Liquidity Shocks and Private Equity Investment*

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Abstract

Private equity (PE) markets provide various institutional investors with alternatives to transform the economy's savings into capital investments. I demonstrate that the composition of these investors influences PE investment dynamics due to their heterogeneous costs of financing illiquid investments during liquidity shocks. The variation stems from differences in the liability structure across investors. During periods of large natural disasters, PE funds with more committed capital from property and casualty insurers invest less compared to other near-identical funds. This investment distortion reduces the productivity of private companies. However, the shock transmission from investors to PE funds is attenuated ex-post when funds can adjust their investor base more easily or enforce drawdowns more effectively. To mitigate liquidity shocks ex-ante, funds exposed to shock-prone investors accelerate drawdowns, leading to inefficient investment. Overall, the growing interconnectedness between PE and other financial markets could create systemic risk and have capital allocation implications.

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1 Introduction

Private equity (PE) increasingly finances a larger share of the real economy (Figure 1a). This trillion-dollar market is dominated by institutional investors and intermediated by PE funds. Unlike hedge funds or mutual funds, PE funds are closed-end and funded with capital commitments rather than upfront contributions. PE funds draw down ("call") capital from their investors over time who contractually commit to providing cash *on demand* based on the pro rata portion of investors' committed capital. On the one hand, this unique feature allows fund managers to raise larger funds ex-ante by providing various benefits to investors. On the other hand, the fund design introduces uncertainty in the amount of capital available for investment ex-post. Investors may be unwilling or even unable to comply with capital calls during liquidity shocks, which raise the costs of financing illiquid investments like private equity. These investors comprise a *wide array* of institutions including pension funds, endowments, and insurance companies, each with different sensitivity to shocks because of their distinct liability structures as emphasized by recent literature (e.g., Chodorow-Reich, Ghent, and Haddad, 2021; Coppola, 2024; Darmouni, Siani, and Xiao, 2024).

This paper investigates the role of investor base composition in PE investment dynamics and capital allocation in response to liquidity shocks. Despite the PE market's interconnection with various financial institutions, investors and their institutional differences have been so far considered to play little role after capital commitments. In a frictionless capital market, investor heterogeneity should be irrelevant to real outcomes as long as investment opportunities stay constant. However, financial institutions can transmit liquidity shocks and lead to inefficient PE investment if market frictions make alternative financing costly.

I start by presenting novel stylized facts about PE funds' investment patterns that could be connected to liquidity shocks and investor base. First, whereas most funds spend all their capital raised at fund inception, many end up *investing less* than the committed amount, which may be attributed to capital supply constraints (Figure 3). Second, PE funds on average call capital quickly with a *monotonically declining pace* instead of spreading out the

capital contribution evenly over several years (Figure 4a). This pattern is consistent with the theoretical prediction of Maurin, Robinson, and Strömberg (2022) that PE funds have incentives to mitigate funding shocks through acceleration of drawdowns. Third, there is *large heterogeneity* in investment pace across funds, especially in the early life cycle (Figure 4b). The variation could reflect PE funds' heterogeneous hedging incentives, influenced by their exposure to investors susceptible to liquidity shocks due to different liability structures.

However, the observed drawdowns are an equilibrium outcome of capital supply and demand. Lower drawdowns might result from narrower sets of investment opportunities for PE funds rather than reduced availability of capital from their investors. Moreover, while liquidity shocks are common and take many forms, events like financial crises are systematic and usually coincide with business cycles that change capital demand.

To overcome these challenges, I use natural disasters as exogenous liquidity shocks to test whether investor base affects PE investment dynamics. Investors face heterogeneous costs of financing illiquid investments in different states of the economy due to their distinct contractual liabilities. Unlike pension funds or endowments, insurers with property and casualty (P&C) divisions are sensitive to natural disasters, the timing and damage of which are difficult to predict (Ge and Weisbach, 2021; Ge, 2022). These events can cause a surge in short-term claims that P&C insurers are obligated to pay out. Consequently, they must maintain large reserves of liquid assets, such as cash and government bonds, rather than illiquid assets like private equity, especially in the aftermath of significant catastrophes. In contrast, other sectors such as life insurance and pension markets are unlikely to experience a substantial increase in contractual liabilities after natural disasters.

The natural experiment generates plausibly exogenous temporal and cross-sectional variation in liquidity shocks to investors at the PE fund level, based on a largely fixed characteristic - these close-end funds' exposure to P&C insurers. By tightly controlling for the calendar quarter, fund age, and fund manager fixed effects interacted with dummy variables for fund characteristics (fund type and size), my empirical design fully absorbs any

confounding variation of investor base fixed at the fund manager level or explained by observable fund characteristics. Therefore, it mitigates concerns about endogenous matching between investors and fund managers (Lerner and Schoar, 2004). The residual variation in funds' exposure to P&C insurers is *sizable* and mainly driven by *idiosyncratic* factors across different fund vintage years, such as investors' demand for private equity as well as search and matching frictions, that are arguably uncorrelated with funds' investment opportunities.

Using the sample of PE funds raised during 1990-2020 in Preqin, I provide causal evidence that investors' liquidity shocks reduce PE funds' investment across several proxies.[1] Funds with high exposure to P&C insurers invest 16% less during quarters with abnormal insured losses from natural disasters. The transmission of liquidity shocks from investors to PE funds lasts for at least two quarters and there are no differential pre-trends in investment. Furthermore, high-exposure funds do not invest more in the following periods, indicating a potential loss of investment opportunities. The results are unlikely to be driven by capital demand and are robust to various subsamples, including subsets of funds with largely limited choices of investor base. Moreover, liquidity shocks ultimately reduce private companies' productivity measured by the number of highly cited patent applications. Overall, PE funds cannot fully insulate themselves from *costly* funding shocks arising from their investors' liquidity mismatch. These findings support the theory of Maurin, Robinson, and Strömberg (2022) and provide micro-level evidence consistent with the procyclicality of aggregate capital calls with market liquidity documented by Robinson and Sensoy (2016).

To further highlight the implications of investor heterogeneity, I show that PE funds with high exposure to various non-P&C investors do not experience any investment declines when natural disasters cause abnormal insured losses in the economy. Among others, these investors include life insurers, endowments and foundations (henceforth endowments), or

[1]The reduced investment can be i) fund managers' accommodation of their investors - due to the relationship business nature, fund managers might choose to slow down capital calls during periods of elevated costs of capital for investors, or ii) LP defaults, in which investors, also known as limited partners (LPs), fail to fully fund managers' drawdowns promptly. See Section 5.4 for a detailed discussion on the mechanism of the shock transmission from investors to their PE funds.

public pension funds, whose contractual liabilities exhibit weak sensitivity to natural disasters. The result adds further causal evidence to the documented shock transmission and suggests that variation in investor base can lead to different state-dependent capital supply.

Due to the illiquidity of their underlying investments, PE funds are typically structured as closed-end vehicles with fixed investor base throughout their life cycle. As a market response to this friction, a secondary market has emerged for trading PE fund shares which increases the transferability of PE investments (e.g., Albuquerque, Cassel, Phalippou, and Schroth, 2018; Nadauld, Sensoy, Vorkink, and Weisbach, 2019). After the transaction, buyers replace sellers who are existing investors in a fund and receive all future fund cash flows based on their equity contribution on a pro rata basis. I find that the distortion in PE funds' investment following liquidity shocks is attenuated when there is a relatively liquid secondary market, which facilitates adjustment of PE funds' investor base.

To overcome investors' limited commitment, fund managers and investors agree on contractual terms stipulated at fund inception. However, capital calls cannot be contracted on liquidity shocks because such events are difficult to specify ex-ante and hard to verify ex-post. Instead, covenants are written that allow fund managers to penalize investors who do not meet drawdowns. Among various penalties, the most punitive and commonly used provision is forfeiture of some portion of investors' fund shares. Even if it does not materialize in the end, the provision functions as a deterrence device that gives fund managers more bargaining power to enforce drawdown when renegotiating with investors (Litvak, 2004). I show that investors' limited commitment is mitigated when more capital has been called because early investments serve as collateral that investors may risk losing if they fail to meet capital calls (Maurin, Robinson, and Strömberg, 2022).

Lastly, I examine whether investor composition can have any ex-ante implications on investment dynamics across PE funds. Although P&C insurers are sensitive to large natural disasters which are exogenous and difficult to predict, they are not necessarily more vulnerable to liquidity shocks ex-ante than other major PE investors, such as life insurers or pension

funds, because investors face various liquidity shocks that are realized with different probabilities. However, in contrast to these "*debt-financed*" investors that have formal contractual liabilities such as insurance claims and pension benefits, endowments are "*equity-financed*" by donations and have flexible payouts (Brown, Dimmock, Kang, and Weisbenner, 2014). This fundamental difference in funding structures implies that endowments are arguably the least susceptible to liquidity shocks. Exploiting variation in investor base across *nearly identical* funds raised by the same manager, I demonstrate that funds with a lower share of endowments tend to invest earlier. By accelerating drawdowns, PE funds reduce the amount of uncalled capital at the risk of not being provided during future liquidity shocks and build up the collateral to punish non-complying investors (Maurin, Robinson, and Strömberg, 2022). However, the acceleration is costly because it distorts PE funds' investment schedule leading to suboptimal selection of portfolio companies. Within-fund estimation confirms this prediction and suggests that investments in the early stage of a fund's life tend to have a lower chance of successful exits, especially among funds with a lower share of endowments.

Overall, this paper documents novel evidence that investor base is an important determinant of PE investment dynamics and capital allocation in response to liquidity shocks. PE investors have distinct contractual liabilities which result in heterogeneous sensitivity to liquidity shocks, such as natural disasters for P&C insurers, pandemics for life insurers, and interest rate changes for pension funds. The continuous expansion of PE markets is partly attributed to the growing portfolio allocation of various institutional investors towards private equity. However, this trend has also amplified the interconnectedness of different financial markets and potentially increased systemic risk by transmitting shocks within the economy.

Related Literature. This paper contributes to three strands of literature. First of all, it relates to the financial intermediation literature on funding shocks, an under-explored topic in the context of private equity.[2] This paper presents the first empirical evidence that investors'

[2]In previous studies, PE funds are considered as facing little funding shocks because investors are often implicitly assumed to follow one of the two approaches: either they invest all their committed capital immediately into illiquid assets (e.g., Sorensen, Wang, and Yang, 2014), or they consistently fulfill sequential capital

liquidity mismatch can create funding shocks to PE funds after fundraising. Existing work on funding shocks to mutual funds and hedge funds usually focuses on trading and prices, influenced by redemption on fund shares, and investigates topics like fire sales, financial fragility and contagion (e.g., Coval and Stafford, 2007; Chen, Goldstein, and Jiang, 2010; Ben-David, Franzoni, and Moussawi, 2012; Goldstein, Jiang, and Ng, 2017; Darmouni, Siani, and Xiao, 2024). In sharp contrast, PE funds, being closed-end and backed by commitments, mainly focus on primary markets. My work emphasizes the significance of funding shocks in affecting the *quantity of investments* made by PE funds, both ex-post and ex-ante. More broadly, the paper highlights investor base composition as a key determinant of funding shocks to pooled investment vehicles.

Moreover, my setting features a high level of interconnectedness among non-bank financial intermediaries and with PE markets, which distinguishes it from the broad literature on the transmission of liquidity shocks within the banking sector (e.g., Khwaja and Mian, 2008; Ivashina and Scharfstein, 2010; Schnabl, 2012; Chodorow-Reich, 2014). These non-bank intermediaries differ significantly from banks and have heterogeneous sensitivity to economic shocks. This paper adds to the growing body of work on the impact of non-bank intermediaries on financial stability in the context of the ongoing structural shift from a bank-centric financial system towards non-bank financial intermediation (e.g., Davydiuk, Marchuk, and Rosen, 2024; Darmouni, Siani, and Xiao, 2024; Jansen, Klingler, Ranaldo, and Duijm, 2024).[3]

Second, I contribute to the emerging literature on the role of institutional investor heterogeneity in financial markets. Recent studies have examined its implications on asset prices (e.g., Koijen and Yogo, 2019; Bretscher, Schmid, Sen, and Sharma, 2022; Coppola, 2024; Darmouni, Siani, and Xiao, 2024), term structure (Vayanos and Vila, 2021), costs of capital (Siani, 2024), and contracting (Chernenko, Lerner, and Zeng, 2021). This paper

calls due to the substantial costs of non-compliance (Giommetti and Sorensen, 2024; Gourier, Phalippou, and Westerfield, 2024).

[3]In terms of PE funds' contribution to systemic risk, Bernstein, Lerner, and Mezzanotti (2019) and Johnston-Ross, Ma, and Puri (2023) show that buyout funds increase financial stability by providing timely financing to public companies and failed banks during crises. Townsend (2015) studies the propagation of shocks among companies backed by the same venture capital fund.

provides causal evidence that the distinct liability structures across investors shape their susceptibility to liquidity shocks and influence capital allocation in PE markets. Moreover, it connects this body of work to the literature on PE return persistence (e.g., Kaplan and Schoar, 2005; Braun, Jenkinson, and Stoff, 2017). While differences in institutional investors' skills and objectives affect their fund selection and investment performance in private equity (Lerner, Schoar, and Wongsunwai, 2007; Hochberg and Rauh, 2013; Andonov, Hochberg, and Rauh, 2018), my findings support the theory that investors' varying illiquidity tolerance is another source of return persistence at both the investor and fund levels (Maurin, Robinson, and Strömberg, 2022).

Third, my paper is closely related to the vast literature on illiquidity and its economic impacts (e.g., Shleifer and Vishny, 1992; Amihud, Mendelson, and Pedersen, 2006; Tirole, 2011). Specifically, my work complements research that studies the implications of illiquidity in PE markets covering areas such as illiquidity premium (e.g., Harris, Jenkinson, and Kaplan, 2014; Robinson and Sensoy, 2016), asset allocation (Giommetti and Sorensen, 2024; Gourier, Phalippou, and Westerfield, 2024), risk-adjusted returns (e.g., Korteweg, 2019; Gupta and Van Nieuwerburgh, 2021) and investor screening (Lerner and Schoar, 2004). A novelty of this paper is its emphasis on illiquidity as an important friction faced by PE funds when intermediating the capital of investors, who have heterogeneous costs of financing illiquid investments in different states of the economy. Moreover, my work contributes to the small but growing body of research on the secondary market for PE fund shares, by examining how it alleviates this friction (e.g., Albuquerque, Cassel, Phalippou, and Schroth, 2018; Nadauld, Sensoy, Vorkink, and Weisbach, 2019).

2 Institutional Background

Financial institutions such as pension funds, insurance companies, and endowments provide various alternatives for households to transform their savings into capital investments including private equity (Figure 1b). These institutional investors usually do not directly invest in private equity but instead, allocate capital through the intermediation of PE funds. In this

section, I describe the major PE investors in the US and compare their liability structures. Then, I provide detailed information on how capital is channeled from investors to private companies through PE funds. At last, I discuss the contractual terms stipulated between investors and fund managers to facilitate this intermediation process, as well as the secondary market for fund shares to mitigate the illiquidity of private equity.

2.1 Private Equity Investors and Their Liability Structures

PE markets are dominated by institutional investors with different liability structures. The major investors that provide capital to PE funds in the US are pension funds, endowments, and insurance companies (Figure 2). These investors have distinct contractual liabilities and susceptibility to liquidity shocks, states of the world that create urgent demand for cash-like securities:

Insurance Companies. Insurance companies are funded by premiums from policyholders and, in return, are obligated to compensate them for covered losses or policy events. Regulators usually require insurers to maintain a certain level of liquid assets to ensure they can meet their obligations to policyholders. These reserves, set aside to cover these contractual claims, represent the primary liability for insurers. Based on insured risks, insurance companies can be broadly categorized into two major types - property & casualty (P&C) insurers and life insurers.

P&C insurers issue short-term contracts and face much more variability in claim outcomes. Although the premium for each policy is usually calculated based on historical data and paid by policyholders in advance of compensation for a covered loss, the actual cost remains unknown until the policy matures. Much of the variability stems from claims caused by large natural disasters, the timing and damage of which are extremely hard to predict. Natural disasters have been documented to affect the product pricing and portfolio rebalancing decisions of P&C insurers (Girardi, Hanley, Nikolova, Pelizzon, and Sherman, 2021; Ge and Weisbach, 2021; Ge, 2022).

In contrast, life insurers issue long-term policies typically with pre-specified claim amounts

or guaranteed interest rates, such as annuities. The liability structure exposes life insurers to unexpected changes in mortality rates, falls in financial markets, and declines in interest rates which increase life insurers' liabilities by lowering the discount rate used to calculate the present value of future contractual claims.

Pension Funds. Pension funds are funded by cash contributions from employers and must pay pension benefits to retired employees based on pre-defined contractual terms. Most public pension funds in the US offer defined benefit plans, while private pension funds have been gradually shifting towards defined contribution plans in the past three decades. For defined benefit pension plans, managers are obligated to deliver guaranteed retirement benefits and will face liquidity shocks if payout liabilities exceed assets to cover those payouts. This underfunding can occur after stock market declines or slowdowns of pension contributions during economic downturns. Moreover, interest rate hedging can create liquidity shocks due to margin calls (Jansen, Klingler, Ranaldo, and Duijm, 2024). On the other hand, in defined contribution pension plans, employees bear the investment risk. However, pension funds will have to hold more liquid assets in response to large pension withdrawals if many employees opt for early retirement or lump-sum payments of pension benefits.

Endowments. Funded by donations, endowments invest to preserve the real value of their principal amounts while using the investment income for financing university operations and philanthropic programs. Similar to dividends, such payouts are usually stated as a predetermined multi-year moving average of endowment values but are flexible as endowments actively reduce payouts below their stated payout policies in response to negative shocks (Brown, Dimmock, Kang, and Weisbenner, 2014). Therefore, endowments *lack formal contractual liabilities* that must be paid out, arguably making them the least susceptible to liquidity shocks.

Overall, the differences in PE investors' liability structures give rise to heterogeneous costs of financing illiquid investments like private equity. Both insurance companies and pension funds are arguably more vulnerable to liquidity shocks due to their contractual

liabilities and regulatory restrictions to maintain reserves for such obligations. Liquidity shocks can arise from both the asset or liability side of their balance sheets.

2.2 Committed Capital and Capital Calls

PE funds are structured with committed capital and capital calls. Investors only need to *contractually commit* to providing capital *on demand* capped in total at the agreed amount at fund inception, known as the committed capital. A capital call is the process by which a fund manager asks the fund investors to contribute the *pro rata* portion of their committed capital, typically with a two-week notice, when the fund plans to make a new investment or collect fees.[4] This ex-ante financing structure facilitates fundraising by mitigating agency frictions faced by fund managers (Axelson, Strömberg, and Weisbach, 2009; Maurin, Robinson, and Strömberg, 2022).

Pro rata capital calls are legally binding as written in the contracts. The feature provides at least two benefits. First, it ensures that every investor has a proportional stake in the performance of the fund, which prevents PE fund managers from favoring certain investors over others in terms of the timing or amount of capital contributions. Second, pro rata capital calls maintain the transparency of fund operations. Arranging non-pro-rata capital calls in response to liquidity shocks faced by a subset of investors, though possible, requires majority investor consent, leading to potential delays and coordination challenges. Meanwhile, the rest of the investors may lack the resources to cover the additional contribution. Moreover, the possibility of ex-post renegotiation can distort incentives ex-ante when investors anticipate the potential for renegotiation, which may lead to suboptimal decision-making such as excess risk-taking.

2.3 Contracting and Enforcement of Capital Calls

Although the contractual design of committed capital allows fund managers to raise larger funds ex-ante by providing various benefits to investors, it potentially poses uncertainty in

[4]The total amount of called capital can sometimes exceed the committed capital because of the recycling provisions, allowing fund managers to reinvest exit proceeds, rather than distribute them back to investors, under certain conditions.

the amount of funds available for investment ex-post due to investors' *limited commitment*. Capital calls are often highly uncertain in timing and quantity because investment opportunities arise randomly. Investors may be *unwilling* to or even *unable* to meet drawdowns if they are hit by liquidity shocks which raise their costs of financing illiquid investments - leading to delayed or reduced capital calls.

The fundamental problem behind investors' limited commitment is incomplete contracting. It is challenging to write state-contingent contracts for drawdowns, because liquidity shocks are hard to specify ex-ante and difficult to verify ex-post. This challenge is compounded by numerous unforeseen contingencies that can emerge during a PE fund's long lifespan, which often exceeds 10 years. Consequently, real-life contracts do not specify the amount of drawdowns under different circumstances. Instead, these contracts rely on default penalties and, occasionally, escrow accounts to enforce capital calls. Next, I discuss these contracts in detail below.

Default Penalties. In limited partnership agreements (LPAs), fund managers establish various penalties for investors, also known as limited partners (LPs), who fail to meet their capital contribution obligations. When an LP investor doesn't fulfill a part of their capital commitment, the fund manager typically informs them in writing about the default. If the default is not resolved within approximately 5 business days, the investor is classified as a defaulting LP. The most severe provision commonly available is the forfeiture of a portion of the fund interest (Litvak, 2004).[5] For example, the 2020 version of the LPA template drafted by the Institutional Limited Partners Association (ILPA) includes

> *"The General Partner in its sole discretion pursue and enforce any and all rights and remedies the Fund, the General Partner or the Fund Manager may have against such Defaulting Partner at law, in equity or pursuant to the Partnership Agreement, including forfeiting up to 100% of its Interest in the Fund without*

[5]See Litvak (2004) for detailed examples of penalty terms ranked by severity of punishment. Among others, penalties may include withholding distribution of fund returns, charging high interest on the uncontributed amount, and forcing secondary sales of the fund interest.

payment or other consideration."

The incomplete contract nature of capital calls implies room for renegotiation between the fund manager and investors. Even if the forfeiture provision is not always used, its presence enhances the fund manager's bargaining power during renegotiations with investors regarding drawdowns. The availability of such a penalty can effectively serve as a deterrent, increasing the enforceability of capital calls (Litvak, 2004).

Escrow Accounts. Investors' limited commitment problems can be eliminated by holding their promised contribution in an escrow account. In this arrangement, investors make a single upfront payment, and any unutilized contributions are invested in liquid securities, with the interest accruing to the investors.

However, escrow accounts are not widely used for several reasons. First, staged capital contributions can boost a fund's internal rate of return (IRR). If a fund receives an excess amount of capital that it cannot immediately invest and instead holds the capital in the fund's bank account, the IRR will become lower making the fund performance less impressive. Second, investors' outside options often dominate the liquid asset making the escrow accounts unattractive. Third, some investors might lack the necessary cash for upfront contributions in PE funds and face liquidity constraints, unable to borrow due to regulatory restrictions or high borrowing costs. Maurin, Robinson, and Strömberg (2022) shows that the escrow account cannot fully solve the investors' limited commitment problem unless borrowing is costless. At last, existing regulations, such as the Dodd-Frank Act, impose restrictions on the amount of publicly traded stocks and bonds that can be held by venture capital funds, a major type of PE funds.

2.4 The Secondary Market for Private Equity Fund Shares

Unlike mutual funds and hedge funds, PE funds primarily invest in private companies, aiming to improve their performance over an extended period and realize returns upon exits such as M&As or IPOs. These investments are inherently illiquid, in contrast to publicly traded securities held by mutual funds or hedge funds, which can usually be sold readily upon

investors' redemption requests.

