Buying from the Family: Private Equity-Owned Insurers and Their Affiliated Investments *

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This version: September 2026
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Abstract

Insurers are increasingly owned by financial conglomerates that also own credit originators. This structure places large pools of policyholder-backed capital within the same organization as credit businesses that require funding. We study how this integration shapes insurer investment using novel data linking ownership structures to insurers' holdings, transactions, and regulatory stress tests. Insurers owned by private equity (PE) firms allocate over 40% of their new investments to structured securities, more than 60% of which are issued by affiliated entities owned by the same PE firm. When investing with affiliates, PE-owned insurers purchase harder-to-value securities and pay higher prices for the same security. Moreover, they provide more persistent capital to affiliated issuers, impairing and selling underwater investments less frequently. PE-owned insurers' affiliated investments do not subsequently perform better: they have lower fair values within two years of purchase and substantially greater downside risk in regulatory stress tests. We estimate that, under a 2008 financial crisis scenario, this additional risk would reduce insurer capital by 4 percentage points beyond the baseline stress loss. Overall, our findings show that integrating capital supply and demand within the same organization has implications for policyholders and financial stability.

Keywords: Insurance, Private equity, Private credit, Affiliated investments, Financial stability

*We thank Steve Kaplan, Ralf Meisenzahl, K. Ramesh, Michael Roberts, Emil Siriwardane, Phil Stocken, and Florin Vasvari for comments; Abhishek Bhardwaj, Shan Ge, Tom Hagenberg, Rawley Heimer, Victoria Ivashina, Kyeonghee Kim, and Anya Nakhmurina for discussions; anonymous industry professionals for institutional background and insights; workshop participants at NBER SI CF, Wharton, Boston University, the LBS Private Capital Symposium, the Ross-Mitsui Symposium, the UW Finance Conference, the Columbia Accounting Theory Conference, the Northwestern Debt Markets Conference, and the Four-School Conference for feedback; and Avinash Goss and Winston Jian for research assistance.
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1 Introduction

Insurance companies are increasingly under the direct ownership of private equity (PE) firms. At the same time, PE firms have expanded rapidly into private credit, originating loans and other credit assets that require funding. These developments place insurers, which generate investment capital through policyholder liabilities, within the same organization as credit businesses that need capital to finance the assets they originate. The result is a financial conglomerate that both supplies and demands investment capital. We study how this integration shapes insurer investment.

Insurers are natural investors in relatively illiquid assets, such as private credit, because their liabilities are stable and long-duration. In fact, many credit businesses access insurance capital at arm's length, without operating within the same organization as the insurer. Even so, integrating insurers with asset originators may reduce information and contracting frictions that impede mutually beneficial investments. At the same time, integration could weaken the market discipline that governs how insurers invest policyholder capital (Coase, 1937). How integration affects which assets insurers are willing to finance and on what terms is therefore an empirical question.

We find that integration relaxes arm's-length discipline for affiliated investments, and these investments perform worse. Insurers directly owned by PE firms, which we refer to as "PE-owned insurers," allocate over 40% of their new investments to structured securities, more than 60% of which are issued by affiliates. They buy harder-to-value affiliated securities and pay higher prices for the same security. They also treat those affiliated investments differently, keeping their capital committed longer when positions are underwater. Importantly, performance does not justify this differential treatment: in a stress scenario comparable to the 2008 financial crisis, affiliated investments would reduce insurer capital by an additional 4 percentage points beyond the baseline stress losses. Collectively, these findings suggest that integration weakens arm's-length discipline in ways that can increase the risk borne by

insurance balance sheets.

We construct a novel dataset that identifies PE ownership of U.S. insurers and links ownership structure to detailed information on insurers' security-level holdings, transactions, and investment performance. Identifying ownership is challenging because PE firms often hold insurers through complex holding-company structures. We map each insurer's complete corporate structure using the National Association of Insurance Commissioners' (NAIC's) Schedule Y and combine these data with the universe of PE investment and M&A transactions in the insurance industry. Importantly, this approach allows us to distinguish insurers directly owned and controlled by PE firms ("PE-owned insurers") from insurers with no PE ownership ("independent insurers"), while separately identifying insurers held as portfolio investments by PE funds on behalf of limited partners ("PE-portfolio insurers").[1,2] We then link the ownership data to insurers' statutory NAIC filings (Schedules D and BA), which provide security-level information on holdings and transactions, including affiliation status, purchase prices, fair values, and impairments. We also link these investments to the NAIC's CLO Stress Tests, which provide standardized, regulator-generated loss projections under adverse macroeconomic scenarios. The resulting data allow us to distinguish both the insurer's ownership structure and, at the security level, whether the insurer and issuer are affiliated.[3]

Our data reveal a substantial shift in how PE firms participate in insurance. In the 15 years following the 2007–2009 financial crisis, the number of PE-owned insurers increased more than thirty-fold, and their assets grew from less than $1 billion in 2009 to $696 billion in 2024. Direct ownership has thus become the dominant form of PE involvement in insurance:

[1]We define PE-owned insurers as those with more than 50% of equity held by a PE firm; in 95% of the cases, the ownership is 100%.

[2]We define a "PE firm" as an organization that has at least one traditional buyout fund. Excluded from this definition are hedge funds, diversified financials, and family offices. Thus, our definition of PE is stricter than that used in studies that also classify hedge funds (Kirti and Sarin, 2024) or diversified financials such as Goldman Sachs (Foley-Fisher, Heinrich, and Verani, 2023) as PE.

[3]Under NAIC definitions, an investment is classified as affiliated if the insurer and the issuer are under common control, where more than 10% of voting rights creates a presumption of control. We manually verify ownership and find that 91% of the affiliated investments by PE-owned insurers are in issuers wholly owned by the PE firm.

by 2024, PE-owned insurers outnumber PE-portfolio insurers two to one and manage more than twice their assets (Figure 1). The distinction between these two forms of ownership is economically important. PE-portfolio insurers are investments made by PE funds on behalf of their limited partners and are typically intended for eventual exit, creating incentives to preserve the insurer's standalone value. In contrast, PE-owned insurers sit directly within the PE firm's organizational structure, with neither the same fund-level investor claims nor the pressure for eventual exit. This structure creates greater scope to integrate the insurer's balance sheet with the PE firm's other businesses, potentially weakening arm's-length discipline. We therefore focus on how direct PE ownership changes insurer investment.

We document shifts in insurers' investment behavior along three dimensions. First, PE-owned insurers redirect capital toward their PE parents' affiliated credit activities. These insurers invest heavily in structured securities, ranging from collateralized loan obligations (CLOs) and asset-backed securities (ABS) to privately-placed securities issued through less conventional structures, such as rated feeder funds and special purpose vehicles (SPVs).[4] These securities finance private credit in different ways: some channel capital directly to private credit funds in structures designed to economize on regulatory capital, while others purchase loans and other assets from those funds, freeing capital for additional lending. We find that, after coming under direct PE ownership, insurers sharply increase their allocations to structured securities and affiliated issuers. By 2024, structured securities account for over 40% of PE-owned insurers' new investments, approximately twice the share among independent insurers. Moreover, over 60% of PE-owned insurers' structured-security investments are issued by affiliated entities, compared with less than 2% for independent insurers. The results suggest that direct ownership links the insurer's balance sheet directly to the funding of affiliated credit activities.

Second, we examine the types of securities that receive affiliated capital and the prices at which affiliated transactions occur. We observe the fair value estimates that each insurer

[4]Nearly half of PE-owned insurers' structured-security investments are privately placed. We identify these securities by the absence of standard CUSIPs, suggesting they are not publicly issued or traded.

assigns to every security it holds. For each security, we measure valuation uncertainty as the dispersion in arm's-length fair values, which are those assigned by independent insurers in unaffiliated transactions. We find that securities with a greater share of investment from affiliated PE-owned insurers show significantly greater dispersion in these arm's-length fair values, implying affiliated investments concentrate in securities with higher valuation uncertainty. We then ask whether affiliated insurers transact differently in these securities. Comparing transactions in the same security on the same day, we find that PE-owned insurers pay higher prices than arm's-length investors when purchasing from affiliated issuers. This difference is largest among privately-placed securities and, within this group, in primary-market transactions, where PE-owned insurers pay 47 basis points more.

Third, we find that PE-owned insurers provide more persistent capital when affiliated investments deteriorate. We define an investment as underwater when its contemporaneous arm's-length fair value, measured as above, falls below the insurer's recorded historical cost. Among independent insurers, affiliation increases the likelihood of impairing an underwater security. PE ownership largely reverses this response, offsetting about 80% of the higher impairment propensity in the same year and the entire differential by the following year. If affiliation provides superior information about the issuer, PE-owned and independent insurers appear to respond differently to that information. Selling decisions reveal a similar pattern. PE-owned insurers generally sell more frequently, but affiliation reduces this differential by approximately 75% for all investments and by 62% when we restrict the analysis to underwater investments. Together, these results show that when arm's-length valuations of affiliated investments decline, PE-owned insurers are more reluctant to recognize losses and more willing to keep their capital committed.

Having documented how direct ownership changes insurer investment, we next examine how these investments perform. We first use the same arm's-length fair values introduced above to measure securities' performance following purchase. One year after purchase, securities attracting greater investment from affiliated PE-owned insurers are more likely to

be valued below historical cost, and beginning two years after purchase, they also exhibit significantly lower arm's-length fair values. These relationships are concentrated outside broadly-syndicated CLOs, among the securities for which information is more limited and that account for most of PE-owned insurers' structured investments. Taken together with our earlier pricing results, these findings suggest that PE-owned insurers pay more for affiliated securities without receiving better subsequent performance. While informative, these realized outcomes provide little insight about downside risk because our sample spans a relatively favorable economic period. We therefore examine downside risk by turning to the NAIC's CLO Stress Tests, which provide regulator-generated loss projections under adverse macroeconomic scenarios. The stress tests cover only broadly-syndicated CLOs, the segment for which we find relatively little evidence of underperformance in reported fair values. Nevertheless, projected losses within this better-performing segment are greater for tranches receiving more investment from affiliated PE-owned insurers, with the gap widening substantially under scenarios comparable to the 2008 financial crisis. Applying these stress-loss estimates to PE-owned insurers' broader structured-security portfolios implies that affiliated investments would generate an additional 4-percentage-point loss beyond baseline stress losses. This loss alone exceeds half of PE-owned insurers' equity buffer, which averaged 7.6% of their fixed-income investment portfolios, suggesting that affiliated investments could substantially erode the capital available to absorb losses precisely when policyholder protection is most needed.

The consequences may extend beyond individual policyholders. Losses on affiliated investments can weaken insurer balance sheets, inducing insurers to sell other assets to restore capital (Ellul, Jotikasthira, and Lundblad, 2011). Because insurers are major investors in corporate bonds and other fixed-income markets, such sales can transmit stress from private credit to broader asset markets. The integration we document may thus create a new channel through which stress in private credit can propagate through the financial system.

Our paper first contributes to the literature on insurers as major providers of long-term

capital. Policyholder liabilities provide insurers with large and stable pools of investment capital, making their portfolio choices important for asset prices and financial stability (Koijen and Yogo, 2023). The composition of these portfolios has repeatedly evolved with financial innovation and changing investment opportunities. A prominent historical example is the expansion of life insurers into high-yield bonds during the 1980s. First Executive, one of the most aggressive insurer investors in the new junk-bond market, experienced a policyholder run as that market deteriorated and ultimately entered regulatory receivership (Scott and Taylor, 1994). More generally, shocks to insurer balance sheets can spill over to asset markets through portfolio rebalancing, generating price dislocations in markets where insurers are major investors (Ellul, Jotikasthira, and Lundblad, 2011). We document a new transformation associated with the growth of private credit, in which insurers not only invest in new credit products but increasingly operate within the same organizations that originate them.

