

The shape of the cybersecurity insurance industry: 2015-2020

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Abstract

Cybersecurity insurance (CSI) is becoming an important offering by insurance companies as a part of their property-liability market. In this paper we examined the state of the cybersecurity insurance industry for 2015 to 2020. The study considered both standalone and packaged insurance offerings across various types of insurance companies – stock, mutuals, large, and small. Loss ratios were also calculated and compared across each of the categories and offerings. Findings indicate that CSI premiums rose by over 170% during the period, with the number of insurers rising by around 70%, with much of the increase driven by large, stock company sales of standalone CSI. No evidence is found for longer-duration participants having lower risk levels, and a puzzle is found in terms of rising loss ratios in conjunction with level premiums per policy.

Keywords: cybersecurity, Insurance, risk, CSI, premiums, loss-ratios

Introduction

Cybersecurity risk and breaches have gained increasing importance in recent decades (Campbell et al., 2003; Cavusoglu et al., 2004; Alshboul et al., 2021). According to the 2022 Global Threat Report, OverWatch tracked a steady increase in the number of interactive intrusion campaigns in 2021. Compared to 2020, OverWatch observed a near 45% increase in the number of campaigns and discovered more in the fourth quarter than in any other quarter (Figure 1).

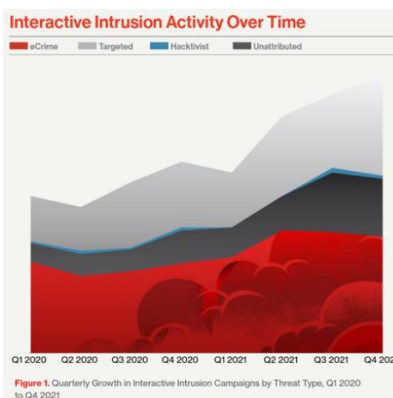


Figure 1: Interaction Intrusion Activity Over Time

The significance of cybersecurity was recognized early on when the Federal Information Security Management Act of 2002 mandated that federal agencies and contractors develop standards for information

security (NIST, 2022). In 2014, the Act was updated as the Federal Information Security Modernization Act, which incorporated the standards developed by NIST (NIST, 2022). Similarly, in 2003, the state of California passed the Security Breach and Information Act, requiring organizations to notify customers of potential breaches of their private information (Office of the Attorney General, 2022). Several other states quickly followed suit (Colony West, 2022).

Over time, cyber-attacks have become increasingly problematic and audacious. For instance, Wikileaks was founded in 2006 with the purpose of publishing classified or censored government and corporate documents (wikileaks.org). In 2017, Equifax, a prominent credit reporting agency, was hacked, resulting in the identity theft of 143 million Americans (Timberg et al., 2017). The situation further worsened after the COVID-19 pandemic compelled many businesses to shift employees online starting in March 2020, leading to a surge in ransomware attacks. Surveys conducted by Sophos in 2020 and 2021 revealed that the average recovery cost of a ransomware attack increased from \$761,106 in 2020 to \$1.85 million in 2021 (Sophos, 2021).

The exponential growth of cybersecurity risks gave rise to the cybersecurity insurance (CSI) industry. Initially, such insurance primarily covered online media or errors in data processing in the 1990s, but it later expanded to provide coverage for property damage in cyber-attacks, network security, business interruption, and extortion damages (Colony West, 2022).

