 2020 (Dionne and Desjardins, 2022).

Reinsurance and premium growth are other sources of capital in the P&C insurance industry (Dionne and Desjardins, 2022). We shall look at these sources of capital later on. In the next section, we continue our statistical analysis of M&As.

6. Validation of the selected treatment date and the presence of parallel trends

In our DID approach, we propose that the increase in natural disaster events observed in the post-2012 period could be a cause of the difference in the number of M&As of target insurers in the non-life insurance sector, relative to the number of M&As of target insurers in the life insurance sector. The varied changes in regulations and economic conditions in the insurance industry during the post-2012 period could also be a cause. These new regulations were motivated by the 2007–2009 financial crisis. Very low interest rates significantly affected the benefits of the insurance industry, particularly in the life insurance industry. Looking at these two potential causes, it appears that a shock event occurred in the years preceding 2013 that might have caused an exogenous change in the

treated units that increased the difference in the number of M&As of the treatment group relative to the control group. In short, we consider the increase in natural disaster losses observed after 2012 as a situation that induced an exogenous variation in the treated units (target non-life insurers) that maintained the number of M&As of target insurers in the non-life insurance sector (treatment group), compared to those in the life insurance sector (control group), which decreased significantly during the post-2012 period.

Based on an analysis of Figure 5, we have identified two years in which the parallel trends observed between our two groups began to disappear: 2009 and 2012. However, our analysis of Figure 10 allows us to propose that it was the insured losses from natural disaster events observed after the year 2012 that likely caused the increase in the number of M&As of target insurers in the non-life insurance sector, compared to the number of M&As of target insurers in the life insurance sector, observed in the post-2012 period. Therefore, we can define our treatment effect as a positive difference between the average number of M&As per year of target insurers in the non-life insurance sector and the average number of M&As of target insurers in the life insurance sector. Alternatively, market conditions and variations in the regulation of the insurance industry may also explain the difference observed in Figure 5. The following analysis is independent of the two potential causes.

6.1. Validation of the choice of treatment date using five statistical tests

To choose the most appropriate treatment date for our data, we use a statistical approach applied to the annual data of M&As in the two insurance sectors (Berck and Villas-Boas, 2016; Imbens and Wooldridge, 2009; Roberts and Whited, 2012). We first calculate the annual difference between the number of M&As of target insurers in the non-life insurance sector versus the number of M&As of target insurers in the life insurance sector observed over our entire study period, that is 1990 to 2022. Next, we calculate the mean and median of the difference between the number of target insurer M&As in the non-life insurance sector and the number of target insurer M&As in the life insurance sector over the pre-treatment period (including the year of the candidate date) and over the post-treatment period for each of our two selected candidate dates (2009 and 2012). Finally, we perform

five statistical tests—the mean statistical test, the median statistical test, the distribution statistical test, the monotonicity test, and the median-criteria test—to validate the choice of treatment date. The results of the first three tests are presented in Table 2, where the differences between various statistics are presented.

Table 2: Statistical descriptions (median, mean of the number of M&As) and validation tests of the treatment date

Period	1990-2009	Post-2009	1990-2012	Post-2012	1990-2022
Median	–2	23	–3	30.5	2
Mean	–2.8	21.615	–3.826	31.3	6.818
Student's test	–1.014	3.592	–1.499	8.111	1.925
Median test[1]	0.481	0.023	0.383	0.002	0.473
Wilcoxon test[2]	–1.028	2.797	–1.446	2.805	1.555

[1] Sign test (Snecdecor and Cochran, 1989).
[2] Signed rank test (Wilcoxon, 1945).

6.1.1. Statistical test based on the mean (Student's test)

Our decision criterion for the choice of treatment date is to test the null hypothesis (H0) that the average number of M&As in the non-life sector and the average number of M&As in the life sector are statistically similar over the period of 1990 to the end of the candidate date (2009 or 2012) on the one hand, and, on the other hand, to test the null hypothesis (H0) that the average number of M&As in the non-life sector and the average number of M&As in the life sector are statistically different over the post-treatment date period (post-2009 or post-2012) due to the treatment effect.

According to Table 2, the *t*-test statistic (Student's test) yields a value of –1.014 over the period of 1990 to 2009 and 3.592 over the post-2009 period. Given that the absolute *t*-test value is less than 1.96 over the period of 1990 to 2009, the null hypothesis (H0) is not rejected. In addition, because the *t*-test value is greater than –1.499 over the post-2009 period, the null hypothesis (H0) is rejected. The year 2009 is therefore retained by our *t*-test criterion as the treatment date for our DID method. Further, Table 2 shows that the *t*-test statistic yields a value of –1.499 over the 1990 to 2012 period and 8.111 over the post-2012 period. The null hypothesis (H0) is not rejected over the 1990 to 2012 period and the

null hypothesis (H0) is rejected over the post-2012 period. We can therefore conclude that the average number of M&As in the non-life sector and the average number of M&As in the life sector are statistically the same over the period of 1990 to 2012 and statistically different over the post-2012 period. Our *t*-test statistic criterion also retains the year 2012 and cannot discriminate between the two years and between the two potential interpretations.

6.1.2. Statistical test based on the median

This test was proposed by Snecdecor and Cochran (1989). Based on this test, the analyze of the null hypothesis (H0) that the difference between the median number of M&As of target non-life insurers and the median number of M&As of target life insurers is equal to 0.

Our treatment date decision criterion is to test the null hypothesis (H0) that the median number of M&As in the non-life sector and the median number of M&As in the life sector are statistically similar over the period of 1990 to the end of the candidate date (2009 or 2012) on the one hand, and, on the other hand, to test the null hypothesis (H0) that the median number of M&As in the non-life sector and the median number of M&As in the life sector are statistically different over the post-treatment date period (post-2009 or post-2012) due to the treatment effect.

Table 2 reports a *p*-value of 0.481 over the period of 1990 to 2009 and 0.023 over the post-2009 period. Because the *p*-value is above the critical threshold of 5%, the null hypothesis is not rejected. In addition, because the *p*-value is lower than the 5% threshold over the post-2009 period, the null hypothesis (H0) is rejected. We can therefore conclude that the median number of M&As in the non-life sector and the median number of M&As in the life sector are statistically similar over the period of 1990 to 2009 and statistically different over the post-2009 period. The year 2009 is therefore retained by our median-based statistical test as the treatment date for our DID method. Further, Table 2 shows a *p*-value of 0.383 over the 1990 to 2012 period and 0.002 over the post-2012 period. Because the p-value is greater than the 5% critical threshold, H0 is not rejected. In addition, because the *p*-value is below the 5% threshold in the post-2012 period, the null hypothesis (H0) is refuted.

We can therefore conclude that the median number of M&As in the non-life sector and the median number of M&As in the life sector are statistically similar over the period of 1990 to 2012 and statistically different over the post-2012 period. Our test based on the median also retains the year 2012 and cannot discriminate between the two dates.

6.1.3. Statistical test based on distributions

This test was proposed by Wilcoxon (1945). We test the null hypothesis (H0) that the distributions of the number of M&As per year of target non-life insurers and the number of M&As per year of target life insurers are close.

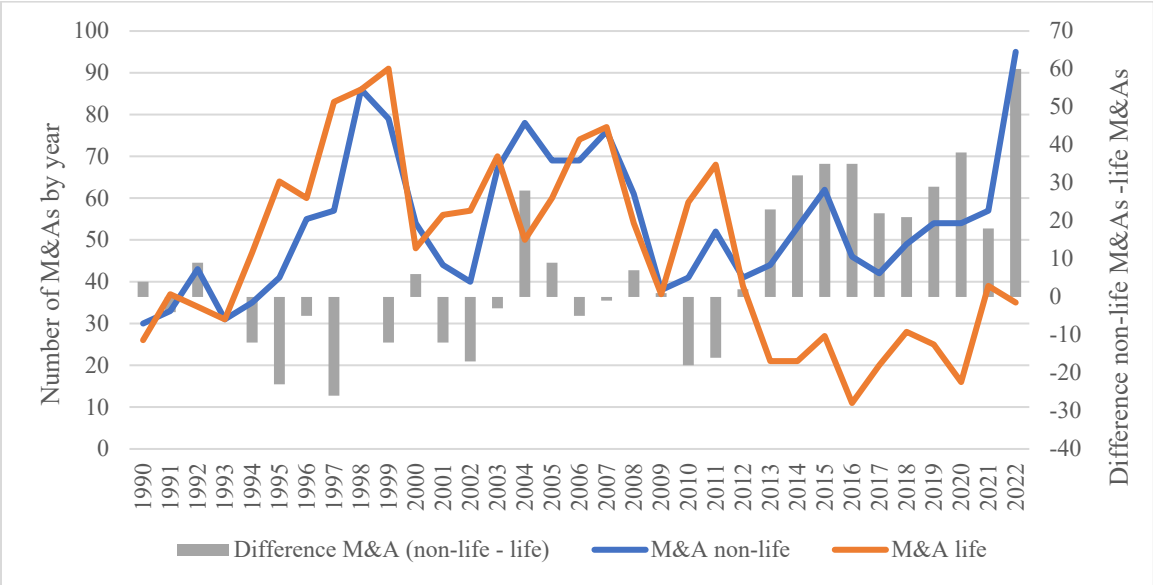
According to Table 2, the Wilcoxon test statistic yields a value of –1.028 over the period of 1990 to 2009 and 2.797 over the post-2009 period. Because the Z-test value in absolute terms is less than 1.96 over the period of 1990 to 2009, the null hypothesis (H0) is not rejected. In addition, because the Z-test value is greater than 1.96 over the post-2009 period, the null hypothesis (H0) is rejected. We can therefore conclude that the distribution of the number of M&As in the non-life sector and the distribution of the number of M&As in the life sector are statistically similar over the period of 1990 to 2009 and statistically different over the post-2009 period. The year 2009 is therefore retained by our statistical test based on the distributions as the treatment date for our DID method. In contrast, Table 2 shows that the Wilcoxon test statistic yields a value of –1.446 over the 1990 to 2012 period and 2.805 over the post-2012 period. Because the value of the Z-test statistic in absolute terms is less than 1.96 over the period of 1990 to 2012, the null hypothesis (H0) is therefore not rejected. In addition, because the Z-test value is greater than 1.96 over the post-2012 period, the null hypothesis (H0) is rejected. We can therefore conclude that the distribution of the number of M&As in the two industries are statistically similar over the period of 1990 to 2012 and statistically different over the post-2012 period. Our test of the distribution-based statistic also retains the year 2012 and cannot discriminate between the two dates.

6.1.4. Monotonicity hypothesis

We employ an additional criterion called the monotonicity hypothesis, often used in econometrics to evaluate the treatment effect. This hypothesis postulates that when there is a change, the treatment effect can go in only one direction. To choose our treatment date based on the criterion of the monotonicity assumption, we used a graphical approach based on the analysis of Figure 12.

Figure 12 clearly shows a large difference between the number of M&As of target insurers in the non-life insurance sector compared with the number of M&As of target insurers in the life insurance sector observed over the post-2012 period. Moreover, we note that our treatment effect, defined as a positive difference between the number of M&As per year of target insurers in the non-life insurance sector and the number of M&As of target insurers in the life insurance sector, is respected for each year of the post-2012 period (10 years with a positive difference versus 0 year with a negative difference). In other words, 2012 changes the treatment effect in only one direction (positive difference) for each of the years in the post-2012 period. This affirms our monotonicity hypothesis. In contrast, Figure 12 shows that the year 2009 does not cause a change in the treatment effect in a single direction for each of the years in the post-2009 period (12 years with a positive difference versus 2 years with a negative difference). As can be seen, we get a negative difference for the years 2010 and 2011 and a positive difference for each of the other years in the post-2009 period. This violates our monotonicity condition (hypothesis). To conclude, because only the year 2012 meets the monotonicity condition, we select the year 2012 as the treatment date for our DID method with the monotonicity hypothesis.

Figure 12: Evolution of the number of M&As per year in each of the two insurance sectors (non-life and life, left) and their difference (in histogram, right)



Data source: SDC database.

6.1.5. Median-criteria test of Guest (2021)

For robustness, a last statistical criterion based on the median is applied to ensure the reliability of the choice of the selected year 2012. To do this, we draw on the work of Guest (2021), who applies a median-based statistical criterion. This allows us to define a selection criterion whereby the treatment effect for each of the years in the post-treatment period (post-2009 or post-2012) is greater than the median value of the difference between the number of M&As per year of target insurers in the non-life insurance sector and the number of M&As of target insurers in the insurance sector over our entire study period (1990 to 2022), which is equal to 2 (see Table 2). This criterion supports the choice of 2012 as the treatment date for our DID method. As can be seen in Figure 12, the positive difference between the number of M&As per year of target insurers in the non-life insurance sector and the number of M&As of target insurers in the life insurance sector is greater than the median value of our entire study period (1990 to 2022) for each of the years in the post-2012 period. This is not the case for the post-2009 period, where we in fact observe a negative difference for the years 2010 and 2011, which is thus lower than the median of the entire sample. Therefore, our median-based criterion rejects the choice of the year 2009

as the treatment date for our DID method. To summarize, the statistical criterion based on the median supports the choice of the year 2012 retained by our affirmation of the monotonicity hypothesis.

6.2. Parallel trends analysis

We have just validated the choice of 2012 as the treatment year for our DID method. We will now perform a validation test for the presence of parallel trends before the end of that period. To do this, we first create 33 dummy variables for each of the years in the period of 1990 to 2022. Then, we create a dummy variable Treated_i with *i* equal to 1 for the treated group and 0 for the control group. Our Treated dummy (non-life sector) is then represented by the Treated_i variable. We also create 33 interaction variables between the Treated dummy and the year dummy for each year from 1990 to 2022. Finally, we regress our dependent variable, number of M&As per year and state, on our 33 $\text{Treated}_i \times \text{Year}$ interaction variables in each of the 51 states and in the two insurance sectors using the OLS method of estimation for panel data. With the OLS method, we capture the individual effect (state) and the time effect (year). The results are presented in Table 3 with 3,366 observations (33 × 51 × 2).

The results of our regressions validate the presence of a parallel trend before the end of 2012. As can be observed, the obtained coefficients are overall not statistically significant for the pre-treatment period (before 2013). Our F-test supports this result. It shows that the F-statistic on our $\text{Treated}_{\text{NL}} \times \text{Year}$ interaction variables prior to the treatment date (1990 to 2012) is F (23, 2250) = 1.10 with a probability Prob > F = 0.3338. Given that the *p*-value is greater than 5%, we do not reject the null hypothesis, and we can conclude that the coefficients obtained before the treatment date are not significantly different from zero overall. In contrast, the coefficients obtained for each of the years during the post-2012 period are all statistically significant at the 1% level (except for the year 2021). Our F-test supports this result. The F-test over the post-treatment period (2013 to 2022) yields an F (9, 1009) = 8.31 with Prob > F = 0.0000. Because the *p*-value is less than 5%, we reject the null hypothesis and can thus say that the coefficients considered as a whole are significant over the post-2012 period. These results allow us to validate our parallel trend test

econometrically and thus confirm the choice of the year 2012 as the treatment year to be retained for our DID method.