Second, this organizational integration connects our paper to the literature on firm boundaries, internal capital markets, and delegated asset management. Bringing activities under the same organization can mitigate information and financing frictions, but doing so can also weaken market discipline and distort capital allocation (Coase, 1937; Campello, 2002; Maksimovic and Phillips, 2013).[5] The implications extend beyond insurance to pension funds and other delegated asset managers, which also control large pools of long-duration capital on behalf of beneficiaries. As private-market firms seek greater access to these pools, our results highlight an important distinction: beneficiary capital flowing into private markets is not the same as the institutions controlling that capital *moving inside* organizations that also originate and manage private assets. The latter can alter both how beneficiary capital is allocated and the market discipline imposed on asset originators.

Finally, our paper contributes to the growing literature on PE, private credit, and the

[5]Incorporating insurance capital into a broader corporate organization is not itself new: Berkshire Hathaway has long emphasized insurance "float" as a source of capital for acquiring securities and businesses (Buffett, 2005). What distinguishes our setting is that the same organization controlling the insurer also operates credit businesses that originate assets requiring financing, bringing the supply of investment capital together with its demand.

changing structure of financial intermediation. Research on PE ownership has primarily studied portfolio companies and the effects of finite-horizon fund ownership on firm outcomes (Kaplan and Strömberg, 2009; Acharya, Gottschalg, Hahn, and Kehoe, 2013; Davis, Haltiwanger, Handley, Jarmin, Lerner, and Miranda, 2014; Bloom, Sadun, and Van Reenen, 2015; Gupta, Howell, Yannelis, and Gupta, 2024; Eaton, Howell, and Yannelis, 2020). Our setting instead examines insurers directly owned by PE firms, an organizational form without the same fund-level investor claims or exit horizon. A separate literature documents the expansion of private credit and its role in lending and credit intermediation (Chernenko, Erel, and Prilmeier, 2022; Ivashina, 2025; Jang, Kim, and Sufi, 2025), while recent work shows that insurers associated with PE firms increasingly invest in private and structured credit (Kirti and Sarin, 2024; Foley-Fisher, Heinrich, and Verani, 2023; Meisenzahl, Overpeck, and Polacek, 2025). We connect these developments by showing that insurance is not merely another source of capital for the growth of private credit, but is instead becoming integrated with the businesses that originate and structure private credit assets. Distinguishing direct PE ownership from conventional PE-portfolio ownership is therefore central to understanding this development. As private-market firms expand across asset origination, asset management, insurance, and other sources of long-term capital, these organizational connections will increasingly shape how financial intermediation allocates capital and risk.

The remainder of the paper proceeds as follows. Section 2 describes how we construct the panel of insurers' investments and PE ownership of insurers. Section 3 investigates how insurers invest when integrated within PE organizations. Section 4 examines the performance of PE-owned insurers' affiliated investments and their potential impact on policyholders and financial stability, and Section 5 concludes.

2 Data Construction

This section describes how we construct the panel of PE ownership in insurance and how we use it to build the sample of transactions used in the pricing analysis and the sample of

holdings used in the performance analysis.

2.1 Data on PE Ownership

We identify PE ownership of the insurers in our sample through a highly manual, multi-step process that combines several data sources.

We begin by mapping the complete holding company structure of each insurer as reported in Schedule Y of NAIC statutory filings. Schedule Y identifies the insurer's ultimate parent and all subsidiaries within the holding company system, along with ownership percentages at each level of the corporate hierarchy. This ownership tree allows us to distinguish insurers owned directly by PE firms from insurers held as portfolio companies within PE funds.

Next, we obtain a comprehensive list of PE firms from Preqin and match these entities to each insurer's ultimate parent. We adopt a conservative definition of a PE firm, restricting the classification to firms that manage PE funds. This definition includes firms such as Apollo Global Management, Blackstone, Carlyle, and KKR, while excluding hedge funds, family offices, and diversified financial services firms such as Eldridge Capital and Guggenheim Partners.

We define PE ownership as direct ownership by a PE firm ("PE-directly-owned," or "PE-owned" for short). Specifically, we classify an insurer as PE-owned only if it is owned directly by the PE management company and not by a PE fund. This distinction is important because insurers held through PE funds ("PE portfolio companies") are typically intended for eventual exit, and their operations are shaped by fund-level return objectives and investment horizons rather than by the PE firm's broader incentives.

To determine the timing of PE ownership, we track the effective dates of all insurance industry mergers and acquisitions during our sample period. We obtain transaction dates from S&P Capital IQ and verify ownership transitions using multiple additional sources, including Schedule Y statutory filings, state insurance regulators' examination reports, and other public sources (e.g., media coverage). We classify an insurer as "PE-owned" whenever

it is majority-owned directly by a PE firm.[6] In more than 95% of the PE-directly-owned cases, the PE firm's direct stake is 100%.

2.2 NAIC Holdings Data

We leverage data on insurers' fixed-income holdings to assess types of securities that receive affiliated capital, whether insurers provide more persistent capital to affiliated investments, and the performance of those investments.

We construct a panel of fixed-income investment holdings from part 1 of NAIC Schedules D and BA between 2009 and 2024. The yearly holdings data contains information on the historical cost of the acquisition, the par value of the holding, the current fair value estimate, the size of any impairment in that year, the NAIC designation, i.e., credit rating, and a flag indicating whether the investment is affiliated.[7] An entity is deemed to be affiliated if it "controls, is controlled by, or is under common control with" the insurer (NAIC, 2021). Ownership of 10% or more of voting securities creates a presumption of control, although control may also arise through other arrangements. In practice, most affiliated entities in our sample are wholly owned by the PE firm that also owns the insurer. For example, when Athene, which is owned by Apollo Global Management ("Apollo"), purchases a CLO issued by ALM XIX, Ltd., the security is classified as affiliated because ALM XIX, Ltd. is a CLO manager that is 100% owned and managed by Apollo. We verify these relationships by manually tracing the corporate ownership structures reported in Schedule Y.

We focus on holdings of structured securities, which are securities classified as "Other Loan-Backed Structured Securities."[8] This classification includes three broad categories of assets: CLOs, ABS tied to collateral ranging from auto loans to business loans, and privately-

[6]The sole exception is Athene. Although Apollo's direct ownership did not exceed 50% before 2022, the combined ownership of Apollo and affiliated entities has exceeded 50% since Athene's inception in 2009.

[7]NAIC clarified its guidance in 2022; prior to that, the reported affiliation classifications were likely conservative, understating the true extent of affiliated investments.

[8]Insurers generally agree on the classification of a given security. When classifications differ, we use the classification reported by the majority of the involved insurers; for securities held by fewer than five insurers, we classify the security as structured if at least one insurer does so.

placed securities that do not have a CUSIP. Notably, we exclude mortgage-backed securities because these are standardized securities with more transparent pricing. To ensure the robustness of our analysis, we exclude securities with missing or invalid security identifiers. We also exclude holdings less than USD 1,000 in aggregate par value or fair value.

For each security-year, we calculate the "arm's-length benchmark fair value", which is the average per-unit fair value, estimated using only unaffiliated holdings by independent insurers. Merging this information back to the holdings data yields a sample of 1,146,558 insurer-security-year holdings with arm's-length pricing information. We use this sample of insurer-security-year holdings for our tests examining fair value estimate dispersion, impairments and sales of underwater investments, and security performance.

2.2.1 Fair Value Dispersion and Security Performance Test Sample

We conduct our fair value dispersion test and our security performance test at the security-year level. To ensure that differences in outcomes across securities are not driven by unobservable credit risks, we compare securities only within a narrow credit rating bucket.

To this end, we restrict the 1,146,558 insurer-security-year holdings data to only those securities that appear in insurers' 2023 or 2024 holdings, when granular NAIC ratings that map closely to S&P ratings from AAA to CC, including +/- notches, are available. We then trace these holdings backward to retain all earlier observations in our sample.[9]

Next, we construct a security-pricing dataset by collapsing this insurer-security-year panel down to the security-year level, yielding a sample of 77,110 observations. For each security-year, we calculate the average arm's-length fair value and the dispersion of arm's-length fair value, again using only unaffiliated holdings by independent insurers.

Finally, we construct a security-specific measure: "Affiliated PE Ownership Share." This measure is the proportion of total par-value insurer holdings of a security that is held by

[9] In 2023, NAIC expanded its designation scale from 6 to 20 levels. Investment-grade securities correspond to the top 2 levels of the 6-level scale and the top 10 levels of the 20-level scale. We verify that results are qualitatively and quantitatively similar in analyses using the full set of securities and coarser ratings information.

insurers that are directly owned by PE and are affiliated with the security issuer. We measure this in the first year the security appears in the sample, so that it is a time-invariant characteristic reflecting the intensity of participation by affiliated PE-owned insurers.

2.2.2 Impairments and Sales Tests Sample

Using the unrestricted sample of 1,146,558 insurer-security-year holdings described above, we conduct tests of impairments and sales of underwater securities. For each insurer-security-year, we determine whether a security is underwater by comparing the insurer's historical acquisition cost with its current arm's-length benchmark fair value, estimated from valuations reported by independent, unaffiliated insurers. The resulting underwater sample includes 592,035 insurer-security-year observations. Information on whether an insurer impairs a security is directly obtained from holdings data. Information on sales is obtained from transactions data, further described below.

2.3 NAIC Transactions Data

We construct a pricing sample using parts 3 and 4 of insurers' Schedules D and BA filings, which provide detailed transaction-level information on insurers' fixed-income purchases and sales. As in our holdings analysis, we focus on purchases of structured securities.

Our objective is to assess the prices paid by PE-owned insurers for affiliated securities relative to benchmark prices constructed from contemporaneous transactions in the same security by independent insurers. We merge transaction records with our hand-collected panel of PE ownership to determine whether an insurer is PE-owned at the time of the transaction. We apply several data-cleaning filters to ensure accurate construction of the benchmark price. First, we drop observations with missing acquisition dates. Second, we exclude transactions with missing or invalid security identifiers. Finally, we drop observations with missing information on par value or transaction price, which are necessary to construct our benchmark price measures. Applying these filters yields a transaction-level dataset of

330,536 structured security purchases, each matched to valid same-day benchmark transactions in the same security.

2.4 CLO Stress Test

To analyze the ex-ante downside performance of insurers' investments, we use the NAIC's 2023 CLO stress test. The stress test provides regulator-generated loss projections for each tranche of every broadly syndicated CLO held by U.S. insurers as of year-end 2023. The NAIC generates these projections by running the underlying loan portfolio through the CLO waterfall under ten scenarios that vary collateral default and recovery rates. Recovery is defined as principal recovered within six months after default. For each scenario, the model estimates tranche-level principal and interest losses, accounting for the CLO waterfall structure, reinvestment assumptions, and the interest rate environment.