Therefore, PE funds are structured as closed-end vehicles. This design enables them to invest without the liquidity constraints imposed by investor redemptions. However, the illiquidity of PE investments does not necessarily imply that PE funds stakes have to be illiquid. In fact, a secondary market has evolved in which buyers, such as specialized intermediaries known as secondary funds, provide liquidity to sellers by purchasing their stakes in PE funds. Following the transaction, the buyer as the new fund investor will pay/receive all future capital calls/cash distributions made by the fund on a pro rata basis of their equity contribution. Therefore, secondary sales allow PE funds to change their investor base.

Liquidity is one of the most important reasons to sell fund shares in the secondary market (Nadauld, Sensoy, Vorkink, and Weisbach, 2019). During liquidity shocks, PE fund investors may need to increase their cash holdings to meet liabilities or to adjust balance sheets because of regulatory requirements and investment mandates.[6] By selling their fund shares before the fund is liquidated, investors can partially reduce their illiquid investments.

The secondary market remains illiquid due to information frictions faced by buyers in valuing PE funds' underlying assets as well as search and matching frictions. In fact, most transactions still occur at a considerable discount to the net asset value (NAV) (Nadauld, Sensoy, Vorkink, and Weisbach, 2019). However, the liquidity of the secondary market has been growing over time, driven in part by a growing volume of trades unrelated to private information about investment quality.

3 Data and Summary Statistics

3.1 Data and Sample

Preqin. My main sample consists of US PE funds covered by Preqin's fund cash flow database, spanning from 1990 to 2020. This database provides detailed information on the

[6]Other reasons include portfolio rebalancing, PE investment strategy shift, sale of tail-end funds, GP-led secondaries. See Nadauld, Sensoy, Vorkink, and Weisbach (2019) for more details.

timing and amount of each capital call made by a PE fund.[7] Additionally, Preqin contains other rich fund-level data including details on investor composition, fund size, and vintage, as well as information about fund managers and investors. I specifically focus on buyout and venture capital funds, which are the two most important and widely studied types of PE funds. I exclude other funds such as secondary funds and funds of funds.

NAIC. Preqin does not differentiate between insurance companies with and without P&C divisions. To identify P&C insurers, I manually checked insurer names in the P&C insurance market share reports issued by the National Association of Insurance Commissioners (NAIC). The data comes from periodical statutory reports filed by insurance companies to the NAIC. I also cross-validate the data by searching the insurance company names on PitchBook, which provides the major line of business for each PE fund investor. Moreover, NAIC also provides data on insurers' portfolios in their statement filings.

EM-DAT. The database was initially created with support from the World Health Organisation and the Belgian Government to serve humanitarian actions against disasters. EM-DAT compiles data from various sources, such as United Nations agencies, the International Federation of Red Cross, insurance companies, and research institutes, and has comprehensive global coverage of disasters. I extract all natural disasters in the US and aggregate insured damages by calendar quarter to identify time periods with abnormal insured loss. Besides insured losses, EM-DAT also provides information such as affected areas and death toll caused by natural catastrophes.

PatentsView. Supported by the United States Patent and Trademark Office (USPTO), PatentsView provides comprehensive patent data such as the assignee name, grant year, and citations of published patent applications. The granular data allows me to assess the productivity of private companies, measured by their patenting outcomes.

[7] Preqin's cash flow data is primarily obtained from various sources including public filings by pension funds, data acquired through Freedom of Information Act (FOIA) requests, as well as voluntarily provided information from fund managers and investors. Preqin is widely used in the literature that studies cash flows of PE funds. An incomplete list of relevant papers includes Harris, Jenkinson, and Kaplan (2014), Korteweg and Nagel (2016), Korteweg and Sorensen (2017), Ang, Chen, Goetzmann, and Phalippou (2018), Gupta and Van Nieuwerburgh (2021), and Begenau and Siriwardane (2023).

SDC Platinum. For my analysis of the capital allocation implications of investors' liquidity shocks, I augment the Preqin private equity exit database with SDC Platinum to construct outcome variables related to IPOs and acquisitions. I merge these two datasets using a combination of fuzzy name matching, along with manual checks after standardizing spellings and removing legal suffixes of company names.

Federal Reserve Board. I supplement my analysis with time-series data collected from the Federal Reserve Board. The data includes the amount of public equity issuance, credit spread, term spread, etc.

3.2 Measures of Investment by Private Equity Funds

I measure PE funds' investment using two outcome variables, *Capital Called (%)*, the quarterly amount of capital called by a PE fund as a percentage of its fund size, or *Number of Investments*, the number of investments made by a fund in each calendar quarter. Since capital calls usually pool investments with private equity fees, I exclude capital calls with amounts below the quarterly amortized amount of management fees and consider each capital call as an investment when constructing *Number of Investments*.

Preqin's cash flow data has three unique features. First, it presents the cash flow from the perspective of a hypothetical investor with a 10 MIL commitment to the fund. As a result, I do not observe more granular cash flow data at the investor-fund level.[8] However, such a level of granularity is unnecessary for our study because capital is usually drawn down based on the pro rata contribution of investors' committed capital. Therefore, both the hypothetical and actual investors contribute in the same way, relative to their commitments when their capital is called.

Second, although Preqin records capital calls as negative cash flows, there are occasionally positive capital calls, likely representing fee rebates (Begenau, Robles-Garcia, Siriwardane, and Wang, 2020). Since I am interested in studying PE investment dynamics rather

[8] Begenau and Siriwardane (2023) uses investor-fund level cash flow data to study the fee dispersion among public pensions in the same PE fund. The authors' data is compiled by Preqin for their analysis.

than returns in my main analysis, I exclude capital calls with positive amounts when constructing *Capital Called (%)* and *Number of Investments*. Including these positive capital calls does not impact the robustness of my results.

Third, PE funds can also borrow debt to finance their investment, as seen in leveraged buyouts and capital call facilities. However, Preqin's cash flow data solely accounts for the equity committed to the fund, and it excludes any debt used to finance investment. Therefore, my cash-flow-based outcome variables capture the fund investors' equity contribution to their PE funds' investment. In the Online Appendix B, I use alternative proxies for investment based on PE deals that can be matched to each PE fund. These outcome variables measure both the equity and debt contribution to PE funds' investment. As discussed in Section 5.7, my results remain quantitatively and qualitatively similar.

3.3 Summary Statistics

There are 1,715 unique PE funds managed by 636 fund managers and 65,805 fund-quarters in my sample. Due to the nature of my analysis, the sample excludes PE funds without cash flow or investor data. The total amount of capital raised by my sample funds is 1.81 trillion USD, accounting for approximately 60% of the aggregate fundraising in the Preqin universe during the period of 1990-2020 in the US.

Panel A of Table 2 reports the summary statistics for my first sample based on fund-quarters. On average, 2.34% of committed capital is called in each quarter and 0.38 investments are made. However, more than half of the funds do not draw down any capital in a quarter. The sporadic nature implies that investment opportunities arrive randomly. While the unconditional mean of the *P&C Insurer Share* is 3.89%, the cross-sectional average value is 9.82%/20.34% conditional on having any/high exposure to P&C insurer LPs.

For the analysis of the ex-ante impacts of investors' liquidity shocks on investment outcomes, I use the cross-sectional data by pairing PE funds with their portfolio companies. The summary statistics are shown in Panel B of Table 2. On average, around 10% of the companies invested by my sample funds have gone public, and 48% of these companies are

invested within the first year after the fund vintage year.

4 Stylized Facts of Capital Calls

Without claiming causality, this section provides stylized facts about PE fund investment that are consistent with the role of liquidity shocks and investor base. These patterns are robust to various subsamples by fund types, size, and sequence, presented in Appendix B.[9]

Uninvested Capital Commitments. Figure 3 shows the cross-sectional distribution of the total amount of drawdowns scaled by fund size at the end of the fund lifespan. The fund size is the amount of capital committed by the investors at fund inception. The sample consists of PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to call capital by 2020. While most funds call capital amounts close to their fund sizes, a large portion of funds either draw down significantly more or less than the committed amount. Some funds' total drawdowns exceed 100% of their fund sizes due to recycling provisions that allow funds to reinvest exit proceeds, rather than distribute them back to investors, under certain conditions.[10] Meanwhile, some funds underinvest - which indicates potential capital supply constraints resulting from liquidity shocks to PE funds' investors. However, lower drawdowns might be caused by a narrower set of investment opportunities available to the fund manager rather than reduced contributions from investors.

Declining Investment Pace. By fund age, Figure 4a presents capital calls as a percentage of the total committed capital at fund inception. The dash and solid lines indicate the mean and median values, respectively. Instead of spending capital contributions evenly over several years, PE funds on average call capital quickly. Around 20% of committed capital is invested in the fund inception year, and the investment pace declines monotonically with fund age. The PE investment dynamic is consistent with the idea that fund managers have incentives

[9]Table B5 in Appendix B provides additional stylized facts suggesting that PE funds tend to call less capital when their investors have a larger preference for cash (Robinson and Sensoy, 2016). A preference for cash can emerge when investors face high funding costs and become cash-constrained.

[10]In a recent survey study by law firm Paul, Weiss, Rifkind, Wharton & Garrison LLP, all PE funds surveyed allow recycling of capital, with 60% of funds permitting recycling when capital is returned within 2 years of investment.

to hedge against funding shocks by accelerating drawdowns, which has been theoretically formalized by Maurin, Robinson, and Strömberg (2022).

Heterogeneous Investment Pace. Although PE fund managers' compensation contracts could also lead to a declining investment pace, these contracts are quite homogeneous across funds and thus unlikely to generate the substantial cross-sectional variation of investment pace shown in Figure 4a.[11] The shaded area represents the range between the 5th and the 95th percentiles of capital calls by fund age. Some funds invest almost 50% of their entire committed capital in the first year of inception, while others only spend less than 5%. Moreover, such heterogeneity in investment pace is particularly pronounced in the early stage of the fund life and gradually diminishes as the fund ages. This pattern may be attributed to funds' heterogeneous hedging incentives caused by different levels of exposure to investors that are ex-ante more susceptible to liquidity shocks. This difference can arise from investors' distinct liability structures. We can find a similar pattern of large heterogeneity when examining the evolution of cumulative drawdowns, as demonstrated in Figure 4b. Funds at the 25th percentile have invested approximately 25% of the committed capital at age 2, whereas funds at the 95th percentile have nearly completed all of their investments by the same point.

5 Ex-Post Impacts of Liquidity Shocks

The investment patterns of PE funds documented in the previous section do not indicate their causal relationships with liquidity shocks. In this section, I provide causal evidence, discuss the channel, examine economic forces that mitigate the transmission of liquidity shocks, and discuss the validity of my results.

[11] See, for example, Metrick and Yasuda (2010) and Robinson and Sensoy (2013) for details about the compensation contracts.

5.1 Identification Strategy

5.1.1 Natural Disasters as Exogenous Liquidity Shocks

Liquidity shocks are common and take many forms. However, events such as financial crises do not happen randomly and usually coincide with confounding macroeconomic shocks that affect the investment opportunities available to PE funds. For identification, my empirical design focuses on natural disasters, the timing and damage of which are arguably exogenous, and exploits investors' heterogeneous sensitivities to these events. Although natural disasters can cause a surge in short-term claims that P&C insurers are obligated to pay out, other investors including life insurers, pension funds, and endowments have much weaker sensitivities to such shocks as discussed in Section 2.1.

Figure 5a shows the quarterly insured losses caused by natural disasters in the US during 1990-2020. The horizontal red dashed line indicates the historical 90th percentile value (13.5 USD BIL). Insured losses equal to or greater than this value are considered abnormal and periods with these abnormal insured losses represent liquidity shocks to P&C insurers. The figure does not indicate any increasing or decreasing trend in the frequency of large natural disasters. The Durbin-Watson statistics for the quarterly time series of the liquidity shocks is 1.89, which cannot reject the null hypothesis of no serial correlation. Moreover, Figure 5b shows that there is no significant partial autocorrelation with a lag extended to 5 years.

Focusing on large natural disasters offers several advantages. First, P&C insurers specialize in assuming and managing catastrophic risk in return for a premium. Therefore, liquidity challenges should only arise after major natural disasters that lead to a large surge in short-term claims. Second, as shown in Figure 5a, insured losses from natural disasters tend to be relatively stable for most quarters, suggesting that these losses are largely anticipated. Since excessive cash holdings are costly, it is optimal for P&C insurers to keep cash holdings to a *minimum* in normal times and manage their cash flows in times of large payout. Third, by concentrating on major natural disasters, I can limit the number of liquidity shocks experienced by a fund and reduce the likelihood of multiple events occurring within

the same event window, which can potentially pose challenges for event-study designs.[12]

Table 1 ranks the calendar quarters of the liquidity shocks in descending order based on the quarterly insured loss. It also reports the total loss and names of major disasters. 2005Q3 is by far the period with the largest insured loss in a total of more than 100 USD BIL, which was mainly caused by Hurricane Katrina and Hurricane Rita. Although the majority of the most costly natural disasters are hurricanes, which are seasonal, other events such as drought, earthquakes, and wildfires have also led to large amounts of insured losses in the past three decades. Importantly, occurrences of natural disasters that lead to abnormal insured losses are arguably unpredictable.

5.1.2 The Importance of Insurers for Private Equity Markets

As shown by Lerner, Schoar, and Wongsunwai (2007), insurers are an important source of capital for private equity. Based on year-end 2022 NAIC annual statement filings, US insurers reported holding 187.33 USD BIL private equity in book/adjusted carrying value (BACV).[13] BACV focuses on the actual invested capital and represents the value of those investments as reported by the fund after necessary adjustment following NAIC's guidelines. Therefore, the reported value is an underestimate of the actual dollar amount of insurers' PE investments because BACV incorporates illiquidity discounts (typically 20%-30%) and does not reflect uncalled capital commitments. Moreover, the BACV does not include fees and expenses paid to PE fund managers. Meanwhile, PE funds in the US raised around 3.38 trillion USD between 2013 and 2022 according to Preqin, excluding funds of funds and secondary funds to avoid double counting capital supply for private companies. Preqin (2012) reports that insurers account for 8% of all LPs and provide 9% of capital invested in private equity as of June 2011. Relatedly, Figure 2 indicates that insurers represent the fourth most important investor class in PE funds based on fund-level LP data. Combined together, these estimates suggest that insurers contribute a significant amount of capital to PE markets.

[12] See Sandler and Sandler (2014) and Miller (2023). Section 5.1 provides details on my empirical designs.
[13] Growth in U.S. Insurers' Schedule BA Assets Slows at Year-End 2022, NAIC

5.1.3 Empirical Design

During periods with abnormal insured losses, P&C insurers face a higher cost of financing illiquid investments including private equity because they have to maintain a liquid portfolio to pay down insurance claims (Girardi, Hanley, Nikolova, Pelizzon, and Sherman, 2021; Ge and Weisbach, 2021; Ge, 2022). Conceptually, PE funds with a higher share of P&C insurers are more intensely treated when large natural disasters happen. Figure 6a indicates that there is substantial cross-sectional variation in the share of P&C insurers at the fund level. While more than 60% of funds do not have P&C insurers, 15% of funds have more than 10% of their investors being P&C insurers. Specifically, I estimate various forms of the following difference-in-differences (DiD) model:

$$y_{it} = \beta \times \textit{Investor Base}_i + \gamma \times \textit{Investor Base}_i \times \textit{Liquidity Shock}_t + \boldsymbol{FEs} + \epsilon_{it} \qquad (1)$$

in which the subscript i and t denote a PE fund and each calendar quarter, respectively.[14] The outcome variable y is either *Capital Called (%)* or *Number of Investments* in the corresponding quarter. *Investor Base* is various measures of the fund's exposure to a specific category of investors. For example, in the case of P&C insurers, *Investor Base* can be *P&C Insurer Exposure*, an indicator variable equal to one if the fund's exposure to P&C insurer is equal to or greater than the 90th percentile value and zero otherwise, or *P&C Insurer Share*, the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers.[15] *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. Standard errors ϵ are two-way

[14] Ideally, the identification can be further sharpened by using fund-investor-quarter cash flow data and estimating the fixed effect model as in Khwaja and Mian (2008). However, such data is not available in standard databases of PE fund cash flows. However, the data structure is unlikely to be a concern, because investors provide cash based on their *pro rata* portion of their committed capital when PE funds make capital calls.

[15] While my sample funds are managed by US private equity firms, some funds have foreign investors. I exclude non-US P&C insurers from the numerator when constructing the measures, since these insurers are unlikely to be affected by US natural disasters.

clustered at the fund and calendar quarter levels. Detailed variable definitions are provided in Appendix A.

In the baseline regression, I include year-quarter and fund age fixed effects to control for macro shocks and the lifecycle of PE funds' investment (Robinson and Sensoy, 2016). Then I gradually add fund manager fixed effects and, in the tightest specification, saturate fund manager fixed effects by interacting them with fund size dummies, based on the fund's size quintile, and a fund type dummy, based on whether the fund is a venture capital or buyout fund. Such inclusion of fixed effects in Equation (1) helps to address the concern that matching between fund managers and investors is not random (Lerner and Schoar, 2004; Lerner, Schoar, and Wongsunwai, 2007). The interacted fixed effects allow me to compare investment activities of *nearly identical* funds raised in different vintage years but managed by the *same* fund manager, by removing confounding cross-sectional variation in fund ownership. The remaining variation in a fund's exposure to P&C insurers primarily arises from idiosyncratic factors, such as the investors' demand for private equity during fundraising. These factors are unlikely to be correlated with a fund's subsequent investment opportunities. Figure 6b shows that these *idiosyncratic* factors generate *sizable* residual variation in P&C insurer shares across PE funds. Table B1 Panel A indicates balanced fund characteristics between funds with high and low residualized P&C insurer shares.

To test the parallel trend assumption and show the dynamic effects of investors' liquidity shocks, I estimate the following event-study regression with a four-quarter window around liquidity shocks caused by large natural disasters:[16]

$$y_{it} = \beta \times \textit{Investor Base}_i + \sum_{n=-4}^{4} \gamma_n \times \textit{Investor Base}_i \times \textit{Liquidity Shock}_{t+n} + \boldsymbol{FEs} + \epsilon_{it} \quad (2)$$

in which $\textit{Liquidity Shock}_{t+n}$ is an indicator variable equal to one for a calendar quarter

[16]This procedure is recommended by Sandler and Sandler (2014) for empirical settings with multiple events across each cross-sectional unit. The authors conduct Monte Carlo simulations to demonstrate that alternative methods of handling multiple events, such as disregarding subsequent events or duplicating observations around events, can introduce trends in the outcome variable before and after an event, resulting in biased estimates. Figure C1 shows that my results are robust to stacked-event-study designs.

if it is n quarters before/after a calendar quarter with abnormal insured losses when n is negative/positive, and zero otherwise. The coefficient γ_{-1} is normalized to zero. The specification includes the same set of fixed effects in Equation (1) and uses standard errors two-way clustered at the fund and calendar quarter levels. As an additional robust check, I estimate alternative event study designs including the specification used in Dessaint and Matray (2017) and a stacked version that duplicates data around each event. My results are robust to these alternative specifications.

5.2 Reduced Investment

Table 3 reports results of the DiD estimations of Equation (1) that investigate the impact of investors' liquidity shocks on the amount of drawdowns. Columns 1-3 use the indicator variable *P&C Insurer Exposure* to assign funds to treatment and control groups. In treated funds, the share of P&C insurers is equal to or greater than the 90th percentile (13.3%) of the sample funds. The rest are in the control group. The DiD coefficient estimates of *P&C Insurer Exposure* × *Liquidity Shock* are negative and statistically significant at the 1% level. For example, the saturated specification in Column 3 includes year-quarter, fund age, and fund manager fixed effects interacted with dummies of fund characteristics, and the DiD estimate suggests that high-exposure funds call 0.38 percentage points (approximately 16% of the unconditional mean) less capital during calendar quarters with funding shocks. Columns 4-6 report the estimates based on *P&C Insurer Share* and show that my results are robust to using a continuous treatment measure. For example, Column 6 suggests that a one-standard-deviation increase in the share of P&C insurers will decrease the amount of quarterly capital calls by 0.14 percentage points (around 6% of the unconditional mean) when natural disasters result in abnormal insured losses.

Table 4 investigates the impact of investors' liquidity shocks on the extensive margin. Across all columns, the DiD coefficient estimates are statistically significant at the 1% level and large in magnitude. For example, in Column 3, the estimate of *P&C Insurer Exposure* × *Liquidity Shock* indicates that funds with high exposure to P&C insurers on average make

-0.049 fewer investments (13% of the unconditional mean) when P&C insurers face large losses from natural disasters. This finding implies that PE funds not only invest less but also have to pass on investment opportunities when their investors are hit by liquidity shocks.

In terms of the dynamic effects of funding shocks on investment, Figure 7a and 7b plot the event study estimates in Equation (2) and the associated two-tailed 95% confidence intervals for *Capital Called (%)* and *Number of Investments* respectively. There are no pre-trends before the event and a drop in investment among high-exposure funds when the liquidity shock hits the P&C insurers. While the decline lasts for two quarters, investment does not increase afterward in terms of investment size or number of investments indicating a loss of the investment opportunities.

Overall, the reduced investment is consistent with PE funds facing important frictions in substituting adversely shocked investors with other investors. For example, funds typically face coordination challenges and agency conflicts if they arrange non-pro-rata capital calls, as discussed in Section 2.2. Meanwhile, investor base cannot be easily adjusted due to PE funds' close-end nature and the illiquidity of the secondary market to transfer fund shares (see Section 5.6.1). My findings support the theory of Maurin, Robinson, and Strömberg (2022) and provide micro-evidence that aligns with the procyclicality of aggregate capital calls with public market liquidity documented by Robinson and Sensoy (2016).[17]

If PE fund cannot draw down capital as planned, it can result in significant costs for them. First, PE funds may need to pass on investment opportunities. Second, PE funds pay upfront costs from deal selection and due diligence before calling capital from investors.

[17]Although committed capital might appear analogous to bank credit lines at first sight, they differ fundamentally in crucial aspects. PE fund managers issue equity-like claims to investors when raising committed capital, whereas credit lines are debt contracts typically containing covenants that address the inherent agency problems in lending relationships. These covenants restrict borrowers' actions and transfer control to lenders if borrowers' financial condition deteriorates (e.g., Sufi, 2009; Acharya, Almeida, Ippolito, and Perez, 2014; Chodorow-Reich and Falato, 2022). Moreover, the sequential drawdown of committed capital aims to facilitate fundraising, while credit lines offer liquidity insurance to borrowers (e.g., Holmström and Tirole, 1998; Brown, Gustafson, and Ivanov, 2021). These differences give rise to distinct channels and implications of shock transmission, including the loan covenant channel and the crowding-out effect on bank lending (e.g., Chodorow-Reich and Falato, 2022; Ivashina and Scharfstein, 2010; Greenwald, Krainer, and Paul, 2021; Acharya, Engle, Jager, and Steffen, 2024).

Third, if PE funds have to retract from deals that were already agreed upon, they would face significant reputational damage and incur various costs associated with the broken deals. Moreover, in Appendix B.1, I show that liquidity shocks ex-post lead to lower realized PE fund returns because funds cannot invest as planned.