There are specific cybersecurity risks that impact the cyber insurance industry. These are similar to attacks seen in other industries:

1. **Data Breaches:** Insurance companies collect and store vast amounts of sensitive data, including personal information and financial records of their policyholders. A data breach could expose this information to unauthorized individuals or hackers, leading to identity theft, financial fraud, or reputational damage.
2. **Social Engineering Attacks:** Cybercriminals may target insurance companies through social engineering techniques, such as phishing emails or phone calls. By tricking employees into divulging sensitive information or granting access to systems, attackers can gain unauthorized entry into the insurer's network and compromise data.
3. **Denial-of-Service (DoS) Attacks:** Insurance companies heavily rely on their online services to interact with customers, process claims, and manage policies. A DoS attack, which floods the insurer's systems with excessive traffic, can disrupt operations, cause service downtime, and lead to financial losses.
4. **Ransomware Attacks:** Insurance companies are attractive targets for ransomware attacks due to the sensitive data they possess and the potential financial impact of disruptions. Ransomware can encrypt critical systems and files, demanding a ransom for their release, potentially resulting in significant financial and reputational damage.
5. **Third-Party Risks:** Cyber insurance companies often work with third-party vendors, such as brokers, claims processors, or underwriters. The interconnectedness with these partners introduces additional risks, as their security vulnerabilities could serve as entry points for cyber attackers to compromise the insurer's systems.

Over the years the US insurance industry has developed insurance products to address these escalating cyberattacks. The U.S. life insurance industry can be broadly divided into two markets: life-health and property-liability, with a limited overlap between them (Cummins et al., 2010). As far as our knowledge

extends, CSI is only found in the property-liability market, which aligns with the fact that most cyber-attacks involve property damage or loss.

Comparing cyber insurance industry risks with other risk factors for the insurance industry as a whole, some notable differences arise:

- **Specificity of Cybersecurity Risks:** Cyber insurance companies face risks unique to the digital realm, such as data breaches and ransomware attacks. Traditional insurers, while also vulnerable to cyber threats, face a broader range of risks, including fraud, natural disasters, and market volatility.
- **Regulatory Compliance:** Cyber insurance companies must navigate an evolving landscape of privacy and data protection regulations, including requirements for breach notifications and customer data handling. Compliance with these regulations adds an extra layer of risk for cyber insurers, distinct from other insurance sectors.
- **Financial Impact:** A successful cyber-attack on an insurance company can have severe financial consequences, resulting in payouts for affected policyholders, potential lawsuits, and reputational damage. While traditional insurers face financial risks too, cyber incidents can be particularly costly due to the complex nature of cyber claims and the potential for widespread impact.
- **Underwriting Challenges:** Cyber insurance companies face unique underwriting challenges as they assess the cybersecurity posture of potential policyholders. Evaluating risk exposure, the effectiveness of security measures, and overall cyber resilience requires specialized expertise not as prevalent in other insurance sectors.

Overall, while cyber insurance shares some risk factors with the broader insurance industry, it faces distinct cybersecurity risks due to the digital nature of its operations, the value of the data it handles, and the evolving regulatory landscape. These risks necessitate tailored risk management strategies to mitigate the specific challenges faced by cyber insurance companies.

Due to the relative novelty of CSI, there is a scarcity of economic analyses on the subject. Eling and Zhu (2020) conducted a study analyzing the types of property-liability insurance companies offering CSI. They utilized annual data from 2015 onwards, which was collected following a statutory requirement imposed by the National Association of Insurance Commissioners to report cybersecurity and identity theft coverage. This data categorized the insurance across lines of CSI and identity theft insurance (ITI), and whether it was offered as a stand-alone product or part of a package with other property-liability insurance types. Information regarding the number of policies, premiums received, losses reported, and losses paid was available for each of the four types. The NAIC provides annual reports summarizing the broad outlines of the industry (e.g., NAIC, 2021).

Those same data are used here as part of a more comprehensive dataset that provides annual data on the U.S. from S&P Global Market Intelligence. This larger dataset enables an analysis of the profitability of cybersecurity offerings over time, specifically from the first year of offering by a company through the following years. In this context, relevant prior research pertains to product innovation in the insurance industry and any cyber-specific issues. Our study also considered new entrants, although tracking companies that moved between categories during this period posed challenges.