Appendix Table A1 summarizes the ten scenarios. Scenarios 1–5 hold recovery rates at historical levels while varying default rates from two standard deviations below the historical mean (Scenario 1) to two standard deviations above it (Scenario 5). Scenarios 6–8 combine stressed recovery assumptions with default rates ranging from the historical mean (Scenario 6) to two standard deviations above it (Scenario 8). Scenarios 9 and 10 are the most severe tail scenarios, combining the highest default rate with severely impaired recoveries, equal to 75% and 50%, respectively, of the stressed recovery rate.

We obtain from Schedules D and BA the par value held by each insurer in its reported CLO holdings and match the reported CLO holdings to their corresponding CLO deal and tranche identifiers in the NAIC stress test. A key challenge is reconciling the NAIC Schedules' inconsistent and irregularly formatted security descriptions, which often combine abbreviated deal and tranche names into a single string, with the standardized identifiers in the NAIC stress test. We address this challenge by programmatically parsing and standardizing descriptions where possible and using an LLM-based method for more complex cases. All LLM-assisted matches are subsequently manually reviewed and corrected.

The resulting matched sample is at the CLO×tranche level, where each tranche represents a distinct seniority in the cash-flow waterfall. Occasionally, an insurer's reported security description is more granular than a CLO×tranche, representing a specific security or note-class issued within a tranche that reflects refinancing history or legal, regulatory, tax, currency, or investor-specific features (e.g., note-class A1R, A1S1R, or A2RB2 within the A-rated tranche). In these rare cases, we aggregate CLO×note-class holdings into CLO×tranches that reflect distinct seniority levels, which prevents CLO×tranches with more granular note-class holdings from mechanically receiving greater weight in the estimation. We then use our hand-collected PE ownership data and Schedule D's affiliation flag to measure, at the CLO×tranche level, the share of the insurer-investor base that is PE-owned and affiliated. The final sample consists of 1,475 CLO×tranche observations with both stress-test loss projections and insurer holding information.

3 Insurer Investment within PE Organizations

In this section, we examine how insurers invest when integrated within PE organizations. We study where they allocate capital, the securities they are willing to finance and the prices they pay, and how they respond when those investments deteriorate.

3.1 Structured Securities and Affiliated Investment

PE-owned insurers invest in systematically different ways than independent insurers: they allocate substantially more capital to structured securities and, in particular, to affiliated structured securities tied to private-credit activities within the same PE organization.

Figure 2 shows that, in recent years, roughly 40% of PE-owned insurers' new investments are in structured securities, compared with less than 20% for independent insurers. These securities comprise three broad categories: CLOs, ABS, and privately-placed securities without CUSIPs. The composition of these structured-security holdings also differs markedly across insurers. Panel (a) of Figure 3 shows that roughly half of PE-owned in-

surers' structured-security investments in 2024 are privately placed. In contrast, Panel (b) shows that independent insurers' structured investments are concentrated in CLOs and ABS backed by conventional collateral such as auto loans, credit-card receivables, and student loans.

Although information on privately-placed securities is limited, many of them appear closely connected to private-credit intermediation. As Figure 4 illustrates, insurer capital can support private credit through two broad channels. First, insurers can provide capital to private-credit funds through structures such as rated feeder funds, which transform limited-partner-like exposure into rated debt securities that receive more favorable regulatory-capital treatment (Mayer Brown, 2026). Second, insurers can finance assets already originated by private-credit funds. CLOs, ABS, and SPVs pool loans and other assets and tranche their cash flows, creating investment-grade securities that insurers can hold with relatively low regulatory capital requirements. The underlying assets range from leveraged loans extended to PE-sponsored firms, to credit backed by operating businesses, infrastructure, and other nontraditional assets; some SPVs also hold tranches of other structured securities. By moving originated assets into these vehicles, private-credit funds obtain liquidity and replenish their capacity to extend additional credit without raising additional equity.

A striking feature of PE-owned insurers' structured-security investments is the extent to which they are issued within the same PE organization. Figure 5 shows that more than 50% of their structured-security acquisitions since 2022 are issued by affiliated entities, with this share rising above 60% in 2024. By contrast, affiliated structured-security investments are virtually absent among independent insurers. Thus, PE-owned insurers differ not only in their greater allocation to structured securities, but also in where that capital ultimately flows: much of it finances credit activities within the same PE organization.

Finally, PE-owned insurers differ from other insurers in both their funding structure and asset composition. We investigate whether these differences reflect characteristics of insurers selected for PE ownership or changes that emerge after acquisition. Table 1 first examines

insurers' liability structure. We focus on life insurers because their liability structures are more comparable across firms than those of property and casualty or health insurers.[10] Life-insurance liabilities consist primarily of life-insurance policies and annuities, with annuities providing a particularly predictable source of funding because their payout schedules are largely predetermined. Table 1 shows that PE-owned insurers rely more heavily on annuities (column (1)) and operate with lower equity ratios (column (3)). These differences become statistically insignificant after we include insurer fixed effects (columns (2) and (4)), suggesting that they reflect PE firms' selection of insurers whose preexisting funding structures already provide the type of capital they seek.

The asset side evolves differently. Table 2 shows that, even after controlling for both insurer and year fixed effects, PE ownership is associated with significant increases in investments in structured securities (column (1)), affiliated securities (column (2)), privately-placed securities (column (3)), and structured securities that are both affiliated and privately-placed (column (4)). Thus, PE firms appear to acquire insurers with suitable liability structures already in place and, following acquisition, redirect how the resulting capital is invested toward structured and affiliated securities.

3.2 Valuation Uncertainty and Pricing

We examine the types of securities in which affiliated PE-owned insurers invest and the terms on which they transact.

3.2.1 Valuation Uncertainty

Structured securities vary considerably in the complexity of their underlying assets and contractual structures, making some more difficult to value than others. We examine whether PE-owned insurers' affiliated investments are concentrated in securities with greater valuation uncertainty. We measure a security's valuation uncertainty as the dispersion in fair

[10] In 2024, life insurers account for 70% of total insurer assets and over 90% of PE-owned insurers' assets.

value estimates reported by independent insurers holding the security on an unaffiliated basis. Because these insurers have neither PE ties nor an affiliation with the issuer, dispersion in their fair value estimates provides an arm's-length measure of valuation difficulty rather than capturing incentives to report values that benefit an affiliate.

We estimate the following regression specification:

$$\textit{Valuation Dispersion}_{s,t} = \beta\, \textit{Affiliated PE Ownership Share}_{s} + \delta_{v,h} + \alpha_g + \epsilon_{s,t}, \qquad (1)$$

where $\textit{Valuation Dispersion}_{s,t}$ is the standard deviation of fair value estimates assigned to security s by independent, unaffiliated insurers at year-end t. For each security, we measure *Affiliated PE Ownership Share* as the share of its total par-value insurer holdings that is held by insurers that are directly owned by PE and affiliated with the issuer, measured in the first year the security appears in our sample. We measure ownership at entry rather than contemporaneously with dispersion, so that our estimates cannot simply reflect affiliated insurers buying more of a security after it becomes harder to value. We include vintage-by-horizon fixed effects ($\delta_{v,h}$), comparing securities that entered the sample in the same year and have been held for the same number of years. Because vintage and horizon jointly determine the reporting year, these fixed effects absorb market conditions both at issuance and at the fair-value reporting date, while also capturing how valuation uncertainty trends over a security's life. We also include fixed effects for the 20 granular NAIC ratings (α_g) to absorb differences in valuation uncertainty attributable to credit quality.[11]

Table 3 reports the results. The coefficient on *Affiliated PE Ownership Share* is positive and significant in column (1) when we include vintage-by-horizon fixed effects. A one-standard-deviation increase in *Affiliated PE Ownership Share* is associated with an in-

[11]The 20 NAIC ratings correspond to the full set of S&P ratings from AAA through CC, including +/- rating notches. These ratings are available only from 2023 onward. We therefore restrict the analysis to securities with granular ratings and trace their holdings backward, allowing our sample to include all years in which those securities appear in our data.

crease in *Valuation Dispersion* of approximately 5% of its mean.[12] The coefficient remains positive and significant in column (2), with only a modest reduction in magnitude, once we additionally include granular rating fixed effects. Thus, PE-owned insurers concentrate their affiliated investments in securities that arm's-length investors find more difficult to value, and differences in credit quality explain little of this pattern.

3.2.2 Pricing

We next examine whether PE-owned insurers pay different prices for affiliated securities. Specifically, we compare purchase prices across insurers trading the same security under nearly identical conditions.

Our identification strategy exploits variation in transaction prices *within the same security and on the same day*. For each focal purchase transaction of insurer i in security s on day t, we construct a benchmark equal to the average transaction price of the same security purchased by independent insurers on an unaffiliated basis on the same day. Restricting comparisons to trades in the same security and on the same day ensures that transactions are subject to identical time-varying market- and security-level conditions.[13]

The relative price is the difference between the price paid and the benchmark price, defined formally as

$$Relative\ Price_{i,s,t}^{Benchmark} = P_{i,s,t} - \overline{P}_{s,t}^{Benchmark},$$

where $P_{i,s,t}$ is the price of the focal transaction, expressed as a percentage of par value, and $\overline{P}_{s,t}^{Benchmark}$ is the value-weighted average price of other purchases of the same security on the same day, excluding transactions involving insurers with any PE ties and any affiliated transactions:

[12] The standard deviation of *Affiliated PE Ownership Share* is 0.037, and the mean of *Valuation Dispersion* is 0.85. The coefficient of 1.132 implies an increase of 5% (=0.037×1.132 / 0.85).

[13] This approach is equivalent to examining raw prices in a weighted regression while including security × day fixed effects to absorb common market conditions and time-varying security-specific shocks.

$$\overline{P}_{s,t}^{Benchmark} = \frac{\sum_{j \in \mathcal{W}_s^{(-i,\text{NoPE})}(t)} P_{j,s}\, Q_{j,s}}{\sum_{j \in \mathcal{W}_s^{(-i,\text{NoPE})}(t)} Q_{j,s}}. \tag{2}$$

We use $Q_{j,s}$ to denote the par value traded in transaction j and $\mathcal{W}_s^{(-i,\text{NoPE})}(t) \subseteq \mathcal{W}_s^{(-i)}(t)$ to denote the set of trades executed by unaffiliated insurers without any PE ties.[14]

Using this relative price measure, we estimate the following regression specification on the sample of transactions by PE-owned and independent insurers:

$$\begin{aligned} \textit{Relative Price}_{i,s,t}^{Benchmark} = \beta_1 \textit{Affiliated}_{i,s,t} \times \textit{PE Owned}_{i,t} + \beta_2 \textit{Affiliated}_{i,s,t} \\ + \beta_3 \textit{PE Owned}_{i,t} + \delta_y + \epsilon_{i,s,t}, \end{aligned} \tag{3}$$

where $\textit{Relative Price}_{i,s,t}^{Benchmark}$ corresponds to the relative price that insurer i paid to acquire security s at time t, measured as the price paid less the benchmark price, expressed as a percentage of par value. $\textit{PE Owned}_{i,t}$ is an indicator variable equal to 1 if insurer i is directly owned by a PE firm at time t. As our sample includes PE-owned and independent insurers' transactions, the coefficient on this indicator captures the difference between the two groups.[15] $\textit{Affiliated}_{i,s,t}$ is an indicator variable equal to 1 if the acquired security s is issued by an entity affiliated with insurer i. We control for transaction-year fixed effects (δ_y) to absorb temporal variation in the regulatory environment, and we cluster standard errors by security.

