Cash for Calls:

Liquidity Shocks and Private Equity Investment*

Yingxiang Li†

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Abstract

Private equity (PE) funds' investment is financed by various investors that commit to providing cash on demand. I document that institutional frictions faced by these investors can distort PE funds' investment. During periods of abnormal insured losses from natural disasters, funds with more committed capital from property & casualty insurers invest less compared to other nearly identical funds. This investment distortion ultimately results in lower fund returns. The shock transmission from investors to PE funds is attenuated ex post when there is a more liquid secondary market for investors' fund stakes and when funds can more effectively enforce drawdowns. To insure against liquidity shocks ex ante, funds exposed to shock-prone investors accelerate drawdowns, leading to inefficient investment. Overall, my findings suggest that the growing interconnectedness between PE and other financial markets can create systemic risk and have capital allocation implications.

Keywords: Financial Intermediation, Liquidity Shocks, Illiquidity, Private Equity, Capital Allocation, Non-bank Financial Intermediaries

JEL Classification: E22, G11, G22, G23, G24

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†University of British Columbia, Sauder School of Business, 2053 Main Mall, Vancouver, BC V6T 1Z2, Canada; E-mail: yingxiang.li@sauder.ubc.ca

1 Introduction

Private equity (PE) has been financing an increasing share of the real economy (Figure 1). This market is dominated by institutional investors and intermediated by PE funds which, unlike hedge funds or mutual funds, are closed-end and not funded upfront. Instead, PE funds draw down ("call") capital from their investors over time that 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.[1] On the other hand, the fund design creates uncertainty in the amount of capital available for investment *ex post*. Investors may be unwilling or even unable to comply with capital calls in the future if liquidity shocks hit them and raise their costs of holding illiquid assets like private equity.[2] These investors comprise a diverse set of financial institutions including pension funds, endowments, and insurance companies, which are subject to different economic shocks due to their distinct business models and funding structures as emphasized by recent literature (e.g., Chodorow-Reich, Ghent, and Haddad, 2021; Coppola, 2022; Darmouni, Siani, and Xiao, 2022).

This paper investigates how the interplay between investors' limited commitment and their institutional frictions influences capital allocation in the PE market. In an efficient capital market, liquidity shocks should not affect real outcomes as long as investment opportunities stay constant. However, financial frictions can lead to inefficient investment by PE funds if other financing alternatives are costly. At the same time, various contractual provisions are written at fund inception to enforce cash drawdowns but they might not be as effective as previously thought. Can liquidity shocks experienced by investors after fundraising affect PE funds' investment? If so, how effective are capital markets and contracts in

[1] Besides reducing the illiquidity of PE funds, the design helps to align the incentives of fund managers and their investors (Axelson, Strömberg, and Weisbach, 2009; Maurin, Robinson, and Strömberg, 2022).

[2] Concern over investors' liquidity shocks attracted a lot of attention during the 2008 financial crisis - even deep-pocket investors such as large university endowments were struggling to meet capital calls of PE funds (J.P. Morgan, 2010; PIMCO, 2021). The recent collapse of Silicon Valley Bank (SVB) also poses a risk for PE funds in their access to capital committed by SVB (PitchBook, 2023).

mitigating the shock transmission from investors to PE funds? Does the investor base matter for PE investment in the context of funding shocks?

I begin my paper by presenting new stylized facts about PE funds' investment patterns that align with the effects of liquidity shocks experienced by their investors. First, whereas a large fraction of funds spend exactly the amount of capital raised at fund inception, many *invest less* than their committed amount (Figure 3). Second, PE funds on average draw down cash 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) which suggests that PE funds have incentives to insure against funding shocks through early drawdowns. Third, there is *large heterogeneity* across funds in terms of their investment pace, especially in the early life cycle (Figure 4b). This variation may stem from PE funds' heterogeneous insurance incentives, influenced by different levels of exposure to investors who are more susceptible to liquidity shocks due to the institutional frictions faced by them.