5.3 Heterogeneous Illiquidity Costs across Investors

To highlight the implications of investor heterogeneity, I show that funds with high exposure to life insurers do not invest less during periods with abnormal insured losses caused by natural disasters. In contrast to P&C insurers, life insurers have more predictable liability based on the mortality table and are much less exposed to losses resulting from natural disasters due to the different nature of their business.

Table 5 shows the estimates using exposure measures *Life Insurer Exposure* and *Life Insurer Share* defined in similar ways to *P&C Insurer Exposure* and *P&C Insurer Share* respectively. Insurance companies with only life or health insurance divisions are considered as life insurers. In both Panel A and Panel B, the DiD coefficient estimates are not only statistically insignificant but also small in magnitude compared to those based on P&C insurers reported in Tables 3 and 4. The regression estimates indicate that funds with high exposure to life insurers do not invest less during periods with abnormal insured losses caused by natural disasters. Figure 8 plots the investment dynamics of PE funds based on their exposure to life insurers. It does not show any differences between funds with high and low shares of life insurers during periods of large natural disasters.

Figure 9 plots the DiD estimates in Equation (1) and the associated two-tailed 95% confidence intervals for different measures of exposure to other types of investors at the PE fund level. These estimates are based on different measures of exposure to various types of investors at the PE fund level, defined similarly to *P&C Insurer Exposure*. These investors include life insurers, endowments and foundations, public pension funds, private pension funds, and fund of funds managers. None of the DiD estimates, except the baseline estimate based on P&C insurers, are statistically significant. This result can be attributed to the fact

that natural disasters pose a unique and plausibly exogenous liquidity shock solely to P&C insurers. P&C insurers' liabilities increase significantly after large natural disasters, creating substantial liquidity mismatches between their liabilities and assets.[18] This finding provides evidence that investors have heterogeneous costs of financing illiquid investments, such as private equity, due to their distinct contractual liabilities in different economic conditions. Therefore, variation in investor base composition can result in different state-dependent PE financing for private companies.

One might worry that abnormal insured losses can coincide with other macroeconomic shocks that significantly affect the balance sheets of investors other than P&C insurers. For example, large natural disasters might disrupt the economy and trigger stock market declines. Meanwhile, the government may decide to adjust interest rates following these catastrophes. Figure B4b plots the quarterly time series of insured damages from natural disasters, S&P 500 returns, and changes in the federal fund effective rate. Visually, there are no co-movements between insured damages and the other market variables. In fact, the correlations of insured damages with S&P 500 returns and with federal fund rate changes are merely -0.04 and 0.17, respectively - both statistically insignificant at the 5% level.

5.4 Mechanism of the Shock Transmission

The reduced investment by PE funds following liquidity shocks does not solely result from LP defaults, in which investors fail to fully fund capital calls.[19] In many cases, fund managers may be pressured to slow down investment when their investors' costs of capital are high.[20]

[18] Figure B4a shows that the total death toll from natural disasters is generally small, except for 2005Q3 when Hurricane Katrina occurred. The life insurance claims resulting from the death are likely small in dollars compared to the P&C insured losses and are unlikely to be liquidity shocks to life insurers. Table C6 shows that my results are robust to excluding 2005Q3.

[19] There is no comprehensive data on actual LP defaults because of confidentiality agreements and the private nature of these transactions. Nonetheless, ample anecdotal evidence suggests that LPs sometimes face difficulties meeting capital calls during periods of market stress, with some even defaulting on their commitments. See Griffith (2009) and Lynn (2020). For example, Silicon Valley Bank defaulted on capital calls of some PE funds after its collapse (PitchBook, 2023).

[20] For example, TPG Partners VI, L.P., a global PE fund, offered to cut its investors' capital commitments by 10% and promised not to call more than 30% of the total commitments in 2009 in response to the financial crisis. See the case study by Chaplinsky, Loutskina, and Walsh (2011) for more details.

Consequently, the pro rata rule of capital calls can create *negative externalities* for the rest of the investors not affected by liquidity shocks, amplifying the impacts on capital calls consistent with the large magnitude I document in the previous sections. Fund managers may offer investors concessions to maintain a mutually beneficial relationship because they usually need to return to their existing investors for fundraising in the future.This need arises due to information asymmetry and search frictions, which give investors significant bargaining power in PE markets (Hochberg, Ljungqvist, and Vissing-Jørgensen, 2014; Begenau and Siriwardane, 2023).

Liquidity shocks can lead to the so-called "*denominator effect*" - selling liquid assets causes over-exposure to private equity, due to investment mandates and capital regulations that impose restrictions on the portfolio allocation to different asset classes. Such constraints reflect investors' liquidity and diversification concerns based on their liability structures.[21] Meanwhile, investors tend to face higher costs of external financing and potential downturns in the prices of their assets due to selling pressure amid liquidity shocks, which can exacerbate investors' balance sheets (Ellul, Jotikasthira, and Lundblad, 2011). Moreover, investors might also become more risk averse because the agents managing the portfolios potentially face a higher chance of losing jobs if their institutions become insolvent. Overall, these factors increase preferences for cash and costs of holding illiquid assets among investors, including P&C insurers which typically hold a large amount of liquid assets.[22] Consistent with this idea, Ge and Weisbach (2021) documents that P&C insurers rebalance their portfolio towards safer and more liquid assets in response to liquidity shocks.

Why do investors want to delay capital calls during liquidity shocks? Unlike mutual funds or hedge funds, PE funds are closed-end because they invest in shares of private companies that are not marketable and difficult to trade. It implies that investors cannot

[21] Recent literature on demand-based asset pricing literature has highlighted the important role of investment mandates in asset prices (e.g., Koijen and Yogo, 2019; Vayanos and Vila, 2021; Bretscher, Schmid, Sen, and Sharma, 2022).

[22] Based on NAIC statement filings, P&C insurers allocate around 18% of their portfolio to safe liquid investments including cash and short-term investments, government bonds, agency-backed RMBS and CMBS.

cash out through redemption of PE fund shares. Instead, investors gain liquidity from their PE funds mainly after sales of portfolio companies through IPOs or M&As, a process known as distributions. However, there is much less flexibility in cash distributions compared to capital calls because PE funds must wait for favorable market conditions for profitable exits if there is any (Gompers, Gornall, Kaplan, and Strebulaev, 2020). Rushed or forced asset sales to meet investors' distribution requests can result in large price discounts due to illiquidity.[23] Consequently, investors usually resort to reducing capital calls to preserve cash during liquidity shocks, especially if they cannot unload their PE investments through secondary transactions.

5.5 Real Effects - Reduced Productivity of Private Companies

Conceptually, private companies' real outcomes will suffer if liquidity shocks lead to financing constraints. I examine whether companies become less productive in terms of their patenting activity after liquidity shocks. The empirical design pools these events, large natural disasters indicated in Table 1, and regresses the first difference in a company's patenting outcomes in the year after and before each event on measures of fund investor base and a set of fixed effects:[24]

$$\Delta y_{ije} = \beta \times Investor\ Base_i + \boldsymbol{FEs} + \epsilon_{ije} \tag{3}$$

in which i, j, and e denote a PE fund, a private company, and an event, respectively. Only pre-existing company-fund pairs are included for each event. Moreover, the sample excludes funds that invested in the company more than five years ago, since these funds are less likely to have uncalled capital to provide additional financing. y is the number of (eventually granted) highly cited patents applied for in a year. Highly cited patents are defined as those with the top tercile numbers of citations among patents granted in the same year. I also

[23] Moreover, PE funds usually have to negotiate with other shareholders in the portfolio company to determine the exit route and timing (Cumming, 2008; Bian, Li, and Nigro, 2023). Appendix B.2 indicates that PE funds do not increase cash distributions to their P&C insurer investors after large natural disasters.

[24] Similar first-differenced estimation methods are used in Khwaja and Mian (2008) and Schnabl (2012).

use the top quintile group as an alternative cut-off to define highly cited patents. Standard errors are two-way clustered at the fund and company levels.

Panel A of Table 6 suggests that private companies become less productive after large natural disasters if their PE funds have higher exposure to P&C insurers. For example, the coefficient estimate in Column 3 implies that companies with a one-standard deviation higher share of P&C insurers on average have 19.8% (= -0.008 × 8.672 / -0.350) greater reduction in the number of higher cited patents. The economic magnitude rises to 23.1% (= -0.007 × 8.672/ -0.263) when we use the top quintile group to define highly cited patents in Column 6, and the estimates are statistically significant at the 5% level. The result is consistent with private companies facing significant frictions in establishing new financing relationships.

As an additional test, Panel B reports results of regressions based on *Life Insurer Share*. Across all columns, the coefficient estimates are statistically insignificant and small in magnitude. Overall, the findings in of Table 6 suggest that investor base is an important determinant of private company financing and subsequently real outcomes due to investors' heterogeneous illiquidity costs in different states of the economy.

5.6 Mitigation of Liquidity Shock Transmission

The previous section documents that liquidity shocks can negatively affect real outcomes. In this section, I investigate the role of capital markets and contracts in mitigating the transmission of liquidity shocks from PE funds' investors to themselves.

5.6.1 Investor Base and the Secondary Market for Fund Shares

As discussed in Section 5.4, the illiquidity of private equity is the key friction in the shock transmission when investors are hit by liquidity shocks. However, the illiquidity of PE funds' underlying assets does not necessarily imply PE fund shares are equally illiquid. The existence of a liquid secondary market can alleviate this illiquidity friction by improving the transferability of investors' illiquid PE investments and allowing PE funds to shift their investor base more easily following liquidity shocks.

Table 7 reports the triple-diff estimation results, which indicate the role of a liquid secondary market in mitigating shock transmission. The design exploits variation in the secondary market liquidity in a fund's lifespan. Specifically, *Liquid Secondary Market* is an indicator variable equal to one for a fund-quarter if the secondary fund dry powder at the beginning of the quarter is in the top quintile group within a fund's lifespan, and zero otherwise. Dry powder is the cash reserves that fund managers hold for investment when they identify attractive opportunities. The secondary market becomes more liquid when there are more buyers looking for fund shares. The coefficient of interest is the slope of *P&C Insurer Share* $\times$ *Liquidity Shock* $\times$ *Liquid Secondary Market*, which measures the difference in the impacts of liquidity shocks on PE investment dynamics when there exists a liquid secondary market and otherwise for funds with the same exposure to P&C insurers. From Columns 1-3, the estimates are all positive and statistically significant, indicating that the presence of a liquid secondary market partially mitigates the impact of investors' liquidity shocks on PE funds' investment when it is more cost-effective for investors to gain liquidity from their existing illiquid positions by transferring their PE fund shares.

My result implies that the secondary market helps to address *idiosyncratic* liquidity shocks, such as natural disasters. However, *systematic* liquidity shocks, such as financial crises, are hard to fully mitigate because these shocks significantly increase almost all investors' preference for cash and thus costs associated with holding illiquid assets. Overall, the finding aligns with the theoretical prediction in Maurin, Robinson, and Strömberg (2022).

5.6.2 Contracting on Capital Calls and Acceleration of Drawdowns

The fundamental issue behind reduced investment is incomplete contracting. A state-contingent contract for capital calls cannot be written based on investors' liquidity shocks, since they are hard to specify ex-ante and challenging to verify ex-post.[25] Therefore, incomplete contracting theory suggests that the fund manager's bargaining power plays an

[25]While the occurrence of natural disasters is publicly observable, losses caused by these catastrophes to each insurer are not verifiable, especially in a short time period after these events. Consequently, it is also difficult to contract on natural disasters.

important role when renegotiating with the investors on capital calls. Then a natural question is how effective the forfeiture provision, the most punitive and commonly used penalty as discussed in Section 2.3, can be in enforcing capital calls. Since LP investors stand to lose their contributed capital and future cash flow rights if they cannot meet capital calls, early investments act as collateral against LP defaults (Maurin, Robinson, and Strömberg, 2022; Gourier, Phalippou, and Westerfield, 2024).

Table 8 reports triple-diff estimates that support such prediction. The design exploits cross-sectional variation in fund managers' bargaining power. *Cumulative Drawdown* is a variable ranging from 1 to 5 that ranks a fund by calendar quarter based on its cumulative drawdown at the beginning of each period, with 5 indicating the highest value. From Columns 1-3, the coefficient estimates of *P&C Share* × *Liquidity Shock* × *Cumulative Drawdown* are positive and highly significant, suggesting that a greater amount of cumulative drawdowns attenuates the transmission of investors' liquidity shocks to PE funds. This finding implies that investors' limited commitment problem is mitigated when the fund manager can more effectively enforce capital calls.

5.7 Discussion - Internal and External Validity

5.7.1 Funds with Limited Choices of Investor Base

My identification strategy relies on plausibly exogenous liquidity shocks with a tight set of fixed effects, which allow me to account for potential confounding factors related to the investor base that remain constant across fund managers or can be explained by observable fund attributes. To further mitigate the concern about endogenous matching between investors and funds, I re-estimate the baseline regressions using different subsets of funds with plausibly constrained choices of investor base.

First, my results are robust to the subset of undersubscribed funds, defined as those that fail to achieve their target size for fundraising, as shown in Table B6 Panel A. Conceptually, these funds are unlikely to select their investors, because the fund managers are strongly incentivized by their compensation contracts to raise larger funds that meet their fundraising

targets (Metrick and Yasuda, 2010; Robinson and Sensoy, 2013). Second, the findings remain quantitatively and qualitatively similar in Table B6 Panel B when the sample is restricted to funds raised during fundraising busts (2001-2002 and 2009). During these periods, funds arguably face higher opportunity costs of selecting investors since funds face around 25 percentage points greater probability of being undersubscribed than those raised in the boom periods as evidenced by Figure B5. Importantly, fundraising conditions are driven by the macro environment and are plausibly exogenous to individual fund managers.

5.7.2 Pseudo Liquidity Shocks

I conduct a placebo test by re-estimating the regressions 1,000 times using pseudo liquidity shocks constructed from randomly selected 10% calendar quarters during 1990-2020. Figure B6 shows the distribution of the DiD coefficient estimates, which is centered around zero. More than 98% of the mass is to the right of the estimates reported in Column 3 of Tables 3 and 4, suggesting that such a level of reduced investment is a low probability event in the data in which high-exposure funds happen to invest less during large natural catastrophes. Therefore, my results are unlikely to be driven by unobservable differences across funds. Alternative explanations must explain why funds with a higher share of P&C insurers invest less *only* when natural disasters lead to abnormal insured losses.

5.7.3 Capital Demand

Natural disasters are both liquidity shocks and real shocks, which directly impact the production and consumption of goods and services. It is possible that PE funds with a higher share of P&C insurers are more likely to be located in areas with higher risk from natural disasters, which can disrupt fund operations and thus reduce funds' demand for capital. I rule out this explanation by excluding fund-quarters of managers located in states impacted by natural disasters. Table B7 Panel A suggests that this story is unsatisfactory.

Another possibility is that P&C insurers might hedge their liquidity risk from catastrophes by choosing PE funds that specialize in industries with potentially lower capital demand during periods of natural disasters, such as manufacturing, infrastructure, and agriculture

industries. In Table B7 Panel B, I only keep funds that focus on industries (IT, internet, information services, media, software, and gaming) where production is not vulnerable to the impacts of natural disasters. The DiD coefficient estimates remain quantitatively and qualitatively similar to the baseline results.

5.7.4 Fund-level Financing and Deal-based Investment Measures

The recent rise of capital call facilities allows PE fund managers to borrow debt against uncalled capital commitments and actively manage the timing of capital calls from investors (Albertus and Denes, 2024; Albertus, Denes, and Li, 2024). However, Preqin only reports cash flow that is from investors' equity contributions but does not cover lenders' debt contributions (see Section 3.2). Therefore, it raises concern that lower drawdowns from investors do not necessarily mean PE funds invest less since they can fill the gap through borrowing when investors are hit by liquidity shocks.

Two pieces of evidence mitigate this issue. First, my findings are robust to alternative measures of investment based on PE deals, as reported in Table B8.[26] The smaller magnitude of coefficient estimates compared to the baseline results implies that capital call facilities might be used to partially undo investors' liquidity shocks.[27] Second, these short-term loans typically span from 90 days to one year, which implies that capital has to be called from investors in the next quarter or so to pay off the debt. However, Figure 7 shows that reduced investment lasts for more than one quarter and there is no significant increase in capital calls afterward, indicating limited use of capital call facilities.

While allowing PE funds to manage cash flows, capital call facilities also introduce costs. These loans can be used to manipulate a fund's returns and make performance less comparable across funds, creating agency concerns (Albertus and Denes, 2024). Moreover, these

[26] Data on deal-level investment is noisier than fund cash flow in Preqin. 17% of private equity deals do not report any investors, and 36% of deals have missing deal size. Therefore, I exclude funds that are matched to fewer than 5 deals for the regressions. Since the investment amount of each fund is not reported, I estimate this value by splitting the investment size by the number of observed investors in each deal.

[27] A theoretical argument from the Modigliani–Miller perspective is that investors could have undone their liquidity shock by borrowing to meet capital calls. My findings suggest that investors are reluctant to do so, indicating frictions in using leverage to finance their illiquid investments during liquidity shocks.

facilities add interest expenses and fees, especially under a high-interest rate environment, and also contribute to increased liquidity risk if investors' capital cannot be called in time to pay off the debt. At last, capital call facilities create additional clawback issues and tax considerations (Preqin, 2019). Due to these costs, capital call facilities are sometimes prohibited in the LPAs while others may restrict their use by limiting the ratio of unfunded capital commitments to the fund's total debt.

5.7.5 Robustness Checks

Besides my baseline findings, I have demonstrated a lack of pre-trends, introduced subsample results, conducted placebo tests, and outlined treatment heterogeneity that indicates that the observed effects are causally driven by liquidity shocks. Nevertheless, I further support my findings by checking the robustness of my results. In Appendix C, I discuss the motivation for each robustness check and show that my results are robust to various modifications of the sample and regression specifications.

6 Ex-Ante Impacts of Liquidity Shocks

The findings in Section 5 suggest PE funds face a costly reduction of investment when their investors are hit by liquidity shocks. Motivated by the ex-post impacts of investors' liquidity shocks and the associated costs to the PE funds, I next examine whether these shocks can have any ex-ante implications on the investment and capital allocation of PE funds. Specifically, I connect the cross-sectional differences in investment pace documented in Figure 4 with the investor base at the fund level.

6.1 Measure of Ex-Ante Fund Exposure to Funding Shocks

As discussed in Section 2.1, the fundamental difference in funding structures between endowments and other major PE investors implies that endowments are less susceptible to liquidity shocks. Endowments are "*equity-financed*" by donations and have largely flexible dividend-like payout schedules. In contrast, pension funds and insurance companies are "*debt-financed*" and need to rely on investment returns to fund their contractual liabilities -

pension benefits and insurance claims that must be met. Due to these obligations, pension funds and insurance companies can face liquidity shocks from either the asset or liability side of their balance sheets.

Motivated by such differences, I measure a fund's ex-ante exposure to funding shocks using *Endowment Share*, the percentage of investors that are endowments or foundations within a fund, which negatively correlates with its funding risk. Figure B7a indicates a large cross-sectional variation of PE funds' exposure to endowments.

6.2 Acceleration of Drawdowns

There are at least two economic motives for PE funds to invest early rather than spending the committed capital evenly in the first few years. First, PE funds can decrease the amount of uncalled capital at the risk of not being readily available for future drawdowns when liquidity shocks hit investors. Second, early investments act as collateral that can help prevent investors from defaulting on capital calls, as implied by my empirical finding in Table 8 and the theoretical work of Maurin, Robinson, and Strömberg (2022).

I estimate the following regression to investigate whether PE funds with lower exposure to endowment investors accelerate drawdowns more:

$$\begin{aligned} y_{it} =& \beta \times \textit{Endowment Share}_i + \kappa \times \textit{Log(1 + Fund Age)}_t \\ &+ \gamma \times \textit{Endowment Share}_i \times \textit{Log(1 + Fund Age)}_t + \boldsymbol{FEs} + \epsilon_{it} \end{aligned} \tag{4}$$

in which i and t denote a PE fund and a calendar quarter. y can be either *Capital Called* or *Number of Investments*. The identification assumption is that the matching between investors and funds is not correlated with investment pace conditional on the same set of fixed effects in Equation (1).[28] Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered at the fund and calendar quarter levels.

[28] Figure B7b shows that these idiosyncratic factors generate sizable residual variation in endowment share across funds. Table B1 Panel B shows the balance of fund characteristics between funds with high and low residualized endowment shares.

Table 9 reports the coefficient estimates in Equation (4). *Log(1 + Fund Age)* has a statistically negative slope across all columns, suggesting that on average PE funds tend to draw down more capital when they are younger, which is consistent with the patterns in Figure 4a and 4b. However, PE funds with a larger presence of endowment investors display a reduced inclination to accelerate drawdowns. This observation is supported by the positive and statistically significant coefficient estimates of *Log(1 + Fund Age)* × *Endowment Share*.

There are other reasons why a fund manager wants to invest early, such as a higher present value of compensation due to earlier exits or agency frictions arising from the compensation contract (Robinson and Sensoy, 2013). However, these motivations do not predict the cross-sectional correlation between the investment pace and fund investor base found in Table 9.

6.3 Distorted Investment Schedules

If accelerating drawdowns can mitigate funding shocks ex-ante, why don't all fund managers do so? First, expecting the fund manager's incentives to call capital early, investors often specify contractual terms that add limitations on drawdowns (Litvak, 2004). For example, about half of the agreements include annual capital contribution caps ranging from 25- 60% of committed capital that limit the amount of cash available for calls in one year. Meanwhile, all the agreements include "call-to-invest" provision which requires the fund manager to call only as much capital as they can promptly invest.[29] Second, accelerating drawdowns implies that fund managers may need to deviate from their optimal investment schedules and lose benefits such as the real option value of waiting (Brennan and Schwartz, 1985; McDonald and Siegel, 1986; Dixit and Pindyck, 1994). As a result, acceleration of drawdowns can distort the investment schedule and thus lower fund returns.[30]

To investigate whether the acceleration of drawdowns leads to suboptimal selection of

[29]Unfortunately, the limited partnership agreements signed between fund managers and investors are not publicly available. As a result, I cannot provide an analysis of contracting.

[30]Under the adverse selection framework of Axelson, Strömberg, and Weisbach (2009), funding shocks can exacerbate fund managers' incentives to finance bad projects leading to worse investment performance.

portfolio companies, I estimate the following cross-sectional regression with paired fund-company data:

$$\begin{aligned} y_{ij} =& \beta \times \textit{Early Investment}_{ij} + \gamma \times \textit{Early Investment}_{ij} \times \textit{Endowment Share}_i \\ &+ \boldsymbol{\delta_i} + \boldsymbol{\lambda_t} + \boldsymbol{\phi_{industry}} + \boldsymbol{\zeta_{state}} + \epsilon_{ij} \end{aligned} \tag{5}$$

in which i and j denote a PE fund and a portfolio company respectively. y is a measure of the company's exit outcomes measured by *IPO*, an indicator variable equal to one if the company goes public, and zero otherwise, or *Successful Exit*, an indicator variable equal to one if the company goes public or is acquired with a valuation equal to or greater than 2.5 (the sample median) to the total amount of capital raised by the company. *Early Investment*, an indicator variable equal to one if the company is invested in less than one year after the fund vintage year, and zero otherwise. $\boldsymbol{\delta_i}$, $\boldsymbol{\lambda_t}$, $\boldsymbol{\phi_{industry}}$ and $\boldsymbol{\zeta_{state}}$ are fund, first investment year, company industry, and company state fixed effects. Standard errors are two-way clustered at the fund and company levels.