Table 4 reports the results of estimating Equation (3). Across both fixed-effects specifications in columns (1) and (2), the interaction between *Affiliated* and *PE Owned* is positive and statistically significant. The coefficient of 0.062 implies that PE-owned insurers pay a premium of approximately 6 basis points relative to what independent insurers pay when investing in affiliated securities. This effect is striking when considering that *PE Owned*

[14] We exclude insurer i's own transaction in the benchmark used for its transactions.

[15] Our sample excludes PE-portfolio insurers' transactions. In untabulated analyses, their pricing for affiliated securities does not significantly differ from independent insurers', and including them in the sample does not affect our results for PE-owned insurers.

insurers on average pay slightly less (−0.005 or 0.5 basis points) than independent insurers for structured securities.

As Figure 3 shows, privately-placed securities constitute an especially large share of PE-owned insurers' structured investments. We therefore re-estimate Equation (3) separately in the subsamples of private and registered securities. The results are in columns (3)–(6) of Table 4. We find positive and significant coefficients on the interaction of *Affiliated* and *PE Owned* in both subsamples, but the magnitude is more than five times larger in privately-placed securities (columns (3) and (4)) than in registered securities (columns (5) and (6)).

One explanation consistent with both the pricing differential and fair-value dispersion is that securities attracting investment from affiliated PE-owned insurers are harder for outsiders to value. Affiliates may have better information and therefore be more willing to invest without demanding the same price discount as arm's-length investors. This information advantage may be particularly important for privately-placed securities, for which little information is publicly available.[16] This interpretation raises an important question about who benefits from the pricing differential. We therefore examine whether it arises in the primary market, where a higher price directly benefits the issuer, or in the secondary market, where the proceeds instead accrue to existing security holders.

Identifying primary-market transactions in privately-placed securities is challenging because issuance dates are unavailable. Simply assigning a security's first-ever insurer acquisition as a primary-market transaction may be inaccurate because this first insurer acquisition could occur in the secondary market. We overcome this data limitation by developing a machine-learning classifier that uses trading patterns in registered securities, for which issuance dates are available, to identify primary-market transactions of privately-placed securities.[17]

[16]We note that this hypothesis is unique to privately-placed structured securities issued by PE-owned credit businesses. Indeed, the coefficient on *Affiliated* is negative in columns (3) and (4), implying that independent insurers purchase affiliated securities at a discount instead of a premium.

[17]Specifically, within registered securities, we consider the first insurer acquisition of a given security to be a primary-market event if it occurs on or before the security's issuance date reported by S&P Capital IQ. We then train an XGBoost classifier using features that capture trading activity around the first acquisition

Table 5 presents the results of estimating Equation (3) in the private primary and secondary market subsamples. We find a strongly positive and significant coefficient on the interaction of *Affiliated* and *PE Owned*, but only in the primary market, implying that the observed pricing difference reflects PE-owned insurers giving affiliated issuers a funding advantage. The magnitude is economically meaningful, at around 47 basis points of the securities' par value. Overall, these results suggest that integrated insurers provide a significant funding advantage to affiliated issuers in the same ownership group.

3.3 Persistent Capital

We next study how insurers respond when an investment's value falls below its historical cost. An insurer can recognize this decline through an impairment or exit the position through a sale. Both actions make the decline more visible. An impairment is reported in an insurer's statutory accounts and indicates that the insurer considers the decline in investment value to be "other than temporary." Recognizing an impairment may affect how regulators and other market participants assess the security, particularly because an affiliated insurer may have superior access to information about the issuer. A sale withdraws capital directly and, for securities trading in thin secondary markets, can also establish a low market price that reveals the extent of the decline. Thus, an affiliated investor that neither impairs nor sells an underwater security can act as an anchor, delaying formal loss recognition while keeping its capital invested as arm's-length valuations deteriorate.

We test whether affiliation and PE ownership jointly make insurers less likely to take

date, including trading volume and patterns of trade occurrence in subsequent periods. These features exploit the fact that trading activity in the primary market is typically more temporally concentrated than in the secondary market. The classifier achieves an out-of-sample AUC of 0.877. We apply the trained classifier to privately-placed securities to identify first insurer acquisition dates that are likely associated with primary-market activity. For each security whose first insurer acquisition date is classified as primary-market, we designate all transactions occurring within 30 days of that date as primary-market transactions. The 30-day window is motivated by the distribution of issuance dates relative to first acquisition dates among registered securities. In the training sample, reported issuance dates occur within 10 days after the first acquisition date at the median and within 30 days at the 90th percentile. Acquisitions are often spread out in the pre-issuance date period. Our results are robust to alternative definitions of the primary-market window; Appendix Table A2 reports estimates using a 10-day window.

either action. We focus on underwater holdings, defined as those for which the security's arm's-length *benchmark* fair value is below the insurer's *own* historical cost. As described in Section 2.2, we construct this benchmark fair value for each security-year using fair values reported by independent insurers holding the security on an unaffiliated basis. We estimate the following linear probability model:

$$y_{i,s,t} = \beta_1 \textit{Affiliated}_{i,s,t} \times \textit{PE Owned}_{i,t} + \beta_2 \textit{Affiliated}_{i,s,t} + \beta_3 \textit{PE Owned}_{i,t} + \delta_{s,t} + \epsilon_{i,s,t}, \quad (4)$$

where $y_{i,s,t}$ is one of two outcomes for insurer i's holding of security s as of year-end t. The first is *Impairment*, an indicator that the insurer recognizes an impairment on the holding; the second is *Sale*, an indicator that the insurer sells the holding. $\textit{PE Owned}_{i,t}$ indicates that the insurer i is directly owned by a PE firm, and $\textit{Affiliated}_{i,s,t}$ indicates that security s is issued by an entity affiliated with insurer i. Security $\times$ year fixed effects ($\delta_{s,t}$) absorb differences in the condition of each security at each point in time, so identification comes from comparing how different insurers treat the same security in the same year. Standard errors are clustered by security-year.

Table 6 reports the impairment results. Because fair values are observed at year-end, we consider impairments over two windows. Columns (1)–(3) examine impairments recognized in the same year in which the security is observed to be underwater, while columns (4)–(6) examine impairments in the next year to capture delayed loss recognition. Columns (3) and (6) allow the effect of affiliation to differ between independent and PE-owned insurers. Among independent insurers, affiliation with the issuer is associated with a higher probability of impairing an underwater security. PE ownership dramatically attenuates this relation. During the year in which the security is observed to be underwater, PE ownership offsets approximately 80% of the higher impairment propensity associated with affiliation. When we examine impairments in the next year, PE ownership offsets this differential entirely,

such that affiliated PE-owned insurers are no more likely to impair than the unaffiliated baseline. The contrast is informative about the role of affiliation. If affiliation provides superior information about the issuer, independent affiliated insurers appear to use that information to recognize losses more readily, while the same is not true when the affiliated insurer is PE-owned. This difference is particularly striking because PE-owned insurers also pay higher prices for affiliated securities, which, all else equal, should make them more likely to recognize an impairment loss on those positions.

Table 7 reports the results for sales. We examine whether a holding is sold during the year following the year-end fair value observation, first for all structured-security holdings (columns (1)–(3)) and then for the underwater subsample (columns (4)–(6)). The results again show that the behavior of PE-owned insurers is different when investments are affiliated. For independent insurers, affiliation does not materially alter their selling behavior. PE-owned insurers are, in general, substantially more likely than independent insurers to sell their holdings. Yet this greater propensity to sell is substantially attenuated when the investment is affiliated. Among all structured securities, affiliation reduces the differential by approximately 75% in the full sample and 62% among underwater holdings.

These results jointly show that direct PE ownership changes how insurers respond when affiliated investments deteriorate. Relative to other affiliated insurers, PE-owned insurers are less willing to recognize an impairment; relative to their own generally higher propensity to sell, they are less willing to exit affiliated positions. In short, affiliated PE-owned insurers provide a distinctive form of support when arm's-length valuations decline.

4 Investment Performance and Implications

In this section, we examine the performance of PE-owned insurers' affiliated investments and their implications for policyholders. We first study performance using subsequent arm's-length valuations. Then, we use regulatory stress tests to assess downside risk in economic states not observed in our sample. Finally, we quantify the potential impact of these losses

on insurer capital.

4.1 Subsequent Performance

The previous section shows that PE-owned insurers are willing to finance difficult-to-value affiliated securities on terms that differ from those available in arm's-length transactions. One possible explanation is that affiliated insurers have superior information about these investments. We therefore ask whether affiliated investments subsequently perform better.

We measure subsequent performance using two outcomes: the fair value of a security and an indicator for whether that fair value falls below the security's historical cost. Because reported valuations may themselves differ systematically across insurers, the fair values we use in both measures are those reported by arm's-length investors. Specifically, for each security and year, we calculate the holdings-weighted average fair value reported by unaffiliated, independent insurers, which we refer to as the "arm's-length fair value." Our unit of observation is a security, allowing us to ask whether subsequent performance varies with the composition of the security's insurer-investor base at issuance.

For each horizon $t \in \{0, 1, 2, 3\}$, where $t = 0$ is the first year the security appears in our sample, we estimate:

$$Y_{s,t} = \beta_t \textit{Affiliated PE Ownership Share}_{s,0} + \alpha_g + \delta_v + \varepsilon_{s,t}, \tag{5}$$

where $\textit{Affiliated PE Ownership Share}_{s,0}$ is the share of par-value insurer holdings in security s attributable to affiliated PE-owned insurers, measured in the year the security first enters our sample.[18] We measure ownership at entry rather than contemporaneously with fair value, so that our estimates cannot simply reflect affiliated insurers buying securities with lower fair values. The outcome $Y_{s,t}$ is either the security's arm's-length fair value (*Fair Value*) or an indicator that the arm's-length fair value is below the average historical cost (*Loss Position*). We include granular credit-rating fixed effects (α_g) and vintage fixed effects (δ_v),

[18] We use the first year that a security appears in our sample as a proxy for its issuance year, or vintage.

so that β_t compares securities that have similar initial credit quality and were issued under similar market conditions.[19]

Table 8 Panel A reports the results for subsequent fair value. Fair values are normalized by par value to facilitate comparisons across securities. At issuance, securities with greater investment by affiliated PE-owned insurers have similar arm's-length fair values to otherwise comparable securities, and no significant difference emerges during the first year. However, starting two years after issuance, securities with a greater affiliated PE-owned insurer share have significantly lower fair values. Thus, the valuations of securities financed more heavily by affiliated PE-owned insurers begin to diverge from otherwise comparable securities within two years of issuance.

Lower subsequent fair values do not necessarily imply investment losses, because securities may have been acquired at different prices. We therefore repeat the analysis using an indicator for whether a security becomes underwater. We define a security as underwater when its arm's-length fair value falls below its initial historical cost, measured as the holdings-weighted average cost reported when the security first enters our sample. Table 8 Panel B shows that a greater investment share from affiliated PE-owned insurers is associated with a higher probability of being underwater starting as early as one year after issuance (column (2)). Taken together, the two tests show that greater investment by affiliated PE-owned insurers predicts both lower subsequent arm's-length valuations and a greater likelihood of loss relative to historical cost, with the differences emerging despite the generally favorable economic conditions during our sample period.