Research Background

Although not specific to CSI, Lado, and Maydeu-Olivares (2001) utilized empirical data to suggest that product innovation is common in the U.S. and E.U. insurance markets, driven by a market orientation. Furthermore, we know that the insurance industry itself has become increasingly reliant on digital technologies (Pisoni, 2021), making them more attentive to cybersecurity issues.

Half a century ago, Rudelius and Wood (1970) found that product innovation is more prevalent among large companies and those organized as mutuals (with policy-holder owners) rather than as stock companies in the U.S. life insurance industry. More recently, Eling and Zhu (2018) discovered that large insurance companies, as measured by capital, are more likely to offer CSI. Mutuals often sell CSI as part of a package, while stock companies tend to offer CSI as a standalone policy. These findings suggest that size may be positively correlated not only with CSI introduction but also with profitability, whether due to greater resources available for product development and promotion or due to a broader market reach.

Insurer size is also important in relation to the potential risks associated with CSI (Eling & Zhu, 2018), where losses are less predictable compared to, for example, life or automobile insurance or protection against fire or natural disasters. Large size provides a protective measure for insurers against these greater risks. Simultaneously, if insurers price high levels of risk into premiums, CSI should be more profitable. In a broader sense, research on the effects of product innovations, including CSI, suggests that successful innovations can enhance business performance in either the short-run or long-run, depending on the business strategy context within which the innovation is implemented (Visnjic et al., 2016). Another perspective to consider is the average duration between initial premium payments and claims. If this average duration exceeds one year, then the first year of offering CSI may be more profitable than subsequent years.

Regarding factors that generally influence profitability in the insurance industry, Greene and Segal (2004) provide a model. They argue that profitability is partially determined by efficiency, which is a product of inputs, outputs, and their prices. Alongside efficiency, other explanatory variables include whether the organization is a mutual or stock company, the logarithm of assets as a measure of size, the mix of long-run (e.g., whole life) versus short-run (e.g., term) insurance sold, and the annual rate of growth in premiums. Since CSI is offered by property-casualty insurers, alternative mix variables are relevant, including the proportion of premiums attached to home insurance, automobile and other vehicle insurance, and property and liability insurance for businesses.

An additional consideration for overall profitability is the insurer's overall level of risk. Generally, insurers that can provide low levels of general risk, accounting for a mix of high and low-risk product lines, should be more profitable (Altuntas, 2011). However, it is also the case that firms taking on high levels of risk (e.g., with subprime mortgages) can achieve high levels of short-term profitability (Jarsulic, 2010), leaving the relationship between risk and profitability an open question.

Data Collection and Methodology

Three measures are available to understand the size of the CSI market. The first measure is the number of policies in force each year. However, this data was only collected from 2017 to 2020, limiting its coverage. The second measure is the dollar value of CSI premiums earned, which is available from 2015 to 2020. The

third measure involves creating a dummy variable from the previous measure to indicate the number of insurers selling CSI each year, providing an alternative indicator of market size.

Given the relatively new and sparse research on the CSI market, the analysis begins with descriptive figures. First, the three measures are provided for each year. Second, they are separated based on whether the CSI is standalone, sold as part of an insurance package, or both, while disregarding the limited data on the number of policies. Third, insurers are classified as mutuals (20.3% of all observations), stock companies (58.7% of all observations), or other, which includes risk retention groups (13.4%), reciprocal exchanges (4.0%), and less common organizations such as LLCs, Lloyds organizations, and syndicates. Additionally, insurers are divided at the median of net total assets to distinguish between large and small insurers. Premiums earned in the CSI market are compared across 2015 and 2020 for standalone versus packaged CSI, as well as for mutuals, stock companies, other insurers, and large and small insurers. Fourth, NAIC (2020) notes an approximate 20% increase in CSI premiums from 2019 to 2020, which raises the question of whether average premiums per policy also rose. To address this question, average premiums per policy are calculated for 2017 to 2020, both in total and separately for standalone and packaged policies.