Table 3: Parallel trends analysis for DID validation test

Dependent variable	Number of M&A per year and state (non-life and life)		Number of M&A per year and state (non-life and life)		Number of M&A per year (non-life and life)	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
$Treated_{NL}$×Year1990	0.078	(0.171)	-		-	
$Treated_{NL}$×Year1991	-0.078	(0.186)	-0.078	(0.188)	-	
$Treated_{NL}$×Year1992	0.176	(0.185)	0.176	(0.185)	0.176	(0.186)
$Treated_{NL}$×Year1993	0.000	(0.211)	0.000	(0.213)	0.000	(0.215)
$Treated_{NL}$×Year1994	-0.235	(0.164)	-0.235	(0.164)	-0.235	(0.164)
$Treated_{NL}$×Year1995	-0.451**	(0.207)	-0.451**	(0.209)	-0.451**	(0.210)
$Treated_{NL}$×Year1996	-0.098	(0.268)	-0.098	(0.267)	-0.098	(0.268)
$Treated_{NL}$×Year1997	-0.510**	(0.232)	-0.510**	(0.231)	-0.510**	(0.231)
$Treated_{NL}$×Year1998	0.000	(0.331)	0.000	(0.330)	0.000	(0.328)
$Treated_{NL}$×Year1999	-0.235	(0.316)	-0.235	(0.315)	-0.235	(0.313)
$Treated_{NL}$×Year2000	0.118	(0.221)	0.118	(0.220)	0.118	(0.220)
$Treated_{NL}$×Year2001	-0.235	(0.211)	-0.235	(0.212)	-0.235	(0.213)
$Treated_{NL}$×Year2002	-0.333	(0.209)	-0.333	(0.209)	-0.333	(0.209)
$Treated_{NL}$×Year2003	-0.059	(0.267)	-0.059	(0.266)	-0.059	(0.265)
$Treated_{NL}$×Year2004	0.549**	(0.263)	0.549**	(0.263)	0.549**	(0.262)
$Treated_{NL}$×Year2005	0.176	(0.245)	0.176	(0.245)	0.176	(0.244)
$Treated_{NL}$×Year2006	-0.098	(0.281)	-0.098	(0.281)	-0.098	(0.282)
$Treated_{NL}$×Year2007	-0.020	(0.300)	-0.020	(0.299)	-0.020	(0.298)
$Treated_{NL}$×Year2008	0.137	(0.245)	0.137	(0.244)	0.137	(0.244)
$Treated_{NL}$×Year2009	0.020	(0.202)	0.020	(0.203)	0.020	(0.204)
$Treated_{NL}$×Year2010	-0.353*	(0.198)	-0.353*	(0.197)	-0.353*	(0.198)
$Treated_{NL}$×Year2011	-0.314	(0.197)	-0.314	(0.197)	-0.314	(0.198)
$Treated_{NL}$×Year2012	0.039	(0.206)	0.039	(0.207)	0.039	(0.207)
$Treated_{NL}$×Year2013	0.451***	(0.162)	0.451***	(0.164)	0.451***	(0.165)
$Treated_{NL}$×Year2014	0.627***	(0.175)	0.627***	(0.176)	0.627***	(0.175)
$Treated_{NL}$×Year2015	0.686***	(0.203)	0.686***	(0.204)	0.686***	(0.204)
$Treated_{NL}$×Year2016	0.686***	(0.184)	0.686***	(0.185)	0.686***	(0.186)
$Treated_{NL}$×Year2017	0.431**	(0.212)	0.431**	(0.213)	0.431**	(0.214)
$Treated_{NL}$×Year2018	0.412**	(0.208)	0.412**	(0.207)	0.412**	(0.207)

Dependent variable	Number of M&A per year and state (non-life and life)		Number of M&A per year and state (non-life and life)		Number of M&A per year (non-life and life)	
Independent variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
$Treated_{NL} \times Year2019$	0.569***	(0.146)	0.569***	(0.147)	0.569***	(0.148)
$Treated_{NL} \times Year2020$	0.745***	(0.181)	0.745***	(0.181)	0.745***	(0.181)
$Treated_{NL} \times Year2021$	0.353	(0.228)	0.353	(0.229)	0.353	(0.229)
$Treated_{NL} \times Year2022$	1.176***	(0.271)	1.176***	(0.271)	1.176***	(0.270)
Constant	3.521***	(0.262)	3.801***	(0.260)	3.783***	(0.272)
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,366		3,264		3,162	
R-squared	0.541		0.542		0.543	

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

To ensure the reliability of our validation test of the choice of treatment date for our DID method, we conduct two robustness tests. The first test consists in ignoring the first year of observation: $Treated_{NL} \times Year1990$. The second test consists in ignoring the first two years of observations: $Treated_{NL} \times Year1990$ and $Treated_{NL} \times Year1991$. The results of these two robustness tests, as shown in Table 3 $Treated_{NL} \times Year1990$, confirm the validation of the year 2012 as the treatment date to retain for our DID method.

7. DID analysis

In this section, we present in detail the variables of interest that we introduced into our regressions to analyze the difference between M&As in the US life and non-life insurance sectors using the DID method. The data utilized in this study come from the SDC database. The SDC database provides comprehensive quantitative and qualitative information on the characteristics of M&A transactions over the period of 1990 to 2022 in the two insurance sectors.

7.1. Description of variables

7.1.1. Natural experiment

In our econometric approach, we opted for a natural experiment methodology using the difference-in-differences estimator (DID). This estimator must separate the firms that have received a treatment (treatment group) and firms that have not received a treatment (control group).

7.1.2. Treatment group and control group variable

The purpose of our study is to determine the impact of climate risks or regulatory changes and market conditions on target insurers in the US. Because insurers in the non-life insurance sector are more exposed to climate risks and less exposed to market conditions and regulatory changes than are insurers in the life insurance sector during our period of analysis, we select insurers in the non-life insurance sector as our treatment group. We create a dichotomous variable Treated_i with *i* equal to 1 for the treatment group (non-life insurance sector) and 0 for the control group (life insurance sector).

7.1.3. Regression model

Based on our variables of interest, we consider the following regression model:

$$\text{Nbr M\&A}_{it} = \alpha + \delta_1 \text{Treated}_{NL} \times \text{Post2012} + c_i + \eta_t + \epsilon_{it} \quad (1)$$

where:

$\text{Nbr M\&A}_{it}$: number of M&A in state *i* during year *t*;

$\text{Treated}_i \times \text{Post2012}$: equal to 1 for the treatment group after the treatment period and equal to 0 otherwise;

α : constant;

c_i : individual effects that exert the same influence on the state *i* in all periods;

η_t: temporal effects that affect all states equally in period *t*;

ϵ_{it} : standard random effects.

What interests us in equation (1) is the interaction variable Treated_i x Post2012. It indicates the impact of the treatment on the insurers in the treatment group. Given that the regulation of insurance companies differs from state to state in the US, we created dummy-states variable to capture the individual effect of each state. The model assumes that the time shocks η_t affect all units in the two groups equally in period *t*. For this reason, we create dummy-periods to capture the time effect in each period. In our estimation of equation (1), we maintain the constant α since we use an estimation procedure that controls for multicolinarity. This approach is contrary to those of Dionne and Liu (2021) and Giorcelli and Moser (2020) who did not use a constant term.

7.1.4. Description of targets

The targets selected for our study are US insurers that were acquired or merged during the period of 1990 to 2022. These targets operated in the life or non-life insurance sectors prior to the M&A transaction. We exclude from our sample of targets financing agency insurers or brokers with an SIC code of 6411 (Insurance Agents, Brokers and Service). The US targets selected for this study have the following SIC codes:

- 6311: Life Insurance
- 6321: Accident and Health Insurance
- 6324: Hospital and Medical Service Plans
- 6331: Fire, Marine, and Casualty Insurance
- 6351: Surety Insurance
- 6361: Title Insurance
- 6399: Insurance Carriers, Not Elsewhere Classified

Targets with the SIC codes 6321, 6324, 6331, 6351, 6361, and 6399 (Non-life Insurers) represent our treatment group, and targets with the Code 6311 (Life Insurance) represent our control group.[7]

After having presented the SIC codes of the target insurers selected for our analysis, we now document geographic information to determine the US states in which target insurers were most affected by the two waves of M&A transactions that we identified in Figure 1.

[7] In Appendix 1, we regroup 6321 and 6324 with 6311. The statistical results remain the same but their interpretation changes.

Most large insurers have developed models based on geographic, seismic, and meteorological information to estimate the level of exposure to climate risks and the associated losses. In this study, we document geographic information to estimate targets' level of exposure to climate risks captured by the fixed effects. To do this, we break down the number of M&A transactions of the targets by state over the period of 1990 to 2022. We find that states such as California (334), Florida (292), New York (264), Texas (272), Illinois (166), Pennsylvania (153), Ohio (125), Michigan (89), Connecticut (104), New Jersey (119), Indiana (77), Massachusetts (74), Georgia (68), Maryland (71), Missouri (65), Minnesota (66), North Carolina (63), Arizona (69), and Delaware (66) each have a number of M&A transactions that exceeds the insurance industry average of 62. In other words, these regions have seen a significant number of M&A transactions over the past 30 years.

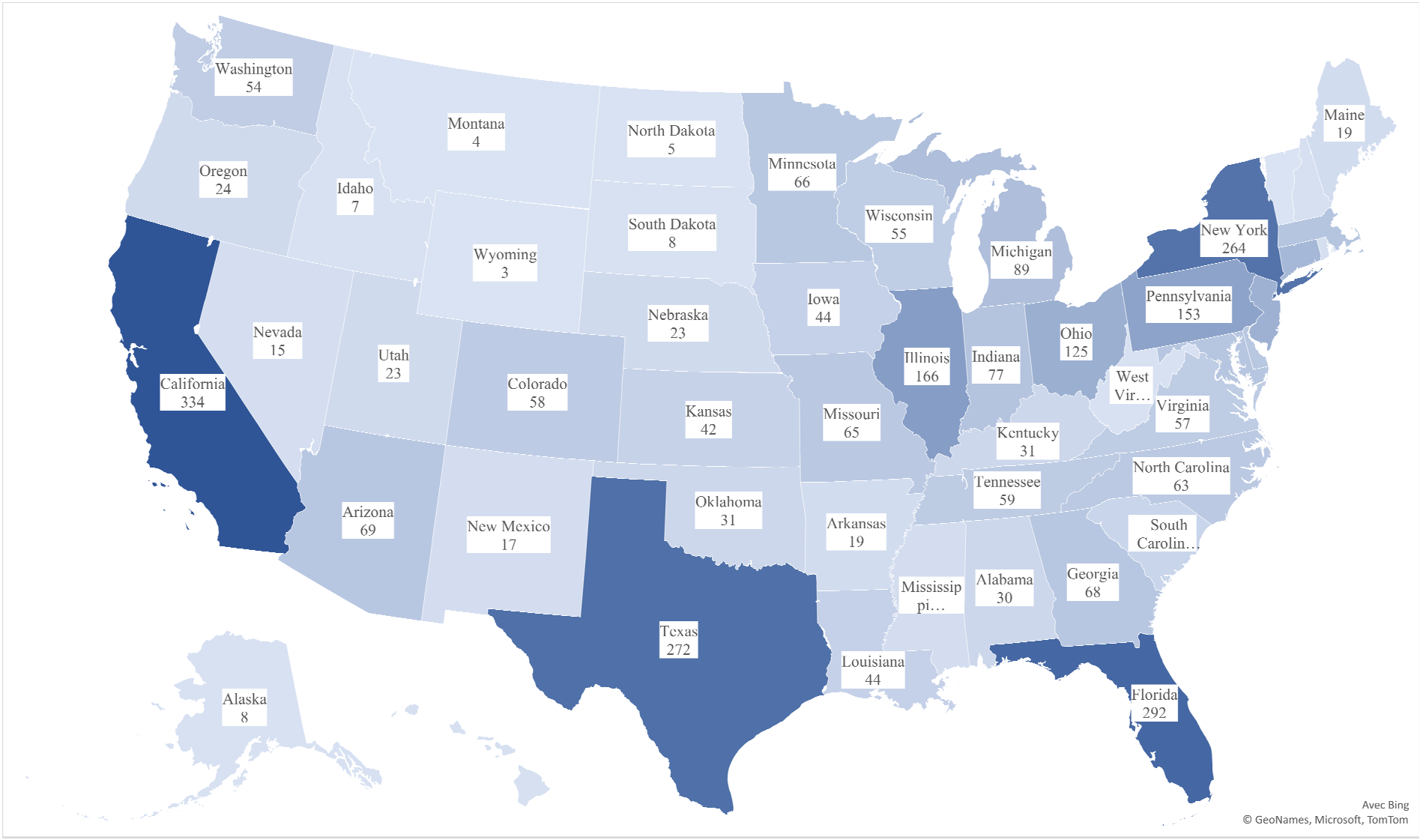
Using the distribution of the number of target M&A transactions by state shows that states can be subdivided into two groups based on whether the state is located in a coastal or a non-coastal zone. According to the National Oceanic and Atmospheric Administration (NOAA) website classification,[8] coastal zones include the following 30 states: New York, Florida, Connecticut, Pennsylvania, Texas, Illinois, California, Georgia, South Carolina, Maryland, Ohio, Virginia, Washington, Louisiana, Mississippi, New Jersey, Michigan, Alabama, North Carolina, Oregon, Maine, Massachusetts, Delaware, New Hampshire, Hawaii, Indiana, Minnesota, Wisconsin, Rhode Island and Alaska. The remaining 21 states (including District of Columbia) are located in non-coastal zones.

Figure 13 shows that all states identified as having a number of M&A transactions that exceeds the all-state average are in coastal zones except for Missouri and Arizona. In contrast, all non-coastal states have a number of M&A transactions per state that is below the all-state average except Missouri and Arizona. This distribution suggests that insurers located in coastal zones are more active in M&As. The extreme weather conditions that occur in these zones could explain this situation. Extreme weather can quickly trigger natural disaster events such as hurricanes, wildfires, tornadoes, and winter storms, and cause significant or extreme losses to insurers located in coastal zones. To summarize,

[8] https://coast.noaa.gov/czm/mystate/.

insurers located in coastal zones have a higher level of exposure to climate risks than do insurers located in non-coastal zones. In our estimations, these differences will be taken into account by the fixed-effects variable.

Figure 13: Geographic distribution of the number of M&As transactions by state (1990 to 2022)



Data source: SDC database.

Additional states with numbers of MA in parentheses: Mississippi (17), South Carolina (36), Connecticut (104), Delaware (66), Maryland (71), Massachusetts (74), New Hampshire (10), New Jersey (119), Vermont (3), West Virginia (7).

The larger the number, the darker the color.

7.1.5. Description of acquirers

The acquirers are US or foreign companies that have carried out M&A transactions with the US target insurers over the period of 1990 to 2022. Based on the distribution of M&A transactions observed between 1990 and 2022, we identify two categories of transactions: inter-state transactions and intra-state transactions. According to this categorization of transactions, we determine that, over the period of 1990 to 2022, 24% of the M&A transactions were carried out by targets and acquirers from the same state (intra-state) and 76% of M&A transactions were carried out by targets with acquirers from different states (inter-state) or with foreign acquirers. Thus, this distribution suggests that acquirers have increased their geographic scope significantly over the period of 1990 to 2022.

Further, based on the distribution of M&A transactions observed between 1990 and 2022, we identify and determine the percentage of M&A transactions that occurred between targets and acquirers that operate in the same industry sector (i.e. that has the same SIC code). Our data show that 36.75% of the transactions were between targets and acquirers that have the same SIC code (concentration). In other words, 63.25% of the transactions were between targets and acquirers that have different SIC codes (diversification). This distribution suggests that acquirers have mostly opted for a management strategy based on diversification of operations rather than on concentration of operations.

7.1.6. Description of explanatory variables

Table 4 presents in detail the description of the variables we introduce into our model (1) to empirically test the difference between M&As in the US life and non-life insurance sectors by adopting the natural experiments method or the DID estimator.

We argue that the increase in natural disaster events that occurred in the post-2012 period, and especially the significant insured losses that they caused to insurers in the non-life insurance sector after 2012, seriously weakened target insurers in the non-life insurance sector. This has caused an increase in the number of M&A targets per year in the non-life insurance sector relative to the life insurance sector in the post-2012 period.