4.2 Downside Risk under Stress

The preceding analysis shows that securities with greater investment by affiliated PE-owned insurers underperform even during the generally favorable economic conditions in our sam-

[19] Beginning in 2023, the NAIC reports granular credit designations that allow us to distinguish securities across 20 rating categories. Prior to 2023, NAIC designations correspond more coarsely to investment-grade and non-investment-grade categories. We restrict the analysis to securities for which granular ratings are available, while tracing their holdings backward to determine vintage and historical cost.

ple. However, the relatively short history of these investments provides little evidence about how they would fare in a severe downturn. Such states are particularly important for policyholders, because insurance claims ultimately depend on insurers having sufficient capital to absorb losses when economic conditions deteriorate. We therefore turn to the NAIC's 2023 CLO Stress Test, which provides standardized, regulator-generated loss projections under ten increasingly adverse macroeconomic scenarios for every broadly-syndicated CLO held by U.S. insurers at year-end 2023. Section 2.4 describes the stress-test methodology and our procedure for matching these projections to insurer holdings.

We ask whether projected losses vary with the share of a CLO tranche held by affiliated PE-owned insurers. The unit of observation is a CLO deal×tranche, and the outcome is the NAIC's projected principal and interest losses under each macroeconomic scenario, scaled by tranche par value. For each scenario k, we estimate:

$$\textit{Loss Rate}_{c,r,k} = \beta_k \textit{Affiliated PE Ownership Share}_{c,r} + \alpha_r + \delta_v + \varepsilon_{c,r,k}, \tag{6}$$

where $\textit{Affiliated PE Ownership Share}_{c,r}$, similar to before, is the share of par-value insurer holdings in tranche r of CLO c attributable to affiliated PE-owned insurers, measured in the year the CLO tranche first enters our sample. We include tranche-seniority fixed effects (α_r) and vintage fixed effects (δ_v), so that β_k compares CLO tranches with similar positions in the payment waterfall and issued under similar market conditions. Standard errors are clustered at the CLO level.

The results of this regression, summarized in Figure 6 and Appendix Table A3, reveal a striking state-dependent pattern. Across benign and moderately adverse scenarios (Scenarios 1–6), a greater share held by affiliated PE-owned insurers is not associated with higher projected losses: the estimated coefficients are economically small and statistically insignificant. The relationship changes sharply as economic conditions deteriorate. Beginning in Scenario 7, CLO tranches with greater affiliated PE-owned insurer investment experience

significantly higher projected losses. A tranche held entirely by affiliated PE-owned insurers is projected to incur an additional 14.6 percentage points of loss under Scenario 7 and 65.3 percentage points under Scenario 8, with the difference increasing further in the most severe tail scenarios. Scenario 8 combines default rates two standard deviations above historical averages with stressed recovery assumptions, broadly comparable in severity to the 2008 financial crisis.[20] Thus, the additional risk associated with these investments is largely hidden in normal states and emerges precisely when aggregate economic conditions become severely stressed.

These results are not driven by speculative-grade tranches. Although our main specification already compares CLOs within the same waterfall seniority, we repeat the analysis restricting the sample to tranches with NAIC designations 1 and 2, which broadly correspond to investment-grade securities.[21] Appendix Table A4 shows that the results are virtually unchanged. The concentration of downside risk therefore persists among the investment-grade tranches that are particularly relevant for insurer portfolios.

4.3 Implications for Policyholders

We next assess the potential implications of these investment risks for policyholders. The NAIC stress test provides projected losses only for broadly-syndicated CLOs, while much of PE-owned insurers' structured-security portfolios consists of privately-placed and other non-CLO securities. Quantifying the potential impact on the overall insurance balance sheet therefore requires an assumption about how these other structured securities would perform under stress.

Although we do not have data on the projected performance of non-CLO securities in a severe downturn, their subsequent performance during our sample provides useful evidence. We re-estimate Equation 5 separately for broadly-syndicated CLOs and for all other

[20] In 2009, the default rate for leveraged loans rose to 9.8% from a 20-year average of 3.2%, while recovery rates declined to 58% from an average of 72% (CollateralizedLoanObligations.com, 2025).

[21] The six-level NAIC designations are regulatory-capital categories. NAIC 1 broadly encompasses AAA, AA, and A ratings, while NAIC 2 broadly corresponds to a BBB rating.

structured securities. Table A5 shows a sharp contrast. Among broadly-syndicated CLOs, greater investment by affiliated PE-owned insurers is not associated with lower subsequent arm's-length fair values or a higher probability of becoming underwater. This result is consistent with the NAIC stress test, in which differences across investor composition are similarly absent under benign and moderately adverse scenarios. However, among other structured securities, greater investment by affiliated PE-owned insurers is associated both with lower subsequent arm's-length fair values and with a greater probability of becoming underwater. Thus, while we cannot directly observe how these securities would perform under severe stress, their valuation performance provides no indication that they are safer than the broadly-syndicated CLOs to which the stress test applies.

With this caveat, we use the stress-test results to provide an order-of-magnitude calculation of the potential impact on insurer capital. Under Scenario 8, which is broadly comparable in severity to the global financial crisis, a CLO tranche whose insurer-investor base consists entirely of affiliated PE-owned insurers has a projected loss rate 65.3 percentage points higher than an otherwise comparable tranche with no affiliated PE-owned insurer investment. Among structured securities receiving investment from affiliated PE-owned insurers, these insurers hold an average of 40% of total insurer par value. Applying the estimated Scenario 8 coefficient to this average exposure implies an *incremental* loss of approximately 26 percentage points on affiliated structured securities ($65.3\% \times 40\% = 26.1\%$).

We then translate this security-level exposure into an effect on the overall portfolios of PE-owned insurers. In 2024, structured securities accounted for 32% of PE-owned insurers' fixed-income investment portfolios, and affiliated securities accounted for 49% of those structured-security investments. Applying the estimates 26-percentage-point incremental loss to this portfolio exposure implies an *incremental* portfolio loss of approximately 4 percentage points ($26.1\% \times 32\% \times 49\% = 4.1\%$).

The potential impact is large relative to insurers' loss-absorbing capacity. In 2024, PE-owned insurers' equity amounted to 7.6% of their fixed-income investment portfolios.

Although the estimated 4-percentage-point loss captures only the loss incremental to the baseline stress scenario, it alone would absorb more than half of PE-owned insurers' equity buffer. Affiliated structured securities could therefore substantially erode insurer equity, reducing the capital available to absorb further losses and protect policyholders precisely when economic conditions are most adverse.

5 Conclusion

We study how insurers' investment behavior changes when they become part of PE organizations that also originate credit assets. We show that this integration redirects insurance capital toward affiliated structured credit and alters the terms on which insurers supply that capital. PE-owned insurers are willing to finance harder-to-value affiliated securities at higher prices, and they provide more persistent capital when those investments deteriorate. These investments subsequently underperform and expose insurers to substantial downside risk under stress. Thus, although integration makes insurance capital particularly valuable to affiliated credit businesses, it also increases the risk borne by the assets backing policyholder claims.

More broadly, our findings highlight the implications of a shift in the organizational structure of financial intermediation. Insurers have historically provided large pools of long-duration investment capital, while asset originators have traditionally competed for that capital at arm's length. Recent trends have brought this relationship inside organizational boundaries, placing institutions that control long-term capital under common ownership with businesses that demand it. Our results show that such integration can weaken the market discipline governing how insurers invest beneficiary capital. As private-market firms increasingly combine asset origination, asset management, and control of long-term capital, it is important to recognize that this organizational relationship can influence both the allocation of beneficiary capital and the transmission of risk through the financial system.

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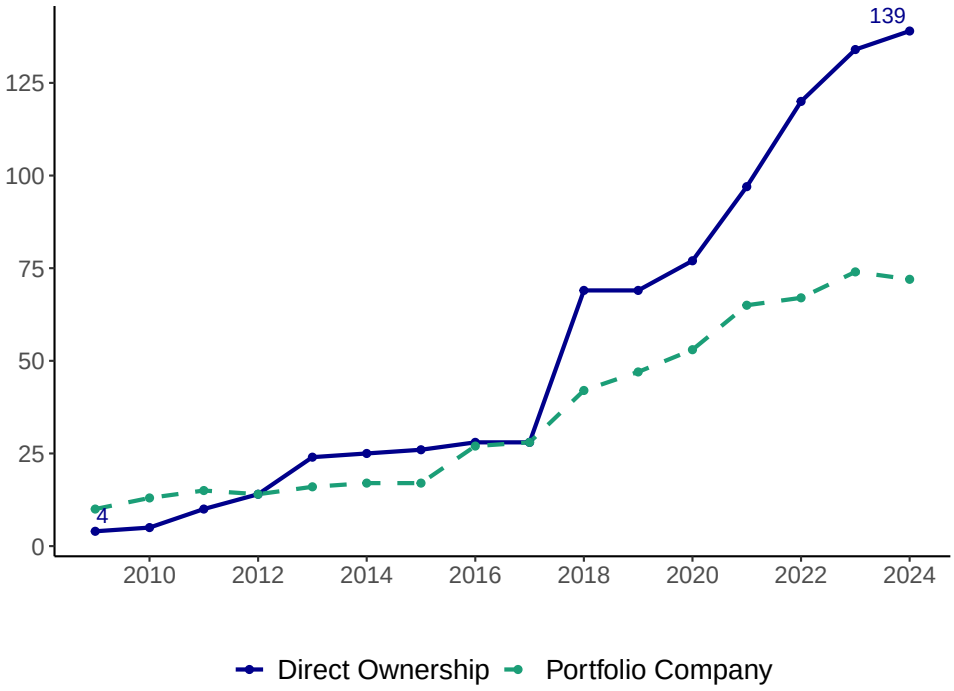
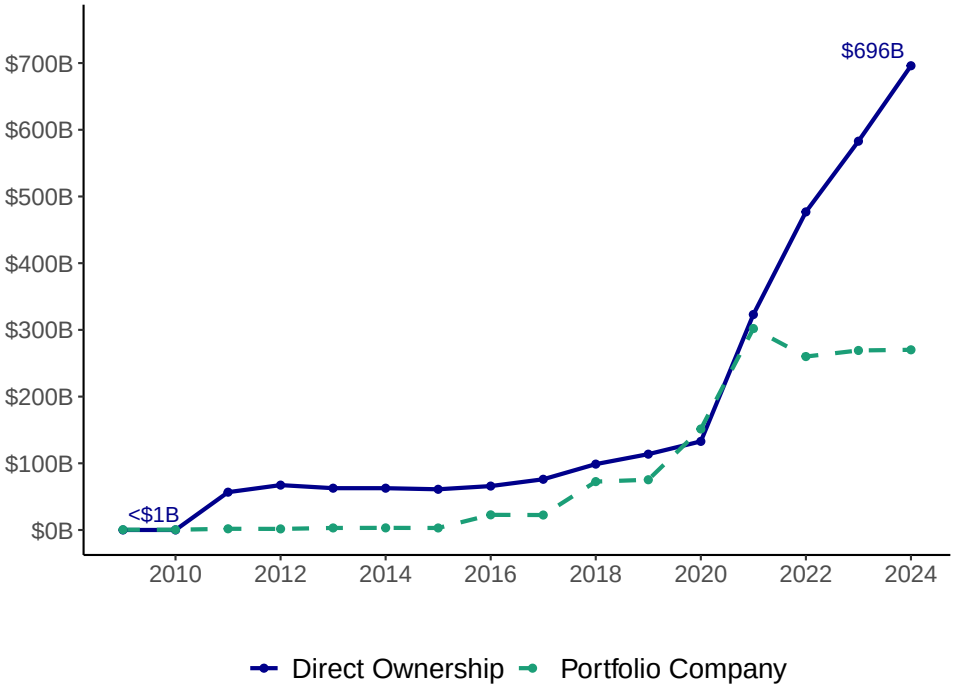
Figure 1: PE Ownership in the Insurance Sector