The profitability analyses involve a comparison of loss ratios for CSI and all types of insurance offered by the same insurer. NAIC (2021) analyzed loss ratios for the top 20 CSI providers from 2017 to 2020, noting that the percentage figures rose from 32.4% in 2017 to 66.9% in 2020. We replicate that analysis for combined packaged and standalone policies, dividing the sum of total losses paid and total loss case reserves by direct premiums earned. This ratio is then compared to the total ratio, constructed by dividing direct losses paid by direct premiums written. The loss ratio for CSI is also calculated separately for standalone and packaged CSI to determine if one type of policy carries more risk than the other. Outlier observations where the total loss ratio exceeds 10 are removed prior to the analysis, resulting in the exclusion of 34 observations.

Furthermore, several subsidiary analyses are performed using the loss ratio variables. First, the four loss ratios are compared across mutual, stock, and other companies, with the mean ratio reflecting risk and the standard deviation capturing uncertainty. Second, the same comparisons are made for large and small insurers. Third, loss ratios are analyzed for insurers earning at least \$1 million in annual direct CSI premiums and those earning less than that amount. It is hypothesized that insurers selling less CSI insurance will have less expertise, leading to higher CSI loss ratios on average. Fourth, insurers are split based on whether they provide both packaged and standalone CSI insurance, only packaged insurance, or only standalone insurance. It is possible that insurers offering both types of policies possess greater expertise and report lower loss ratios.

The rising loss ratios found in the NAIC analysis could, in part, be attributed to new CSI insurers entering the market early in the period. The rationale behind this is that relatively few losses are likely to be incurred during the first year of coverage. To investigate this possibility, 95 new entrants were identified during the period, and we calculated loss ratios for those insurers during their first year in the market. It was expected that these ratios would be below average.

Additionally, profitability analyses were conducted, considering either return on assets or return on equity. The analyses controlled for net assets using a quadratic function, the risk-based capital ratio, variables indicating whether the company was a stock or mutual (with the other types of companies serving as the omitted category to identify the system), and the proportion of premiums from commercial policies compared to commercial and individual policies. Using a fixed effects specification, total premiums from

CSI, as well as the three CSI loss ratios (separately), were assessed. However, none of these variables achieved significance at conventional levels. This lack of significance is likely since CSI represents only a small fraction of total premiums for most CSI insurers.

Results

Table 1 provides figures for the number of policies, the number of insurers, and the dollar value of CSI premiums earned each year. The number of policies expanded by 54% from 2017 to 2020, with the number of insurers increasing by 74% from 2015 to 2020. The value of premiums increased more substantially, by 229%, from 2015 to 2020.

Table 1: CSI market size indicators

Year	Number of policies in force	Number of insurers	Total value of CSI premiums (thousands of \$)
2015		106	\$707,759
2016		130	\$1,045,467
2017	2,603,565	151	\$1,508,718
2018	2,997,005	161	\$1,763,423
2019	3,337,116	179	\$1,958,523
2020	4,017,150	184	\$2,330,686

Table 2 separates the number of insurers and CSI premiums figures across packaged and standalone policies. The number of insurers providing packaged policies increased by 91% from a base of 85 in 2015, with a 36% increase for insurers selling standalone policies, from a base of 44 in 2015. Given there are fewer standalone policies figures, it is surprising that the dollar value of those policies is larger in 2015 (by 15%), and that figure reached 61% by 2020.