Table 4: Description of explanatory variables

Explanatory variable	Description	Expected sign
$\text{Treated}_{\text{NL}}$ (dichotomous)	$\text{Treated}_{\text{NL}}$ variable with *i* equal to 1 for the treated group (non-life insurance sector) and 0 for the control group (life insurance sector)	n.a
Post2012 (dichotomous)	The Post2012 variable takes the value 0 if the period is before the treatment (12-2012) and the value 1 if the period is after the treatment.	n.a
$\text{Treated}_{\text{NL}} \times \text{Post2012}$ (dichotomous)	The interaction variable $\text{Treated}_{\text{NL}} \times \text{Post2012}$ captures the effect of the treatment administered to the insurers in the treated group (non-life insurance sector) after the treatment.	+

We expect a positive sign of the coefficient of the variable $\text{Treated}_{\text{NL}} \times \text{Post2012}$ on the number of target M&As per year. Otherwise, market conditions and changes in regulation after 2012 seem to have more negatively affected the life insurance industry. This observation may also explain a positive sign on the coefficient of the interaction variable.

7.2. Data and descriptive statistics of variables

The database used is the population of state-aggregated data on the characteristics of the target insurers' M&A transactions, observed in the two main sectors of US insurance (non-life and life) over a 32-year period and documented in the SDC database. Our data includes the 50 states of USA and the District of Columbia. This means that if a typical non-life insurance company operates across the country, it will be subject to 51 different regulations and different climate risk exposures. In order to capture the different structure of insurance companies as it often changes from state to state, we separate our data by state (51) and by year (33) according to each of our two insurance sectors. We obtain a total of 3,366 observations.

Table 5 presents the descriptive statistics of the variables related to the characteristics of M&As according to the two groups in our study sample. To compile this table, we calculate the means and standard deviations of the different variables within our two groups.

Table 5 shows that the average number of M&As per year and by state is 1.055 in the non-life insurance sector and 0.922 in the life insurance sector. In addition, the number of M&As for our two groups as a whole is 0.988 with a standard deviation of 1.650. Table 6 presents the mean and standard deviation of mergers and acquisitions by period. The mean is lower after 2012.

Table 5: Mean and standard deviation of the variables by insurance sector

Sample	Total sample (N=3366)	Non-life sector (N=1683)	Life sector (N=1683)
Dependent variable			
Number of M&As per year and by state	0.988 (1.650)	1.055 (1.703)	0.922 (1.594)
Variable of interest			
$\text{Treated}_{\text{NL}} \times \text{Post2012}$	0.152 (0.359)	0.303 (0.460)	n.a n.a

Numbers in parentheses are standard deviations.

Table 6: Mean and standard deviation of the M&A by period

Period	1990-2022		1990-2012		Post-2012	
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Number of M&As per year and by state	0.988	1.650	1.078	1.744	0.783	1.392

Table 5 indicates that the average number of M&As per year and by state observed in the non-life insurance sector over the period of 1990 to 2022 is roughly the same as that observed in the life insurance sector. To validate this observation, we statistically test the null hypothesis that the average number of M&As per year and by state in the non-life sector and the average number of M&As per year and by state in the life sector are statistically the same. The results indicate that the average number of M&As per year

observed in the non-life insurance sector over the period of 1990 to 2022 is roughly the same as that observed in the life insurance sector. To validate this observation, we statistically test the null hypothesis that the average number of M&As per year in the non-life sector and the average number of M&As per year in the life sector are statistically the same. Our statistical *t*-test yields a value of 1.92. Because the *t*-test value obtained is below the critical value of 1.96 (5% threshold), the hypothesis is not rejected. We can therefore conclude that the average number of M&As per year in the non-life sector and the life sector are statistically the same over our entire study period, i.e. from 1990 to 2022.

7.3. Estimation results

The regression results of model (1) were obtained using the OLS method of estimation with fixed-effects. Our results presented in Table 7 indicate that the coefficient of our variable $\text{Treated}_{\text{NL}} \times \text{Post2012}$ is positive and statistically significant at the 1% level. This result suggests a higher number of M&As in the treated group following the treatment date of 2012.

Table 7: Regression results for model (1) using OLS with fixed effect on the state and on time

Dependent variable	Number of M&As per year and state (non-life and life)	
Independent variables	Coefficient	Standard error
$\text{Treated}_{\text{NL}} \times \text{Post2012}$	0.614***	0.159
Constant	3.561***	0.246
State FE	Yes	
Year FE	Yes	
Observations	3,366	
R-squared	0.536	

Robust standard errors.
*** p<0.01.

The sign of the coefficient of the variable $\text{Treated}_{\text{NL}} \times \text{Post2012}$ is as expected. This result empirically validates the assumption that the increase in natural disaster events or the variations of market conditions and in regulation that occurred during the post-2012

period may have seriously modified the insurers consolidation behavior between the two insurance sectors. These potential causes may have increased the difference of target M&As per year in the non-life insurance sector compared with the life insurance sector during the post-2012 period.

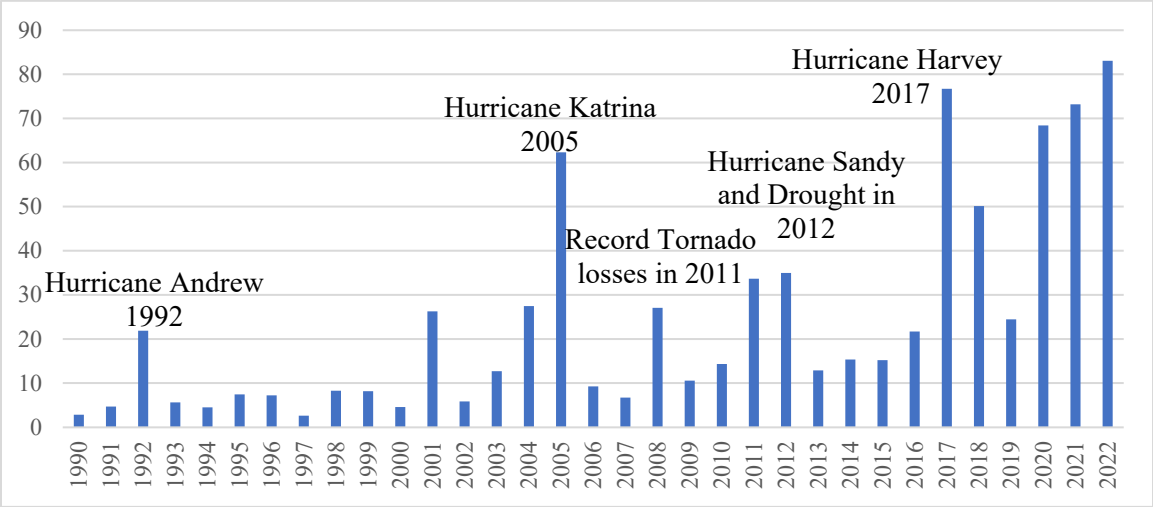
8. Financial health of US P&C insurers, 1990 to 2022

8.1. Combined ratio

Figure 14 shows the insured losses from natural disasters, while Figure 15 describes the evolution of the combined ratio. The combined ratio of the US non-life insurance industry has reached three major peaks since the 2000s. The first was in 2001 and reflects the major economic losses associated with the September 11, 2001, terrorist attack. The second peak occurred in 2005 and reflects the large economic losses associated with hurricanes Katrina, Rita, and Wilma, in 2005. Finally, the third peak was reached in 2011 and illustrates the costs of major claims generated by the exceptional series of violent tornadoes that occurred in 2011 in the US Midwest. If one considers only the level of the combined ratio attributable to natural catastrophe events in the US since the early 2000s, it is clear that 2011 was the second-most costly year for US insurers, after 2005.

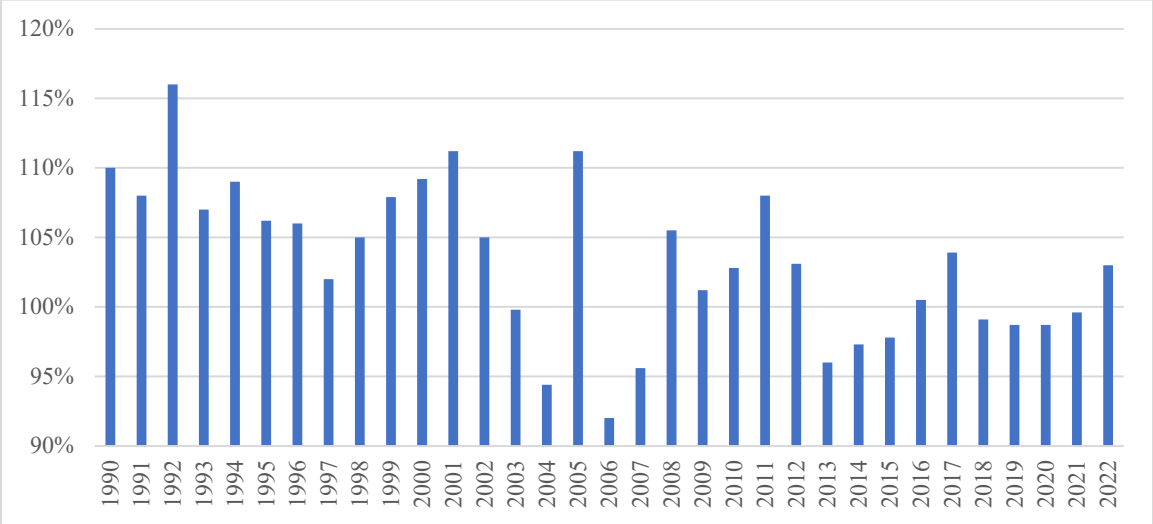
Analysis of Figure 15 shows that the combined ratio for 2011 is higher than for 2017, which was a year of extremes in terms of US natural event losses, as shown in Figure 14. In other words, insured losses from natural catastrophe events in 2011 are lower than in 2017, but the combined ratio is higher.

Figure 14: Insured losses (billion $) from natural disaster events in US, 1990 to 2022



Data source: VERISK database. VERISK selects events with insured losses of $25 million and above. Insured losses: property damage and business interruption, excluding liability and life damage.

Figure 15: Combined ratio US property-casualty, 1990 to 2022



Data source: NAIC data, Federal Insurance Office, US Department of the Treasury, Annual Report on the Insurance Industry (before 2018), and Statista data. Combined ratio formula = (claims costs + management expenses) / premiums earned.

The combined ratio is affected by the claims losses variable (the combined ratio being an increasing function of insured losses). The combined ratio is also affected by the management expenses variable (the combined ratio being an increasing function of management expenses). Another variable that affects the level of the combined ratio is the

premiums earned variable. As the formula noted below Figure 15 indicates, the combined ratio is a decreasing function of the premiums earned variable.

Our data from the NAIC[9] indicate that total claims costs (including those due to natural catastrophe events) in 2011 were $296 billion, as compared to $354 billion in 2017, an increase of 20% from 2011 to 2017. These loss cost figures suggest that the 2017 combined ratio level should be higher than that of 2011. In addition, management expenses in 2011 were $180 billion, versus $214 billion in 2017, for an increase of 19% from 2011 to 2017.

In other words, we should expect a higher combined ratio in 2017 than in 2011, given that the total loss costs and management expenses, which were $477 billion in 2011, rose to $568 billion in 2017, an increase of 19%. Our data, however, indicate the opposite: in Figure 15, a ratio of 108% in 2011 (the record year for natural event losses in the US) versus a ratio of 104% in 2017, equal to a 4% decrease in the combined ratio.

Our NAIC data also indicate that net premiums earned, which were $443 billion in 2011, grew to $550 billion in 2017, an increase of 24%. By contrast, the same data source shows that total loss costs and management, which were $477 billion in 2011, increased to $568 billion in 2017, a 19% increase. We clearly see that it is the increase in the growth of net premiums earned of 24% versus the increase in total loss costs and management expenses of 19% over the period from 2011 to 2017 that could explain the reduction in the combined ratio level observed over the same period (108% in 2011 versus 104% in 2017).

8.2. ROA and asset-turnover of targets

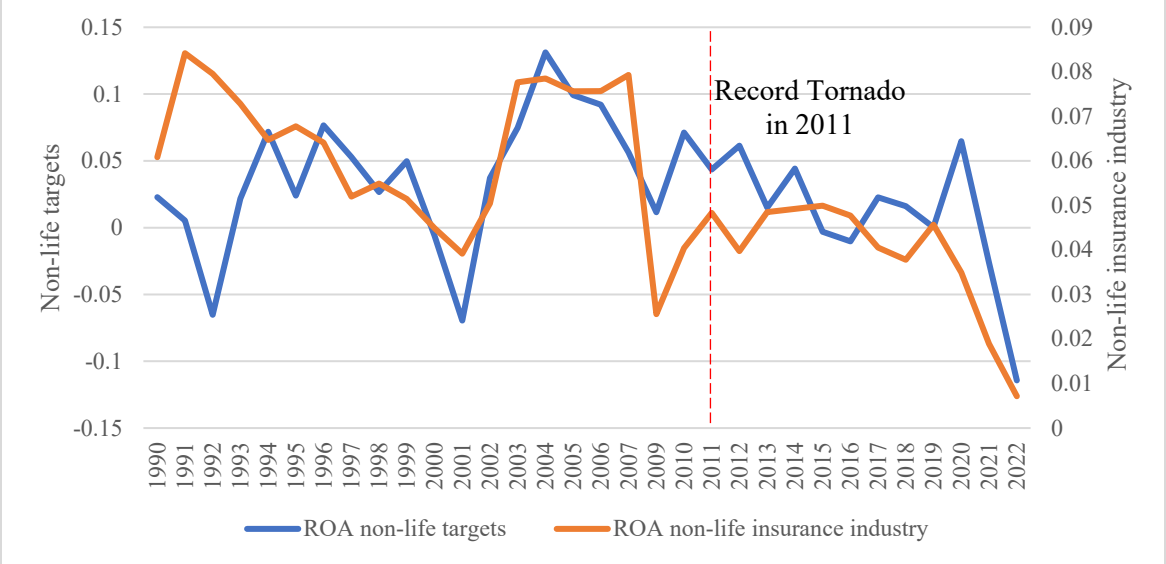
To illustrate the very sharp deterioration in growth volume of all public non-life target insurers after the series of violent tornadoes that occurred in 2011, we use two profitability measures. The first is the return on total assets (ROA) profitability indicator and the second is the asset-turnover efficiency ratio. We use the ROA profitability indicator as a reliable instrument to measure the viability (growth) of our targets and non-life insurers. To be viable, insurers, like any other company, must generate profitability in all their businesses.

[9] US Property & Casualty and Title Insurance Industries – 2020 Full Year Results.

They must repay their clients and creditors, satisfy their shareholders' demands, and finance their growth (on which their viability depends). Second, we use the asset-turnover ratio as another reliable measure of the viability of our non-life public targets. This ratio measures the efficiency with which a company uses its assets to produce revenue. In other words, asset-turnover measures performance in terms of return on assets.

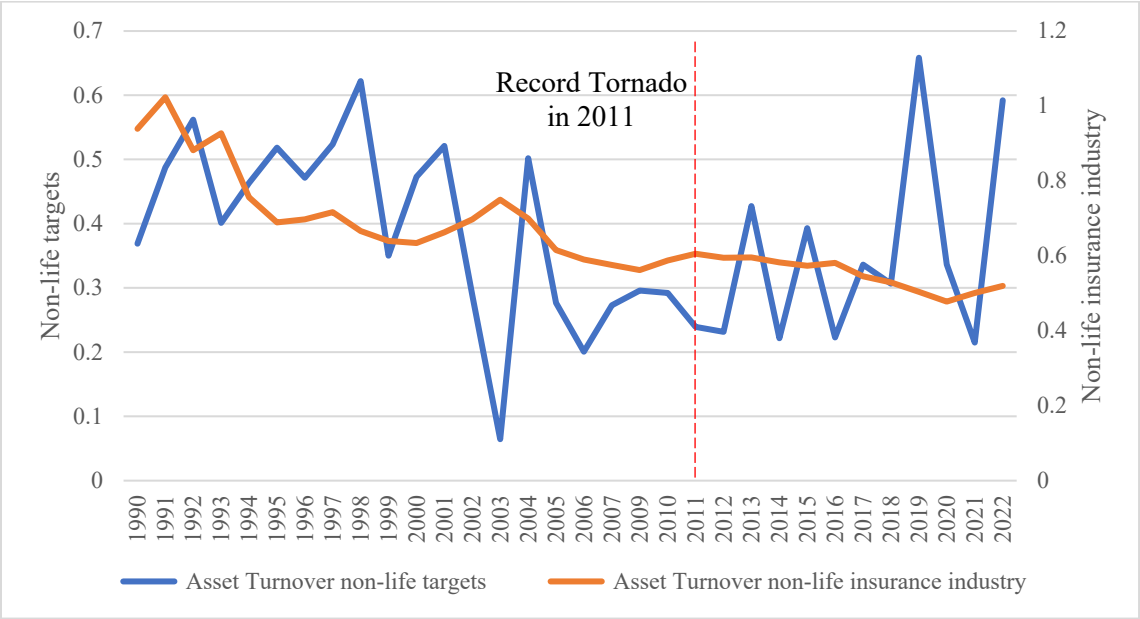
Figure 16 and Figure 17 compare the ROA and asset-turnover efficiency ratios of a sample of M&A targets in the US non-life insurance market with those of the non-life insurance industry. The two target ratios do not look very different than those of the industry, which indicates that the financial conditions of the targets were not necessarily bad at the merger or acquisition dates. We must note that these results are limited to a sample of 224 targets that may not represent the entire industry. They do not necessarily make it possible to reach a final conclusion about the overall insurance industry.