Table 10 confirms this prediction by comparing the difference between early and late investments made by funds with high and low proportions of endowment investors. The regression results indicate that early investments tend to have a worse exit outcome compared to late investments made by the *same* fund, as demonstrated by negative and statistically significant coefficient estimates of *Early Investment*. Such a finding provides evidence of investment distortion caused by funds' acceleration of drawdowns. Moreover, funds with higher exposure to endowments face less distortion. For example, Column 2 suggests that while an early investment has around 0.015 percentage points (15% of the unconditional mean) lower chance of going public, such a probability is 0.011 higher (11% of the unconditional mean) for a PE fund that has one standard deviation more *Endowment Share*.

6.4 Discussion - Return Persistence in Private Equity

In sharp contrast to mutual funds, PE funds have been documented to have persistent returns. At the fund level, certain managers consistently deliver superior returns even after risk adjustment, and such persistence is often attributed to manager skills (e.g., Kaplan and Schoar, 2005; Acharya, Gottschalg, Hahn, and Kehoe, 2013; Braun, Jenkinson, and Stoff, 2017). At the investor level, different financial institutions display varying performance based on the net returns of PE funds. The difference is usually explained through investors' fund selection, which stems from inherent variation in their investment objectives, financial sophistication, and fund access (e.g., Lerner, Schoar, and Wongsunwai, 2007; Hochberg and Rauh, 2013; Andonov, Hochberg, and Rauh, 2018). In essence, most existing research suggests that investors do not significantly influence fund performance after making capital commitments.

This paper demonstrates that liquidity shocks faced by investors result in reduced investment ex-post and distorted investment schedules ex-ante across PE funds. These findings imply that the Heterogeneous Illiquidity Costs across Investors can be another source of return persistence at both the fund and investor levels. Funds with a larger share of investors susceptible to liquidity shocks experience greater distortion in their investment and achieve inferior performance. Conversely, investors that are less shock-prone provide "premium" capital to funds and are in turn compensated by higher net returns (Maurin, Robinson, and Strömberg, 2022).

In terms of external validity, my results align with the higher PE returns earned by endowments compared to other investors, as documented by Lerner, Schoar, and Wongsunwai (2007). While the authors attribute the return persistence to endowments' access to better PE funds, my findings suggest that endowments' illiquidity tolerance due to their lack of contractual liabilities can also contribute to their outperformance in private equity.[31]

[31]The decline in return persistence across investor type documented by Sensoy, Wang, and Weisbach (2014) and Cavagnaro, Sensoy, Wang, and Weisbach (2019) can potentially result from the development of the secondary market for fund shares, which reduces the competitive advantage of capital provided by

7 Conclusion

Private equity has been playing an increasingly important role in financing businesses and supporting economic growth. This market is intermediate by PE funds that pool capital committed by various types of institutional investors including pension funds, endowments, and insurance companies. Their distinct contractual liabilities give rise to heterogeneous costs of financing illiquid investments like private equity.

This paper shows that investor base composition shapes investment and capital allocation outcomes in response to liquidity shocks. Liquidity shocks experienced by investors reduce PE funds' investment ex-post and distort their investment schedules ex-ante, leading to inefficient capital allocation. Specifically, I use natural disasters as exogenous liquidity shocks and provide causal evidence of the reduced investment following liquidity shocks. The transmission of shocks is mitigated by a liquid secondary market, which facilitates PE funds to adjust their investor base, and contracting on capital call defaults, which helps to enforce capital calls. Moreover, I demonstrate that funds with less capital from endowments experience more distortion in investment schedules. This is attributed to these funds' higher funding risks, leading to stronger incentives to accelerate capital calls.

As an integral part of the broader financial system, PE markets provide various non-bank financial intermediaries with alternatives to transform the economy's savings into capital investments. Liquidity shocks to these intermediaries can disrupt funding for private companies, affect economic development, and spill over to other financial markets potentially leading to systemic risks.[32] Studying the transmission of these shocks allows policymakers to identify vulnerabilities and design measures, including regulations on PE investor base and the development of PE secondary markets as well as the PE fund financing sector, to

investors that have higher illiquidity tolerance.

[32]For example, Bernstein, Lerner, and Mezzanotti (2019) and Johnston-Ross, Ma, and Puri (2023) show that PE funds increase the financial stability of public companies and failed banks by providing timely financing during the 2008 financial crisis. Therefore, my findings imply that liquidity shocks to investors can prevent PE funds from providing timely financing to distressed companies.

increase financial stability.[33] At the macroeconomic level, this study emphasizes a crucial point. Even when there is a substantial amount of uncalled capital commitments, PE funding can become scarce due to liquidity shocks experienced by investors, challenging the common assumption of the easy accessibility of uncalled capital.

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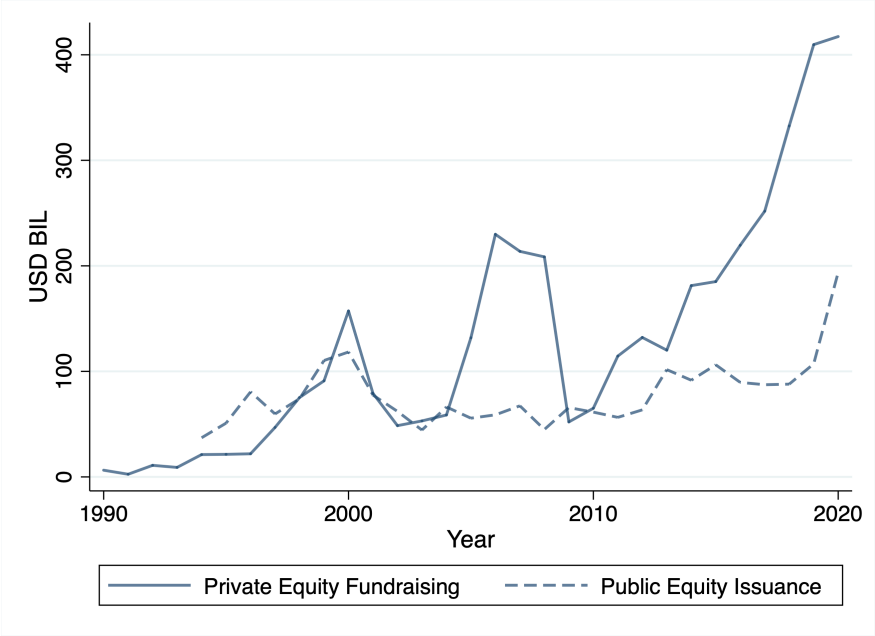
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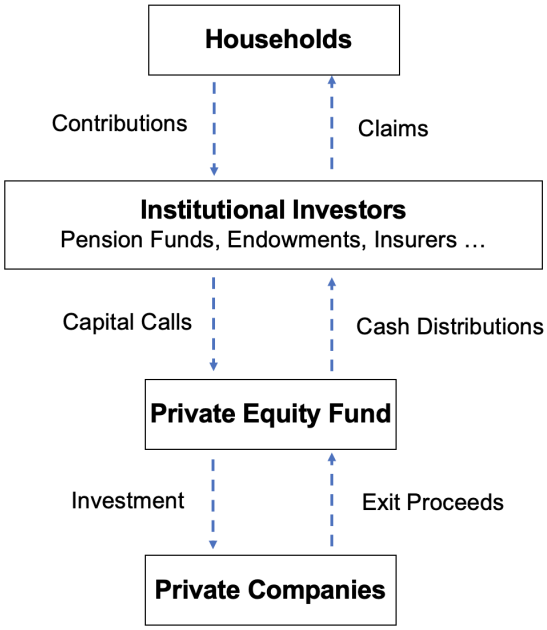
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(a) Expansion of Private Equity Markets



(b) Financial Intermediation in Private Equity Markets

Figure 1: Private Equity Market Size and Capital Flows

Figure 1a illustrates the amount of capital raised by PE funds in the US during 1990-2020. Buyout funds and venture capital funds are included, while funds such as secondary funds and funds of funds are excluded. As a benchmark, the dashed line shows the equity issuance of initial public offerings and seasoned equity offerings in the same period. The fundraising data is collected from Preqin and the equity issuance data is sourced from the Federal Reserve Board. Figure 1b shows the capital flow from households to private companies in the economy through financial intermediation in private equity markets.

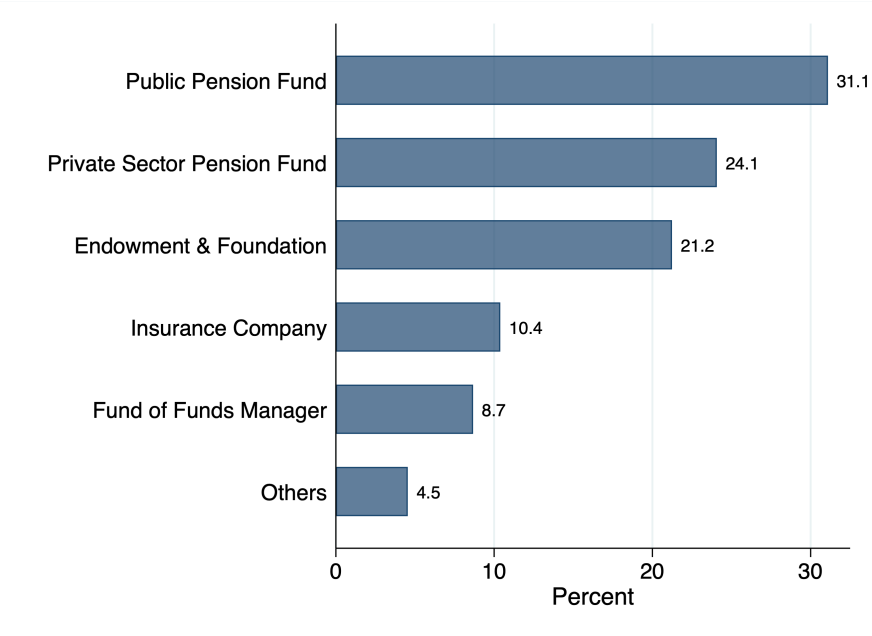


Figure 2: Private Equity Investors by Institutional Type

This figure ranks different types of institutional investors based on the number of their PE fund investments. The sample consists of investors in US PE funds raised between 1990 and 2020. Investors such as family offices, sovereign wealth funds, corporate investors, banks, government agencies, and asset managers are categorized into Others.

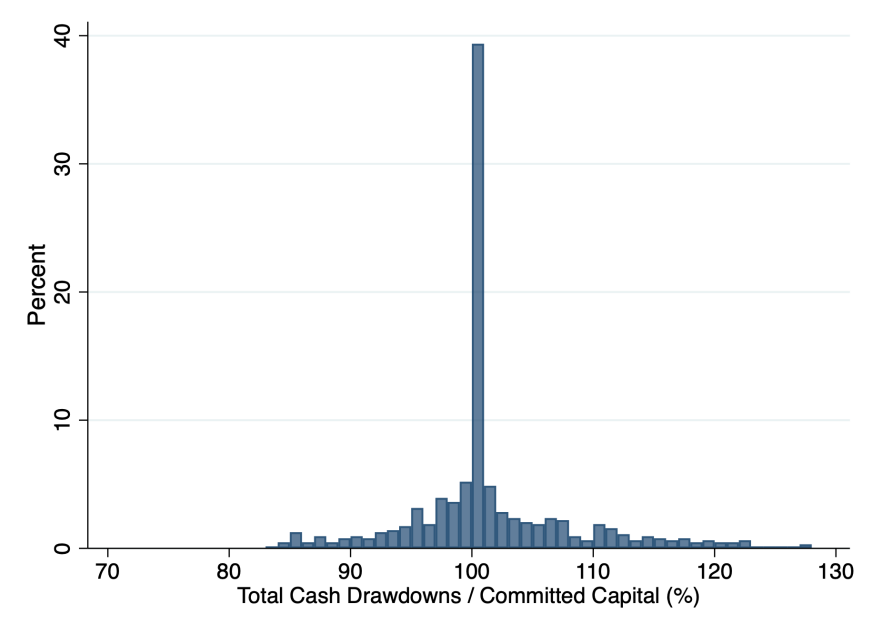
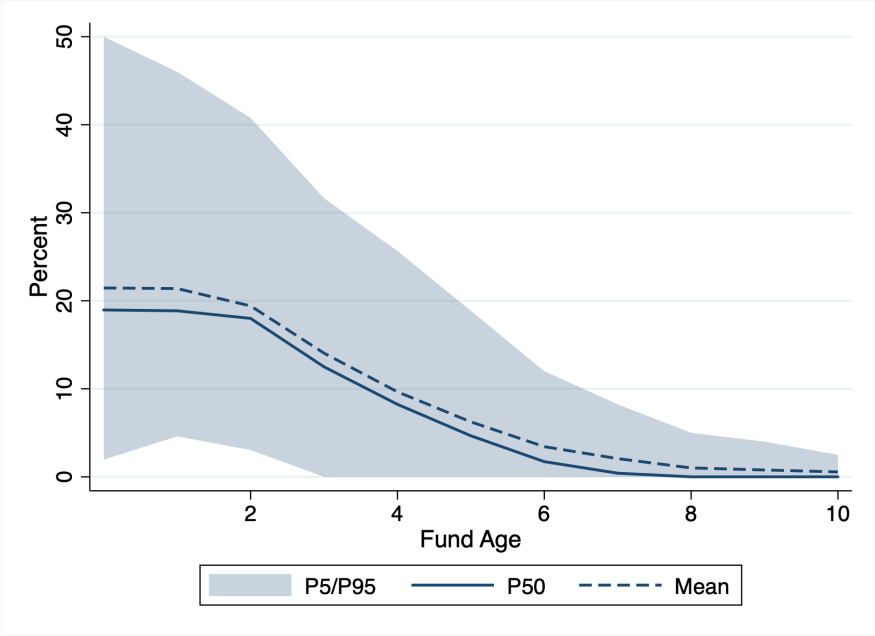
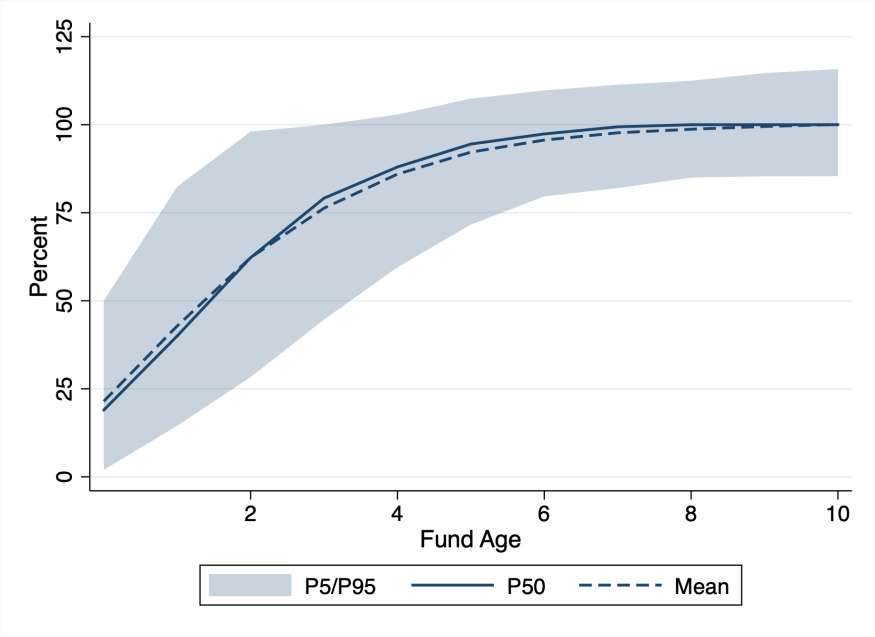


Figure 3: Cross-sectional Distribution of Total Investment Amount

This figure displays the cross-sectional distribution of the total amount of drawdowns as a percentage of committed capital. The sample consists of US PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to call capital by 2020. Some funds have drawdowns exceeding 100% of their committed capital due to recycling provisions that allow fund managers to reinvest exit proceeds, rather than return them to investors, under certain conditions. Most funds make capital calls that are in total close to their fund size. Figure B1 shows that the patterns are robust to subsamples by fund type, fund size, and fund sequence.



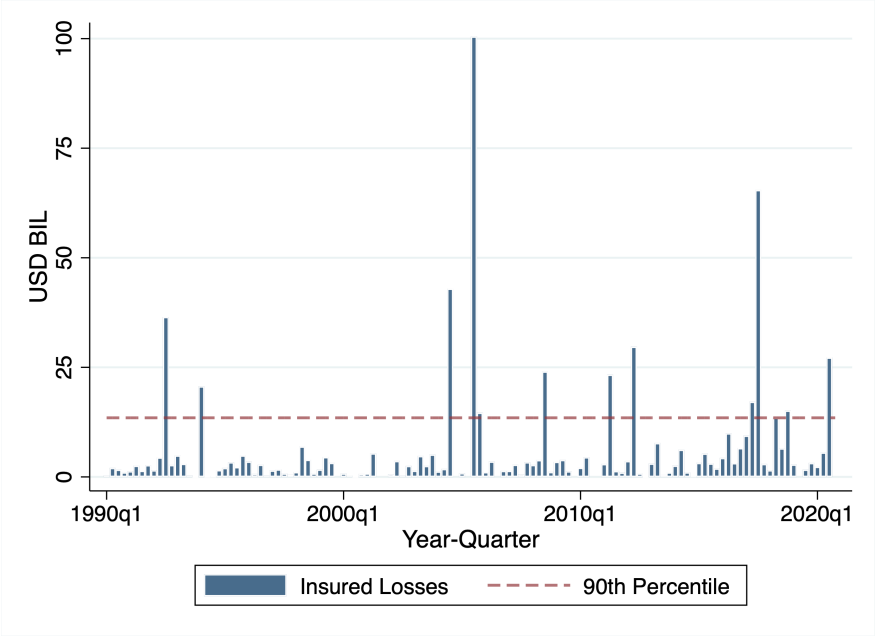
(a) Drawdowns by Fund Age



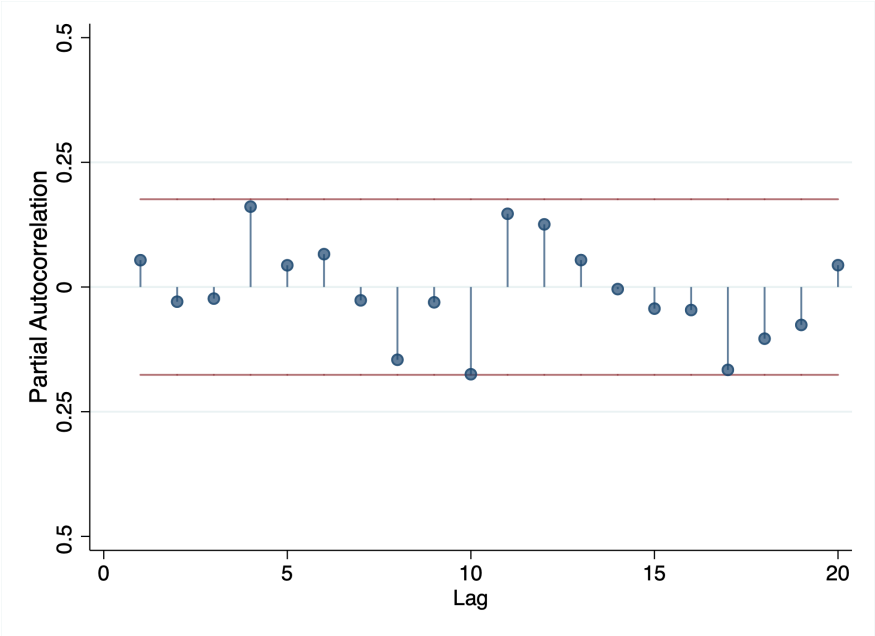
(b) Cumulative Drawdowns by Fund Age

Figure 4: Investment Pace of Private Equity Funds

Figure 4a displays the mean, median, and tails of capital calls as a percentage of total committed capital, by fund age in years. The sample consists of US PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to draw down cash from investors by 2020. The dash and solid lines represent the mean and median values. The shaded area illustrates the range between the 5th percentile and the 95th percentile. Figure 4b plots the distribution of cumulative capital calls over the fund life cycle. Figure B2 and B3 show that the patterns are robust to subsamples by fund type, fund size, and fund sequence.



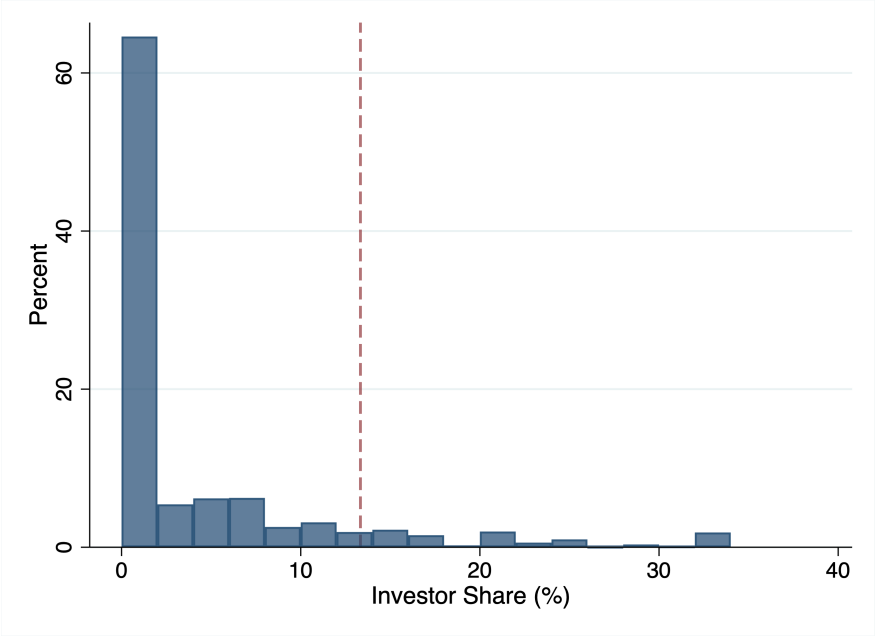
(a) Quarterly Insured Losses Caused by Natural Disasters



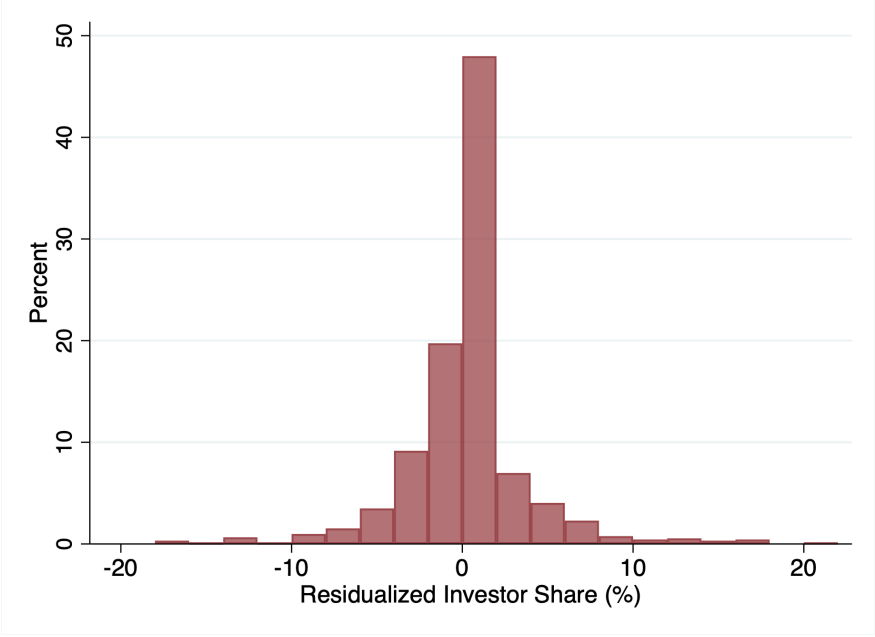
(b) Partial Autocorrelation of the Occurrence of Liquidity Shocks

Figure 5: Liquidity Shocks and Abnormal Insured Losses Caused by Natural Disasters

Figure 5a shows the quarterly insured losses resulting from natural disasters in the US during 1990-2020. The horizontal red dashed line indicates the 90th percentile value (13.5 USD BIL). Periods with insured losses equal to or greater than this value are considered as having abnormal insured losses caused by natural disasters, and are liquidity shocks to property & casualty (P&C) insurers. Figure 5b shows the partial autocorrelation of the time series of the indicator variable *Liquidity Shock*. The red horizontal lines indicate the 95% confidence intervals. The Durbin-Watson statistics for the time series is 1.89, which cannot reject the null hypothesis of no serial correlation. These tests suggest that liquidity shocks resulting from large natural disasters are unpredictable for P&C insurers. Figure B4a presents the quarterly death toll caused by natural disasters, indicating their weak impacts on life insurers.