Table 2. CSI market size indicators, by packaged or standalone policies

Year	Number of insurers, packaged policies	Number of insurers, standalone policies	Total value packaged CSI premiums (thousands of \$)	Total value of standalone CSI premiums (thousands of \$)
2015	85	44	\$329,499	\$378,260
2016	106	48	\$234,432	\$811,035
2017	129	53	\$631,497	\$877,221
2018	141	56	\$737,762	\$1,025,661
2019	158	59	\$825,816	\$1,132,707
2020	162	60	\$893,909	\$1,436,777

CSI premiums, just for 2015 and 2020, are provided in Table 3, after splitting across lines of packaged or standalone policies, whether the insurer is a mutual, stock, or other type of company, and whether the insurer is large or small. The figures suggest that mutuals focused almost 90% of their business on packaged policies in both 2015 and 2020. Stock company figures for either are an order of magnitude larger, with a ratio of standalone to packaged that rises from around 1.25 in 2015, to 1.81 in 2020, with other companies representing only a small fraction of the total market. In terms of size, large insurers sell more than 100 times as much CSI as small insurers. Overall, it is large stock companies that dominate the market.

It is our interpretation that given that mutual insurance companies are owned by its policyholders, and not by outside investors their approach to CSI insurance is far more cautious and therefore packaged with other offerings. This makes it different from a stock insurance company, which is owned by shareholders and traded publicly. Both kinds of companies are in the business of selling insurance, but the large stock insurance companies are able to offer standalone packages.

Table 3: CSI premiums for 2015 and 2020: Policies, Insurer and Asset Size (1000s of \$)

Year	Mutual company	Stock company	Other company	Large size	Small size
2015					
Packaged	\$18,214	\$298,446	\$12,787	\$328,460	\$987
Standalone	\$2,321	\$373,064	\$2,875	\$377,377	\$883
Total CSI	\$20,535	\$671,510	\$15,662	\$705,837	\$1,870
2020					
Packaged	\$94,283	\$776,730	\$22,895	\$892,190	\$1,718
Standalone	\$11,521	\$1,408,328	\$7,204	\$1,245,236	\$1,817
Total CSI	\$105,803	\$2,185,058	\$30,099	\$2,317,426	\$3,535

Note: Large size is greater than \$70m in net total assets, with small \$70m or less.

Although premiums rose by around 20% from 2019 to 2020, the total number of policies in force rose by slightly more (see Table 1). Indeed, dividing the premiums by the number of policies in force suggest the average earned premium was around \$580 in both years. To identify any price patterns and changes over time, those same figures were estimated for 2017 to 2020, separately for standalone and packaged policies. The packaged policies averaged \$253 in 2017, \$257 in 2018, \$260 in 2019, and \$234 in 2020, yielding a slight decline from 2019 to 2020.

The standalone policies averaged \$8,479 in 2017, \$8,265 in 2018, \$7,018 in 2019, and \$7,279 in 2020, again yielding a slight decline over the years. Overall, these patterns suggest that price increases were moderate from 2017 to 2020, and that standalone policies are approximately 30 times more expensive for customers, relative to packaged policies. That higher price may reflect sales of standalone policies to larger entities, where losses could be more substantial, but also higher levels of risk. The latter can be teased out in the next analysis.

Initial loss ratios are provided in Table 4. The CSI total loss ratio rises steadily from .157 in 2015 to .372 in 2020. The ratio for packaged CSI policies is more *volatile*, declining from .486 in 2015 to .164 in 2016, before rising to .852 in 2019, then falling to .405 in 2020. Those same figures for standalone policies tend to be stable, within a range of .253 to .323 for 2015 to 2019, before increasing to .551 in 2020. With the potential exception of 2020, it is reasonable to suggest from these figures that packaged CSI is more risky than standalone CSI for insurers. Total loss ratio figures for the relevant subsamples of CSI insurers are provided in parentheses. In general, there appears to be a minimal correlation between the CSI and total loss ratios for the same set of insurers, suggesting that CSI typically represents a small fraction of an insurer's portfolio. A check of the ratios of CSI premiums to total premiums confirms this suspicion.

For insurers providing CSI policies, that ratio has a mean of .009, with a median of .002. Indeed, there are only six observations with ratios above .25, and Beazley PLC, a London-based insurer, accounts for five of those six observations. These findings suggest that insurers offering CSI typically self-insure against any

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catastrophic cyber event by having a large, diverse insurance portfolio, with CSI representing only a small fraction of that portfolio.