(a) Number of Insurers

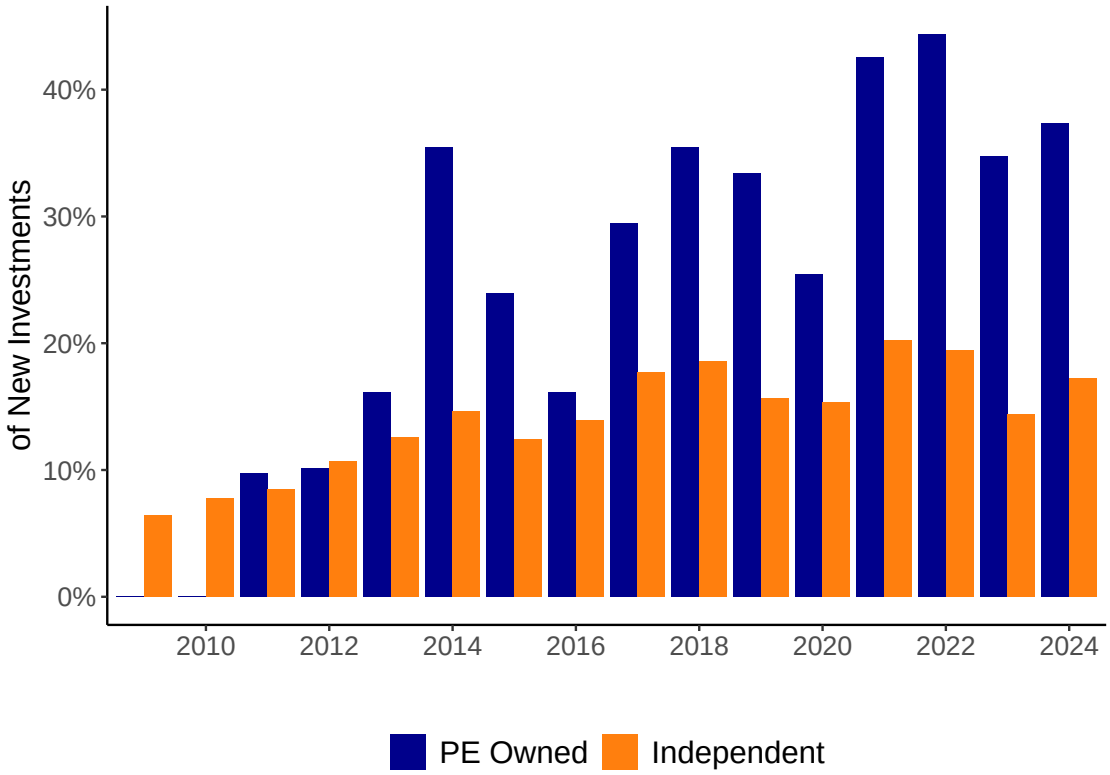


(b) Total Insurance Assets



Panel (a) reports the number of U.S. insurance companies owned by PE firms in the period between 2009 and 2024. Panel (b) reports the total assets (in $ billions) of these insurers. Each panel distinguishes between direct PE ownership and ownership by a PE buyout fund.

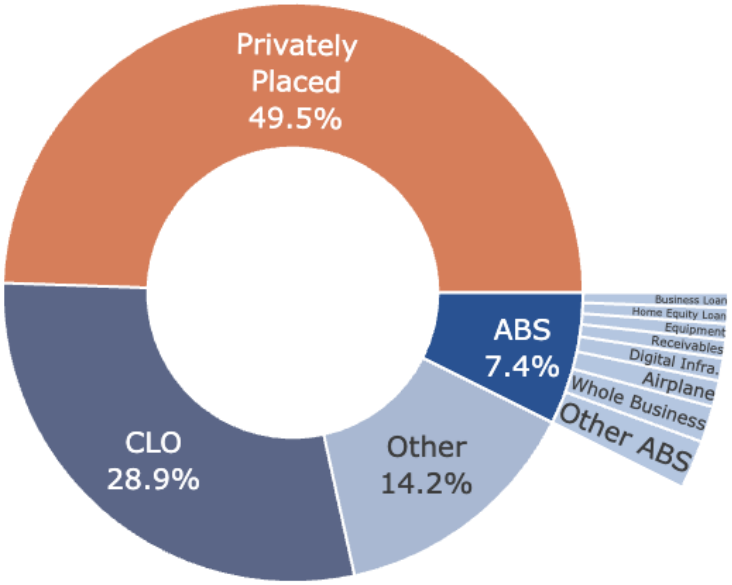
Figure 2: Acquisitions of Structured-Security Assets



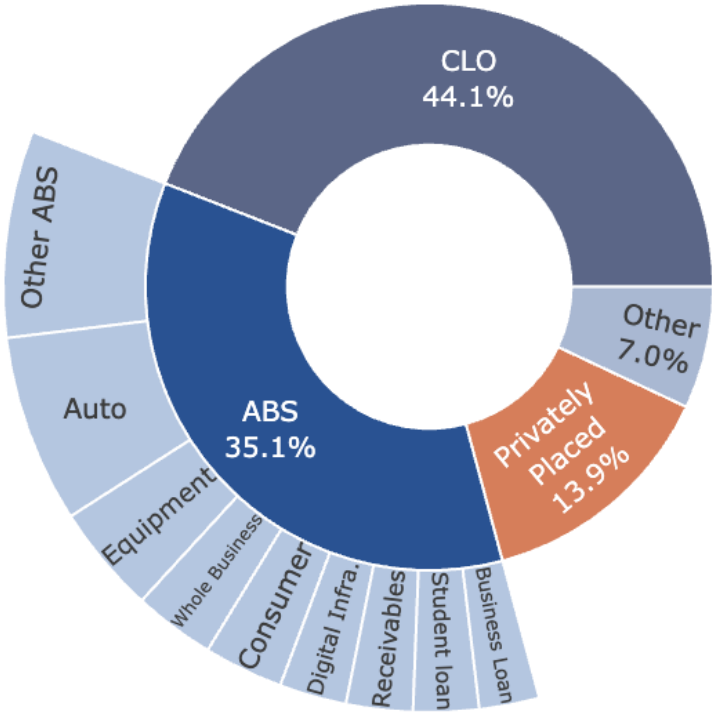
This figure presents the share of insurers' new investments that is allocated to structured securities in the period between 2009 and 2024. The figure distinguishes between insurers directly owned by PE firms and independent insurers.

Figure 3: Composition of 2024 Structured-Security Investments by Insurer Type

(a) PE-Owned Insurers

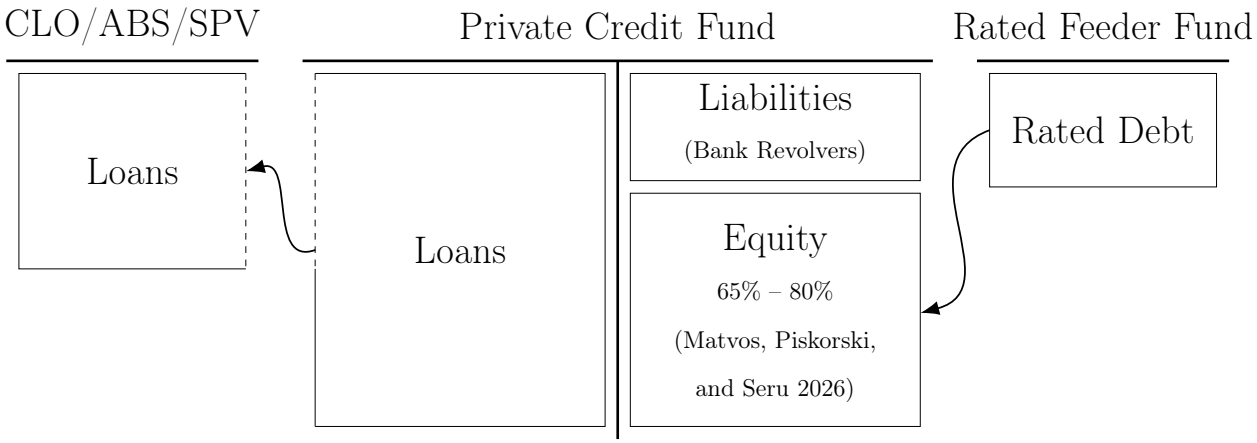


(b) Independent Insurers



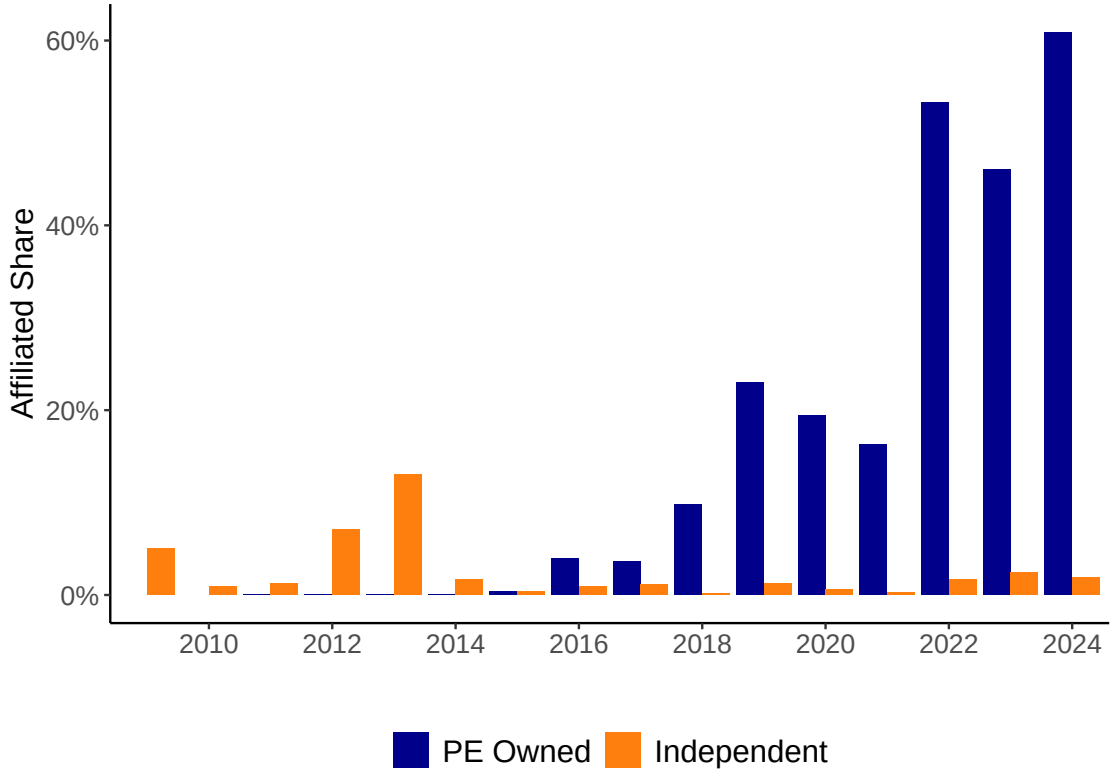
This figure presents the composition of insurers' new investments in structured securities by security type in 2024. Panel (a) reports the composition for insurers directly owned by PE firms, while Panel (b) reports the composition for independent insurers.