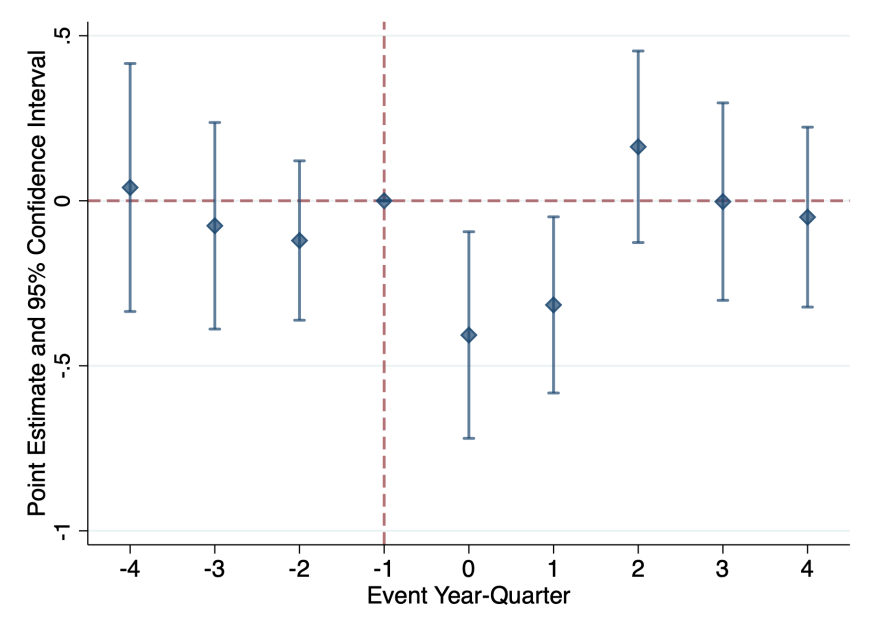
(a) P&C Insurer Share (%)



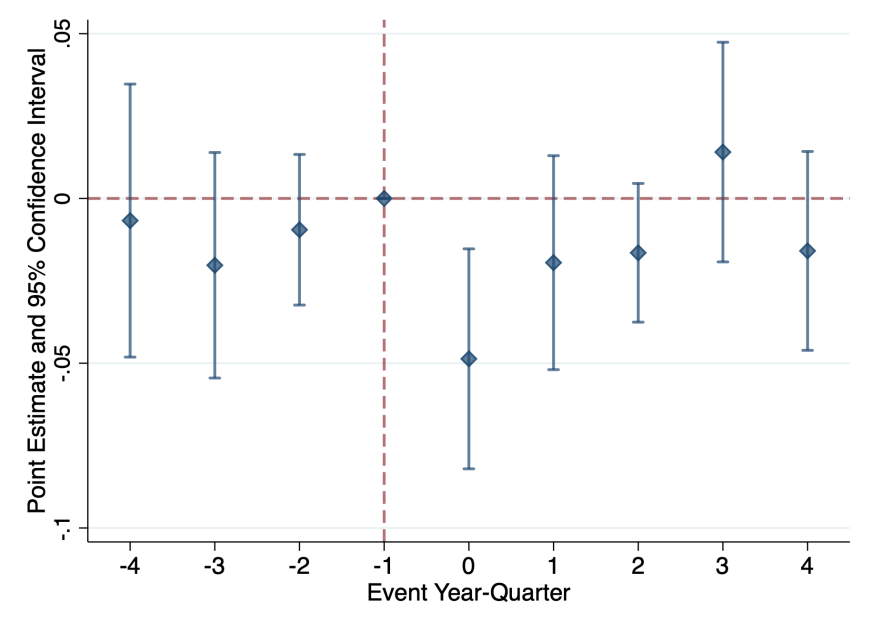
(b) Residual P&C Insurer Share (%)

Figure 6: Share of Property & Casualty Insurers at the Private Equity Fund Level

Figure 6a shows the cross-sectional distributions of the property & casualty insurer share at the PE fund level. Insurance companies with P&C insurance divisions are considered as P&C insurers. The sample consists of PE funds raised in the US between 1990 and 2020. The red vertical dashed line represents the 90th percentile value (13.3%). Figure 6b shows the cross-sectional distribution of the residual property & casualty insurer share at the PE fund level. The residual is obtained by regressing the unconditional value on fund manager × fund type × fund size dummies. The adjusted R^2 is 0.51, indicating sizable variation in the residual P&C insurer share. Table B1 reports the balance of fund characteristics.



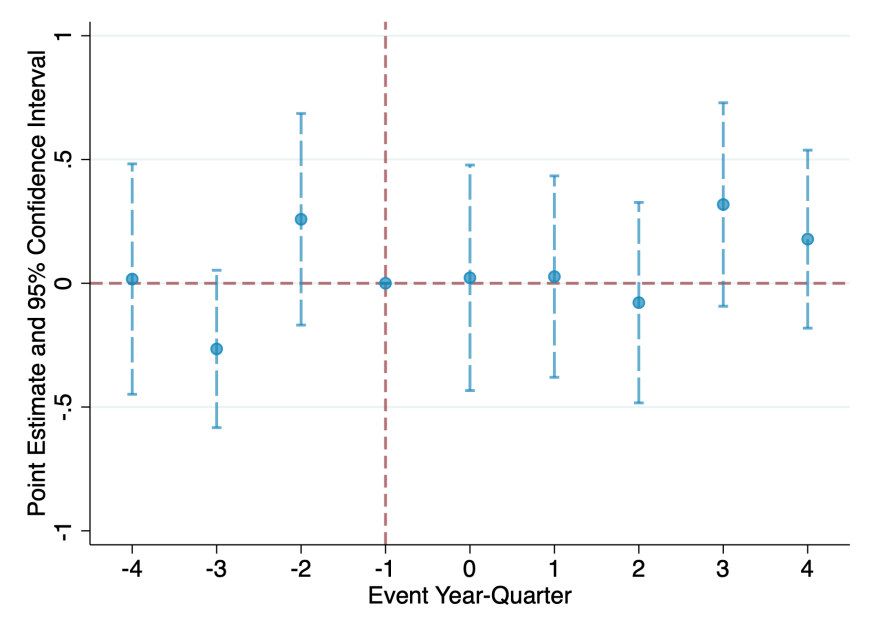
(a) Capital Called (%)



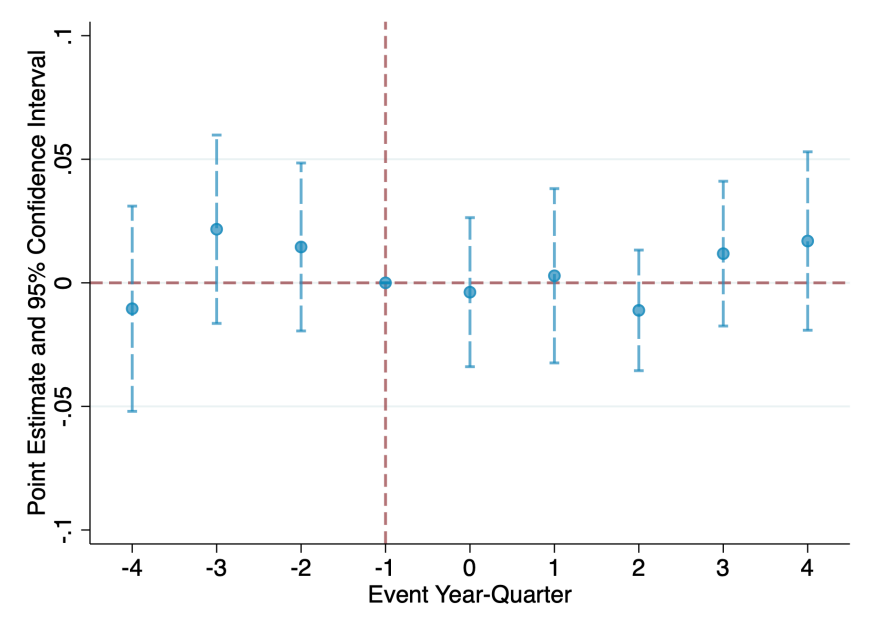
(b) Number of Investments

Figure 7: Private Equity Funds' Investment Dynamics Around Funding Shocks

This figure plots the coefficient estimates of *P&C Insurer Exposure* × *Liquidity Shock*$_{t+n}$ in Equation (2) and the associated two-tailed 95% confidence intervals. The red vertical dashed line marks the quarter before liquidity shocks, with the coefficient normalized to zero. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *Liquidity Shock*$_{t+n}$ is an indicator variable equal to one for a calendar quarter if it is n quarters before/after a calendar quarter with abnormal insured loss when n is negative/positive, and zero otherwise. The outcome variables are indicated in subcaptions. The regressions include year-quarter, fund age, fund manager × fund type × fund size fixed effects and use standard errors two-way clustered at the fund and calendar quarter levels. Detailed variable definitions are provided in Appendix A.



(a) Capital Called (%)



(b) Number of Investments

Figure 8: Investment Dynamics - Natural Disasters and Exposure to Life Insurers

This figure plots the coefficient estimates of *Life Insurer Exposure* × *Liquidity Shock*$_{t+n}$ in Equation (2) and the associated two-tailed 95% confidence intervals. The red vertical dashed line marks the quarter before liquidity shocks, with the coefficient normalized to zero. *Life Insurer Exposure* is an indicator variable equal to one if the share of life insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *Liquidity Shock*$_{t+n}$ is an indicator variable equal to one for a calendar quarter if it is n quarters before/after a calendar quarter with abnormal insured loss when n is negative/positive, and zero otherwise. The outcome variables are indicated in subcaptions. The regressions include year-quarter, fund age, fund manager × fund type × fund size fixed effects and use standard errors two-way clustered at the fund and calendar quarter levels. Detailed variable definitions are provided in Appendix A.

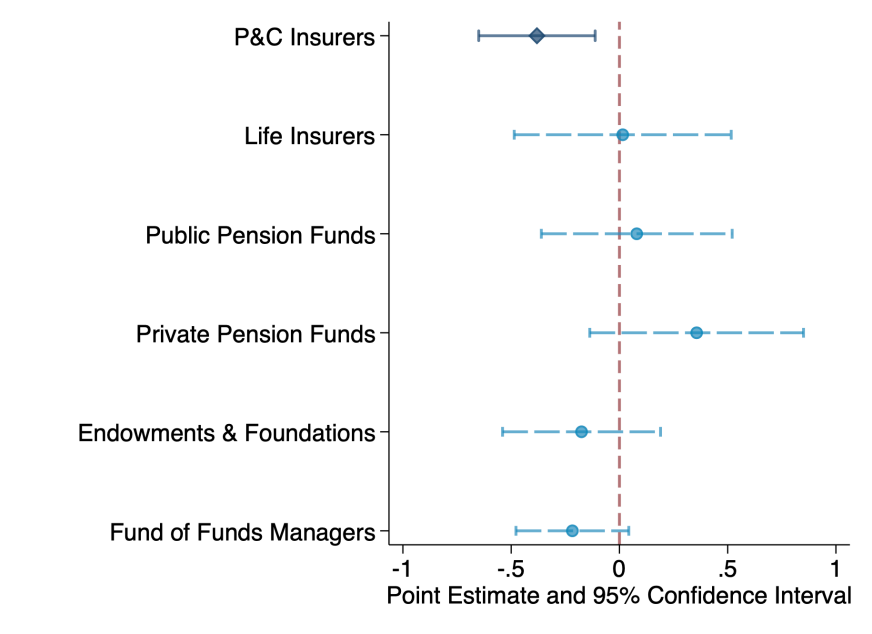


Figure 9: DiD Estimates Based on Exposure to Different Investor Types

For *Capital Called (%)*, this figure plots the difference-in-differences (DiD) coefficients in Equation (1) and the associated two-tailed 95% confidence intervals estimated separately based on PE funds' exposure to different types of investors. The exposure measures are defined similarly to *P&C Insurer Exposure*, an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. Insurance companies with P&C insurance divisions are considered as P&C insurers. Insurance companies with only life or health insurance divisions are considered as life insurers. Each row corresponds to the estimated coefficient of one alternative measure. The top row shows the estimate for *P&C Insurer Exposure* × *Liquidity Shock*. The regressions include year-quarter, fund age, fund manager × fund type × fund size fixed effects and use standard errors two-way clustered at the fund and calendar quarter levels.

Table 1: Periods with Abnormal Insured Losses Caused by Natural Disasters

This table shows the calendar quarter in which natural disasters lead to abnormal insured losses to insurance companies. Abnormal insured losses are defined as those equal to or greater than the 90th percentile value of quarterly losses during 1990 and 2020. The table includes details such as insured loss amounts, total losses, and the names of major disasters. The calendar quarters are ranked by total insured loss in descending order.

Ranking	Year-Quarter	Insured Loss (USD BIL)	Total Loss (USD BIL)	Major Disasters
1	2005Q3	100.48	198.73	Hurricane Katrina & Hurricane Rita
2	2017Q3	65.44	168.25	Hurricane Maria & Hurricane Irma
3	2004Q3	42.94	76.84	Hurricane Ivan & Hurricane Charley
4	1992Q3	36.48	61.17	Hurricane Andrew
5	2012Q2	29.69	46.66	Draught
6	2020Q3	27.22	45.02	Hurricane Laura
7	2008Q3	24.04	48.50	Hurricane Ike
8	2011Q2	23.31	45.15	Storms
9	1994Q1	20.65	54.84	Northridge Earthquake
10	2017Q2	17.13	23.44	Tubbs, Atlas, Nuns Fires
11	2018Q4	15.11	23.47	Hurricane Michael
12	2005Q4	14.64	20.32	Hurricane Wilma
13	2018Q2	13.49	21.58	Camp Fire

Table 2: Summary Statistics

This table reports the summary statistics for the main variables used in the analysis. The sample consists of PE funds raised in the US between 1990 and 2020. In Panel A, a unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *Cash Distributed (%)* is the quarterly amount of capital returned to the investors by a PE fund as a percentage of its fund size. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Life Insurer Exposure* and *Life Insurer Share* are defined similarly and based on insurers only with life or health insurance divisions. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Fund Age* is the fund age in calendar quarters. In Panel B, the sample consists of PE funds and their portfolio companies financed during the period 1990-2015. A unit of observation is a fund-company pair. *IPO* is an indicator variable equal to one if the company goes public, and zero otherwise. *Successful Exit* is an indicator variable equal to one if the company goes public or is acquired with a valuation equal to or greater than 2.5 (the median value of acquisition multiple) to the total amount of capital raised by the company. *Early Investment* is an indicator variable equal to one if the company is invested in less than one year after the fund vintage year, and zero otherwise. Detailed variable definitions are provided in Appendix A.

	Mean	Std.	p10	p25	p50	p75	p90	N
Panel A: Fund-Quarter Level								
Capital Called (%)	2.34	4.80	0.00	0.00	0.00	2.80	8.00	65,805
Number of Investments	0.38	0.51	0.00	0.00	0.00	1.00	1.00	65,805
P&C Insurer Exposure	0.09	0.28	0.00	0.00	0.00	0.00	0.00	65,805
P&C Insurer Share (%)	3.89	6.70	0.00	0.00	0.00	6.06	12.50	65,805
Liquidity Shock	0.13	0.34	0.00	0.00	0.00	0.00	1.00	65,805
Life Insurer Exposure	0.08	0.27	0.00	0.00	0.00	0.00	0.00	65,805
Life Insurer Share (%)	4.98	7.74	0.00	0.00	0.00	8.11	15.38	65,805
Liquid Secondary Market	0.19	0.39	0.00	0.00	0.00	0.00	1.00	65,535
High Drawdown	0.50	0.50	0.00	0.00	1.00	1.00	1.00	65,805
Endowment Share (%)	16.85	16.04	0.00	0.00	13.56	25.00	40.00	65,805
Fund Age (Quarters)	23.19	16.03	3.00	9.00	21.00	35.00	47.00	65,805
Panel B: Fund-Company Pair Level								
IPO	0.10	0.30	0.00	0.00	0.00	0.00	1.00	37,358
Successful Exit	0.18	0.39	0.00	0.00	0.00	0.00	1.00	37,358
Early Investment	0.48	0.50	0.00	0.00	0.00	1.00	1.00	37,358
Endowment Share (%)	23.20	22.37	0.00	5.26	19.05	33.33	52.00	37,358

Table 3: Liquidity Shocks and Amount of Drawdowns

This table presents the difference-in-differences estimates of the regression in Equation (1) examining the impact of investors' liquidity shocks on PE fund drawdowns. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Capital Called (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Exposure	-0.083*	-0.088	-0.030			
	[0.048]	[0.060]	[0.162]			
P&C Insurer Exposure × Liquidity Shock	-0.435***	-0.404***	-0.381***			
	[0.144]	[0.139]	[0.137]			
P&C Insurer Share				0.000	-0.003	0.001
				[0.002]	[0.003]	[0.010]
P&C Insurer Share × Liquidity Shock				-0.023***	-0.022***	-0.021***
				[0.007]	[0.007]	[0.007]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.195	0.203	0.207	0.195	0.203	0.207

Table 4: Liquidity Shocks and Number of Investments

This table presents the difference-in-differences estimates of the regression in Equation (1) examining the impact of investors' liquidity shocks on the number of investments made by PE funds. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Number of Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Exposure	-0.035**	-0.026*	-0.013			
	[0.014]	[0.015]	[0.016]			
P&C Insurer Exposure × Liquidity Shock	-0.066***	-0.053***	-0.049***			
	[0.019]	[0.015]	[0.014]			
P&C Insurer Share				-0.001	0.000	0.001
				[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock				-0.003***	-0.002***	-0.002***
				[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.251	0.297	0.313	0.250	0.297	0.313

Table 5: Private Equity Investment - Natural Disasters and Life Insurers

This table presents the difference-in-differences estimates of the regression in Equation (1) examining the investment difference between funds with high versus low exposure to life insurers during large natural disasters. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *Life Insurer Exposure* is an indicator variable equal to one if the share of life insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *Life Insurer Share* is the percentage of investors that are life insurers within a fund. Insurance companies with only life or health insurance divisions are considered as life insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Amount of Drawdowns

	Capital Called (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
Life Insurer Exposure × Liquidity Shock	-0.007	0.021	0.015			
	[0.251]	[0.249]	[0.256]			
Life Insurer Share × Liquidity Shock				0.002	0.003	0.002
				[0.009]	[0.009]	[0.009]
Life Insurer Variable	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.195	0.203	0.207	0.195	0.203	0.207

Panel B: Number of Investments

	Number of Investments					
	(1)	(2)	(3)	(4)	(5)	(6)
Life Insurer Exposure × Liquidity Shock	-0.013	-0.009	-0.006			
	[0.015]	[0.014]	[0.015]			
Life Insurer Share × Liquidity Shock				-0.000	-0.000	-0.000
				[0.001]	[0.001]	[0.001]
Life Insurer Variable	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.250	0.297	0.313	0.250	0.297	0.313

Table 6: Liquidity Shocks and Private Company Productivity

This table reports the estimates of the regression specification in Equation (3). A unit observation is a fund-company pair across different years affected by liquidity shocks as indicated in Table 1. Δ*Number of Highly Cited Patents* is the first difference in the number of (eventually granted) highly cited patents applied for in the year after and before liquidity shocks. Highly cited patents are defined as those with the top tercile/quintile numbers of citations among patents granted in the same year. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Life Insurer Share* is the percentage of investors that are life insurers within a fund. Insurance companies with only life or health insurance divisions are considered as life insurers. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and company levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Fund Exposure to P&C Insurers

	ΔNumber of Highly Cited Patents					
	Top Tercile			Top Quintile		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-0.001	-0.005*	-0.008*	-0.001	-0.004**	-0.007**
	[0.001]	[0.003]	[0.004]	[0.001]	[0.002]	[0.003]
Year FE	✓	✓	✓	✓	✓	✓
Company FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	123,493	123,434	118,408	123,493	123,434	118,408
R^2	0.446	0.453	0.453	0.437	0.444	0.445

Panel B: Fund Exposure to Life Insurers

	ΔNumber of Highly Cited Patents					
	Top Tercile			Top Quintile		
	(1)	(2)	(3)	(4)	(5)	(6)
Life Insurer Share	0.000	0.000	0.002	-0.000	-0.001	0.001
	[0.001]	[0.002]	[0.002]	[0.001]	[0.001]	[0.002]
Year FE	✓	✓	✓	✓	✓	✓
Company FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	123,493	123,434	118,408	123,493	123,434	118,408
R^2	0.446	0.453	0.453	0.437	0.444	0.445

Table 7: Secondary Market Liquidity and Investor Base

This table reports the results from triple-diff estimations examining whether a liquid secondary market for PE fund shares attenuates the impacts of investors' liquidity shocks on PE funds' investment. A liquid secondary market allows PE funds to adjust their investor base more easily due to the increased transferability of PE investments. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Liquid Secondary Market* is an indicator variable equal to one for a fund-quarter if the secondary fund dry powder at the beginning of the quarter is in the top quintile group within a fund's lifespan, and zero otherwise. Dry powder is the cash reserves that fund managers hold for investment when they identify attractive opportunities. Control variables including the stand-alone and other two-way interaction terms are suppressed in the table. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share × Liquidity Shock	-0.031***	-0.029***	-0.028***	-0.004***	-0.003***	-0.003***
	[0.009]	[0.009]	[0.009]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock × Liquid Secondary Market	0.029***	0.027***	0.027***	0.004**	0.004**	0.004**
	[0.009]	[0.009]	[0.009]	[0.001]	[0.001]	[0.002]
Control Variables	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,535	65,535	64,430	65,535	65,535	64,430
R^2	0.195	0.203	0.207	0.251	0.298	0.314

Table 8: Cumulative Drawdowns and Enforceability of Capital Calls

This table reports the results from triple-diff estimations examining whether increased cumulative drawdowns mitigate the transmission of investors' liquidity shocks to PE funds. Early investments act as collateral against capital call defaults due to the forfeiture provision - investors risk losing their contributed capital if they cannot meet capital calls. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Cumulative Drawdown* is a variable ranging from 1 to 5 that ranks a fund by calendar quarter based on its cumulative drawdown at the beginning of each period, with 5 indicating the highest value. Control variables including the stand-alone and other two-way interaction terms are suppressed in the table. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share × Liquidity Shock	-0.065***	-0.065***	-0.065***	-0.004	-0.003	-0.003
	[0.019]	[0.019]	[0.019]	[0.002]	[0.002]	[0.002]
P&C Insurer Share × Liquidity Shock × Cumulative Drawdown	0.015***	0.015***	0.015***	0.000	0.000	0.000
	[0.005]	[0.005]	[0.005]	[0.001]	[0.001]	[0.001]
Control Variables	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.200	0.216	0.225	0.258	0.308	0.324

Table 9: Investor Base and Acceleration of Drawdowns

This table reports the estimates of the panel regression in Equation (4) investigating the relationship between PE funds' investor base and investment pace in response to expected liquidity shocks. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.014***	-0.009	-0.009*	-0.001*	-0.001	-0.000
	[0.005]	[0.006]	[0.006]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.955***	-1.880***	-1.720***	-0.219***	-0.205***	-0.160***
	[0.054]	[0.062]	[0.073]	[0.006]	[0.006]	[0.007]
Log(1 + Fund Age) × Endowment Share	0.004**	0.004*	0.003*	0.000*	0.000	0.000
	[0.002]	[0.002]	[0.002]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.159	0.167	0.172	0.168	0.216	0.243

Table 10: Investor Base and Suboptimal Selection of Portfolio Companies

This table reports the results from cross-sectional regressions investigating the relationship between PE funds' investor base and distorted investment schedule resulting from expected liquidity shocks. The sample consists of PE funds paired with their portfolio companies financed during the period 1990-2015. A unit of observation is a fund-company pair. *IPO* is an indicator variable equal to one if the company goes public, and zero otherwise. *Successful Exit* is an indicator variable equal to one if the company goes public or is acquired with a valuation equal to or greater than 2.5 (the median value of acquisition multiple) to the total amount of capital raised by the company. *Early Investment* is an indicator variable equal to one if the company is invested in less than one year after the fund vintage year, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and company levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels. The coefficient estimates and standard errors are scaled by 100.