Table 4: CSI and total loss ratios, 2015-2020 (total loss ratio for subsample in parentheses)

Year	CSI total loss ratio	CSI packaged loss ratio	CSI standalone loss ratio	Total loss ratio
2015	.157 (.477)	.486 (.507)	.323 (.466)	.487
2016	.208 (.506)	.164 (.506)	.276 (.519)	.505
2017	.224 (.574)	.315 (.572)	.267 (.597)	.587
2018	.231 (.541)	.694 (.546)	.253 (.522)	.557
2019	.253 (.540)	.852 (.550)	.292 (.530)	.510
2020	.372 (.559)	.405 (.549)	.551 (.580)	.549
All years	.251 (.539)	.509 (.544)	.333 (.538)	.531

Table 5 provides loss ratios for various insurer characteristics. In general, the CSI packaged policy loss ratios are larger than for standalone policies across types of insurers, with the exceptions of other companies, small insurers, and those earning less than \$1m in CSI premiums. Indeed, some of the largest loss ratios in the table are for CSI packaged policies and stock companies (.803), large insurers (.563), and those earning at least \$1m in CSI premiums (.973).

Further, the standard deviations for those same three figures are orders of magnitude larger than any others (5.89, 4.49, and 6.24, respectively). The latter suggests that the high means are driven by extreme positive values in some cases. As a check, we identified all cases where the CSI loss ratio was above 2. There were 23 such observations for packaged CSI policies, but only 5 for standalone CSI policies (with 18 for total CSI loss ratios).

Note further that those 23 observations are associated with mean total direct written premiums for all insurance types of \$7,286m, with other insurers having a mean of only \$664m. It seemed counterintuitive that large insurers would be faced with such large losses, an issue we return to shortly.

Table 5: CSI and total loss ratios, various insurer characteristics, means (standard deviations)

Characteristics	CSI total loss ratio	CSI packaged loss ratio	CSI standalone loss ratio	Total loss ratio
Mutual company	.196 (.609)	.209 (.706)	.183 (.450)	.485 (.300)
Stock company	.289 (.451)	.803 (5.89)	.360 (.409)	.561 (.679)
Other company	.261 (.648)	.179 (.425)	.333 (.874)	.532 (.521)
Large insurer	.267 (.538)	.563 (4.49)	.329 (.398)	.577 (.547)
Small insurer	.142 (.552)	.064 (.353)	.368 (.923)	.486 (.561)
At least \$1m CSI premiums	.373 (.640)	.973 (6.24)	.356 (.378)	.529 (.578)
Less than \$1m CSI premiums	.151 (.418)	.121 (.381)	.284 (.661)	.543 (.430)
CSI packaged and standalone	.436 (.516)	1.59 (8.51)	.349 (.426)	.551 (.137)
CSI packaged only		.163 (.492)		.395 (.691)
CSI standalone only			.309 (.570)	.523 (.332)

The three sets of figures at the bottom of Table 5 capture the difference between CSI insurers selling both packaged and standalone CSI, just packaged CSI, and just standalone CSI. For those selling both packaged and standalone CSI insurance, the overall loss ratio is .436, but far higher at 1.59 for packaged, and somewhat lower at .349 for standalone insurance. The contrast with the high packaged loss ratios is heightened by considering the ratio for those only selling packaged insurance: .163. On the other hand, for those selling only standalone insurance, the ratio is .309, which is like the .349 standalone ratio for those selling both types of CSI insurance.

Why would those be selling both types of insurance report such high losses on packaged policies? One possibility is that they use those policies as loss leaders, enticing businesses to purchase other, more profitable types of property insurance. A check of average premiums for packaged policies across the two types undercuts this argument, given the mean is \$251 for those selling both types, and \$250 for those only selling packaged CSI.