Figure 16: Return on total assets (ROA) for a sample of non-life targets (left) and for the non-life insurance industry (right) in the US, 1990 to 2022



Sources: COMPUSTAT and NAIC databases.

Figure 17: Asset-turnover efficiency ratios for a sample of non-life targets (left) and non- life insurance companies (right), 1990 to 2022



Sources: COMPUSTAT and NAIC databases.

8.3. CAT bonds

The exceptional series of severe tornadoes in 2011 also resulted in very high losses on two Mariah Re catastrophe (CAT) bonds: the Mariah Re 2010-1 CAT Bond triggered[10] on September 30, 2011; and the Mariah Re 2010-2 CAT Bond triggered on August 30, 2011. These two CAT bonds were issued in November 2010 (for Mariah Re 2010-1) and December 2010 (for Mariah Re 2010-2) by Mariah Re Ltd. They covered the risks of severe storms in the US. The losses on these two Mariah Re CAT bonds issued in 2010 represent the highest losses in the history of CAT bonds in the US. These results indicate how the utilization of ILS instruments helps the insurance industry maintain capital in years of very high losses.

[10] Triggered means that the risk underlying the (CAT) bond has materialized and that the principal or capital is used to cover the insurer's loss instead of going back to the investors.

8.4. World Economic Forum

The magnitude of the loss costs caused by the natural disasters in the US in 2011, to which can be added the natural disaster events that occurred internationally, notably in Japan, Thailand, New Zealand, and Australia, may have raised the collective awareness of the danger of natural (or weather) disasters, as indicated by the works from the experts of the World Economic Forum (Table 8).

The experts of the World Economic Forum show that awareness of environmental risks appeared among companies' top five concerns only starting in 2011, that is to say, after the occurrence of very large natural disasters. The analysis is based on an assessment of hazards by specialists from various sectors through a risk mapping model. Risk mapping is one of the risk management tools most widely used by companies, particularly insurers. It involves a graphic representation of a number of risks and serves to identify the threats and dangers incurred by organizations, synthesizing them in a hierarchical form. According to *Atlas* magazine (consulted on 6 December 2022), this hierarchy is based on criteria such as probability of occurrence, potential impact, and level of risk control. Further, mapping natural, economic, and social catastrophe risks enables insurance companies to better identify the threats likely to impact their business. Table 8 presents the World Economic Forum's assessment of the perception (by year) of the five global risks to which companies are most sensitive, for the years 2007 to 2013.

The table shows that in 2011, the overall risk that leaders considered most worrisome for the next 10 years is meteorological catastrophes (storms, tornadoes and hurricanes). Climatological catastrophes (rain, snow, or hail) are ranked fifth, following the series of violent tornadoes in the Midwestern US and the natural and nuclear disasters in Japan and Thailand.

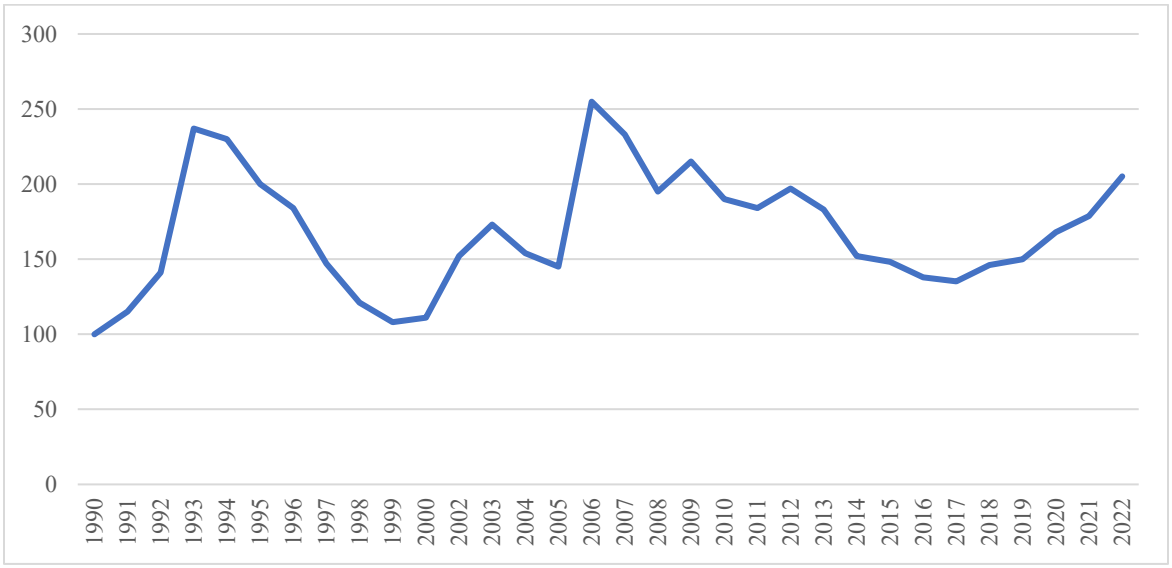
Table 8: Top five global risks in terms of probability of occurrence

	2007	2008	2009	2010	2011	2012	2013
1st	Breakdown of critical information infrastructure	Asset price collapse	Asset price collapse	Asset price collapse	Meteorological catastrophes	Severe income disparity	Severe income disparity
2nd	Chronic disease in developed countries	Middle East instability	Slowing Chinese economy (<6%)	Slowing Chinese economy (<6%)	Hydrological catastrophes	Chronic fiscal imbalances	Chronic fiscal imbalances
3rd	Oil price shock	Failed and failing states	Chronic disease	Chronic disease	Corruption	Rising greenhouse gas emissions	Rising greenhouse gas emissions
4th	China economic hard landing	Oil and gas price spike	Global governance gaps	Fiscal crises	Biodiversity loss	Cyber attacks	Water supply crises
5th	Asset price collapse	Chronic disease, developed world	Retrenchment from globalization (emerging)	Global governance gaps	Climatological catastrophes	Water supply crises	Mismanagement of population ageing

Economic Environmental Geopolitical Societal Technological

Source: World Economic Forum.

Figure 18: US Property catastrophe rate-on-line index (private and public insurers)



Data source: Data from Guy Carpenter, presented by Artemis.bm.

Definition: Rate-on-line index (ROL) is the ratio of premium paid to loss recoverable in a reinsurance contract. In simple terms, ROL represents the amount of money an insurer must commit to obtain reinsurance coverage. A high ROL indicates that the insurer must pay more for coverage, while a low ROL means that an insurer pays less for the same level of coverage.

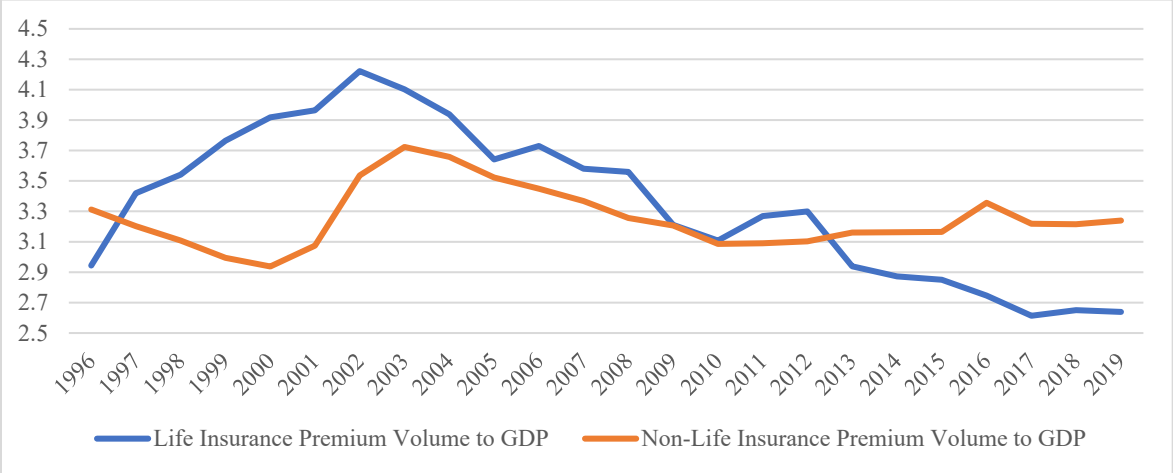
8.5. ROL index

Figure 18 indicates that major disasters led to large changes in the ROL index until 2012, and small changes thereafter. This is the case, for example, with Hurricane Andrew in 1992 and Hurricane Katrina in 2005. After Andrew in 1992, the catastrophe index increased 68% in 1993. It increased 76% in 2006 after Hurricane Katrina in 2005, and by 7% in 2012 after the series of severe tornadoes in the Midwest in 2011. By contrast, Figure 18 shows very small changes in the ROL index after 2012. All ROL changes remained below the 7% mark (ROL change from 2011 to 2012) throughout the post-2012 period, even after major hurricanes Harvey, Maria, and Irma of 2017 (the year of extremes); the ROL increased by only 2.6% in 2018.

8.6. Premium earned

Premiums earned are one of the main resources available to insurers to cover loss costs. Therefore, the small changes in the ROL index observed after 2012 suggest that non-life insurers increased their level of premium collection in the post-2012 period. To verify this, we use premium earned data and calculate the market share of each of our insurance sectors (non-life and life) over the period of 2007 to 2017. We retain this period because data on premiums earned, from the Insurance Information Institute, are available only for the period of 2007 to 2017.

Figure 19: Insurance Premium Volume to GDP (private and public) (%)



Data source: FRED Economic Data. St-Louis FED.

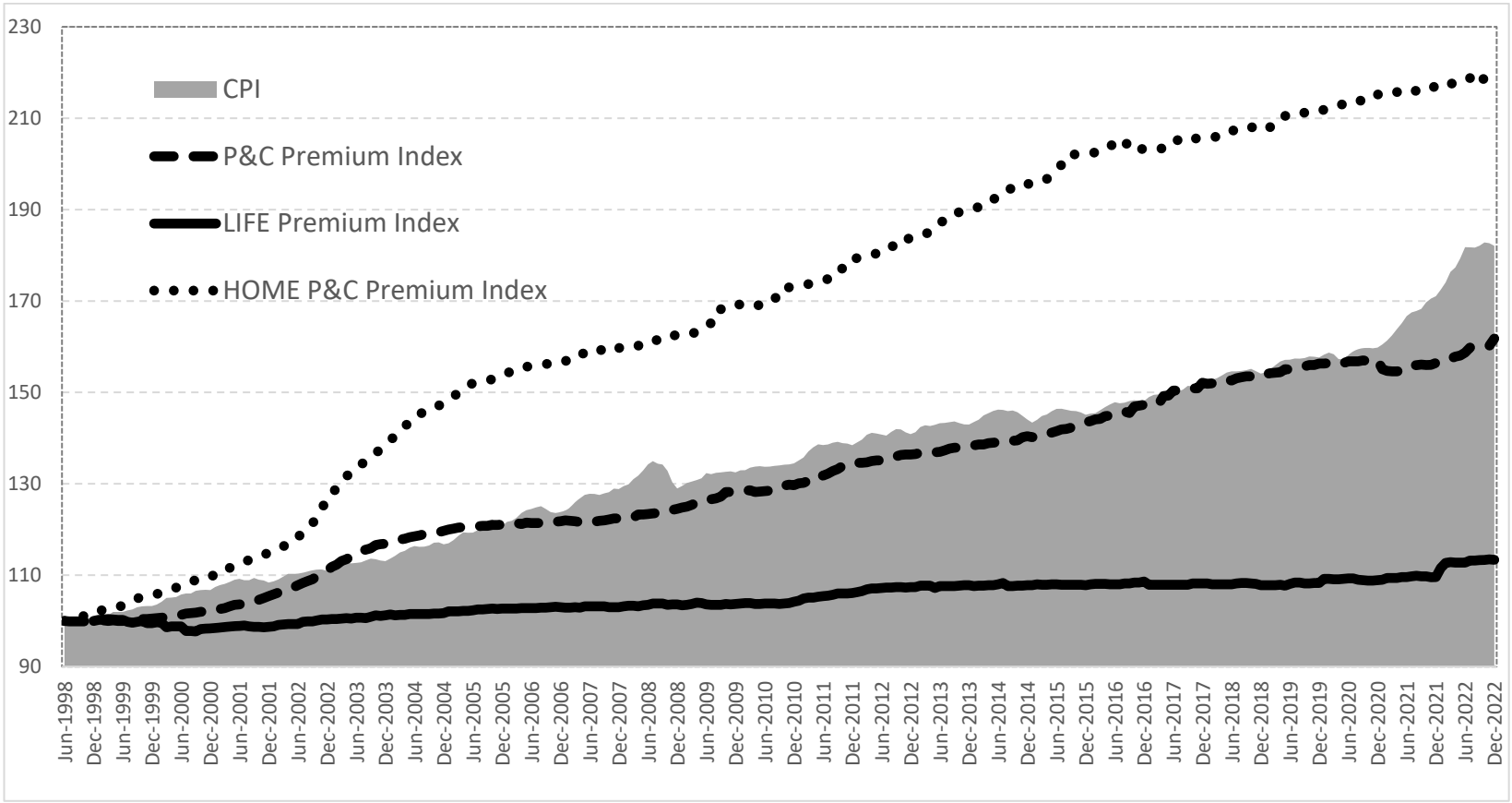
Figure 19 shows that premiums earned share increased significantly in the post-2012 period in the non-life insurance sector. By contrast, premiums earned share decreased significantly during the post-2012 period in the life insurance sector. Over five years (2012 to 2017), the non-life sector's premium market share grew by 12%, while the life insurance sector's premium market share declined by 9%.

Figure 19 shows that, after 2012, life insurance activity decreased by 20% with respect to GDP while it as slightly increased, by 4%, for the non-life insurance sector.

Figure 20 presents the different premium indexes during the period of analysis. Life premium growth is much lower than P&C premium growth. The P&C Homeowner's Insurance Premium Index more than doubles during the period of analysis.

The results obtained from figures 19 and 20 suggest that the recognition of natural catastrophe risk may have led insurers to readjust their pricing, to properly take climate risk into account. The net increase in the level of premiums earned in the post-2012 period illustrates this.