The above findings do not indicate causal impacts of investors' liquidity shocks on investment by PE funds. Identifying such a relationship is empirically challenging for at least two reasons. First, the observed cash drawdowns are an equilibrium outcome of capital supply and demand. Lower drawdowns might be caused by a narrower set of investment opportunities for PE funds rather than reduced availability of capital from their investors. Second, liquidity shocks are generally difficult to measure, while shocks such as financial crises are often endogenous and systematic thus creating concerns of confounding factors that might complicate the interpretation of causality.

To overcome these endogeneity concerns, I use natural disasters as an experiment and exploit the rich variety of financial institutions that invest in private equity. Investors have heterogeneous opportunity costs of meeting capital calls in different states of the world due to differences in their contractual liabilities. Unlike pension funds and endowments, insurance companies with property and casualty (P&C) divisions face unique exogenous

liquidity shocks from natural disasters, the timing and damage of which are extremely hard to predict (Ge and Weisbach, 2021; Ge, 2022). Natural disasters can cause a surge in short-term claims that P&C insurers must pay out. Consequently, they have to maintain a large reserve of liquid assets, such as cash and government bonds, rather than illiquid assets like private equity, especially in the aftermath of significant catastrophes.

Conceptually, the natural experiment generates plausibly exogenous temporal and cross-sectional variations in investors' liquidity shocks at the fund level, based on a largely fixed characteristic - funds' exposure to P&C insurers. By tightly controlling for the calendar quarter, fund age, and fund manager fixed effects interacted with dummies for fund characteristics (fund type and size), my empirical design fully absorbs any confounding variation of investor base that is fixed at the fund manager level or explained by observable fund characteristics. Therefore, it allows me to mitigate concerns about endogenous matching between investors and fund managers (Lerner and Schoar, 2004). The residual variation in a fund's exposure to P&C insurers is sizable and mainly caused by idiosyncratic factors, such as investors' demand for private equity at the time of fund inception, that are unlikely to be correlated with the fund's investment opportunities.

Using the sample of PE funds raised during 1990-2020 in the Preqin universe, I provide causal evidence that liquidity shocks reduce PE funds' investment across several proxies.[3] It rationalizes the procyclicality of aggregate capital calls with market liquidity (Robinson and Sensoy, 2016). Funds with high exposure to P&C insurers invest 0.38% (16% of the unconditional mean) less of committed capital 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 robust to various subsamples and unlikely to be

[3]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 in a timely manner. See Section 5.4 for a detailed discussion.

driven by changes in PE funds' capital demand. Moreover, funds with a higher share of P&C insurers achieve lower returns if large natural disasters happen shortly after fundraising.

PE investors face distinct institutional frictions because of differences in their liability structures and investment objectives. To test this hypothesis, I show that funds with high exposure to other types of investors including life insurers, endowments and foundations (henceforth endowments), or public pension funds do not experience any decline in investment when natural disasters lead to abnormal insured losses in the economy. The finding provides additional causal evidence of shock transmission and, more importantly, suggests that investor base compositions lead to state-dependent PE financing for private companies.

As a market response to the illiquidity of PE investments, a secondary market has emerged in which PE fund stakes are traded. Buyers offer liquidity to sellers who are existing investors in a fund. After the transaction, buyers will become the new fund investors and provide/receive all future fund cash flows on the pro rata basis of their equity contribution. I find that the distortion in investment by PE funds following funding shocks is attenuated when there is a liquid secondary market. This finding supports the illiquidity channel of the shock transmission. PE funds cannot promptly return more cash to investors without selling illiquid investments at a discount. As a result, investors usually resort to reducing capital calls to preserve cash after liquidity shocks if they cannot easily transfer their fund stakes.

To overcome the limited commitment problem, fund managers and investors agree on contractual terms stipulated at fund inception. However, capital calls cannot be contracted on investors' liquidity shocks because such shocks 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 punishments, the most punitive and commonly used provision is forfeiture of some portion of investors' fund stakes. 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 drawn down because early investments serve as collateral that investors may risk losing if they fail to meet capital calls (Maurin, Robinson, and Strömberg, 2022).