Another vantage point for considering this issue lies in analyzing new entrants. Table 6 provides figures for new entrants into the CSI packaged policy market only, standalone policy market, or both. There was a total of 91 new entrants selling packaged policies only, 11 selling only standalone policies, with only 2 entering the CSI market selling both. Figures for the total number of providers in the market are found in parentheses. These figures contrast somewhat from those for new entrants for two reasons. First, exits included 16 insurers leaving the packaged only market, 6 leaving the standalone only market, and 1 insurer leaving both markets. Second, the new entrant figures do not account for movement between the three categories.

Given the relative stability of the standalone only market, most of the increase from 23 to 38 for sales in both markets is accounted for by firms initially selling only packaged CSI later adding standalone products. Regardless of that pattern, most expansion into the market is found in the packaged only market, which

increased from 62 providers in 2015, to 124 in 2020. That growth is justified by markets yielding the smallest loss ratios (.163) for packaged only providers (see Table 5).

Table 6. New entrants and total insurers 2015-2020 (total insurers in parentheses)

Year	CSI packaged only	CSI standalone only	CSI both packaged and standalone
2015	NA (62)	NA (21)	NA (23)
2016	22 (82)	4 (24)	1 (24)
2017	25 (98)	3 (22)	0 (31)
2018	17 (105)	0 (20)	0 (36)
2019	19 (120)	2 (21)	0 (38)
2020	8 (124)	2 (22)	1 (38)
All years	91 (591)	11 (130)	2 (190)

With the analysis of new entrants in hand, we return to the question of why packaged CSI, when offered with standalone CSI, yields such high loss ratios. One possibility not yet mentioned is the role of learning. That is, if insurers learn more about markets they participate in over time, then insurers offering both types of CSI in all six years should report lower packaged loss ratios than those who enter or exit the market during those years. There are a total of 94 observations for insurers in all six years, and 129 for participation in part of the period. The former yield a packaged loss ratio of .955, with the latter yielding a far higher figure of 1.63. This is consistent with learning occurring.

It is, however, possible that a few outliers can explain this difference. In response, the means were re-estimated after removing loss ratio figures above 2 (9% of observations on all six years, and 7% for fewer years). That exercise yields a packaged loss ratio of .348 for those participating in the market in all six years, but only .153 for those with less than six years of participation. Those figures undercut any potential for learning. Instead, they suggest that insurers selling both packaged and standalone CSI insurance as of 2015 and continuing through 2020 either set packaged premiums too low or had riskier clients for packaged CSI. A comparison of average premiums suggests they were not set too low (\$251 for six-year participants, and \$251 for less than six years).

Those results suggest that long-duration market participation, beginning early, involved riskier clients. Was this also true for other packaged only insurers? The short answer is ‘yes,’ with a similar though less striking difference in packaged loss ratios found among those offering only packaged policies in all six years (.204) or for fewer than six years (.131), which again undercuts any potential role for learning. Performing the same exercise for those offering standalone CSI, whether with packaged or without, shows the same pattern.

For those participating in all six years, the standalone loss ratio is .423, while for those participating in fewer years, the ratio is less than half as large (.185). It is therefore reasonable to conclude that earlier, long-duration entrants into either type of CSI market attracted riskier clients.

Discussion

By any measure, the CSI market expanded substantially between 2015 and 2020. The number of policies rose by 54% from 2017 to 2020. The number of insurers increased by 74% from 2015 to 2020, and the value of premiums increased by 229% from 2015 to 2020.

Comparing CSI policies packaged with other types of property insurance to standalone policies, the number of insurers offering the prior, increased from 85 to 162 from 2015 to 2020, with an increase for the latter from 44 to 60 over the same period. Even with this difference, premiums for packaged policies almost tripled to just under \$900m in 2020, and the value of standalone policy premiums increased almost four-fold to \$1,437m as of 2020. While average premiums per policy were relatively stable from 2017 to 2020, the average for packaged policies is approximately 1/30th of the premiums for standalone policies. Mutual insurance companies tend to specialize in packaged policies, with stock companies somewhat specialized in standalone policies, and most CSI is sold by large insurers.