Figure 20: Insurance Premium Indices

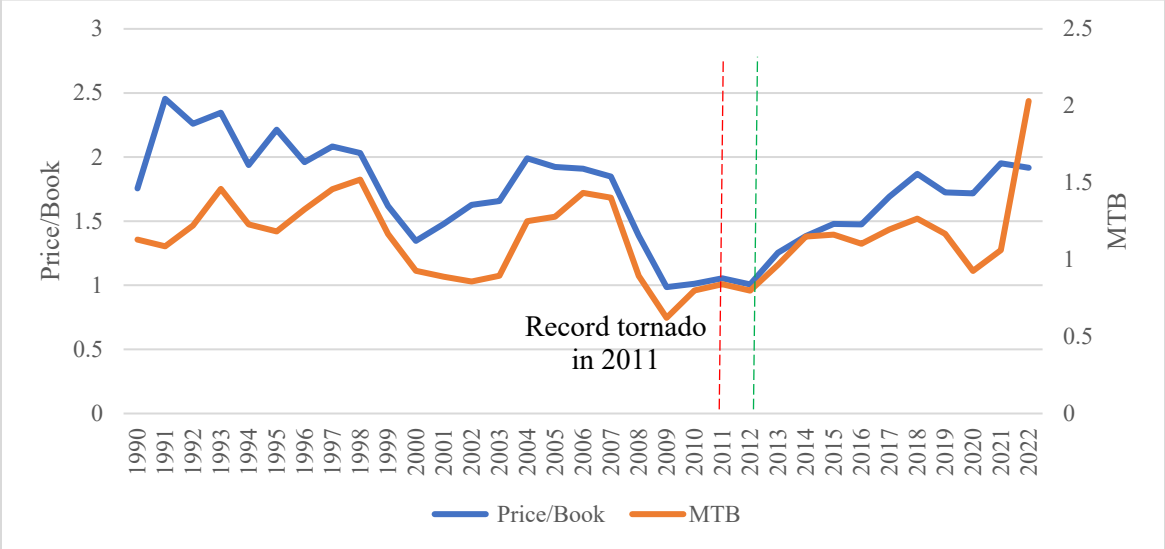


Data source: US Bureau of Labor Statistics.

8.7. Market-to-book and price/book

The results in Figure 21 suggest that there has been resilience to property damage due to natural disasters, in the non-life insurance industry in the post-2012 period, a period that was marked by sharp increases in claims costs due to natural disasters, especially starting in 2017 (the year of Harvey, Maria, and Irma). In other words, recognition of the risk of large claims from natural disasters in post-2012 allowed US non-life insurers to sufficiently cover loss costs with reserves from written premiums, allowing them to improve their financial health in the post-2012 period, as shown in Figure 21. Indeed, Figure 21 shows that the financial health (as measured by the price/book and market-to-book (MTB) indicators) of all insurers in the US non-life insurance industry improved significantly in the post-2012 period.

Figure 21: Evolution of the price/book and MTB ratios in the US non-life sector



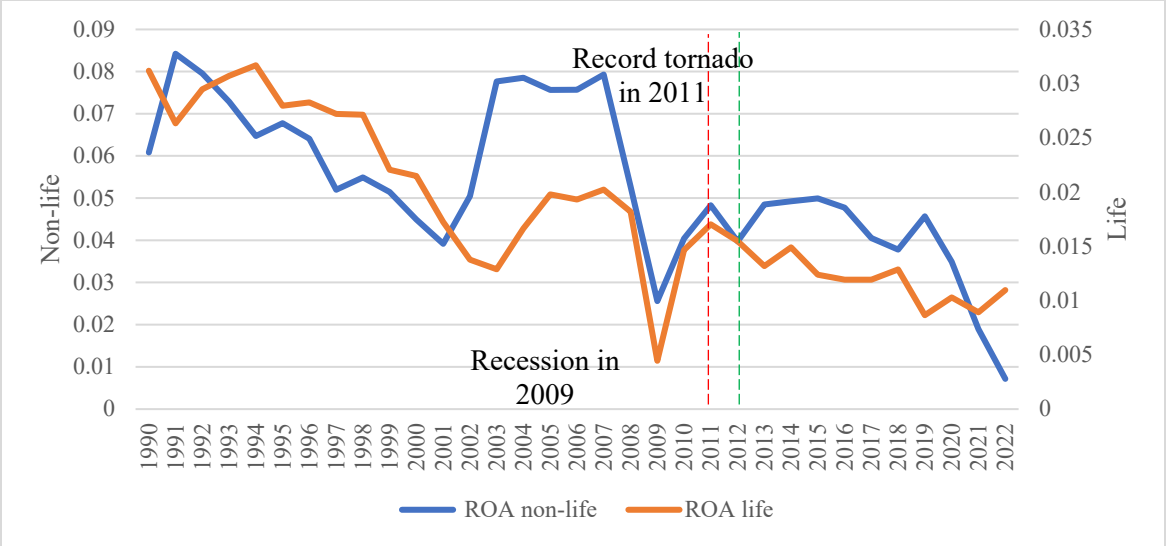
Data source: COMPUSTAT database.

8.8. ROA in both sectors

Figure 22 shows the evolution of the ROA ratio. It suggests that non-life insurers as a whole have returned to growth after the great economic recession of 2009 and the decline in 2012 caused by the Midwestern tornados in 2011 and the impact of Hurricane Sandy in 2012. By contrast, Figure 22 still points to a deterioration in organic growth across all life insurers

during the same period. Figure 22 also shows a divergence in the trend between overall growth of non-life insurers and life insurers after 2012.

Figure 22: Evolution of the ROA ratio in the non-life and life insurance sectors in the US, 1990 to 2022



Data source: COMPUSTAT database.

Our data show, as Figure 22 indicates, that there is a clear positive difference between the ROA of the US non-life insurance industry and that of the US life insurance industry for almost every year in the post-2012 period. This difference was also observed between M&As of the US non-life insurance industry and those of the US life insurance industry, for each of the years over the same post-2012 period.

9. Conclusion and discussion

The main objective of this study is to test for the presence of a statistical link between climate risk and mergers and acquisitions (M&As) in the US property and casualty (P&C) insurance industry. The main research question is the following: is the observed increase in claims costs associated with climate risk events a causal factor for M&As growth during the 1990-2022 period? More generally, the study examines how the costs of catastrophic weather events associated with climate risk have impacted the insurance industry's

resilience by affecting economic capital during the 1990-2022 period. The financial literature often describes M&As as consolidation activities in different industries.

We develop a natural experimental event study by identifying two groups of insurers that are exposed differently to climate risk events. The control group of insurers was less exposed to weather risk events, and the treatment group of insurers was more exposed to weather risk events. Life insurers were considered less exposed than P&C insurers. Our statistical results indicate that the post-2012 period was associated with a difference in M&A activity between the two insurance sectors, while both sectors had parallel trends in M&A prior to January 2013. The number of M&As was statistically higher in the P&C insurance sector than in the life insurance sector in the post-2012 period.

We faced two major difficulties isolating climate risk as having a causal effect on M&As. The first was separating M&As from other sources of capital consolidation that insurers can use to protect themselves from natural catastrophes. Dionne and Desjardins (2022) show that US P&C insurers significantly increased their capital between 1997 and 2020. These authors also identify different potential sources of capital, such as reinsurance, premium management, M&As, capital regulation, and insurance linked securities (ILS).

The second difficulty was identifying potential factors other than weather risk events that may have affected M&As in the two insurer groups in the 1990-2022 period of analysis. The US insurance industry overall was affected by the 2007-2009 financial crisis, and the life insurance industry in particular (Barnes et al., 2016). Market conditions were difficult after the crisis for the life insurance industry (NAIC, 2022; Federal Insurance Office, 2022). Premium growth was low in this line of business, and interest rates were very low in the whole economy. Different federal regulations for capital were introduced, particularly in and after 2012, to consolidate capital risk management following the financial crisis. These new regulations affected capital levels and may have introduced uncertainty into the markets about the potential future growth of M&As.

Our main results do not support a causal link between climate risk and M&As in the US insurance market during the period of analysis. We obtain a significant increase in the number of M&A events in the treatment group (target non-life insurers) compared to the

control group (target life insurers) after the year 2012, but we cannot yet identify the actual cause of this result. Climate risk costs significantly increased after 2012 in the P&C insurance industry, but it is not clear that M&As were chosen to consolidate the industry. The observed difference could also be attributed to a significant reduction in M&As in the life insurance industry after 2012, which could be explained by stagnant activity growth in insurance premiums and very low interest rates in the economy.

It seems that P&C insurers choose other diversification activities, including reinsurance and premium management. ILS, including catastrophe bonds, became more popular during our period of analysis, but cannot be considered one of the main sources of capital in the US P&C insurance industry. Better capital risk management under the stronger risk regulation introduced in 2012 and following years could also have been another significant source of resilience for the P&C insurance industry. A preliminary analysis of all these potential sources of capital is presented in Appendix 3. It indicates that premium growth and reinsurance demand were the two main sources of capital in the P&C insurance industry during our period of analysis. Finally, our analysis of different financial indicators confirms the relative good health of P&C insurers after 2012.

Many extensions of our research are in development. Reinsurance is important to diversify climate risks around the world over time (Cummins and Weiss, 2000, 2004). It has been documented that the presence of reinsurance can affect P&C insurers' behavior (Desjardins et al., 2022). The introduction of a more active role for reinsurance in modeling insurers' capital should improve our understanding of the stability of this industry despite the increasing number and severity of climate risk events. But reinsurance capacity may have its limit, particularly with the increase of climate risk worldwide, which reduces international diversification capacities.

Our period of analysis ends with the year 2022. Many extreme events have been observed in the P&C insurance industry since 2017, which was a record year. The years 2021 and 2022 were particularly expensive and have significantly affected both the insurance and reinsurance industries. Some reinsurance companies have been downgraded by rating agencies and others have reduced their participation in the extreme weather risk market.

Reinsurance premiums are very high in 2023, and insurers are also leaving the market in high-risk states such as Florida. To date, 2022 was the third-highest for total insured costs, behind 2017 and 2005, according to Aon re (2023) and Munich re (2023). Total economic losses were $165 billion in the US, with about $100 billion in insured losses for 2022. It seems that the annual $100 billion in insured losses is becoming the standard, or perhaps even a minimum! Updates of the data and analyses from this report will be needed to take into account the new trend in the severity of catastrophic events that began in recent years.

Before 2021, many reports described the US P&C insurance industry as overcapitalized. It is not clear that this will remain true in the future, when we look at insured costs since 2017. These costs are not only high, they repeat every recent year. The years 2005 and 2011 used to be considered outliers, with a low probability of recurrence. This does not seem to be the case anymore with the recent years, as we observe the climate changing.

Finally, another issue concerns the effect of climate risk on life insurance. In a recent SCOR analysis (2022), climate change risks are related to potential life liabilities in the long run. The relevance of climate change risks for life insurance liabilities depends mainly on the insurer's location in the world. For example, the study shows that climate change could generate additional US heat mortality over a time horizon of several decades. More research on the effect of climate risk on the life insurance industry also seems necessary.

10. References

Aerts, J.C.J.H., Wouter Botzen, W.J., Emanuel, K., Lin, N., de Moel, H., Michel-Kerjan, E.O., 2014. Evaluating flood resilience strategies for coastal megacities. Science 344, 6183, 473-475.

Akhigbe, A., Madura, J., 2001. Intra-industry signals resulting from insurance company mergers. The Journal of Risk and Insurance 68, 489-506.

Amel, D., Barnes, C., Panetta, F., Salleo, C., 2004. Consolidation and efficiency in the financial sector: a review of the international evidence. Journal of Banking and Finance 28, 2493-2519.

Amihud, Y., Lev, B., 1981. Risk reduction as a managerial motive for conglomerate mergers. Bell Journal of Economics 12, 1, 605-617.

AON, 2023. Weather, climate and catastrophe insight. https://www.aon.com/weather-climate-catastrophe/index.aspx.

Atlas magazine. https://www.atlas-mag.net/en/category/regions-geographiques/monde/natural-catastrophes-115-billion-usd-of-insured-losses-in-2022. Consulted on 6 December 2022.

Baldauf, M., Garlappi, L., Yannelis, C., 2020. Does climate change affect real estate prices? Only if you believe in it. The Review of Financial Studies 33, 3, 1256-1295.

Betton, S., Eckbo, B.E., Thorburn, K., 2009. Merger negotiations and the toeholds puzzle. Journal of Financial Economics, 91, 2, 158-178.

Boubakri, N., Dionne, G., Triki, T., 2008. Consolidation and value creation in the insurance industry: The role of governance. Journal of Banking and Finance 32, 56-68.

Brockman, P., Yan, X., 2009. Block ownership and firm-specific information. Journal of Banking and Finance 33, 2, 308-316.

Chamberlain, S., Tennyson, S., 1998. Capital shocks and merger activity in the property-liability insurance industry. The Journal of Risk and Insurance 65, 563-595.

Cummins, D., Klumpes, P., Weiss, M.A., 2015. Mergers and acquisitions in the global insurance industry: Valuation effects. The Geneva Papers on Risk and Insurance - Issues and Practice, 40 (3), pp. 444-473. ISSN 1018-5895.

Cummins, D., Tennyson, S., Weiss, M., 1999. Consolidation and efficiency in the US life insurance industry. The Journal of Banking and Finance 23, 325-357.

Cummins, D., Weiss, M., 2004. Consolidation in the European insurance industry: Do mergers and acquisitions create value for shareholders? Working Paper, The Wharton Financial Institutions Center.

Cummins, D., Xie, X., 2008. Mergers and acquisitions in the US property-liability insurance industry: Productivity and efficiency effects. Journal of Banking and Finance 32, 1, 30-55.

Deloitte, 2022. 2022 insurance M&A outlook (27 pages document internet). https://www2.deloitte.com/us/en/pages/financial-services/articles/insurance-m-and-a-outlook.html.

Denis, D.K., McConnell, J.J., 2003. International corporate governance. Journal of Financial and Quantitative Analysis 38, 1-36.

Desjardins, D., Dionne, G., Koné, N., 2022. Reinsurance demand and liquidity creation: A search for bicausality. Journal of Empirical Finance 66, 137-154.

Dionne, G., Desjardins, D., 2022. A re-examination of the U.S. insurance market's capacity to pay catastrophe losses. Risk Management and Insurance Review 25, 4, 515-549.

Dionne, G., Liu, Y., 2021. Effects of insurance incentives on road safety: Evidence from a natural experiment in China. Scandinavian Journal of Economics 123, 2, 453–477.

Dionne, G., 2015. Policy Making and Climate Risk Insurability: How Can (Re)Insurers Contribute to Economic Resilience in Climate Risk Events? Working paper 15-06, Canada Research Chair in Risk Management, HEC Montréal.

Dionne, G., La Haye, M., Bergerès, A.S., 2015. Does asymmetric information affect the premium in mergers and acquisitions? Canadian Journal of Economics 48, 3, 819-852.

Estrella, A., 2001. Mixing and matching: prospective financial sector mergers and market valuation. Journal of Banking and Finance 25, 2367-2392.

Fama, E.F., French, K.R., 1993. Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33, 3-56.

Floreani, A., Rigamonti, S., 2001. Mergers and shareholders' wealth in the insurance industry. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=267554.

Geneva Association 2022. Anchoring Climate Risk Change Risks Assessment in Core Business Decisions in Insurance, Third report of the Geneva Association task force on climate change risk assessment fo the insurance industry (Maryam Golnaraghi coordinator and lead author), 51 pages document internet. https://www.genevaassociation.org/sites/default/files/2022-10/Climate%20Risk%203_web.pdf.

Giorcelli, M., Moser, P., 2020. Copyrights and creativity: Evidence from Italian opera in the Napoleonic Age. Journal of Political Economy 128, 11, 4163-4210.

Guest, P.M., 2021. Risk management in financial institutions: A Replication. Journal of Finance 76, 5, 2689-2707.

Imbens, G.W., Wooldridge, J.M., 2009. Recent developments in the econometrics of program evaluation. Journal of Economic Literature, 47, 1, 5-86.

Issler, P., Stanton, R., Vergara-Alert, C., Wallace, N., 2020. Mortgage markets with climate-change risk: Evidence from wildfires in California. Working paper, University of California, Berkeley.

Jensen, M., 1986. Agency costs of free cash flow, corporate finance and takeovers. American Economic Review 76, 323-329.

Kessler, D., 2015. Conference at the SCOR Scientific Seminar About Climate Risks, Paris, June. https://www.scor.com/en/media/news-press-releases/scientific-seminar-about-climate-risks.