Finally, I examine whether investor base has any ex ante implications on the capital allocation of PE funds. I find that funds with greater ex ante exposure to shock-prone investors tend to invest earlier to insure against funding shocks. Specifically, the exposure is measured by and *negatively* correlated with the fund-level share of investors that are endowments. Unlike pension funds and insurance companies, endowments are "*equity-financed*" by donations and have little sensitivity to short-term market fluctuations because they do not have any formal contractual liabilities that must be paid. Therefore, endowments are arguably less susceptible to liquidity shocks than other major PE investors and choose to have the highest portfolio allocation to private equity. By accelerating drawdowns, PE funds can reduce the amount of uncalled capital at the risk of not being provided in the future when liquidity shocks hit their investors, and also build up the collateral that can be used to punish non-complying investors (Maurin, Robinson, and Strömberg, 2022). However, the acceleration of drawdowns is costly because it distorts PE funds' investment schedule. I find that investments in the early stage of a fund's life tend to have a lower chance of successful exits, especially when the fund has a lower fraction of endowment investors.

Overall, this paper documents novel evidence that investor base is an important determinant of PE financing and capital allocation outcomes in the context of funding shocks. Although I focus on natural disasters faced by P&C insurers as an experimental setting, liquidity shocks are common and take various forms, such as stock market losses for public pensions, the COVID-19 pandemic for life insurers, and regulatory changes in banking or insurance industries.[4] The continuous expansion of PE markets is partly attributed to the rising portfolio allocation of various institutional investors towards private equity. However, this trend might have also amplified the interconnectedness of different financial markets and increased the risks of shock transmissions within the economy.

[4]For example, the Volcker Rule and Solvency II respectively put pressure on US banks and European insurers to cut their PE investments. See McGuireWoods (2010) and McCrystal (2011).

Related Literature. This paper contributes to three strands of literature. First of all, it is closely related to the vast literature on illiquidity and its implications on the economy (e.g., Shleifer and Vishny, 1992; Amihud, Mendelson, and Pedersen, 2006; Tirole, 2011). More specifically, my work complements research that studies the implications of illiquidity in PE markets. These topics include illiquidity premium (e.g., Harris, Jenkinson, and Kaplan, 2014; Robinson and Sensoy, 2016), asset allocation (Giommetti and Sorensen, 2021; Gourier, Phalippou, and Westerfield, 2022), 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 to highlight illiquidity as an important friction faced by PE funds while intermediating the capital of investors, who have heterogeneous opportunity costs of holding illiquid assets in different states of the world. By examining how the secondary market for PE fund stakes alleviates the friction, my work adds to the small but growing body of research on this market (e.g., Albuquerque, Cassel, Phalippou, and Schroth, 2018; Nadauld, Sensoy, Vorkink, and Weisbach, 2019; Boyer, Nadauld, Vorkink, and Weisbach, 2022).

Second, my paper relates to the broader financial intermediation literature on the transmission of liquidity shocks, which is under-explored in the context of private equity.[5] In existing work, liquidity shocks to investors do not affect investment after capital commitment 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 calls due to the substantial costs of non-compliance (Giommetti and Sorensen, 2021; Gourier, Phalippou, and Westerfield, 2022). This paper is the first to empirically show that investors' liquidity mismatch can create funding shocks to PE funds and affect their investment after fundraising. The setting features a high level of interconnectedness among non-bank financial intermediaries and with PE markets, which distinguishes it from previous studies that predominantly focus on the shock propagation within the banking sector (e.g., Khwaja and Mian, 2008; Ivashina

[5] Townsend (2015) studies the propagation of financial shocks among companies that are backed by the same venture capital fund.

and Scharfstein, 2010; Schnabl, 2012; Chodorow-Reich, 2014).