	IPO		Successful Exit	
	(1)	(2)	(3)	(4)
Early Investment	-1.523**	-1.432**	-1.631**	-1.607*
	[0.646]	[0.646]	[0.812]	[0.825]
Early Investment × Endowment Ratio	0.034**	0.049***	0.026	0.042*
	[0.017]	[0.017]	[0.024]	[0.025]
Fund FE	✓	✓	✓	✓
First Investment Year FE	✓		✓	
Company Industry FE	✓		✓	
Company State FE	✓		✓	
Company Industry × Investment Year FE		✓		✓
Company State × Investment Year FE		✓		✓
Observations	37,939	37,777	37,939	37,777
R^2	0.187	0.219	0.197	0.225

Online Appendix for "Liquidity Shocks and Private Equity Investment"

Yingxiang Li

City University of Hong Kong

November 2024

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A Variable Definitions

Variable Name	Definition
Panel A: Fund-Quarter Level	
Capital Called (%)	Quarterly amount of capital called by a PE fund as a percentage of its fund size.
Number of Investments	Number of investments made by the fund in each calendar quarter.
Investment Amount / Fund Size (%)	Quarterly total deal size as a percentage of the fund size.
Number of Deals	number of deals invested by a fund in each calendar quarter.
Cash Distributed (%)	Quarterly amount of capital returned to the investors by a PE fund as a percentage of its fund size.
P&C Insurer Exposure	An indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. Insurance companies with P&C insurance divisions are considered as P&C insurers.
P&C Insurer Share	The percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers.
Liquidity Shock	An indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise.
Liquidity Shock$_{t+n}$	An indicator variable equal to one for a calendar quarter if it is n quarters before/after a calendar quarter with abnormal insured losses when n is negative/positive, and zero otherwise.
Life Insurer Exposure	An indicator variable equal to one if the share of life insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. Insurance companies with only life or health insurance divisions are considered as life insurers.
Life Insurer Share	The percentage of investors that are life insurers within a fund. Insurance companies with only life or health insurance divisions are considered as life insurers.
Endowment Share	The percentage of investors that are endowments or foundations within a fund. Both endowments and foundations are included.
Liquid Secondary Market	An indicator variable equal to one for a fund-quarter if the secondary fund dry powder at the beginning of the quarter is in the top quintile group within a fund's lifespan, and zero otherwise. Dry powder is the cash reserves that fund managers hold for investment when they identify attractive opportunities.
Cumulative Drawdown	A variable ranging from 1 to 5 that ranks a fund by calendar quarter based on its cumulative drawdown at the beginning of each period, with 5 indicating the highest value.
Log(1 + Fund Age)	Natural logarithm of one plus the fund age in calendar quarters.
Credit Spread	Average quarterly difference between the yields on BAA- and AAA-rated corporate bonds.

Term Spread	Average quarterly difference between the 10-year and 3-month yields on US Treasury bills.
Panel C: Fund-Company-Event Level	
Δ*Number of Highly Cited Patents*	The first difference in the number of (eventually granted) highly cited patents applied for in the year after and before liquidity shocks. Highly cited patents are defined as those with the top tercile/quintile numbers of citations among patents granted in the same year.
Panel C: Fund-Company Level	
IPO	An indicator variable equal to one if the company goes public, and zero otherwise.
Successful Exit	An indicator variable equal to one if the company goes public or is acquired with a valuation equal to or greater than 2.5 to the total amount of capital raised by the company.
Early Investment	An indicator variable equal to one if the company is invested in less than one year after the fund vintage year, and zero otherwise.
Endowment Share	The percentage of investors that are endowments or foundations within a fund.
Panel D: Fund Level	
DPI (%)	The ratio of cash distributed to investors by a fund, relative to their capital contributions.
TVPI (%)	The ratio of the current value of remaining investments within a fund, plus the total value of all distributions to date, relative to the total value of investors' capital contributions.
Shock Vintage	An indicator variable equal to one for a fund if natural disasters lead to abnormal insured losses in the next 4 quarters after its vintage year, and zero otherwise.
Buyout Fund	An indicator variable equal to one for a buyout fund, and zero for a venture capital fund.
Target Size	The target amount of capital to be raised by the PE fund.
Fund Size	Amount of capital raised by a PE fund at the end of fundraising.
Fund Sequence	The order in which a fund is raised by a private equity firm.
Number of Investors	The number of investors providing capital to the PE fund.
CA	An indicator variable equal to one if the fund manager is located in California. *NY*, *MA*, *IL*, and *TX* are defined similarly based on whether the fund manager is located in New York (NY), Massachusetts (MA), Illinois (IL), or Texas (TX).

B Appendix: Additional Results

Besides tests discussed in Section 5.7, Appendix B presents additional results on the impacts of liquidity shocks.

B.1 Lower Realized Fund Returns

To evaluate whether funding shocks are costly to PE funds, I estimate various forms of the following cross-sectional regression based on funds raised in the US between 1990 and 2005:[34]

$$y_i = \beta \times \textit{Investor Base}_i + \gamma \times \textit{Investor Base}_i \times \textit{Shock Vintage}_t + \boldsymbol{FEs} + \epsilon_j \qquad (6)$$

in which i and t denote a PE fund and a vintage year. The outcome variable y is a measure of PE fund returns realized through sales of portfolio companies via IPOs and M&As. *Shock Vintage* is an indicator variable equal to one for a fund if natural disasters lead to abnormal insured losses in the next 4 quarters after its vintage year, and zero otherwise. The standalone *Shock Vintage* is absorbed by the vintage year fixed effects. Standard errors are clustered at the fund manager level. *Shock Vintage* is plausibly random because the fund completed its fundraising before significant natural disasters occurred, and the timing of these events is difficult to anticipate. The identification assumption is that the matching between investors and PE funds is random conditional on the time-invariant characteristics of fund managers and observable characteristics of the funds they manage.

Table B2 Panel A shows that PE funds realize lower returns if they are hit by funding shocks in the initial investment stage. In Columns 1-3, the outcome variable is *DPI (%)*, the ratio of cash distributed to investors by a fund, relative to their capital contributions. This return measure is fully based on *realized* cash flows during the life of a PE fund. The

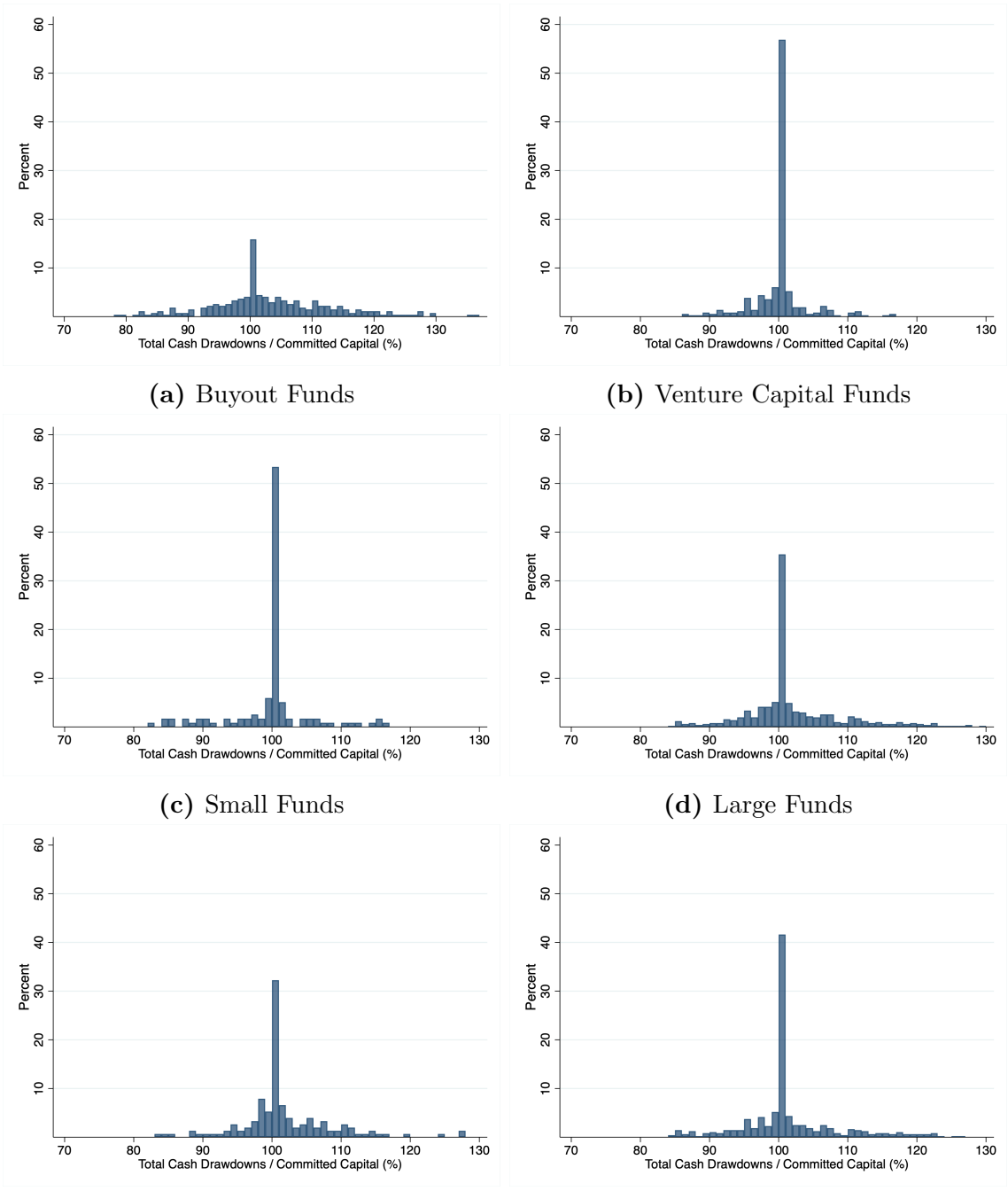
[34] These funds are chosen because they are likely to have been liquidated by the time of the study. The non-traded nature of PE funds gives rise to challenges in estimating their returns since returns often depend on funds' self-reported quarterly valuation of their portfolios, which is often stale and subject to manipulation, leading to biases in performance comparison (e.g., Korteweg, 2019; Gupta and Van Nieuwerburgh, 2021). This reporting issue can be solved by examining the returns of liquidated funds since all of their cash flow has been realized. Table B3 reports the summary statistics for the sample funds.

coefficient estimates of *P&C Insurer Share* × *Shock Vintage* are negative and statistically significant. Column 3 indicates that a one-standard-deviation increase in *P&C Insurer Share* will reduce *DPI* by around 27 percentage points (17% of the unconditional mean) if the fund is formed shortly before large natural disasters. To take into account the value of some potential tail-end funds, I use an alternative measure *TVPI (%)*, the ratio of the current value of remaining investments within a fund, plus the total value of all distributions to date, relative to the total value of investors' capital contributions. As reported in Columns 4-6, My results are quantitatively and qualitatively similar. In Panel B, the insignificant coefficient estimates of *Life Insurer Share* × *Shock Vintage* across all columns provide additional support for causality. Overall, the differences in realized fund returns shown in Table B2 suggest that liquidity shocks lead to suboptimal investment outcomes since PE funds cannot invest as planned.

B.2 Amount of Cash Distributions

There is much less flexibility in cash distributions compared to capital calls because PE funds must wait for favorable market conditions for profitable exits if there is any (Gompers, Gornall, Kaplan, and Strebulaev, 2020). Rushed or forced asset sales to meet investors' distribution requests can result in large price discounts due to illiquidity.

Table B4 shows that PE funds do not increase cash distributions to their P&C insurer investors after large natural disasters. *Cash Distributed (%)* is the quarterly amount of capital returned to investors by a PE fund as a percentage of its fund size. From Columns 1 to 6, the coefficient estimates of the DiD term are small in magnitude and highly insignificant, indicating no differences in cash distributions between funds with a higher and lower share of P&C insurers during quarters of large natural disasters.



(a) Buyout Funds

(b) Venture Capital Funds

(c) Small Funds

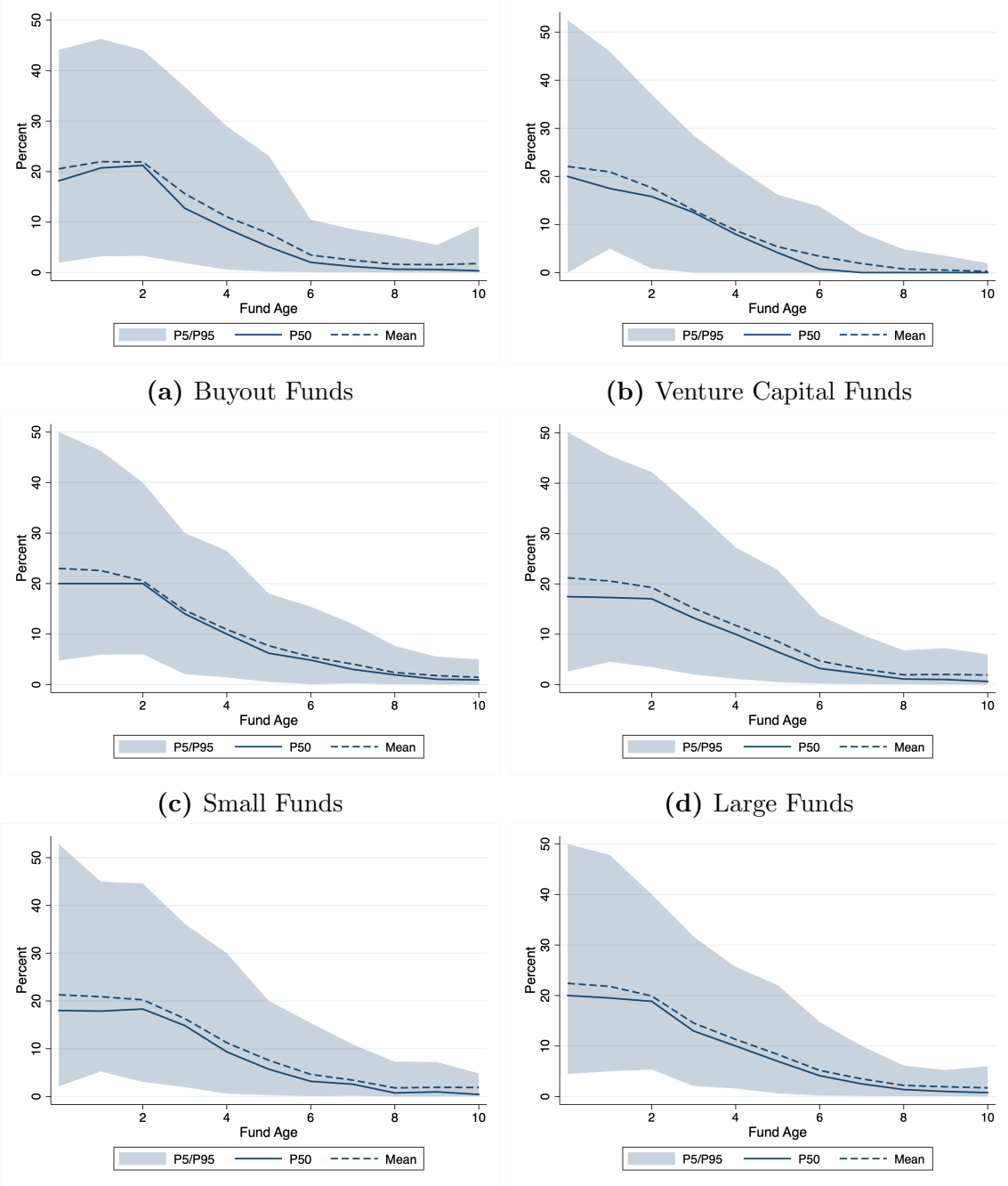
(d) Large Funds

(e) First Funds

(f) Non-First Funds

Figure B1: Cross-sectional Distribution of Total Investment Amount - Subsamples

For each subsample indicated in subcaptions, this figure displays the cross-sectional distribution of the total amount of drawdowns as a percentage of committed capital. The sample consists of US PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to call capital by 2020. The figure with the full sample is presented in Figure 3.



(a) Buyout Funds

(b) Venture Capital Funds

(c) Small Funds

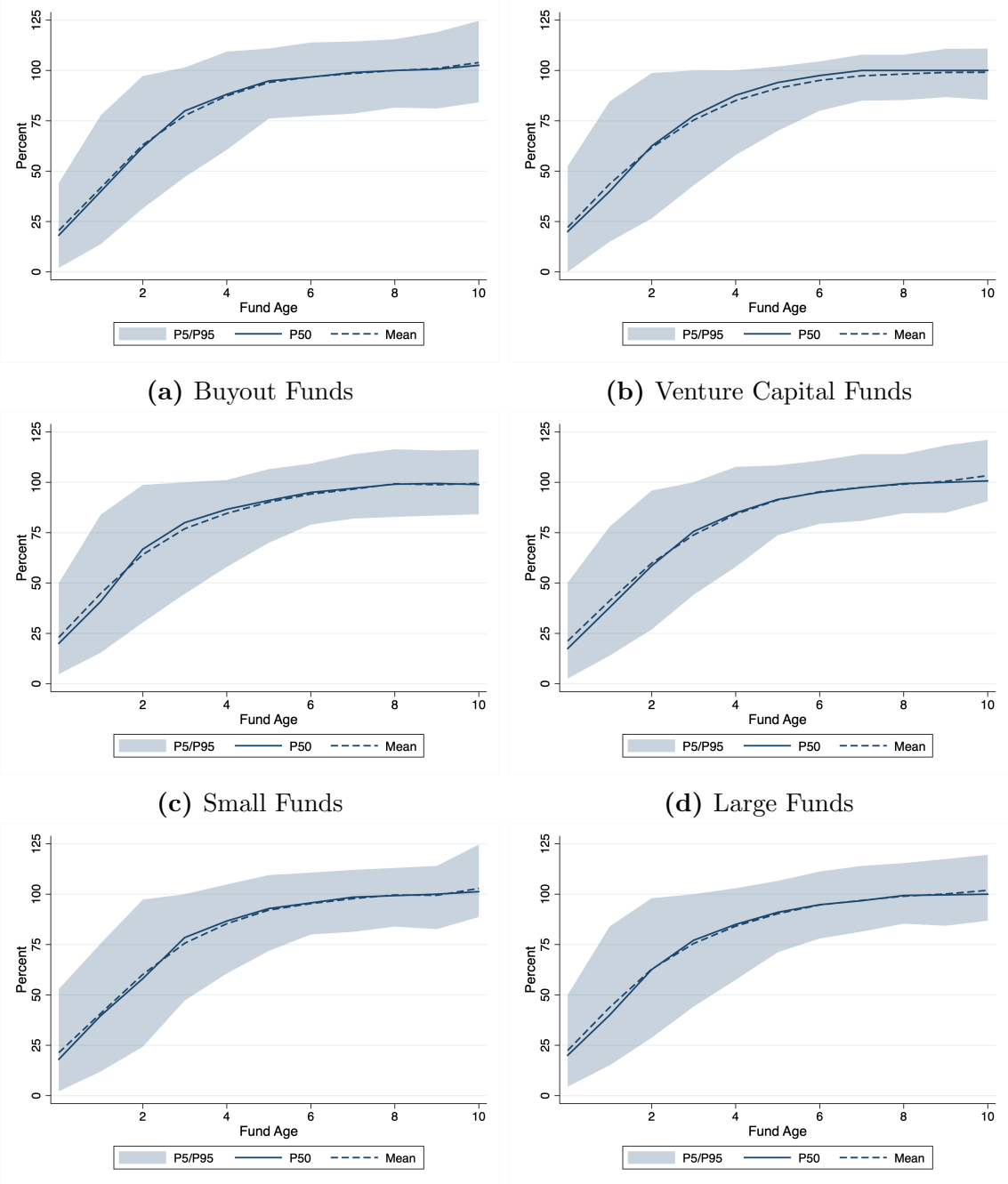
(d) Large Funds

(e) First Funds

(f) Non-First Funds

Figure B2: Drawdowns by Fund Age - Subsamples

For each subsample indicated in subcaptions, this figure presents the mean, median, and tails of capital calls as a percentage of total committed capital, by fund age in years. The sample consists of US PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to draw down cash from investors by 2020. The dash and solid lines represent the mean and median values. The shaded area illustrates the range between the 5th percentile and the 95th percentile. The figure with the full sample is presented in Figure 4a.