Klein, R.W., Wang, S., 2009. Catastrophe risk financing in the United States and the European Union: A comparative analysis of alternative regulatory approaches. The Journal of Risk and Insurance 76, 3, 607-637.

Klumpes, P., 2022. Consolidation and efficiency in the major European insurance markets. Working paper, Accounting Research Group, Aalborg University Business School.

KPMG, 2020. KPMG Zoom: Mergers and Acquisitions Trends – 2020. https://home.kpmg/tr/en/home/insights/2021/02/kpmg-zoom-mergers-acquisitions-trends-2020.html.

Mayer Brown. Global Insurance Industry Year in Review. Web reports 2013 to 2021. https://www.mayerbrown.com/en/information/global-insurance-industry-year-in-review.

Michel-Kerjan, E., 2012. How resilient is your country? Nature, 491, p. 497. https://www.nature.com/news/how-resilient-is-your-country-1.11861.

Mills, E., 2009. A global review of insurance industry responses to climate change. The Geneva Papers 34, 323-359.

Moeller, S., Schlingemann, F., 2005. Global diversification and bidder gains: A comparison between cross-border and domestic acquisitions. Journal of Banking and Finance 29, 533-564.

Munich re, 2023. Climate change and La Niña driving losses: the natural disaster figures for 2022. https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2023/natural-disaster-figures-2022.html.

NAIC, 2013. The U.S. National state-based system of insurance financial regulation and the Solvency Modernization Initiative. NAIC White paper. https://content.naic.org/sites/default/files/inline-files/committees_e_us_solvency_framework.pdf.

Roberts, M.R., Whited, T.M., 2012. Endogeneity in empirical corporate finance. In: G. Constantinides (ed.), Handbook of the Economics of Finance. Vol. 2, Elsevier North-Holland, Amsterdam, 493-572.

Roll, R., 1986. The hubris hypothesis of corporate takeovers. Journal of Business 59, 197-216.

Rossi, S., Volpin, P. 2004. Cross country determinants of mergers and acquisitions. Journal of Financial Economics 74, 277-304.

SCOR, 2022. The Relevance of Climate Risk Change for Life and Health Insurance (Irene Merk, author), 10 pages, document internet. https://www.scor.com/en/expert-views/relevance-climate-change-life-insurance.

Seifert, D.L., Lindberg, D.L., 2012. Managing climate change risk: Insurers can lead the way. Risk, Hazards & Crisis in Public Policy 3, 2, article 5.

Sigma, 2015. Natural catastrophes and man-made disasters in 2014: Convective and winter storms generate most losses. https://www.swissre.com/institute/research/sigma-research/sigma-2015-02.html.

Snecdecor, G.W., Cochran, W., 1989. Statistical Methods, 8th Edition. Wiley-Blackwell.

Wagner, K., 2020. Adaptation and Adverse Selection in Markets for Natural Disaster Insurance. American Economic Journal: Economic Policy 14, 3, 380-421.

Wilcoxon, F., 1945. Individual comparisons by ranking methods. Biometrics Bulletin 1, 6, 80-83.

Appendix 1 Grouping Life and Health instead of grouping Health and P&C

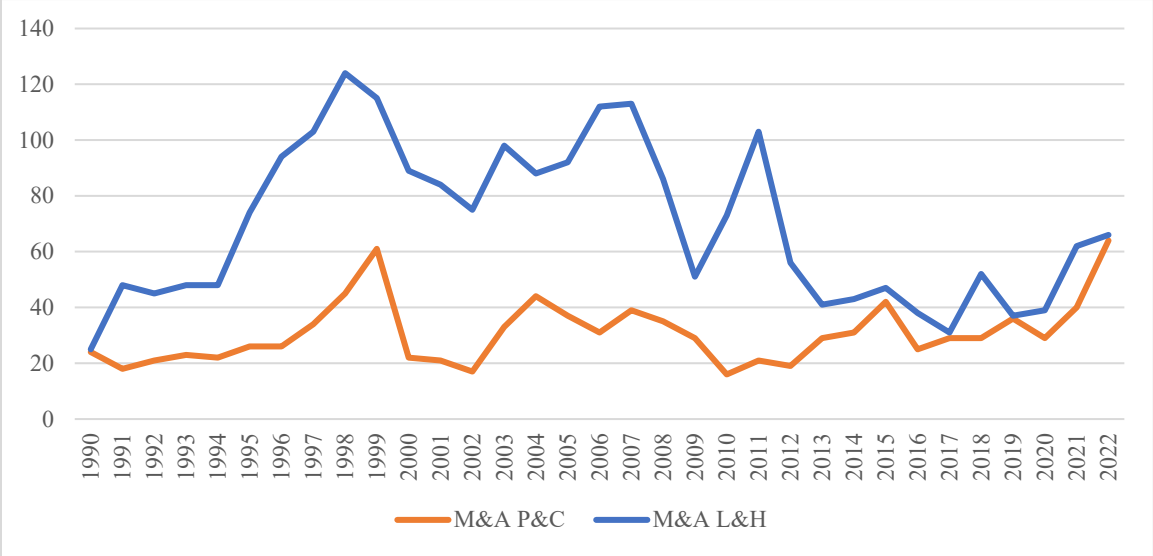
A1. US insurance market

According to Atlas Magazine, the US insurance industry comprises two main sectors: life insurance and non-life insurance. The first sector includes the life and health lines, and the second includes the property and casualty line. In this appendix, we test whether the distinction made by Atlas Magazine, namely grouping life and health, versus the distinction used so far which groups health and property and casualty, may have affected our analysis.

Three major product families dominate the US life and health insurance market (L&H insurance sector): death and life policies (traditional life products), health and disability benefits (health), and annuity contracts (capitalization products that pay out annuities to beneficiaries). The US property and casualty (P&C) insurance market is dominated by the following products: automobile, property, construction, personal liability and commercial lines. Property and casualty products include fire, theft, water damage, bodily injury and hail.

A2. Trends in life and health (L&H) and property and casualty (P&C) M&As

Figure A1: M&A annual trends of target insurers in the two main insurance sectors (L&H and P&C) in the US, 1990 to 2022



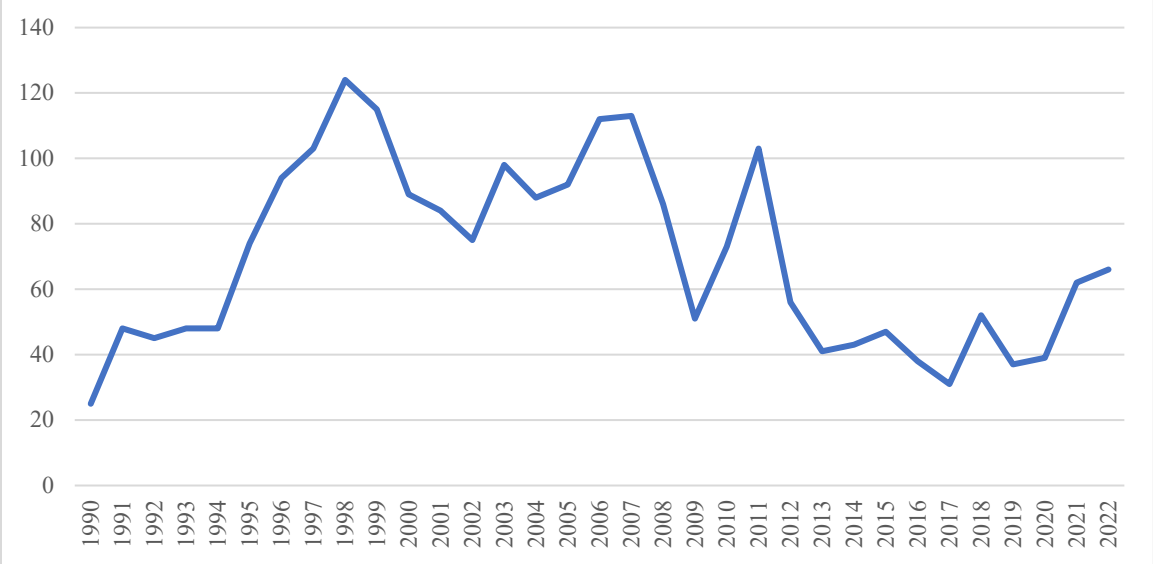
Data source: SDC database.

Figure A1 shows the trends in annual M&As involving target insurers in each of the two major US insurance sectors for the period of 1990 to 2022. The figure indicates that the L&H sector is more dynamic in the M&A market, with 2,300 transactions over the entire period of 1990 to 2022, versus 1018 for the P&C sector. It indicates some parallel time trends in the evolution of target insurer M&As for our two main insurance sectors starting from 2013 (i.e. the post-2012 period). This result suggests that the evolution of target insurer M&As in the P&C insurance sector is more similar to that observed in the L&H insurance sector during the 2013 to 2022 period. Using an econometric approach applied to annual series, we will statistically validate this result.

A3. Choice of treatment group

Before performing the statistical validation of the results suggested by Figure A1, we first need to identify and select our treatment group, i.e., identify which of our two sectors, L&H or P&C, experienced a significant shock that led to the change observed during the post-2012 period (2013-2022). This will allow us to construct the variables $\text{Treated}_i \times \text{Year}$ needed for our paralleled trends validation test.

Figure A2: M&A annual trends of target insurers in the US L&H insurance industry, 1990 to 2022



Data source: SDC database.

Figure A2, derived from our SDC database, suggests three main waves of target insurer M&As recorded in the L&H insurance industry over the past 32 years. The first wave is around 1998-1999, the second around 2006-2007, and the third wave in 2011. In the L&H sector, M&A transactions were apparently particularly dynamic before 2011. This dynamism has weakened considerably after 2012.

This suggests that there was a shock event around 2012 that caused the significant decline in M&As observed in the L&H sector from 2012 onwards. We created a Post2012 variable to assess the impact of this shock in each of our two sectors in order to identify our treatment group.

A4. Statistical validation using the DID method and the parallel trend test between the L&H and P&C sectors

Based on our results in Figure A2, we select the L&H insurance sector as the treatment group. We consequently constructed the variable $\text{Treated}_{L\&H}\times\text{Year}$ required for our DID validation test. The results of our regressions provide empirical validation of the graphical results suggested by Figure A1.

As can be seen in Table A1, the coefficients obtained for each year during the period 1990 to 2012 are all statistically significant (with the exception of 1990), meaning that the two sectors are different during this period. Our F-test supports this result. The F-test over the period of 1990 to 2012 yields an F statistic (23, 2300) = 12.30 with a probability Prob > F = 0.0000. The null hypothesis is rejected and thus the coefficients considered as a whole can be said to be significant during the period of 1990 to 2012. In contrast, the coefficients obtained are overall not statistically significant for the post-2012 period. Our F-test supports this result; it shows that the F-statistic on our Treated×Year interaction variables for the post-2012 period is F (9,900) = 1.17 with probability Prob > F = 0.3121. Since the p-value is greater than 5%, we do not reject the null hypothesis and can thus conclude that the coefficients obtained during the post-2012 period are not significantly different from zero as a whole, thus overall not significant. The results of our regressions allow us to empirically validate the post-2012 period as a period marked by the presence of a parallel

time trend between the evolution of M&As of target insurers for our two main insurance sectors (L&H and P&C).

Table A1: Selection of treatment date and DID validation test

Dependent variables	Number of M&As per year (L/H and P/C)		Number of M&As per year (L/H and P/C)		Number of M&As per year (L/H and P/C)	
Independent variables	Coefficient	Std error	Coefficient	Std error	Coefficient	Std error
$Treated_{LH}$×Year1990	0.020	0.165	-		-	
$Treated_{LH}$×Year1991	0.588***	0.172	0.588***	0.174	-	
$Treated_{LH}$×Year1992	0.471***	0.143	0.471***	0.145	0.471***	0.146
$Treated_{LH}$×Year1993	0.490**	0.209	0.490**	0.210	0.490**	0.211
$Treated_{LH}$×Year1994	0.510***	0.152	0.510***	0.153	0.510***	0.154
$Treated_{LH}$×Year1995	0.941***	0.210	0.941***	0.211	0.941***	0.211
$Treated_{LH}$×Year1996	1.333***	0.253	1.333***	0.252	1.333***	0.252
$Treated_{LH}$×Year1997	1.353***	0.239	1.353***	0.238	1.353***	0.238
$Treated_{LH}$×Year1998	1.549***	0.356	1.549***	0.355	1.549***	0.353
$TreatedL_{LH}$Year1999	1.059***	0.362	1.059***	0.36	1.059***	0.358
$Treated_{LH}$×Year2000	1.314***	0.279	1.314***	0.278	1.314***	0.278
$Treated_{LH}$×Year2001	1.235***	0.268	1.235***	0.268	1.235***	0.269
$Treated_{LH}$×Year2002	1.137***	0.193	1.137***	0.193	1.137***	0.194
$Treated_{LH}$×Year2003	1.275***	0.289	1.275***	0.288	1.275***	0.288
$Treated_{LH}$×Year2004	0.863***	0.242	0.863***	0.241	0.863***	0.241
$Treated_{LH}$×Year2005	1.078***	0.315	1.078***	0.315	1.078***	0.314
$Treated_{LH}$×Year2006	1.588***	0.349	1.588***	0.348	1.588***	0.349
$Treated_{LH}$×Year2007	1.451***	0.324	1.451***	0.323	1.451***	0.322
$Treated_{LH}$×Year2008	1.000***	0.298	1.000***	0.297	1.000***	0.297
$Treated_{LH}$×Year2009	0.431**	0.192	0.431**	0.193	0.431**	0.194
$Treated_{LH}$×Year2010	1.118***	0.218	1.118***	0.219	1.118***	0.220
$Treated_{LH}$×Year2011	1.608***	0.262	1.608***	0.261	1.608***	0.261
$Treated_{LH}$×Year2012	0.725***	0.200	0.725***	0.200	0.725***	0.201
$Treated_{LH}$×Year2013	0.235	0.180	0.235	0.181	0.235	0.183
$Treated_{LH}$×Year2014	0.235	0.188	0.235	0.189	0.235	0.189
$Treated_{LH}$×Year2015	0.098	0.172	0.098	0.172	0.098	0.172
$Treated_{LH}$×Year2016	0.255	0.182	0.255	0.184	0.255	0.185
$Treated_{LH}$×Year2017	0.039	0.192	0.039	0.194	0.039	0.196
$Treated_{LH}$×Year2018	0.451**	0.186	0.451**	0.186	0.451**	0.185
$Treated_{LH}$×Year2019	0.020	0.149	0.020	0.151	0.020	0.153
$Treated_{LH}$×Year2020	0.196	0.178	0.196	0.179	0.196	0.180
$Treated_{LH}$×Year2021	0.431**	0.188	0.431**	0.188	0.431**	0.188
$Treated_{LH}$×Year2022	0.039	0.213	0.039	0.213	0.039	0.211
Constant	3.455***	0.314	3.398***	0.325	3.512***	0.321
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,366		3,264		3,162	
R-squared	0.545		0.546		0.547	

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05.

To ensure the reliability of our choice of treatment date for the validation test of our DID method, we conduct two robustness tests. The first test consists in ignoring the first year of observations, Treated×Year1990. The second test ignores the first two years of observations, Treated×Year1990 and Treated×Year1991. The results of these two robustness tests confirm the validation of the year 2012 as the treatment date to be retained for our DID method, as shown in Table A1 (columns 4 and 6).