Although committed capital seems 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. In contrast, credit lines are debt contracts, which typically include covenants that address the inherent agency problems in lending relationships. These covenants restrict the borrower's actions and transfer control to the lender if the borrower's 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 is designed to facilitate fundraising, while credit lines are used by borrowers to provide liquidity insurance (e.g., Holmström and Tirole, 1998; Brown, Gustafson, and Ivanov, 2021). These differences give rise to distinct channels and implications of shock transmission.[6]

Third, I contribute to the growing body of work on institutional frictions in financial markets by providing causal evidence on the real effects of investor heterogeneity. Recent studies have examined the financial implications of heterogeneous investor characteristics on asset prices (e.g., Koijen and Yogo, 2019; Bretscher, Schmid, Sen, and Sharma, 2022; Coppola, 2022; Darmouni, Siani, and Xiao, 2022), term structure (Vayanos and Vila, 2021), costs of capital (Siani, 2022), and contracting (Chernenko, Lerner, and Zeng, 2021). This paper illustrates that differences in funding structures across PE investors play a role in determining their susceptibility to liquidity shocks and in turn influence the real investment and capital allocation outcomes in PE markets. While variations across investors' skills and objectives lead to different fund selection and investment performance in private equity (Lerner, Schoar, and Wongsunwai, 2007; Hochberg and Rauh, 2013), my findings support the theory that investors' varying illiquidity tolerance is another source of return persistence at both the fund and investor levels (Maurin, Robinson, and Strömberg, 2022).

[6] Chodorow-Reich and Falato (2022) shows that breach of loan covenants by borrowers allows banks to renegotiate loan contracts including credit lines, leading to most of the cross-sectional variation in credit supply during the 2008 financial crisis. In terms of liquidity insurance, Ivashina and Scharfstein (2010), Greenwald, Krainer, and Paul (2021) and Acharya, Engle, and Steffen (2021) document that the surge of credit line drawdowns by large firms during macroeconomic shocks weakens banks' balance sheets and crowds out bank lending to other potentially more financially constrained firms.

2 Institutional Background

Due to various transaction costs such as search frictions and information asymmetry between investors and private companies, PE markets are a typical example in which the benefits of financial intermediation would be large (e.g., Benston and Smith, 1976; Leland and Pyle, 1977; Chan, 1983). In this section, I describe the major PE investors 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 stakes to mitigate the illiquidity of private equity.

2.1 Private Equity Investors and Their Liability Structures

The PE markets are dominated by institutional investors. The major investors that provide capital to PE funds are pension funds, endowments, and insurance companies, which have different funding structures and liabilities (Figure 2):

Insurance Companies. Insurance companies are funded by premiums paid by policy holders. In return, insurers are obligated to pay claims to policyholders for a covered loss or policy event. Regulators usually require insurers to maintain a certain level of liquid assets to ensure they can meet their obligations to policyholders. The reserves set aside to cover these contractual claims represent the primary liability for insurers. Based on insured risks, insurance companies can be divided into two major types - property & casualty (P&C) insurers and life insurers. P&C insurers usually issue short-term contracts and face much more variability of claim outcomes. Although the premium for each policy is usually calculated based on historical data and paid by insurees in advance of compensation for a covered loss, the actual cost is unknown until policy maturity. Most of the variability stems from claims caused by natural disasters, the timing and damage of which are extremely hard to predict. In contrast, life insurers issue long-term policies typically with pre-specified claim amounts or guaranteed interest rates such as annuities. This funding structure makes

life insurers vulnerable to unexpected changes in mortality rates due to pandemics, falls in financial markets, and declines in interest rates.[7]

Pension Funds. Pension funds are funded by cash contributions from employers and must pay pension benefits to retired employees based on predefined 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. Defined benefit pension plan managers are obligated to deliver guaranteed retirement benefits and will face liquidity shocks when the pension plans become under-funded, particularly following market declines or slowdowns of pension contributions during economic downturns. While employees enrolled in defined contribution pension plans bear the investment risk, pension funds will have to hold more liquid assets in response to large pension withdrawals if many employees retire early or choose lump-sum payments of their 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.[8] Therefore, endowments *lack formal contractual liabilities* that must be paid out, making them more resilient to short-term market fluctuations and less susceptible to liquidity shocks.

Therefore, the differences in PE investors' funding structures give rise to heterogeneous opportunity costs of holding illiquid assets like private equity. Both insurance companies and pension funds are more susceptible to liquidity shocks that arise from the asset side or liability side of their balance sheet, due to their obligations to pay out contractual liabilities and regulatory restrictions to maintain reserves for such payments.