(a) Buyout Funds

(b) Venture Capital Funds

(c) Small Funds

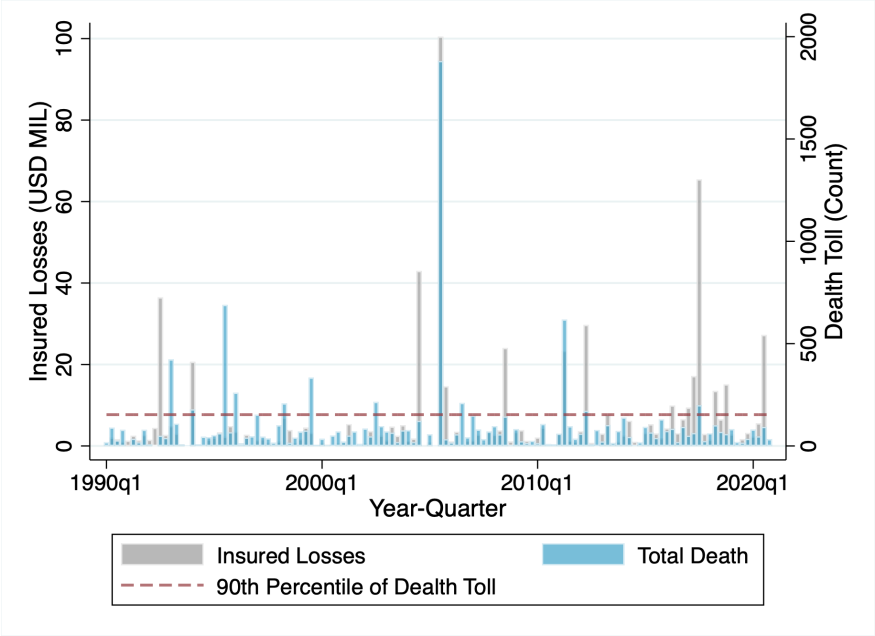
(d) Large Funds

(e) First Funds

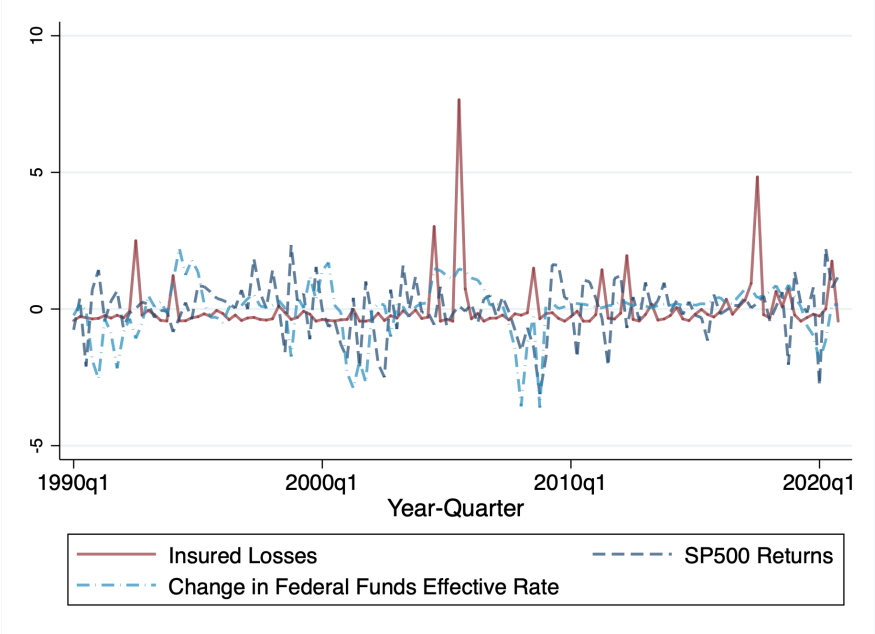
(f) Non-First Funds

Figure B3: Cumulative Drawdowns by Fund Age - Subsamples

For each subsample indicated in subcaptions, this figure presents the mean, median, and tails of cumulative capital calls as a percentage of total committed capital, by fund age in years. The sample consists of US PE funds raised between 1990 and 2005, ensuring that each fund has at least 15 years to draw down cash from investors by 2020. The dash and solid lines represent the mean and median values. The shaded area illustrates the range between the 5th percentile and the 95th percentile. The figure with the full sample is presented in Figure 4b.



(a) Property & Casualty vs. Life Insurance during Natural Disasters



(b) Natural Disasters and Marco Economic Shocks

Figure B4: Natural Disasters and Shocks to Different Investors

Figure B4a shows the quarterly insured losses and total death resulting from natural disasters in the US during 1990-2020. The horizontal red dashed line indicates the 90th percentile value of the quarterly death toll (153 counts), while the 90th percentile value of quarterly insured losses is 13.5 USD BIL. The life insurance claims resulting from natural disasters are small in dollars compared to the P&C insured losses and are unlikely to be liquidity shocks to life insurers. Table C6 reports rebostness checks excluding 2005Q3. Figure B4b shows the quarterly time series of insured damages caused by natural disasters, S&P 500 returns, and changes in the federal fund effective rate. All variables are standardized. The correlations of insured damages with S&P 500 returns and federal fund rate changes are -0.04 and 0.17, both statistically insignificant at the 5% level.

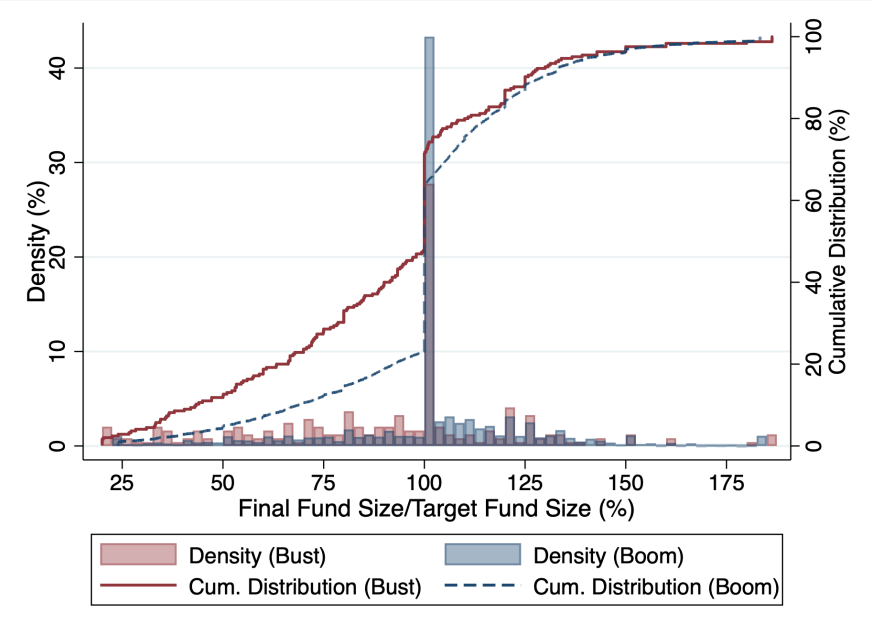
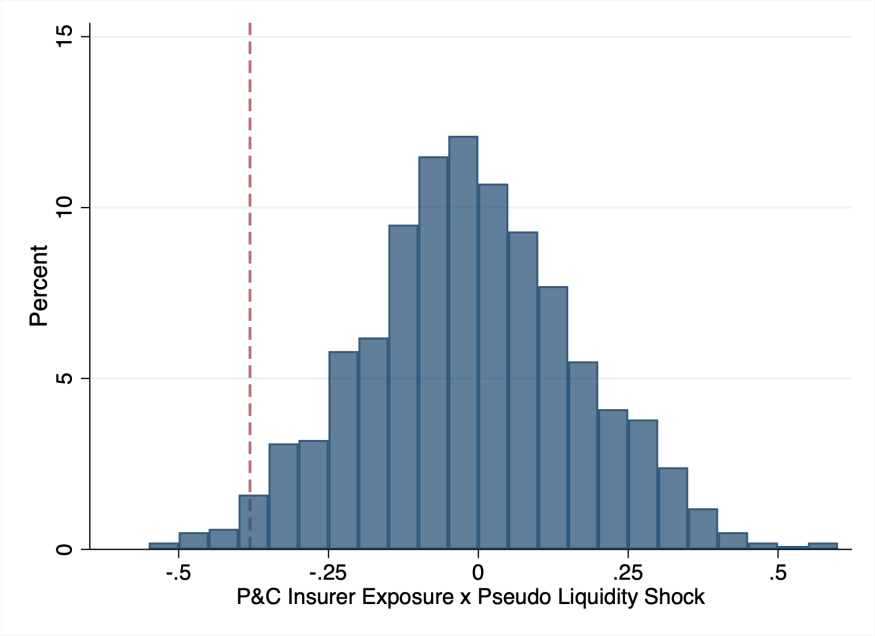
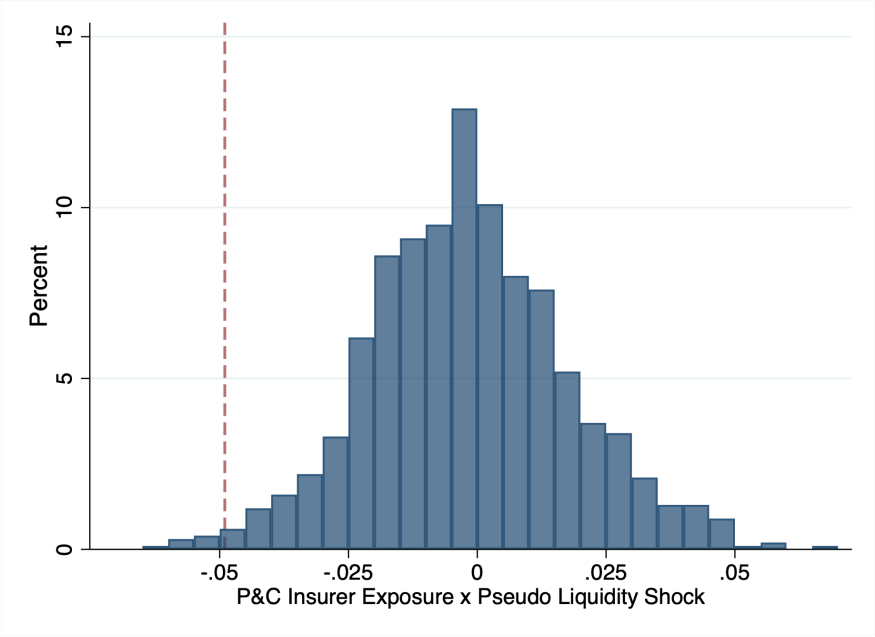


Figure B5: Subscription Ratio during Fundraising Boom and Bust Periods

This figure shows the (cumulative) distribution of PE fund subscription ratio during by fundraising boom and bust periods. The subscription ratio is defined as the ratio of the final fund size to the target fund size. Bust periods are 2001-2002 and 2009 (see Figure 1a), while the rest are considered boom periods. Around 48% of funds can not reach their target size during the bust period, while only 23% of funds are undersubscribed during the boom period. Funds raised in bust periods have more limited choices of their investor base than those raised in boom periods.



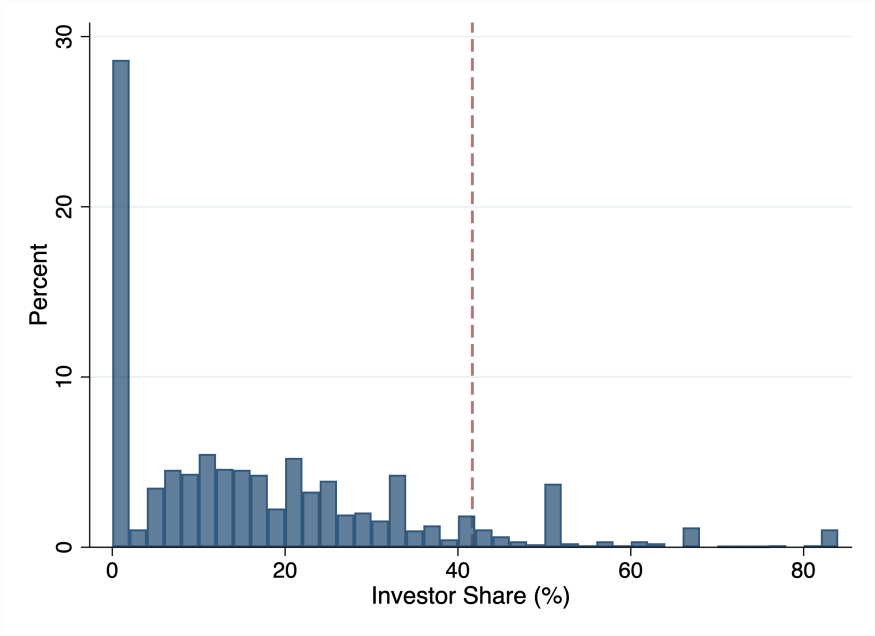
(a) Capital Called (%)



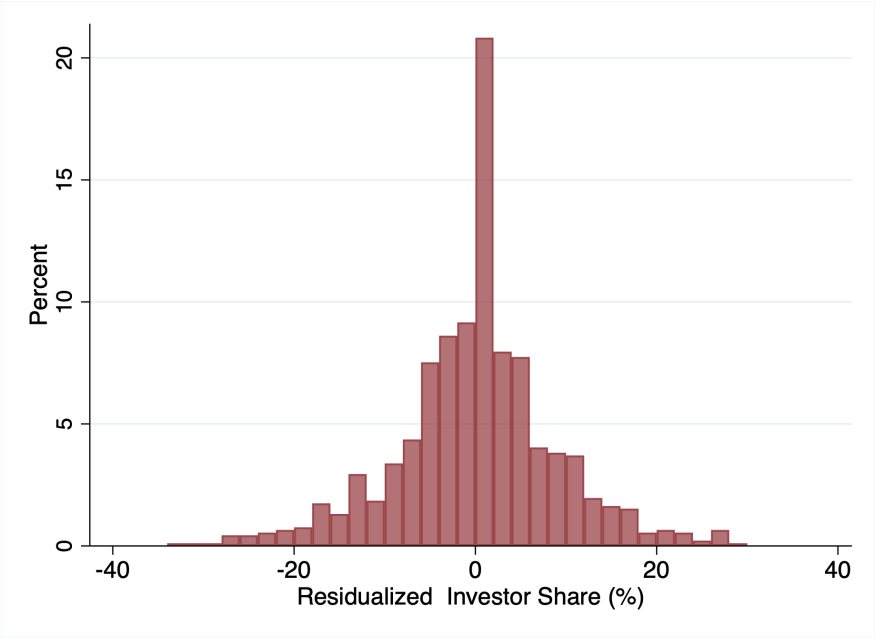
(b) Number of Investments

Figure B6: DiD Coefficients Estimated With Pseudo Liquidity Shocks

This figure plots the histogram of estimated DiD coefficients from 1,000 trials of a placebo test that randomly chooses 10% of the calendar quarters during 1990-2020 as those with pseudo liquidity shocks to P&C insurers. The DiD coefficient of *P&C Insurer* × *Pseudo Liquidity Shock* is estimated using the specification in Column 3 of Table 3 and 4, with the outcome variables indicated in subcaptions. The vertical dashed line in each figure indicates the corresponding coefficient estimates. More than 98% of the mass in Panels (a) and (b) is on the right side of the vertical dashed line.



(a) Endowment Share (%)



(b) Residual Endowment Share (%)

Figure B7: Share of Endowments at the Private Equity Fund Level

Figure B7a shows the cross-sectional distributions of the endowment share at the PE fund level. Both endowments and foundations are included. The sample consists of PE funds raised in the US between 1990 and 2020. The red vertical dashed line represents the 90th percentile value (41.7%). Figure B7b shows the cross-sectional distribution of the residual endowment share at the PE fund level. The residual is obtained by regressing the unconditional value on fund manager × fund type × fund size dummies. The adjusted R^2 is 0.52, indicating sizable variation in the residual P&C insurer share. Table B1 reports the balance of fund characteristics.

Table B1: Balance of Fund Characteristics

This table presents PE fund characteristics for funds in the first and last deciles based on the residualized share of P&C insurers (Panel A) and endowments (Panel B). The residual is obtained by regressing the unconditional value on fund manager × fund type × fund size dummies. The examined PE funds are buyout and venture capital funds raised between 1990 and 2020, excluding funds of funds, secondary funds, and co-investment funds. *Buyout Fund* is an indicator variable equal to one for a buyout fund, and zero for a venture capital fund. *Target Size* is the target amount of capital to be raised by the PE fund. *Fund Size* is the amount of capital raised by a PE fund at the end of fundraising. *Fund Sequence* is the order in which a fund is raised by a private equity firm. *CA* is an indicator variable equal to one if the fund manager is located in California. *NY*, *MA*, *IL*, and *TX* are defined similarly based on whether the fund manager is located in New York (NY), Massachusetts (MA), Illinois (IL), or Texas (TX). *Number of Investors* is the number of investors providing capital to the PE fund. Detailed variable definitions are provided in Appendix A. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Residualized P&C Insurer Share

	First Decile Mean	Last Decile Mean	Difference	t-stats
Buyout Fund	0.60	0.61	-0.01	-0.15
Target Size ($ MIL)	1333.35	1461.59	-128.24	-0.41
Fund Size ($ MIL)	1238.55	1388.51	-149.96	-0.54
Fund Sequence	4.26	4.78	-0.52	-1.41
Number of Investors	14.91	14.96	-0.04	-0.03
CA	0.35	0.26	0.09	1.28
NY	0.21	0.28	-0.08	-1.20
MA	0.12	0.12	0.00	0.00
IL	0.12	0.12	0.00	0.00
TX	0.02	0.02	0.00	0.00

Panel B: Residualized Endowment Share

	First Decile Mean	Last Decile Mean	Difference	t-stats
Buyout Fund	0.42	0.42	0.00	0.00
Target Size ($ MIL)	1321.10	1478.86	-157.75	-0.39
Fund Size ($ MIL)	1247.38	1423.56	-176.18	-0.55
Fund Sequence	4.59	4.77	-0.18	-0.42
Number of Investors	11.17	20.37	-9.20	-3.09***
CA	0.33	0.29	0.03	0.48
NY	0.16	0.18	-0.02	-0.39
MA	0.25	0.27	-0.02	-0.33
IL	0.03	0.02	0.01	0.45
TX	0.03	0.04	-0.01	-0.38

Table B2: Liquidity Shocks and Realized PE Fund Returns

This table reports the results from cross-sectional regressions investigating the real impacts of investors' liquidity shocks, based on realized PE fund returns. The sample consists of PE funds raised in the US between 1990 and 2005. These funds are chosen because they are likely to have been liquidated by the time of the study. A unit of observation is a fund. *DPI (%)* is the ratio of cash distributed to investors by a fund, relative to their capital contributions. The cash flow is realized through sales of portfolio companies in IPOs and M&As. To take into account the value of some potential tail-end funds, *TVPI (%)* is the ratio of the current value of remaining investments within a fund, plus the total value of all distributions to date, relative to the total value of investors' capital contributions. *Shock Vintage* is an indicator variable equal to one for a fund if natural disasters lead to abnormal insured losses in the next 4 quarters after its vintage year, and zero otherwise. The specifications in Columns 1 and 4 include vintage year and fund manager fixed effects. Columns 2 and 5 absorb the fund manager fixed effects with fund manager by fund type fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. The standalone *Shock Vintage* is absorbed by the vintage year fixed effects. The standalone *Shock Vintage* is absorbed by the vintage year fixed effects. Detailed variable definitions are provided in Appendix A. Standard errors are clustered at the fund manager level and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Fund Exposure to P&C Insurers

	DPI (%)			TVPI (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-1.043	0.737	-0.663	-0.967	0.823	-0.762
	[1.856]	[1.337]	[1.743]	[1.861]	[1.335]	[1.763]
P&C Insurer Share × Shock Vintage	-3.721*	-4.001*	-4.129*	-4.024*	-4.311**	-4.240*
	[2.121]	[2.155]	[2.456]	[2.096]	[2.129]	[2.419]
Vintage Year FE	✓	✓	✓	✓	✓	✓
Fund Manager FE	✓			✓		
Fund Manager × Fund Size FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	488	473	254	488	473	254
R^2	0.569	0.585	0.742	0.560	0.576	0.747

Panel B: Fund Exposure to Life Insurers

	DPI (%)			TVPI (%)		
	(1)	(2)	(3)	(4)	(5)	(6)
Life Insurer Share	1.080	0.593	-1.104	1.031	0.549	-1.291
	[1.088]	[1.060]	[1.242]	[1.101]	[1.075]	[1.258]
Life Insurer Share × Shock Vintage	5.482	6.832	-2.298	5.414	6.792	-2.263
	[5.267]	[5.333]	[3.307]	[5.341]	[5.406]	[3.211]
Vintage Year FE	✓	✓	✓	✓	✓	✓
Fund Manager FE	✓			✓		
Fund Manager × Fund Type FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	488	473	254	488	473	254
R^2	0.575	0.592	0.741	0.565	0.583	0.745

Table B3: Summary Statistics - Subsample for the Analysis of Fund Returns

This table reports the summary statistics for the variables used in the analysis of fund returns. The sample consists of PE funds raised in the US between 1990 and 2005. These funds are chosen because they are likely to have been liquidated by the time of the study. A unit of observation is a fund. *DPI (%)* is the ratio of cash distributed to investors by a fund, relative to their capital contributions. *TVPI (%)* is the ratio of the current value of remaining investments within a fund, plus the total value of all distributions to date, relative to the total value of investors' capital contributions. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Life Insurer Exposure* and *Life Insurer Share* are defined similarly and based on insurers only with life or health insurance divisions. *Shock Vintage* is an indicator variable equal to one for a fund if natural disasters lead to abnormal insured losses in the next 4 quarters after its vintage year, and zero otherwise. Detailed variable definitions are provided in Appendix A.