A5. DID analysis

We estimate whether the decline in M&As observed in the L&H sector after the year 2012 caused the loss of the significant difference between our two sectors (L&H and P&C) observed over the post-2012 period (from 2013 to 2022). We create an interaction variable between our two variables of interest, Treated_{LH}×Post2012, to assess the impact of the treatment on the units in our treatment group. Our interaction variable Treated_{LH}×Post2012 is the variable of interest because it allows us to capture the effect of the treatment administered to units in the treatment group (the L&H insurance industry in our case). Based on our variables of interest, we consider the following regression model:

$$\text{Nbr M\&A}_{it} = \alpha + \delta_1 \text{Treated}_{LH} \times \text{Post2012} + c_i + \eta_t + \epsilon_{it}. \quad \text{(A1)}$$

$\text{Treated}_{LH} \times \text{Post2012}$ equal one for the treatment group after the treatment period, zero otherwise;

c_i: individual shocks that have the same influence on state *i* in all periods;

η_t: time shocks that affect all states in the same way in period *t*;

ϵ_{it}: idiosyncratic shocks that occur for a certain state *i* at a certain date *t*;

α: constant.

What interests us in equation (A1) is the interaction variable $\text{Treated}_{LH} \times \text{Post2012}$. It indicates the impact of the treatment on the units in the treatment group.

Table A2 presents the statistics of the variables used in the regression analysis. Our results presented in Table A3 indicate that the coefficient of our variable $\text{Treated}_{LH} \times \text{Post2012}$ is negative and statistically significant at 1%. This suggests a downward effect on the number of M&As in the treated group during the post-2012 period.

Table A2: Mean and standard deviation of the variables

Period	1990-2022		1990-2012		2013-2022	
Variable	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
M&A annual number	0.986	1.736	1.069	1.888	0.794	1.303
$\text{Treated}_{\text{LH}} \times \text{Post2012}$	0.152	0.359	0.000	0.000	0.500	0.500

$\text{Treated}_{\text{LH}}$ represents the sector Life + Health.

Table A3: Regression results using the fixed effect method

Dependent variable	Number of M&As per year (L&H and P&C)	
	Coefficient	Standard error
$\text{Treated}_{\text{LH}} \times \text{Post2012}$	–0.678***	0.123
Constant	1.088***	–0.0186
State FE	Yes	Yes
Year FE	Yes	Yes
Observations	3,366	
R-squared	0.035	

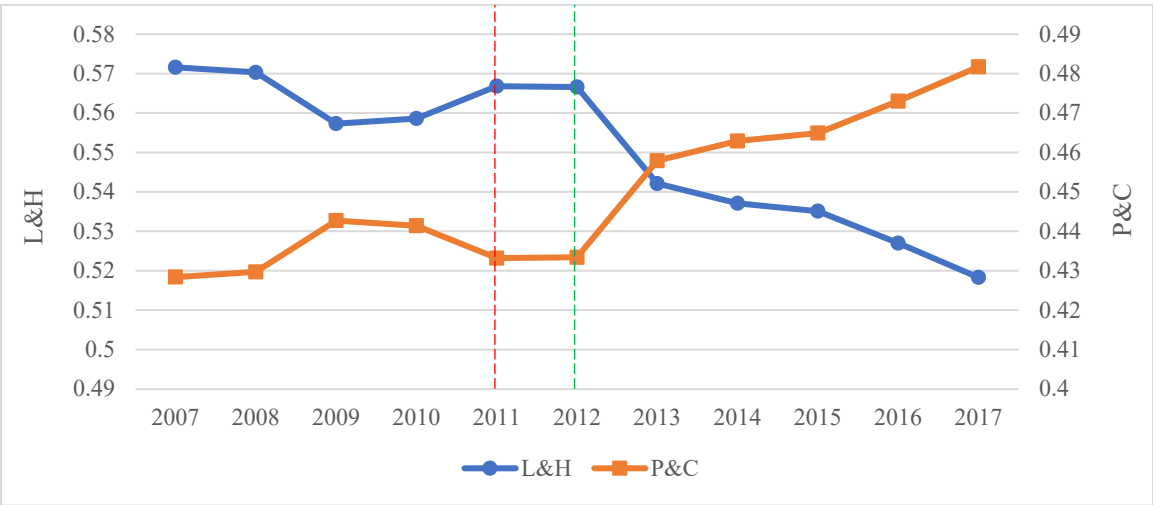
Robust standard errors.
*** p<0.01.

A6. Origins of the loss of the significant difference in M&As between L&H and P&C in the post-2012 period

Our results in Table A3 suggest that the treatment in the L&H sector decreased the number of M&As in the L&H sector relative to the P&C sector in the post-2012 period.

Two major facts observed in the US insurance market may explain the loss of the significant difference in M&A observed between the L&H and P&C sectors in the post-2012 period: The decline in insurance activity in the L&H sector since 2012 and the relative stability of insurance capacity in the P&C sector since 2012 in presence of an increase in climate risk events. To demonstrate this, we first use the share of premiums collected, a reliable indicator for measuring activity in the insurance industry.

Figure A3: Market share of premiums collected by all L&H and P&C insurers



Data sources: NAIC data and S&P Global Market Intelligence and Insurance Information Institute.

A6.1 Share of premiums

According to Figure A3, the L&H insurance sector attracted more premiums than did the P&C insurance sector before 2013. We observe a complete reversal of the market share of premiums collected by the P&C insurance sector after 2012, and thus over the post-2012 period (2013 to 2022).

A6.2 Density indicator

The insurance density indicator is an instrument often used by insurance professionals to assess the insurance consumption per capita of a country or region.

Table A4: Insurance density 2000-2017

	2000			2007			2017		
	L/H	P/C	Total	L/H	P/C	Total	L/H	P/C	Total
Insurance density	1547	1529	3076	1922	2164	4086	1674	2542	4216

Data source: Sigma.

The growth in the insurance density indicator observed in the US in recent years is mainly attributed to the non-life (P&C) sector, which rose from 2164 in 2007 to 2542 in 2017, a growth of 17%. The life (L&H) sector, in contrast, sustained a 13% decline over the ten

years, equal to an annual average decline of 1.3%. These results indicate that insurance consumption per capita, and hence insurance business, remained stable in the P&C sector but declined in the L&H sector in recent years.

A6.3 Penetration rate

The penetration rate is also used by insurance professionals to assess the importance of insurance activity in the economy of a country.

Table A5: Penetration rates 2000-2017

	2000			2007			2017		
	Life	Non-Life	Total	Life	Non-Life	Total	Life	Non-Life	Total
Penetration rate (%)	4.20	4.20	8.40	4.20	4.70	8.90	3.12	4.11	7.23

Data source: Sigma.

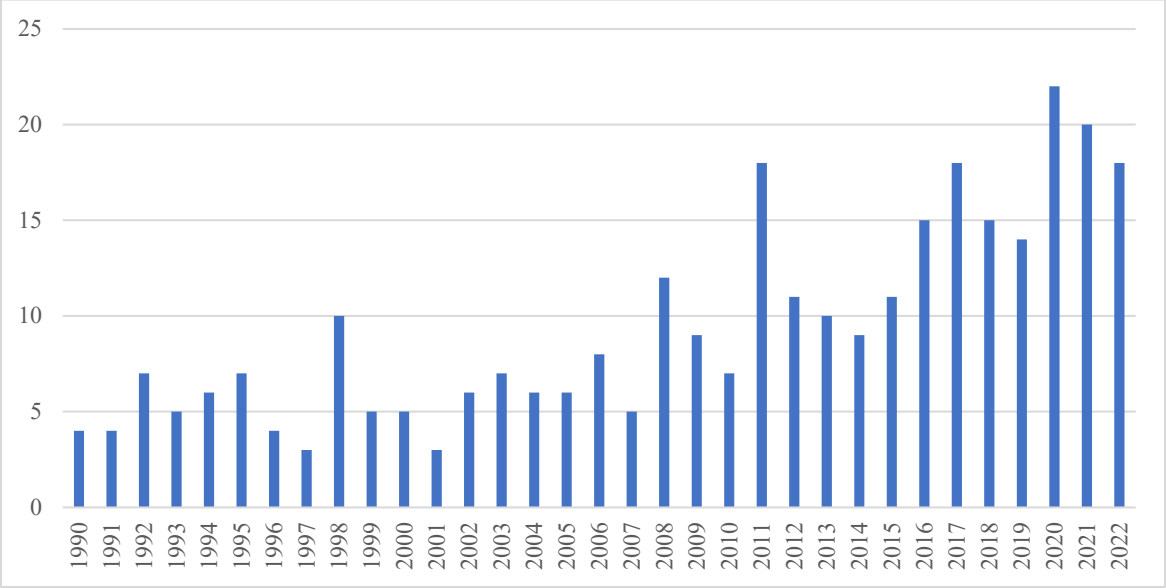
Table A5 shows that insurance business taken as a whole (L&H and P&C) is declining in GDP in the US in 2017 compared with the year 2000. It fell from 8.40% in 2000 to 7.23% in 2017. An analysis of this table clearly indicates that this decline is due to the decrease in life (L&H) business. In the year 2000, the two sectors, L&H and P&C, each represented 4.2% of GDP. At the end of 2017, the life and health sector dropped to 3.12%, a decline of 25%, and the non-life (P&C) sector diped slightly, to 4.11%, a decrease of 2%.

In the following section, we analyze the possible link between M&As and natural disaster events in the US to see if the drop in M&A deal momentum from 2012 onward can be linked to natural disaster events.

A7. Climate change and the link between L&H M&As and extreme natural disaster events in the US

In this part of our analysis of natural disasters or extreme weather events in the US, we used the NOAA's database to capture the increase in severe natural disaster events observed in the US starting in 2011. This database retains only natural disaster events that cause economic losses of US$1 billion. These losses are not necessarily insured.

Figure A4: Number of extreme natural disaster events observed in the US, 1990 to 2022

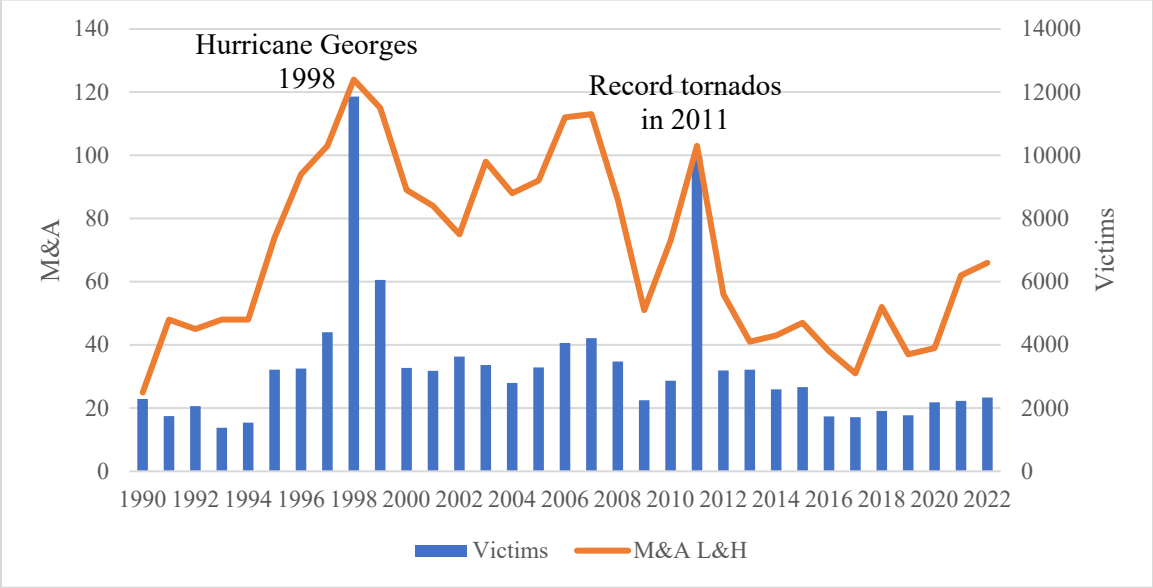


Data source: NOAA database. NOAA retains events with economic losses of US$1 billion or more that are not necessarily insured.

Figure A4 shows that these events can be subdivided into two periods, according to the frequency of the events. Based on the distinction of these two periods of extreme natural disaster events, we observe that the annual number of extreme natural disaster events occurring before 2011 is lower than the median for many years. In contrast, this distinction shows that the annual number of extreme natural disaster events occurring from 2011 onwards is higher than the median for each of the years over the entire period from 2011 to 2022. Our data indicate an average of six extreme natural disaster events per year in the period before 2011 versus 15 in the period from 2011 through the end of 2022, an increase of over 150%.

Figure A5 shows that the number of casualties (injuries and deaths) caused by extreme natural disaster events in the US reached two significant peaks, the first in 1998 and the second in 2011. These two peaks can be linked to two exceptional weather events in the US.

Figure A5: Trends in L&H M&As and casualties from extreme natural disasters in the US, 1990 to 2022



Data sources: SDC and Weather Related Fatality and Injury Statistics databases. People injured or killed by natural disasters are not necessarily insured.

The first peak is linked to Hurricane Georges, a major weather event that hit the US in 1998. According to Wikipedia, this hurricane was the second major hurricane during the 1998 hurricane season in the south Atlantic. Hurricane Georges generated a series of 28 tornadoes, most of which were recorded in Florida and Alabama. The event caused insured losses of US$2.765 billion in the US. The 2011 peak can be linked to the exceptional series of severe tornadoes that occurred in 2011 in the Midwestern US. The National Oceanic and Atmospheric Administration states that the 2011 severe tornado season was the deadliest and most costly in US history. Atlas magazine (2011) mentions that "According to Swiss Re, the natural catastrophe losses for the first semester amount to 70 billion USD. It is twice the sums paid at the same period of 2010. After 2005 which saw hurricanes Katrina, Rita and Wilma lash American coasts, 2011 stands as the costliest year for reinsurers."

The significant increase in the number of casualties (injuries and deaths) caused by natural disaster events in 1998 and 2011 put downward pressure on M&A activity in the L&H sector. Figure A5 shows that after the 1998 peak, the L&H insurance sector revitalized M&A activity in 2002, yet these transactions came to a sudden halt with the 2007-2009 financial crisis. Regarding the 2011 peak, Figure A5 shows that the dynamism of M&A

transactions in the L&H insurance sector has been strongly undermined. The very high number of injuries and large loss costs caused by the exceptional series of severe tornadoes in the Midwestern US in 2011 seems to explain this trend.

We now analyze the link between different financial indicators of the insurance industry in relation to extreme natural disasters.

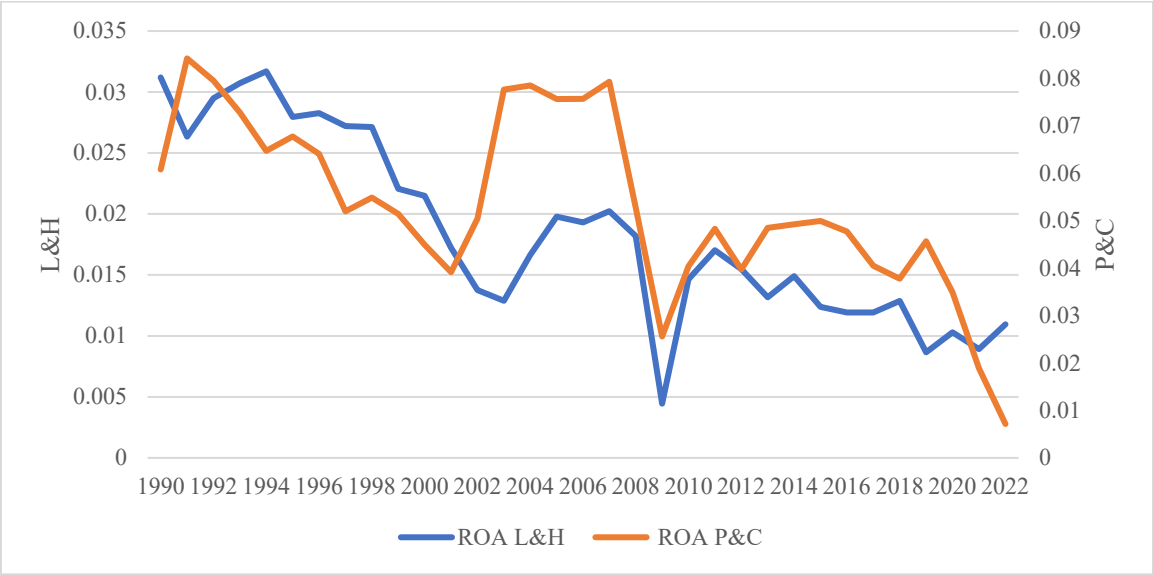
A8. Return on Asset (ROA)

We have retained the ROA profitability indicator to illustrate the financial difficulties that the L&H insurance sector has experienced as a result of natural disaster events observed since 2011. The ROA indicator is a reliable instrument for measuring insurer viability (growth). To be viable, insurers, like any other company, must generate profitability in all their operations in order to repay their creditors, compensate insureds, satisfy shareholders' demands and finance their growth (on which their viability depends). The ROA indicator reflects insurers' ability to increase the value of their assets across their entire commercial (insurance policy sales) and financial operations (investments). Figure A6 shows the evolution of the ROA profitability ratio for each of our two sectors (P&C and L&H).