[7] A falling interest rate environment increases life insurers' liabilities by lowering the discount rate used to calculate the present value of future contractual claims. Additionally, life insurers usually experience reduced returns on their assets because they typically have a substantial allocation to fixed-income securities.

[8] Endowments often reduce payouts during negative financial shocks (Brown, Dimmock, Kang, and Weisbenner, 2014).

2.2 Committed Capital and Capital Calls

Unlike mutual funds and hedge funds, PE funds primarily invest in private companies, often taking significant ownership stakes. Their goal is to actively improve the performance of these companies over an extended period and realize returns upon exits such as M&As or IPOs of the portfolio companies. These PE investments are illiquid by nature, in contrast to publicly traded securities held by mutual funds or hedge funds, which can usually be sold whenever investors need liquidity.

As a result, PE funds are structured differently with committed capital and sequential capital calls. Investors only need to make an *ex ante contractual commitment* to providing capital *on demand* capped in total by 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 their *pro rata* portion of their committed capital typically with a two weeks' notice when the fund plans to make a new investment or collect fees.[9] The ex ante financing feature facilitates fundraising by reducing the agency frictions faced by fund managers (Axelson, Strömberg, and Weisbach, 2009; Maurin, Robinson, and Strömberg, 2022). Moreover, the fund design also reduces the illiquidity of PE funds by reducing the lock-up period of investors' capital.

2.3 Contracting and Enforcement of Capital Calls

Although allowing the manager to raise larger funds ex ante by providing various benefits to investors, the contractual design of committed capital potentially poses uncertainty in the amount of funds available for investment ex post due to the *limited commitment* of investors. Capital calls are often highly uncertain in timing and quantity because investment opportunities arrive randomly. Investors may be *unwilling* to or even *unable* to meet cash drawdowns if they are hit by liquidity shocks which raise their costs of holding illiquid assets - leading to delayed or reduced capital calls.

[9]The total amount of called capital sometimes can be greater than the committed capital because of the recycling provisions that allow fund managers to reinvest exit proceeds rather than distributing them back to investors.

The fundamental problem behind investors' limited commitment is incomplete contracting. It is challenging to write a state-contingent contract on cash drawdowns, since liquidity shocks experienced by investors are hard to specify ex ante and difficult to verify ex post. This issue is further exacerbated by numerous unforeseen contingencies that can arise during a PE fund's long lifespan, which are often more than 10 years. Therefore, the real-life contract does not specify the amount of drawdowns under different circumstances. Instead, default penalties and sometimes escrow accounts are used to enforce capital calls. Next, I discuss these contracts in detail.

Default Penalties. In the limited partnership agreements (LPAs), fund managers typically establish various penalties for investors 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 rectified within approximately 5 business days after receiving the notice, the investor is classified as a defaulting LP. Among the various penalties, which may include withholding distribution of fund returns, charging high interest on the uncontributed amount, and forcing secondary sales of the fund interest, the most severe provision commonly available is the forfeiture of a portion of the fund interest (Litvak, 2004).[10] 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 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 enforced, its presence enhances the fund manager's bargaining power during renegotiations with investors

[10] See Litvak (2004) for detailed examples of penalty terms ranked by severity of punishment.

regarding cash drawdowns. The availability of such a penalty can effectively serve as a deterrent, influencing investor behavior and ensuring compliance (Litvak, 2004).

Escrow Accounts. Investors' limited commitment problems can be eliminated by holding their promised contribution in an escrow account. Investors are asked to make a single upfront payment and their unused contribution will be invested in liquid securities with the interest going to investors.

However, escrow accounts are not widely used for at least four 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 not have enough cash to invest upfront in PE funds and face liquidity constraints 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 Stakes

Due to the illiquidity of their underlying assets, PE funds are designed as closed-end so that they can invest without liquidity constraints imposed by investor redemption. As a market response to the illiquidity of private equity, a secondary market has evolved in which buyers such as secondary funds provide liquidity to sellers by purchasing their stakes in PE funds (Figure B1). After the transaction, the buyer as the new LP will pay all capital calls and receive all cash distributions made by the fund in the future on a pro rata basis of the equity contribution.