	Mean	Std.	p10	p25	p50	p75	p90	N
TVPI (%)	161.98	111.28	56.59	94.66	143.28	201.00	269.37	710
DVPI (%)	156.14	112.03	45.90	88.59	136.17	197.18	267.08	710
P&C Insurer Share	3.93	6.44	0.00	0.00	0.00	6.25	12.50	710
Life Insurer Share	4.11	7.13	0.00	0.00	0.00	6.25	14.29	710
Shock Vintage	0.16	0.37	0.00	0.00	0.00	0.00	1.00	710

Table B4: Liquidity Shocks and Amount of Cash Distributions

This table reports the results of difference-in-differences estimations suggesting that PE funds do not provide liquidity to investors through cash distributions when investors face liquidity shocks. Cash distributions are capital returned to investors when fund managers realize their investments in underlying companies, often through IPOs and M&As. The sample consists of PE funds raised in the US between 1990 and 2020. A unit of observation is a fund-quarter. *Cash Distributed (%)* is the quarterly amount of capital returned to the investors by a PE fund as a percentage of its fund size. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Cash Distributed (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Exposure	-0.140	-0.068	0.713			
	[0.266]	[0.370]	[0.794]			
P&C Insurer Exposure × Liquidity Shock	-0.043	-0.056	-0.151			
	[0.436]	[0.431]	[0.449]			
P&C Insurer Share				0.003	0.008	0.058**
				[0.010]	[0.016]	[0.029]
P&C Insurer Share × Liquidity Shock				0.001	0.001	-0.004
				[0.016]	[0.015]	[0.017]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,805	65,805	64,675	65,805	65,805	64,675
R^2	0.041	0.061	0.079	0.041	0.061	0.079

Table B5: Capital Calls and Investors' Funding Costs

This table reports OLS regression results that show PE funds call less capital when their investors' funding costs are high. Funding costs are measured by *Credit Spread*, the average quarterly difference between the yields on BAA- and AAA-rated corporate bonds, and *Term Spread*, the average quarterly difference between the 10-year and 3-month yields on US Treasury bills. Both variables are collected from the Federal Reserve Board. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Capital Called (%)					
	Full Sample		Buyout Funds		VC Funds	
	(1)	(2)	(3)	(4)	(5)	(6)
Credit Spread	-0.498***		-0.498***		-0.498***	
	[0.087]		[0.075]		[0.114]	
Term Spread		-0.174***		-0.171***		-0.168***
		[0.044]		[0.048]		[0.051]
Fund Age FE	✓	✓	✓	✓	✓	✓
Observations	66,681	66,681	30,989	30,989	35,692	35,692
R^2	0.175	0.175	0.155	0.155	0.199	0.199

Table B6: Reduced Investment - Funds with Limited Choices of Investor Base

This table shows that liquidity shocks reduce PE funds' investment, based on subsamples of funds with limited choices of investor base. In Panel A, the subsample consists of undersubscribed funds. In Panel B, the sample is restricted to funds raised during fundraising bust periods. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Undersubscribed Funds

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	0.008	-0.018	0.103	-0.002	0.004	0.024
	[0.012]	[0.073]	[0.131]	[0.002]	[0.011]	[0.018]
P&C Insurer Share × Liquidity Shock	-0.045**	-0.051**	-0.048**	-0.004**	-0.005***	-0.004***
	[0.020]	[0.021]	[0.021]	[0.001]	[0.001]	[0.002]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	8,692	8,692	8,692	8,692	8,692	8,692
R^2	0.050	0.130	0.148	0.078	0.204	0.240

Panel B: Funds Raised during Fundraising Bust Periods

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-0.018	0.001	0.000	-0.003	-0.007	0.000
	[0.011]	[0.005]	[.]	[0.002]	[0.004]	[.]
P&C Insurer Share × Liquidity Shock	-0.035***	-0.039***	-0.037***	-0.003	-0.003*	-0.003*
	[0.011]	[0.013]	[0.013]	[0.002]	[0.002]	[0.002]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	6,378	6,378	6,290	6,378	6,378	6,290
R^2	0.118	0.179	0.184	0.173	0.306	0.312

Table B7: Rule Out Alternative Explanations - Reduced Capital Demand

This table reports regression results that rule out reduced capital demand as an alternative explanation. In Panel A, fund-quarters in states affected by natural disasters are excluded from the sample. In Panel B, the sample is restricted to funds specializing in industries (IT, internet, information services, media, software, and gaming) that are less likely to be affected by natural disasters. The full sample consists of US PE funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Exclude Fund-Quarters in States Affected by Natural Disasters

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-0.001	0.001	-0.003	-0.000	0.000	0.002
	[0.003]	[0.005]	[0.012]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.029***	-0.027***	-0.024**	-0.003***	-0.002**	-0.002**
	[0.009]	[0.010]	[0.010]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	31,730	31,727	31,166	31,730	31,727	31,166
R^2	0.195	0.214	0.225	0.248	0.308	0.330

Panel B: Restrict to Funds in Unaffected Industries

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	0.002	-0.002	0.007	0.001	0.000	0.002*
	[0.002]	[0.005]	[0.006]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.032***	-0.032***	-0.029***	-0.004***	-0.003***	-0.003***
	[0.008]	[0.008]	[0.007]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	37,696	37,695	37,094	37,696	37,695	37,094
R^2	0.227	0.236	0.239	0.275	0.323	0.337

Table B8: Liquidity Shocks and Reduced Investment - Deal-based Outcome Measures

This table investigates the relationship between investors' liquidity shocks and PE funds' investment, using deal-based outcome measures. The regression is restricted to PE funds that can be matched to at least 5 deals. The full sample consists of US PE funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Investment Amount / Fund Size (%)* is the quarterly total deal size as a percentage of the fund size. *Number of Deals* is the number of deals invested by a fund in each calendar quarter. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Investment Amount / Fund Size (%)

	Investment Amount / Fund Size (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Exposure × Liquidity Shock	-0.332**	-0.196**	-0.133			
	[0.147]	[0.076]	[0.097]			
P&C Insurer Share × Liquidity Shock				-0.017**	-0.010**	-0.007
				[0.008]	[0.005]	[0.005]
P&C Insurer Variable	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	48,953	48,953	48,952	48,953	48,953	48,952
R^2	0.080	0.133	0.159	0.079	0.133	0.159

Panel B: Number of Deals

	Number of Deals					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Exposure × Liquidity Shock	-0.106**	-0.069***	-0.039			
	[0.043]	[0.026]	[0.027]			
P&C Insurer Share × Liquidity Shock				-0.005*	-0.003	-0.001
				[0.003]	[0.002]	[0.002]
P&C Insurer Variable	✓	✓	✓	✓	✓	✓
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	49,579	49,579	48,952	49,579	49,579	48,952
R^2	0.179	0.326	0.373	0.178	0.326	0.373

Table B9: Acceleration of Investment - Funds with Limited Choices of Investor Base

This table shows funds accelerate investment in response to expected liquidity shocks, based on subsamples of funds with limited choices of investor base. In Panel A, the subsample consists of undersubscribed funds. In Panel B, the sample is restricted to funds raised during fundraising bust periods. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. *Endowment Share* is absorbed by fixed effects in Columns 3 and 6 in Panel B due to the relatively small sample size. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

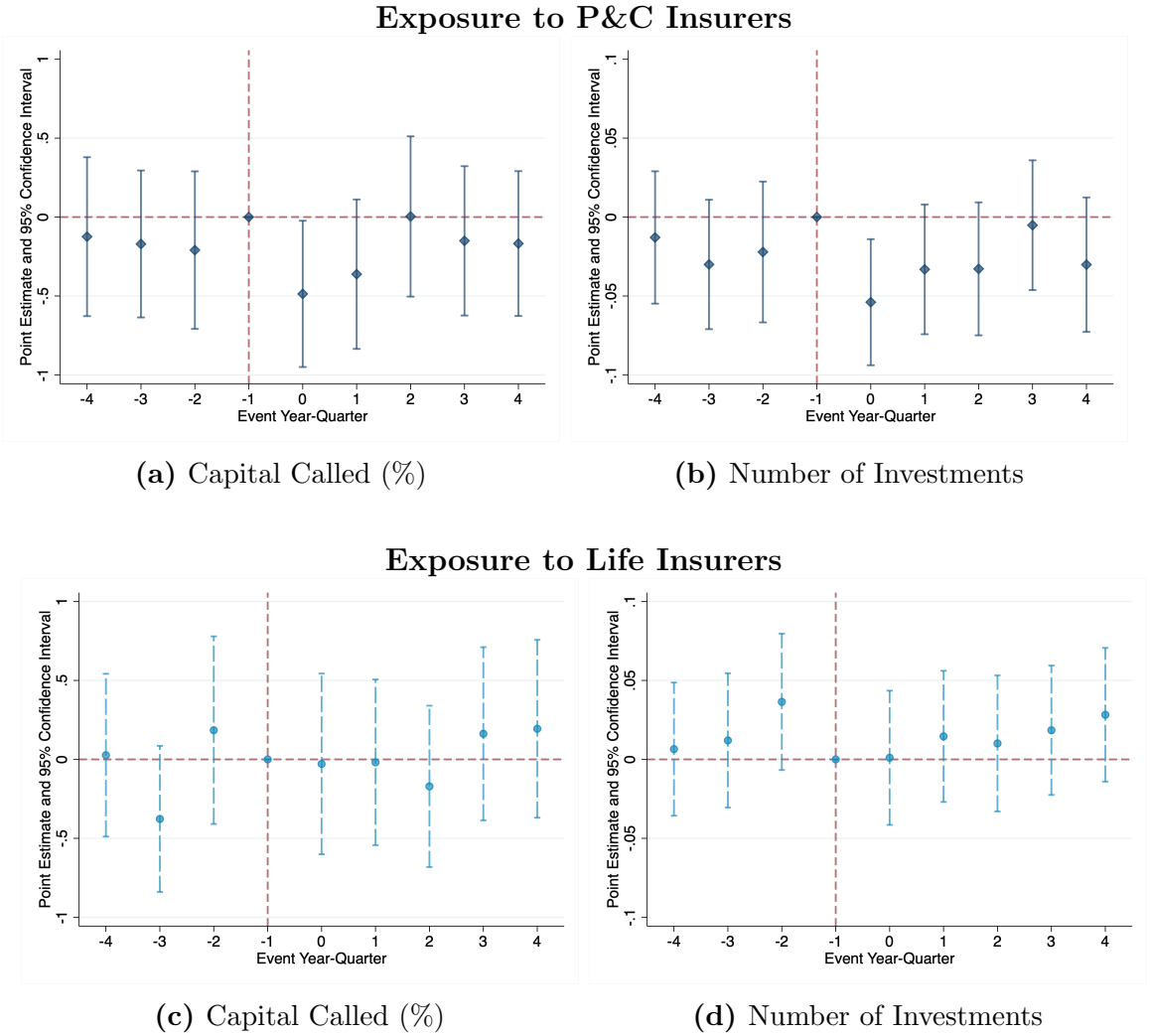
Panel A: Undersubscribed Funds

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.033***	-0.034**	-0.028	-0.000	0.001	0.004
	[0.011]	[0.013]	[0.017]	[0.001]	[0.002]	[0.003]
Log(1 + Fund Age)	-2.180***	-2.002***	-1.908***	-0.171***	-0.135***	-0.071***
	[0.121]	[0.196]	[0.244]	[0.013]	[0.020]	[0.024]
Log(1 + Fund Age) × Endowment Share	0.010***	0.012***	0.013***	0.000	0.000	0.000
	[0.004]	[0.004]	[0.005]	[0.000]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	8,692	8,692	8,692	8,692	8,692	8,692
R^2	0.157	0.172	0.174	0.155	0.227	0.244

Panel B: Funds Raised during Fundraising Bust Periods

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.038*	-0.045*	0.000	-0.000	-0.010***	0.000
	[0.020]	[0.027]	[.]	[0.002]	[0.004]	[.]
Log(1 + Fund Age)	-2.195***	-1.625***	-1.415***	-0.235***	-0.002	0.023
	[0.217]	[0.411]	[0.469]	[0.030]	[0.037]	[0.042]
Log(1 + Fund Age) × Endowment Share	0.011*	0.010	0.014**	0.000	0.000	0.000
	[0.006]	[0.007]	[0.006]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	6,378	6,378	6,290	6,378	6,378	6,290
R^2	0.183	0.190	0.191	0.236	0.307	0.312

C Appendix: Robustness Checks



(a) Capital Called (%)

(b) Number of Investments

(c) Capital Called (%)

(d) Number of Investments

Figure C1: Stacked Event Study Plots

For each outcome variable indicated in subcaptions, this figure presents the stacked event-study plots using a PE fund's exposure to P&C insurers and life insurers respectively. The data is organized by fund-event, with each quarter featuring abnormal insured losses considered as an event. Figures C1a and C1b plot the coefficient estimates of *P&C Insurer Exposure* × *Liquidity Shock*$_{t+n}$ in Equation (2) and the associated two-tailed 95% confidence intervals. Figures C1c and C1d plot the coefficient estimates of *Life Insurer Exposure*× *Liquidity Shock*$_{t+n}$ and the associated two-tailed 95% confidence intervals. The red vertical dashed line in each subplot marks the quarter before liquidity shocks, with the coefficient normalized to zero. The regressions include event, year-quarter, fund age, fund manager × fund type × fund size fixed effects and use standard errors clustered at the fund by event level. Detailed variable definitions are provided in Appendix A.

C.1 Alternative Specifications

More Granular Fixed Effects. To further control for unobservable demand shocks that potentially affect fund managers differentially, I saturate the year-quarter fixed effects with fund manager by year-quarter fixed effects and report the coefficient estimates in the odd columns of Table C1. While statistically insignificant due to lack of power, the coefficient estimates remain similar to the baseline results in terms of magnitude.

The baseline specifications exploit temporal and cross-sectional variation in liquidity shocks caused by natural disasters. The inclusion of fund manager $\times$ fund type $\times$ fund size fixed effects arguably addresses the concern that the cross-sectional variation in the fund base might be correlated with confounding factors that affect a fund's investments. As a robustness check, I absorb all unobservable time-invariant characteristics across different funds by re-estimating Equation (1) with fund fixed effects. These differences include the investor base and contractual terms written between the fund manager and investors. Reported in the even columns in Table C1, my results are robust to this specification.

C.2 Alternative Samples

Restrict to the First Five Years of a Fund's Life. Figure 4a and 4b suggest that the first 5 years are the most active phase for investments during a fund's life cycle, which is consistent with the industry practice that many PE funds have a 5 year investment period after which the management fee basis will shift from committed to net invested capital defined as invested capital minus the cost basis of any exited investments (Metrick and Yasuda, 2010; Robinson and Sensoy, 2013). I re-estimate the equations after excluding fund-quarters after 5 years since fund inception. The DiD coefficient estimates reported Table C2 are larger in magnitude compared to the baseline estimates and statistically significant, which suggests greater impacts of investors' liquidity shocks in the early stage of a fund life cycle.

Exclude Funds with a Small Number of Observed Investors. In my main analyses, I exclude PE funds with only one observed investor. The average/median number of investors

in my sample funds is 16/11. Around 40% of these funds report fewer than ten investors, raising concerns about measurement issues. As a robustness check, I restrict the regressions to a subsample of funds with fewer than ten investors and report the coefficients in Table C3, which shows that my results remain robust.

Subsamples by Fund Types. Tables C4 and C5 report the estimates separately for the subsamples of buyout funds and venture capital funds. The DiD coefficient estimates are negative and statistically significant for both subsamples, indicating that the transmission of investors' liquidity shocks is relevant for both buyout and venture funds.

Exclude the Period when Hurricane Katrina Happened. Table C6 reports the regression results based on the subsample without the period when Hurricane Katrina took place. Although the coefficients of *P&C Insurer Exposure* $\times$ *Liquidity Shock* are smaller in magnitude compared to the baseline estimates, they are highly significant and economically meaningful. Therefore, my results are not driven by Hurricane Katrina, by far the largest natural disaster in recent US history (see Table 1).

Table C1: More Granular Fixed Effects

This table reports robustness checks using more granular fixed effects. The sample consists of US PE funds raised between 2002 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The fund size dummy is based on the fund's size quintile, and the fund type dummy is based on whether the fund is a venture capital or buyout fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Ex-Post Effects

	Capital Called (%)		Number of Investments	
	(1)	(2)	(3)	(4)
P&C Insurer Share	0.005		-0.000	
	[0.012]		[0.001]	
P&C Insurer Share × Liquidity Shock	-0.043	-0.022***	-0.002	-0.002**
	[0.029]	[0.007]	[0.002]	[0.001]
Year-Quarter FE		✓		✓
Fund Age FE	✓	✓	✓	✓
Fund Manager × Fund Type × Fund Size FE	✓		✓	
Fund Manager × Year-Quarter FE	✓		✓	
Fund FE		✓		✓
Observations	47,152	65,800	47,152	65,800
R^2	0.512	0.214	0.578	0.330

Panel B: Ex-Ante Effects

	Capital Called (%)		Number of Investments	
	(1)	(2)	(3)	(4)
Endowment Share	-0.013		0.000	
	[0.010]		[0.001]	
Log(1 + Fund Age)	-1.887***	-0.656***	-0.187***	0.057***
	[0.083]	[0.110]	[0.009]	[0.009]
Log(1 + Fund Age) × Endowment Share	0.004	0.004*	-0.000	0.000*
	[0.003]	[0.002]	[0.000]	[0.000]
Year-Quarter FE		✓		✓
Fund Manager × Fund Type × Fund Size FE	✓		✓	
Fund Manager × Year-Quarter FE	✓		✓	
Fund FE		✓		✓
Observations	47,152	65,800	47,152	65,800
R^2	0.468	0.191	0.509	0.310

Table C2: Restrict to First Five Years

This table reports robustness checks excluding fund-quarters that occur after 5 years from fund inception. The full sample consists of US PE funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The fund size dummy is based on the fund's size quintile, and the fund type dummy is based on whether the fund is a venture capital or buyout fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Ex-Post Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-0.000	-0.005	-0.005	-0.001	-0.001	0.002
	[0.004]	[0.006]	[0.015]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.038***	-0.035***	-0.034***	-0.005***	-0.003**	-0.003**
	[0.012]	[0.013]	[0.013]	[0.002]	[0.002]	[0.002]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	31,124	31,124	30,426	31,124	31,124	30,426
R^2	0.057	0.073	0.079	0.045	0.136	0.158

Panel B: Ex-Ante Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.018**	-0.014*	-0.014*	-0.002***	-0.002***	-0.002**
	[0.007]	[0.008]	[0.007]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-0.873***	-0.846***	-0.742***	-0.021***	-0.021***	-0.003
	[0.101]	[0.102]	[0.105]	[0.008]	[0.008]	[0.008]
Log(1 + Fund Age) × Endowment Share	0.005*	0.005	0.005	0.001**	0.001**	0.001*
	[0.003]	[0.003]	[0.003]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	31,124	31,124	30,426	31,124	31,124	30,426
R^2	0.042	0.058	0.064	0.030	0.121	0.144

Table C3: Exclude Funds with a Small Number of Observed Investors

This table reports robustness checks excluding PE funds with fewer than 10 observed investors. The full sample consists of US PE funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The fund size dummy is based on the fund's size quintile, and the fund type dummy is based on whether the fund is a venture capital or buyout fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Ex-Post Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	0.003	0.005	0.015	-0.001	0.003**	0.003**
	[0.004]	[0.008]	[0.012]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.036**	-0.034**	-0.034**	-0.003**	-0.003**	-0.002**
	[0.016]	[0.015]	[0.015]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	41,084	41,084	40,718	41,084	41,084	40,718
R^2	0.215	0.219	0.222	0.273	0.310	0.325

Panel B: Ex-Ante Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.016*	-0.014	-0.015	-0.002**	-0.001	-0.001
	[0.009]	[0.009]	[0.010]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.977***	-1.897***	-1.666***	-0.232***	-0.216***	-0.159***
	[0.063]	[0.069]	[0.081]	[0.007]	[0.007]	[0.009]
Log(1 + Fund Age) × Endowment Share	0.005*	0.005*	0.004	0.001**	0.001	0.000
	[0.003]	[0.003]	[0.003]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	41,084	41,084	40,718	41,084	41,084	40,718
R^2	0.168	0.173	0.179	0.178	0.217	0.247

Table C4: Subsample of Buyout Funds

This table reports results based on the subsamples of buyout funds. The sample consists of US buyout funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The fund size dummy is based on the fund's size quintile, and the fund type dummy is based on whether the fund is a venture capital or buyout fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Ex-Post Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	-0.003	-0.002	0.013**	-0.000	0.000	0.002
	[0.003]	[0.002]	[0.006]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.023***	-0.021**	-0.022**	-0.003***	-0.003***	-0.003**
	[0.009]	[0.009]	[0.009]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	30,899	30,899	30,592	30,899	30,899	30,592
R^2	0.167	0.175	0.179	0.228	0.267	0.285

Panel B: Ex-Ante Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.011	-0.009	-0.020**	0.000	0.001	-0.001
	[0.008]	[0.010]	[0.009]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.873***	-1.823***	-1.622***	-0.189***	-0.182***	-0.141***
	[0.070]	[0.079]	[0.090]	[0.007]	[0.007]	[0.009]
Log(1 + Fund Age) × Endowment Share	0.003	0.003	0.002	-0.000	-0.000	-0.000
	[0.003]	[0.003]	[0.003]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	30,899	30,899	30,592	30,899	30,899	30,592
R^2	0.129	0.136	0.142	0.150	0.188	0.216

Table C5: Subsample of Venture Capital Funds

This table reports results based on the subsamples of venture capital funds. The sample consists of US venture capital funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations within a fund. *Log(1 + Fund Age)* is the natural logarithm of one plus the fund age in calendar quarters. The fund size dummy is based on the fund's size quintile, and the fund type dummy is based on whether the fund is a venture capital or buyout fund. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

Panel A: Ex-Post Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	0.005***	-0.003	-0.008	0.000	0.001	0.000
	[0.002]	[0.005]	[0.009]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.024**	-0.023**	-0.022*	-0.002**	-0.002*	-0.002*
	[0.010]	[0.011]	[0.011]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	34,904	34,904	34,081	34,904	34,904	34,081
R^2	0.237	0.247	0.251	0.281	0.333	0.349

Panel B: Ex-Ante Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.019***	-0.013*	-0.013**	-0.003***	-0.002**	-0.001
	[0.007]	[0.007]	[0.006]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-2.042***	-1.939***	-1.800***	-0.256***	-0.233***	-0.185***
	[0.067]	[0.077]	[0.090]	[0.008]	[0.008]	[0.011]
Log(1 + Fund Age) × Endowment Share	0.006**	0.005**	0.006**	0.001***	0.001***	0.001***
	[0.002]	[0.002]	[0.002]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	34,904	34,904	34,081	34,904	34,904	34,081
R^2	0.200	0.210	0.214	0.193	0.249	0.275

Table C6: Exclude the Hurricane Katrina Period (2005Q3)

This table reports robustness checks excluding the period when Hurricane Katrina happened (2005Q3). The full sample consists of US PE funds raised between 1990 and 2020. A unit of observation is a fund-quarter. *Capital Called (%)* is the quarterly amount of capital called by a PE fund as a percentage of its fund size. *Number of Investments*, the number of investments made by a fund in each calendar quarter. *P&C Insurer Exposure* is an indicator variable equal to one if the share of P&C insurers within a fund is equal to or greater than the 90th percentile value, and zero otherwise. *P&C Insurer Share* is the percentage of investors that are P&C insurers within a fund. Insurance companies with P&C insurance divisions are considered as P&C insurers. *Liquidity Shock* is an indicator variable equal to one for a calendar quarter if the insured loss in this period is equal to or greater than the historical 90th percentile, and zero otherwise. The specification in Columns 1 and 4 includes fund age and year-quarter fixed effects. Columns 2 and 5 add fund manager fixed effects. Columns 3 and 6 use the saturated specification by interacting the fund manager fixed effects with the fund type dummy, based on whether the fund is a venture capital or buyout fund, and fund size dummies, based on the fund's size quintile. Detailed variable definitions are provided in Appendix A. Standard errors are two-way clustered, at the fund and calendar quarter levels, and reported in brackets. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Cash Called (%)					
	(1)	(2)	(3)	(4)	(5)	(6)
P&C Insurer Share	0.001	-0.003	0.000	-0.001	0.000	0.001
	[0.002]	[0.004]	[0.010]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.024***	-0.023***	-0.022***	-0.003***	-0.002***	-0.002***
	[0.007]	[0.007]	[0.007]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	65,218	65,218	64,092	65,218	65,218	64,092
R^2	0.194	0.202	0.207	0.250	0.297	0.313