Overall, Figure A6 shows that since the 2011 shock, the L&H insurance sector has been struggling to regain momentum in M&A transactions. However, we know that the more M&A transactions insurers carry out, the more they will seek growth in market share of premiums collected, and therefore more premiums to cover claims costs, and the more it will generate ROA profitability. Further, the more M&A operations insurers undertake, the more they will seek in economies of scale, which will lower their claims costs to cover by premiums collected while raising their ROA profitability. Consequently, the lack of dynamism in M&A transactions observed in the L&H sector has greatly weakened the financial stability of L&H insurers, which have been facing financial difficulties.

Another potential explanation of Figure A6 is more related to poor market conditions in the L&H insurance industry after 2012, as documented in the report: low premium growth, strong new federal regulation, and low interest rates after the 2007-2009 financial crisis.

Figure A6: Evolution of the ROA ratio in the life and health (L&H, left) and non-life (P&C, right) insurance sectors in the US, 1990 to 2022



Data source: COMPUSTAT database.

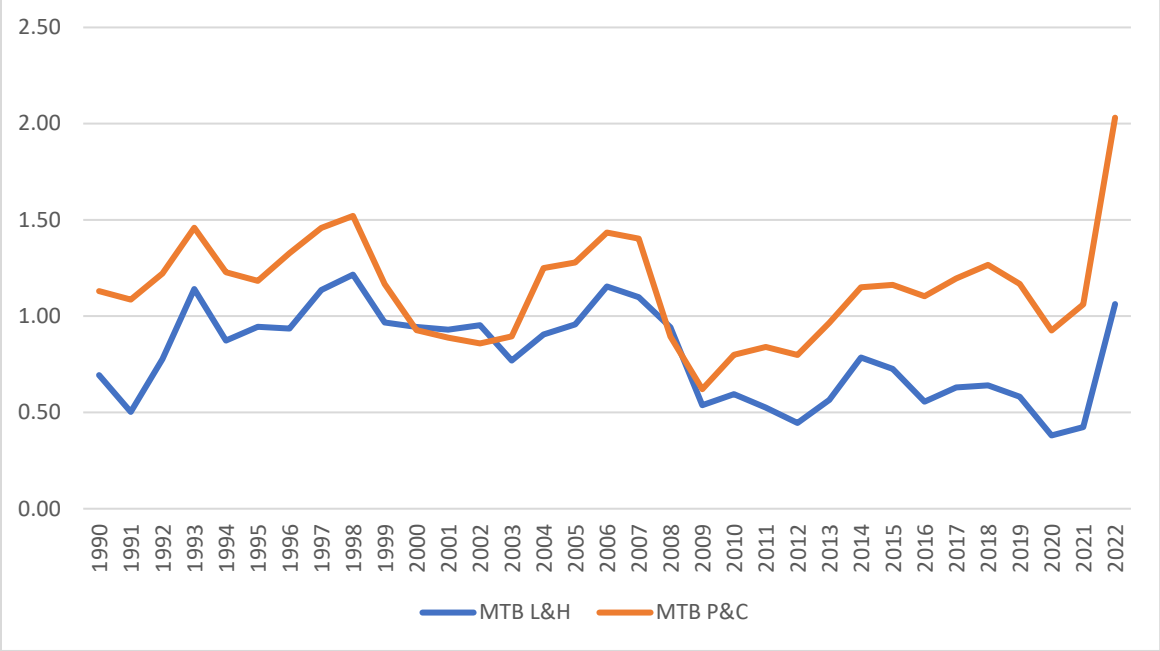
A9. Market-to-book (MTB)

The second indicator we have chosen to illustrate the financial difficulties that the L&H insurance industry has experienced as a result of natural disaster events or poor market conditions and strong regulation from 2011 to 2022 is the market-to-book (MTB) ratio. This ratio reflects not only the profitability of insurers' business, but also the market's perception of insurer's overall level of financial risk. An MTB ratio below unity means that the public insurer is undervalued by the market (market value lower than book value). If the market value is lower than the book value, it suggests that the expected performance is poor for market investors. Conversely, an MTB ratio greater than unity means that the non-life insurer is well valued by the market. If the market value exceeds the book value, this suggests that the expected performance is good and well anticipated by the market.

Figure A7 shows that the MTB in the L&H sector has been below one since the financial crisis of 2007-2009 and during the period following 2011 (2011 to 2022). This illustrates the poor financial health of L&H insurers during this period. Figure A7 also shows that the financial health of P&C insurers improved significantly after the financial crisis of 2007-2009. The MTB indicator exceeds one after 2013. In other words, the financial health of

P&C insurers has improved significantly in the post-2012 period, despite the increase in natural disaster events.

Figure A7: Evolution of the MTB ratio in the life (L&H) and non-life (P&C) insurance sectors in the US, 1990 to 2022 (public firms only)



Data source: COMPUSTAT database.

To summarize, figures A6 and A7 indicate that the resurgence of extreme natural disaster events or market conditions and regulation rules have exerted downward on ROA profitability indicator and the MTB market indicator of insurers in the L&H sector.

A10. Reinsurance activity

Today, most of the US natural disaster risk is reinsured outside the US. According to the Reinsurance Association of America, two-thirds of locally written natural disaster premiums are reinsured by foreign companies.

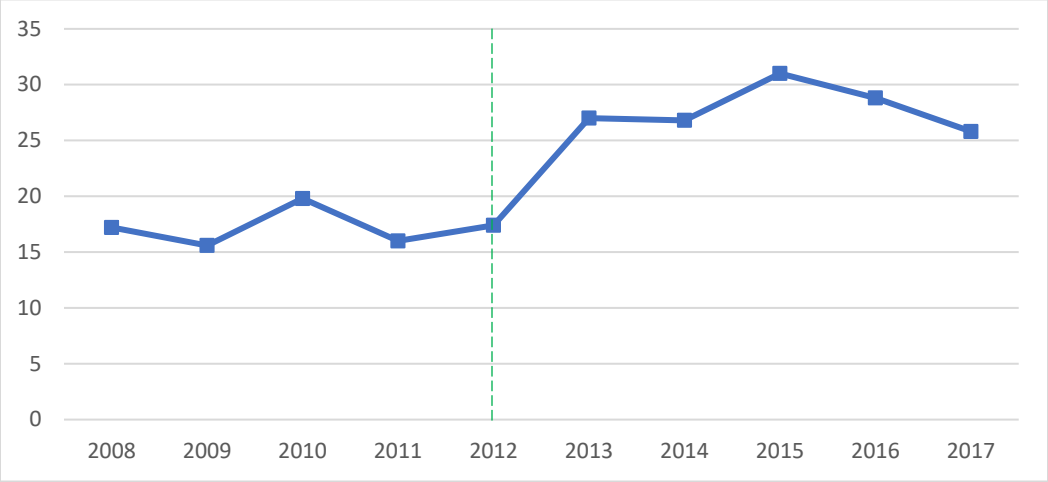
Table A6: Difference between premiums ceded to foreign reinsurers and premiums ceded to local reinsurers

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Cessions to offshore reinsurers in %	58.60	57.80	59.90	58.00	58.70	63.50	63.40	65.50	64.40	62.90
Cessions to local reinsurers in %	41.40	42.20	40.10	42.00	41.30	36.50	36.60	34.50	35.60	37.10
Difference in %	17.20	15.60	19.80	16.00	17.40	27.00	26.80	31.00	28.80	25.80

Data source: Reinsurance Association of America (2018).

Table A6 shows the percentages of premiums ceded to offshore reinsurers and to local reinsurers over the period of 2008 to 2017. According to the Reinsurance Association of America figures, the share of US direct premiums accepted by US-domiciled reinsurers has declined significantly over the past 20 years. It has dropped from 61% in 1998 to 37% in 2017. This table also shows that the gap between premiums ceded to offshore reinsurers and those ceded to local reinsurers is very significant from 2013 (post-2012).

Figure A8: Difference between cessions to offshore reinsurers and cessions to local reinsurers in the non-life sector, 2008 to 2017



Data source: Reinsurance Association of America.

Figure A8 clearly indicates that the gap between premiums ceded to foreign reinsurers and premiums ceded to local reinsurers has increased significantly over the post-2012 period. This demonstrates that offshore reinsurers, particularly in Bermuda and Europe, have been heavily enlisted to support the US market during the post-2012 period. The penetration of foreign reinsurers into the US reinsurance market, especially during the post-2012 period, suggests that the US reinsurance market is being penalized by competition.

Appendix 2 Other statistics

The next tables present different correlations between the key variables of our study.

Table A7: Correlation coefficients over the 1990-2022 period in the non-life insurance industry

Variables	(1)	(2)	(3)	(4)
(1) M&A non-life	1.000			
(2) Number of events	0.306*** (0.000)	1.000		
(3) Insured losses (in log)	0.237*** (0.000)	0.621*** (0.000)	1.000	
(4) Number of injuries	0.204*** (0.000)	0.178*** (0.000)	0.130*** (0.000)	1.000

*** p<0.01.

Table A7 shows a positive and significant correlation at the 1% level over the 1990-2022 period between the number of natural disaster events and the number of M&As per year observed in the non-life insurance sector and a positive and significant correlation between insured losses and both the number of injuries from natural disasters and the number of M&As per year in the non-life insurance sector. Other positive correlations are also of interest.

Table A8: Correlation coefficients over the 1990-2022 period in the life insurance industry

Variables	(1)	(2)	(3)
(1) M&A life	1.000		
(2) Number of events	0.228*** (0.000)	1.000	
(3) Number of deaths	0.259*** (0.000)	0.323*** (0.000)	1.000

*** p<0.01.

Table A8 shows a positive and significant correlation between the number of natural disaster events from natural disasters and the number of M&A in the life insurance sector, and a positive and statistically significant correlation between the number of observed

natural disaster events and the number of natural disaster deaths over the 1990-2012 period. Similar results are obtained in the two sectors during the 1990-2012 and post-2012 sub-periods, as shown in Table A9 and Table A10.

Table A9: Correlation coefficients over the 1990-2012 period and post-2012 period in the non-life insurance industry

Period	1990 to 2012				Post-2012			
Variables	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
(1) M&A non-life	1.000				1.000			
(2) Number of events	0.282*** (0.000)	1.000			0.413*** (0.000)	1.000		
(3) Insured losses (in log)	0.231*** (0.000)	0.641*** (0.000)	1.000		0.268*** (0.000)	0.611*** (0.000)	1.000	
(4) Number of injuries	0.216*** (0.000)	0.237*** (0.000)	0.149*** (0.000)	1.000	0.184*** (0.000)	0.183*** (0.000)	0.107** (0.022)	1.000

*** p<0.01.

Table A10: Correlation coefficients over the 1990-2012 period and post-2012 period in the life insurance industry

Period	1990 to 2012			Post-2012		
Variables	(1)	(2)	(3)	(1)	(2)	(3)
(1) M&A life	1.000			1.000		
(2) Number of events	0.312*** (0.000)	1.000		0.305*** (0.000)	1.000	
(3) Number of deaths	0.340*** (0.000)	0.328*** (0.000)	1.000	0.180*** (0.000)	0.293*** (0.000)	1.000

*** p<0.01.

Table A11 (corresponding to Figure 5)

Year	Non-life	Life
1990	30	26
1991	33	37
1992	43	34
1993	31	31
1994	35	47
1995	41	64
1996	55	60
1997	57	83
1998	86	86
1999	79	91
2000	54	48
2001	44	56
2002	40	57
2003	67	70
2004	78	50
2005	69	60
2006	69	74
2007	76	77
2008	61	54
2009	38	37
2010	41	59
2011	52	68
2012	41	39
2013	44	21
2014	53	21
2015	62	27
2016	46	11
2017	42	20
2018	49	28
2019	54	25
2020	54	16
2021	57	39
2022	95	35

Appendix 3 Sources of capital in the US insurance industry

Table A12: Descriptive statistics, P&C insurance industry, 1990-2022

Variable in 10^{12} $	N	Mean	Std	Min	Median	Max	Data source
Total capital	33	0.77924	0.25179	0.36562	0.75623	1.30444	NAIC
Reinsurance demand ratio	33	0.46362	0.03401	0.40622	0.47480	0.50991	NAIC
Liquidity creation ratio	33	–0.51443	0.03018	–0.58240	–0.51103	–0.45720	NAIC
Direct premium written	33	0.58814	0.12487	0.13280	0.60954	0.79358	NAIC
Net premium written	33	0.53869	0.10580	0.13053	0.54595	0.71815	NAIC
Premiums earned	33	0.54447	0.07765	0.44336	0.53951	0.69408	NAIC
MA	33	30.84848	11.35265	16	29	64	SDC
Catastrophic losses	33	0.02918	0.02478	0.00439	0.01755	0.08644	VERISK
CAT and ILS issued	26	0.00645	0.00410	0.00133	0.00647	0.01400	Artemis
ILS issued	26	0.00064	0.00063	–0.00019	0.00043	0.00212	Artemis
CAT issued	26	0.00572	0.00356	0.00132	0.00593	0.01251	Artemis

Note: Annual values in 2022$.

Table A13: Sources of capital in the US P&C insured industry, 1997-2022 (all variables)

	With ILS		Without ILS	
Variable	Parameter	*t*	Parameter	*t*
Intercept	–2.03045**	–3.87	–1.98335**	–3.99
Reinsurance demand	1.00254	1.23	1.02441	1.32
Liquidity creation ratio	–2.63624**	–5.22	–2.56081**	–5.25
Post-2012	0.10805**	3.18	0.10660**	3.32
Premium earned	1.70947**	4.90	1.65353**	4.87
MA	–0.00098	–0.80	–0.00081	–0.68
Catastrophic losses	0.74838	1.44	0.76692	1.54
Catastrophe bonds and ILS	9.43785	1.80	–	–
Catastrophe bonds	–	–	11.9361*	2.18
Number of observations	26			
R-squared	0.9553		0.9583	
R-squared adjusted	0.9379		0.9421	

*p<0.05; ** p<0.01

We observe in Table A13 that MA, catastrophe losses, ILS, and reinsurance demand are not statistically significant to explain the sources of capital in the P&C insurance industry. Premium earned and catastrophe bonds are important sources of capital.

Table A14: Sources of capital in the US P&C insurance industry, 1997-2022 (significant variables only)

	With ILS		Without ILS	
Variable	Parameter	*t*	Parameter	*t*
Intercept	–2.00834***	–3.82	–1.97442***	–3.93
Reinsurance demand	1.26420*	1.81	1.25213*	1.88
Liquidity creation ratio	–2.35150***	–5.08	–2.30629***	–5.14
Post-2012	0.09925***	2.94	0.09974***	3.11
Premium earned	1.67518***	5.93	1.65816***	6.10
Catastrophe bonds and ILS	11.66639**	2.30	–	–
Catastrophe bonds	–	–	13.93963**	2.63
Number of observations	26			
R-squared	0.9493		0.9523	
R-squared adjusted	0.9366		0.9404	

*p<0.10; ** p<0.05; *** p<0.01

Table A14 presents a robustness analysis of results of Table A13 when we drop non-significant variables. P&C insurers significantly increased their capital after 2012 (Post2012).