Liquidity is one of the most important reasons to sell fund stakes in the secondary

market (Nadauld, Sensoy, Vorkink, and Weisbach, 2019). After liquidity shocks, PE fund investors may need to increase its cash and other short-term holdings to meet liabilities, or to adjust balance sheet because of regulatory requirements and investment mandates.[11] By selling their fund stakes before the fund is liquidated, investors can partially cash out from their illiquid PE investments and gain liquidity.

In terms of pricing, secondary sales are usually quoted as a percentage of the net asset value ("NAV") of the fund stake being sold. Unlike stocks of public companies, PE fund stakes are not traded on exchanges and do not have publicly available market values or information. Despite its recent growth, the secondary market is still illiquid - in fact most transactions still occur at discount to NAV (Nadauld, Sensoy, Vorkink, and Weisbach, 2019).

3 Data and Summary Statistics

3.1 Data and Sample

Preqin. My main sample consists of PE funds covered by the fund cash flow database of Preqin from 1990 to 2020, which provides the amount and timing of each capital call made by the fund.[12] Preqin also contains other rich fund-level information including the composition of LPs, fund size, and vintage, as well as information on the fund manager and LP investors. I focus on buyout and venture capital funds, the two most important and widely studied types of PE funds, by excluding funds such as secondary funds and funds of funds. My sample consists of US PE funds raised between 1990 and 2020. Figure B9 shows the distribution of my sample funds by vintage and fund type.

NAIC. Preqin does not distinguish insurance company LPs with and without P&C divisions. To identify P&C insurer LPs, I manually check the market share reports for P&C groups and companies issued by the National Association of Insurance Commissioners (NAIC). The data

[11] 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.

[12] 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).

comes from periodical statutory reports filed by insurance companies to the NAIC. I cross-validate the data by searching the insurance company LPs on PitchBook, which provides the major line of business for each LPs.

EM-DAT. The database is created with the initial support of the World Health Organisation (WHO) and the Belgian Government to serve humanitarian actions against disasters. Compiled from various sources such as United Nation agencies, the International Federation of Red Cross, insurance companies and research institutes, EM-DAT has comprehensive world-wide coverage of the occurrence and effects of disasters. I extract all natural disasters in the US and aggregate the insured damages by each quarter to identify time periods with abnormal insured loss.

SDC Platinum. To investigate capital allocation implications of liquidity shocks to investors, I augment the Preqin private equity exit database with the SDC Platinum to construct outcome variables related to IPOs and acquisitions. The two data sets are merged using fuzzy name matching combined with manual checks after standardizing spellings and removing legal suffixes of private companies' 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, and term spread, etc.

3.2 Measures of Investment by Private Equity Funds

I measure investments 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 when counting the number of capital calls made in each period and consider each capital call as an investment.

There are three unique features of the Preqin cash flow data. First, Preqin presents the cash flow data from the perspective of a hypothetical investor with a 10 MIL commitment

to the fund. Therefore, I do not observe more granular cash flow data at the investor-fund level.[13] However, more granular data is not needed for the purpose of this study because capital is usually drawn down based on the pro rata contribution of investors' committed capital. Therefore, the drawdown amount relative to the committed capital is the same between the hypothetical investor and the actual investors in the fund.

Second, PE funds such as buyout funds often use leverage to finance private companies. According to Preqin, its cash flow data is based on only the equity committed to the fund, excluding any debt used to finance investment. Therefore, my outcome measures capture the fund investors' equity contribution to investments made by the fund.

Third, while the capital calls are recorded as negative cash flow by Preqin, there are occasionally capital calls with positive amounts. According to Begenau, Robles-Garcia, Siriwardane, and Wang (2020), these positive capital calls are most likely fee rebates. Since I am interested in studying investment rather than investor returns in my main analysis, I exclude capital calls with positive amounts. My results are robust to including these positive capital calls.

My main analysis uses granular cash-flow-based investment measures. In the Online Appendix B, I use alternative proxies for investment based on private equity deals that can be matched to each private equity fund. As discussed in Section 5.7, my results remain quantitatively and qualitatively similar.