Figure 4: Illustrative Connection Between Structured Securities and Private Credit



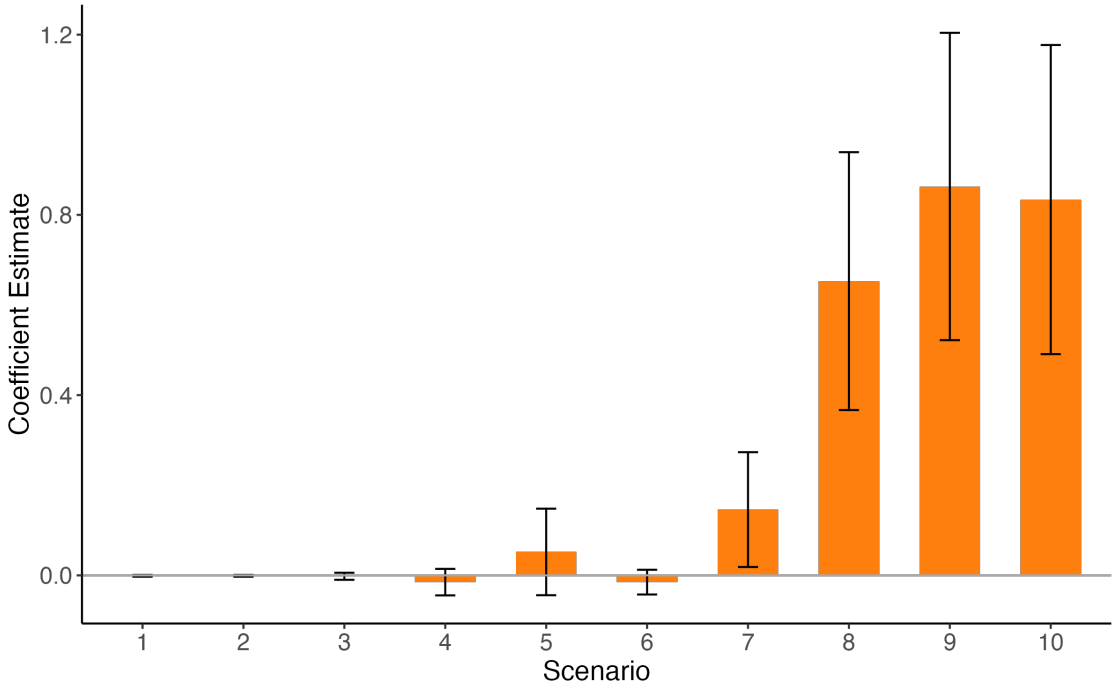
This figure illustrates that insurer capital can support private credit through two broad channels. The left side of the figure shows that insurers can finance assets already originated by private-credit funds, through CLOs, ABS, and SPVs. The right side of the figure shows that insurers can provide capital to private-credit funds through structures such as rated feeder funds.

Figure 5: Affiliated Portion of Structured-Security Acquisitions



This figure presents the share of insurers' new structured-security investments that is allocated to affiliated securities in the period between 2009 and 2024. The figure distinguishes between insurers directly owned by PE firms and independent insurers.

Figure 6: Stress-Test Loss Regression Results



This figure presents the estimates of β_k in $\textit{Loss Rate}_{c,r,k} = \beta_k \textit{Affiliated PE Ownership Share}_{c,r} + \alpha_r + \delta_v + \varepsilon_{c,r,k}$, for all ten scenarios of the 2023 NAIC CLO Stress Test. All regressions include Seniority fixed effects (α_r) and Vintage fixed effects (δ_v) and have 1,475 observations. Each bar shows the estimated β_k for the respective scenario, accompanied by 95% confidence intervals. Appendix Table A3 reports the full regression results.

Table 1: Funding Structures of PE-Owned Insurers

	Annuities		Equity	
	(1)	(2)	(3)	(4)
PE Owned	0.149***	0.062	-0.076*	-0.036
	(0.055)	(0.042)	(0.039)	(0.024)
Year fixed effects	Yes	Yes	Yes	Yes
Insurer fixed effects	No	Yes	No	Yes
Observations	10,777	10,777	10,777	10,777
R^2	0.011	0.880	0.004	0.865

This table presents the results of regressions examining the relation between a life insurer's ownership status and the makeup of its insurance liabilities. *PE Owned* is an indicator variable equal to one if the insurer is directly owned by a private equity firm at the end of a fiscal year. *Annuities* is the proportion of the insurer's liability made up by annuity reserves. *Equity* is insurer surplus divided by total assets. Standard errors clustered by insurer are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 2: Asset Structures of PE-Owned Insurers

	Structured	Affiliated Structured	Private Structured	Affiliated Private Structured
	(1)	(2)	(3)	(4)
PE Owned	0.049***	0.011**	0.012***	0.010**
	(0.011)	(0.005)	(0.005)	(0.005)
Year fixed effects	Yes	Yes	Yes	Yes
Insurer fixed effects	Yes	Yes	Yes	Yes
Observations	64,102	64,102	64,102	64,102
R^2	0.587	0.267	0.325	0.229

This table presents the results of regressions examining the relation between an insurer's ownership status and the makeup of its fixed-income security holdings. *PE Owned* is an indicator variable equal to one if the insurer is directly owned by a private equity firm at the end of a fiscal year. *Structured* is the proportion of the insurer's investment portfolio allocated to structured securities. *Affiliated Structured* is the proportion of the insurer's investment portfolio allocated to structured securities issued by affiliated entities. *Private Structured* is the proportion of the insurer's investment portfolio allocated to privately-placed structured securities. *Affiliated Private Structured* is the proportion of the insurer's investment portfolio allocated to privately-placed structured securities issued by affiliated entities. Standard errors clustered by insurer are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 3: Fair Value Estimate Dispersion

	Valuation Dispersion	
	(1)	(2)
Affiliated PE Ownership Share	1.132***	0.942**
	(0.388)	(0.384)
Vintage-Horizon fixed effects	Yes	Yes
Granular Rating fixed effects	No	Yes
Observations	77,110	76,780
R^2	0.090	0.113

This table presents results of regressions examining the relation between the standard deviation in fair value estimates and the share of a security held by affiliated and PE-directly-owned insurers. The sample includes all security-years for structured securities that are still held in 2023 or 2024 (and therefore have data available on granular NAIC ratings). *Valuation Dispersion* is measured as the standard deviation in fair value per 100 of par value reported for a security-year by all insurers that are not PE-owned and are not affiliated with the security issuer. *Affiliated PE Ownership Share* is the proportion of total par-value insurer holdings of a security that is held by insurers that are directly owned by PE and are affiliated with the security issuer, measured in the first year the security appears in the sample. Both specifications include *Vintage-Horizon* fixed effects, comparing securities that entered the sample in the same year and have been held for the same number of years. Vintage and horizon jointly determine the reporting year. Column (2) also includes granular NAIC rating fixed effects. Standard errors clustered by security are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 4: Pricing of Structured-Security Investments

	Relative Price					
	All		Private		Registered	
	(1)	(2)	(3)	(4)	(5)	(6)
Affiliated × PE Owned	0.061***	0.062***	0.203**	0.214**	0.039**	0.039**
	(0.020)	(0.020)	(0.090)	(0.089)	(0.020)	(0.020)
Affiliated	-0.017	-0.017	-0.155*	-0.157*	-0.010	-0.010
	(0.011)	(0.011)	(0.088)	(0.089)	(0.010)	(0.010)
PE Owned	-0.004***	-0.005***	-0.002	-0.016**	-0.005***	-0.005***
	(0.001)	(0.001)	(0.005)	(0.008)	(0.001)	(0.001)
Year fixed effects	No	Yes	No	Yes	No	Yes
Observations	330,536	330,536	11,871	11,871	318,665	318,665
R^2	0.000	0.000	0.002	0.008	0.000	0.000

This table presents the results of regressions examining the relation between the purchase transaction price, relative to the price paid by independent insurers purchasing on an unaffiliated basis for the same security on the same day, and indicators for whether the transacting insurer is PE-owned and whether the security is affiliated with the insurer. Columns (1) and (2) present results for all transactions, columns (3) and (4) present results in the subsample of private securities, and columns (5) and (6) present results in the subsample of registered securities. We define registered securities as those with a valid CUSIP and treat securities as private if the CUSIP is a pseudo-CUSIP used by the NAIC to identify privately-placed securities. *Relative Price* is defined as the difference between the focal transaction price and the benchmark price, measured in percentage points of par value. The benchmark price is the par-value-weighted average price paid on the same day for the same security in transactions by independent insurers purchasing on an unaffiliated basis. The construction of the benchmark prices is described in Equation (2). *PE Owned* is an indicator variable equal to one if the transacting insurer is directly owned by a private equity firm. *Affiliated* is an indicator variable equal to one if the security is issued by an entity affiliated with the transacting insurer. We estimate Equation (3) with and without year fixed effects. The transaction sample is described in Section 2. Standard errors clustered by security are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 5: Pricing of Privately-Placed Investments in Primary and Secondary Markets

	Relative Price			
	Primary		Secondary	
	(1)	(2)	(3)	(4)
Affiliated × PE Owned	0.481***	0.465***	0.114	0.128
	(0.100)	(0.102)	(0.111)	(0.110)
Affiliated	-0.141*	-0.125	-0.162	-0.169
	(0.085)	(0.088)	(0.110)	(0.111)
PE Owned	0.008	0.011	-0.008	-0.022**
	(0.007)	(0.008)	(0.007)	(0.010)
Year fixed effects	No	Yes	No	Yes
Observations	3,549	3,549	8,322	8,322
R^2	0.082	0.094	0.002	0.009

This table presents the results of the private securities pricing regressions separately in the subsamples of primary and secondary market transactions. Primary-market transactions are classified using the machine-learning procedure and 30-day primary-market window described in Section 3.2. *Relative Price* is defined as the difference between the focal transaction price and the benchmark price, measured in percentage points of par value. The benchmark price is the par-value-weighted average price paid on the same day for the same security in transactions by independent insurers purchasing on an unaffiliated basis. The construction of the benchmark prices is described in Equation (2). *PE Owned* is an indicator variable equal to one if the transacting insurer is directly owned by a private equity firm. *Affiliated* is an indicator variable equal to one if the security is issued by an entity affiliated with the transacting insurer. We estimate Equation (3) with and without year fixed effects. The transaction sample is described in Section 2. Standard errors clustered by security are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 6: Impairments of Underwater Investments

	Impairment					
	Same Year			Next Year		
	(1)	(2)	(3)	(4)	(5)	(6)
Affiliated × PE Owned			-0.034***			-0.062***
			(0.008)			(0.009)
Affiliated	0.032***		0.043***	0.045***		0.062***
	(0.005)		(0.007)	(0.007)		(0.009)
PE Owned		-0.002***	-0.002***		-0.001	-0.001
		(0.001)	(0.001)		(0.001)	(0.001)
Security × year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	592,035	592,035	592,035	404,643	404,643	404,643
R^2	0.470	0.470	0.470	0.544	0.544	0.545