The value of CSI insurance to insurers is proxied by loss ratios, or claims paid divided by premiums earned. Four findings stand out from the initial analysis of loss ratios. First, loss ratios for CSI insurance tend to fall below either overall loss ratios for the same insurers or overall loss ratios for all insurers each year (see Table 4). This finding might suggest that CSI insurance is more profitable, but that possibility hinges on whether other costs associated with CSI insurance are like those for other types of property insurance. It is at least possible that CSI insurance requires greater monitoring of the insured by the insurers, implying that lower loss ratios may not signal greater profitability.

Second, CSI loss ratios increased substantially over the period, with total CSI ratios rising from .157 in 2015 to .372 in 2020 (see Table 4). That increase implies that CSI became less profitable over time, and that levels of risk rose. Considering that finding, it is surprising that average premiums did not rise from 2019 to 2020, although it is possible that premiums did in fact rise in 2021, as the COVID-19 pandemic continued.

Third, packaged CSI typically has higher loss ratios than standalone policies (i.e., averages of .509 and .333, respectively, see Table 4). It is not obvious why this is so, but part of the reason may be found in the very small average premiums (i.e., around \$250) for packaged policies. Given the low premiums, insurers may engage in only minimal screening of applicants, thereby resulting in higher levels of risk. What is also puzzling is that, considering the high risk-ratios, average premiums for packaged policies have not been increased in recent years. Further, it is not clear why, given the lower profitability, so many new entrants would flock into the packaged only market that they accounted for a full two-thirds of insurers in the market by 2020 (see Table 6). One possible explanation is that property insurers serving small and medium sized businesses faced increasing demands to provide CSI insurance in addition to other types of property insurance. Simultaneously, given the high premiums of standalone policies (above \$7,000 for 2017 to 2020), these may only be purchased by large, vulnerable firms, who both invest substantially in cybersecurity internally, and pay sufficient premiums to cover extensive monitoring by insurers. New entrants may not find it viable to enter that market absent substantial resources and experience. While this logic is consistent with patterns of new entrants (see Table 6), absent data on who is purchasing CSI, it cannot be confirmed or discounted. Further research is needed to shed light on this possibility.

Fourth, loss ratios are consistently highest among insurers who entered the CSI market prior to or during 2015 and remained in the market thereafter. That finding holds for comparisons of loss ratios for packaged CSI offered in tandem with standalone CSI, for packaged CSI only, and for standalone CSI. There are at least two possible explanations for this pattern. One possibility is that adverse selection operated in terms

of those who purchased CSI early as opposed to later in the period. The logic here is that early purchasers of CSI knew that they faced high levels of cybersecurity risks, so entered the market earlier than others. The other possibility is that insurers became more proficient at screening potential customers for CSI products, which either led customers to ramp up internal cybersecurity resources or limited new purchasers to clients with relatively low levels of risk. The data here cannot shed light on which possibility is most relevant, or whether some other dynamic is involved. However, research by Khalili et al. (2019) suggests that CSI providers typically hold limited information on cyberthreats facing clients in general or specifically, suggesting we discount the improved screening argument.

Overall, we expect the market for CSI, and particularly packaged CSI, will continue to grow at a rapid pace. There are two underlying reasons for expansion: the near limitless potential for the development of new, and expensive, forms of cyber intrusions, as well as the continued expansion of regulatory and shareholder calls for CSI at all institutions dependent upon the internet. Further, there are signs that the market for CSI is not functioning well. Loss ratios rose, particularly for packaged CSI, while premiums remained stagnant. Further study is clearly called for to track future developments in the market, and perhaps to develop new regulatory interventions.

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