This table presents the results of regressions examining whether insurers are less likely to write down underwater investments issued by affiliated entities. The unit of observation is an insurer × security × year holding, and the sample is restricted to holdings that are underwater. We define a holding as *underwater* when the insurer's pre-impairment historical cost exceeds the security's benchmark fair value, measured as the equal-weighted average fair value assigned to the same security in the same year by insurers that are independent and hold it on an unaffiliated basis. $Impairment^{SameYear}$ is an indicator variable equal to one if the insurer recognizes a positive other-than-temporary impairment on the holding in year t. $Impairment^{NextYear}$ is an indicator variable equal to one if the insurer recognizes such an impairment in year $t+1$, and is defined for holdings observed in consecutive years; it accommodates the discretion insurers have over the timing of loss recognition. *PE Owned* is an indicator variable equal to one if the insurer is directly owned by a private equity firm. *Affiliated* is an indicator variable equal to one if the security is issued by an entity affiliated with the insurer. Insurers held as portfolio investments by PE funds are excluded from the sample, so each column compares PE-directly-owned insurers with independent insurers. All specifications include security × year fixed effects. The holdings sample is described in Section 2. Standard errors clustered by security-year are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 7: Sales of Affiliated Investments

	Sale					
	All Investments			Underwater		
	(1)	(2)	(3)	(4)	(5)	(6)
Affiliated × PE Owned			-0.064***			-0.051***
			(0.014)			(0.020)
Affiliated	0.013*		0.012	-0.011		-0.017
	(0.007)		(0.009)	(0.010)		(0.013)
PE Owned		0.081***	0.083***		0.080***	0.082***
		(0.003)	(0.003)		(0.004)	(0.004)
Security × year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,146,558	1,146,558	1,146,558	592,035	592,035	592,035
R^2	0.266	0.267	0.267	0.316	0.317	0.317

This table presents the results of regressions examining whether insurers are less likely to sell investments issued by affiliated entities. The unit of observation is an insurer × security × year holding. *Sale* is an indicator variable equal to one if the insurer initiated a disposal of the holding—a sale to a counterparty, a tender, or an exchange—during the year following the year-end t snapshot. Maturities, scheduled paydowns, sinking-fund retirements, and issuer calls are excluded because they do not reflect the insurer's decision. Columns (1)–(3) use all investments and columns (4)–(6) use the subsample of *underwater* investments, defined as those for which the insurer's pre-impairment historical cost exceeds the security's benchmark fair value, measured as the equal-weighted average fair value assigned to the same security in the same year by insurers that are independent and hold it on an unaffiliated basis. Both blocks are restricted to holdings for which this benchmark can be constructed, so that the underwater subsample is contained in the full sample. *PE Owned* is an indicator variable equal to one if the insurer is directly owned by a private equity firm. *Affiliated* is an indicator variable equal to one if the security is issued by an entity affiliated with the insurer. Insurers held as portfolio investments by PE funds are excluded from the sample, so each column compares PE-directly-owned insurers with independent insurers. All specifications include security × year fixed effects. The holdings sample is described in Section 2. Standard errors clustered by security-year are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table 8: Security Performance

Panel A: Fair Value

	Fair Value			
Horizon	t + 0	t + 1	t + 2	t + 3
	(1)	(2)	(3)	(4)
Affiliated PE Ownership Share	0.414	-1.578	-4.435***	-6.689**
	(1.129)	(1.232)	(1.513)	(3.090)
Vintage fixed effects	Yes	Yes	Yes	Yes
Granular Rating fixed effects	Yes	Yes	Yes	Yes
Observations	21,796	16,124	12,953	9,764
R^2	0.338	0.243	0.171	0.123

Panel B: Loss Status

	Loss Position			
Horizon	t + 0	t + 1	t + 2	t + 3
	(1)	(2)	(3)	(4)
Affiliated PE Ownership Share	-0.133**	0.159***	0.217***	0.130
	(0.055)	(0.052)	(0.069)	(0.118)
Vintage fixed effects	Yes	Yes	Yes	Yes
Granular Rating fixed effects	Yes	Yes	Yes	Yes
Observations	21,795	16,124	12,953	9,764
R^2	0.353	0.466	0.345	0.185

This table presents the results of regressions examining the performance of structured securities held by insurers over a four-year horizon. *Fair Value* is measured as the average fair value reported for a security at a point in time by all insurers that are not PE-owned and are not affiliated with the security issuer. *Loss Position* is an indicator equal to one if the average arm's-length fair value of a security is below the average cost recorded by all insurers in the first year the security appears in the sample. *Affiliated PE Ownership Share* is the proportion of total par-value insurer holdings of a security that is held by insurers that are directly owned by PE and are affiliated with the security issuer, measured in the first year the security appears in the sample. All specifications include vintage and granular NAIC rating fixed effects. The sample construction is described in Section 2. Robust standard errors are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

A Additional Tables and Figures

Table A1: CLO Stress Test Scenarios

Scenario	**Default Rate**	**Recovery Rate**	**Notes**
1	Historical -2σ	Historical	
2	Historical -1σ	Historical	
3	Historical	Historical	
4	Historical $+1\sigma$	Historical	
5	Historical $+2\sigma$	Historical	
6	Historical	Stress	
7	Historical $+1\sigma$	Stress	Tail scenarios: Probability $\leq 2\%$
8	Historical $+2\sigma$	Stress	
9	Historical $+2\sigma$	$0.75 \times$ Stress	
10	Historical $+2\sigma$	$0.5 \times$ Stress	

This table summarizes the assumptions used for the 10 stress scenarios in the 2023 NAIC CLO Stress Test. Scenarios 9 and 10 are expected to happen with probabilities less than 0.25% and 0.1% respectively. The table is adapted for readability from https://content.naic.org/sites/default/files/industry-ssg-clo-adhoc-session-modeling-presentation-10.5.pdf.

Table A2: Pricing of Privately-Placed Investments in Primary and Secondary Markets – 10-Day Classification

	Relative Price			
	Primary		Secondary	
	(1)	(2)	(3)	(4)
Affiliated × PE Owned	0.494***	0.486***	0.083	0.093
	(0.099)	(0.099)	(0.097)	(0.097)
Affiliated	-0.143*	-0.131	-0.121	-0.128
	(0.085)	(0.085)	(0.097)	(0.097)
PE Owned	0.003	0.004	-0.001	-0.011*
	(0.007)	(0.008)	(0.004)	(0.006)
Year fixed effects	No	Yes	No	Yes
Observations	2,885	2,885	8,986	8,986
R^2	0.101	0.111	0.002	0.007

This table presents the results of the private securities pricing regressions separately in the subsamples of primary and secondary market transactions. Primary-market transactions are classified using the machine-learning procedure described in Section 3.2. We use a 10-day primary-market window, as opposed to the 30-day window used in our main tests. *Relative Price* is defined as the difference between the focal transaction price and the benchmark price, measured in percentage points of par value. The benchmark price is the par-value-weighted average price paid on the same day for the same security in transactions by independent insurers purchasing on an unaffiliated basis. The construction of the benchmark prices is described in Equation (2). *PE Owned* is an indicator variable equal to one if the transacting insurer is directly owned by a private equity firm. *Affiliated* is an indicator variable equal to one if the security is issued by an entity affiliated with the transacting insurer. We estimate Equation (3) with and without year fixed effects. The transaction sample is described in Section 2. Standard errors clustered by security are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A3: CLO Stress-Test Loss Rates

	Loss Rate by Stress Scenario									
	1	2	3	4	5	6	7	8	9	10
Affiliated PE Ownership Share	−0.001	−0.001	−0.002	−0.015	0.052	−0.015	0.146**	0.653***	0.863***	0.834***
	(0.001)	(0.001)	(0.004)	(0.015)	(0.049)	(0.014)	(0.065)	(0.146)	(0.174)	(0.175)
Seniority fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vintage fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475	1,475
R^2	0.022	0.027	0.074	0.415	0.643	0.449	0.680	0.740	0.785	0.804

This table presents the results of regressions examining the relation between projected CLO loss rates and affiliated PE ownership. The unit of observation is a CLO deal×tranche. The dependent variable is the projected principal and interest loss as a share of par value under each of the ten NAIC stress scenarios (columns 1–10). *Affiliated PE Ownership Share* is the share of total insurer par-value holdings of a given CLO×tranche that is held by affiliated PE-directly-owned insurers. We estimate Equation (6) for each scenario with seniority and vintage fixed effects. The holdings sample is described in Section 2. Standard errors clustered by CLO deal are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A4: CLO Stress-Test Loss Rates: Investment-Grade Subsample

	Loss Rate by Stress Scenario							
	3	4	5	6	7	8	9	10
Affiliated PE Ownership Share	−0.001	−0.008	0.058	−0.006	0.146**	0.644***	0.859***	0.831***
	(0.001)	(0.006)	(0.048)	(0.004)	(0.066)	(0.148)	(0.176)	(0.177)
Seniority fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Vintage fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,337	1,337	1,337	1,337	1,337	1,337	1,337	1,337
R^2	0.011	0.027	0.265	0.040	0.346	0.651	0.742	0.779

This table presents the results of regressions examining the relation between projected CLO loss rates and affiliated PE ownership in the subsample of investment-grade CLO tranches, i.e., those with NAIC designations of 1 or 2. The unit of observation is a CLO deal×tranche. The dependent variable is the projected principal and interest loss as a share of par value under NAIC stress scenarios 3–10 (columns 3–10). Scenarios 1 and 2 are omitted because no investment-grade tranche experiences any projected loss under those benign scenarios. *Affiliated PE Ownership Share* is the share of total insurer par-value holdings of a given CLO×tranche that is held by affiliated PE-directly-owned insurers. We estimate Equation (6) for each scenario with seniority and vintage fixed effects. The holdings sample is described in Section 2. Standard errors clustered by CLO deal are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.

Table A5: Security Performance – Subsample Analysis

Panel A: Broadly Syndicated CLO Sample

	Fair Value			Loss Position		
Horizon	t + 0	t + 1	t + 2	t + 0	t + 1	t + 2
	(1)	(2)	(3)	(4)	(5)	(6)
Affiliated PE Ownership Share	3.088*	1.238*	1.013*	-0.337*	-0.110	0.041
	(1.874)	(0.682)	(0.573)	(0.190)	(0.177)	(0.033)
Vintage fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Granular Rating fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,329	1,316	1,146	1,329	1,316	1,146
R^2	0.617	0.701	0.448	0.440	0.640	0.638

Panel B: All Other Securities

	Fair Value			Loss Position		
Horizon	t + 0	t + 1	t + 2	t + 0	t + 1	t + 2
	(1)	(2)	(3)	(4)	(5)	(6)
Affiliated PE Ownership Share	0.232	-1.713	-5.151***	-0.127**	0.171***	0.222***
	(1.190)	(1.312)	(1.625)	(0.057)	(0.053)	(0.074)
Vintage fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Granular Rating fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	20,467	14,808	11,807	20,466	14,808	11,807
R^2	0.337	0.239	0.171	0.343	0.456	0.335

This table presents the results of regressions examining the performance of structured securities held by insurers over a three-year horizon. *Fair Value* is measured as the average fair value reported for a security at a point in time by all insurers that are not PE-owned and are not affiliated with the security issuer. *Loss Position* is an indicator equal to one if the average arm's-length fair value of a security is below the average cost recorded by all insurers in the first year the security appears in the sample. *Affiliated PE Ownership Share* is the share of total insurer par-value holdings of a given security that is held by affiliated PE-directly-owned insurers, measured in the first year the security appears in the sample. Panel A reports the analysis on the subsample of broadly syndicated CLOs that were subject to the CLO stress test. Panel B reports the results for the subsample of all other securities. All specifications include vintage and granular NAIC rating fixed effects. The sample construction is described in Section 2. Robust standard errors are reported in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.