3.3 Exogenous Liquidity Shocks Caused by Natural Disasters

Figure 5a shows the quarterly insured losses from natural disasters in the US during 1990-2020. The horizontal red dashed line indicates the historical 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 from natural disasters, and are liquidity shocks to P&C insurers. Figure 5a does not indicate any increasing or decreasing trend in the frequency of

[13] Begenau and Siriwardane (2023) uses investor-fund level cash flow data to study the fee dispersion among investors in the same PE fund.

periods with abnormal insured losses. Nor does it suggest the presence of autocorrelation of liquidity shocks. In fact, the Durbin-Watson statistics for the quarterly time series is 1.89, which cannot reject the null hypothesis of no serial correlation. Figure 5b shows that there is no significant partial autocorrelation with a lag extended to 5 years. These tests provide strong evidence that the timing of natural disasters that cause abnormal insured losses is unpredictable.

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. While the majority of the most costly natural disasters are hurricanes, other events such as drought, earthquakes, and wildfires have also led to large amounts of insured losses in the past three decades.

3.4 Summary Statistics

There are 1,715 unique PE funds managed by 636 fund managers and 65,805 fund-quarters in my sample. 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.[14] 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. Around 13% of the fund-quarters are periods with abnormal insured losses from natural disasters.

[14]Due to the nature of my analysis, the sample excludes PE funds without cash flow or investor data. 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. Table B1 shows that the sample used in this study over-represents buyout funds, larger funds, and funds with high sequence numbers.

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 a set of stylized facts of cash drawdowns that are consistent with the impacts of investors' liquidity shocks on PE funds. Section 5 provides causal evidence. These patterns are robust to a wide array of subsamples by fund types, size, and sequence, presented in Appendix B.[15]

Uninvested Capital Commitments. Figure 3 shows the cross-sectional distribution of the total amount of cash drawdowns to fund size by Q2 2021. The fund size is the amount of capital commitments promised by the fund investors at fund inception. The sample consists of PE funds raised between 1990 and 2005 so each fund has at least 15 years to draw down cash. While the majority of funds make capital calls that are in total close to the fund size, a large fraction of funds invest either significantly more or less than the committed amount. Some funds' total cash drawdowns are more than 100% of their fund sizes due to recycling provisions that allow fund managers to reinvest exit proceeds rather than distributing them back to investors.[16] Meanwhile, some funds underinvest - which aligns with the notion of liquidity shocks affecting investors and causing delays or even reductions in investment made by PE funds. However, lower drawdowns might be caused by a narrower set of investment opportunities available to the fund manager rather than reduced contributions from investors. Therefore, exogenous variation in capital supply is needed to identify the impacts of investors'

[15]Table B4 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.

[16]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.

liquidity shocks on PE investment.

Declining Investment Pace. By fund age, Figure 4a presents capital calls in percentage of the total committed capital at fund inception based on the same sample. The dash and solid line indicate the mean and median values. Instead of spending capital contributions evenly over several years, the average fund calls capital quickly - around 20% of committed capital is invested in the first year of inception - and the investment pace declines monotonically with fund age. The investment pattern over the life-cycle of PE funds suggests that the fund manager has incentives to insure against funding shocks by accelerating drawdowns, which has been theoretically formalized by Maurin, Robinson, and Strömberg (2022).

Heterogeneous Investment Pace in the Early Stage. The shaded area in Figure 4a shows the range between the 5th percentile and the 95th percentile of capital calls by fund age. While some funds invest almost 50% of their entire committed capital in the first year of inception, others only spend less than 5%. Such heterogeneity in investment pace is particularly pronounced in the early stage of the fund life and becomes weaker as the fund ages - potentially due to their heterogeneous insurance incentives caused by different levels of exposure to investors that are ex ante more susceptible to liquidity shocks. We can also find such large heterogeneity when examining the evolution of cumulative cash drawdowns as shown in Figure 4b. While funds at the 25th percentile have invested around 25% of the committed capital at age 2, funds at the 95th percentile have nearly completed all of their investments at the same age.

5 Ex Post Impacts of Investors' Liquidity Shocks

The investment patterns of PE funds documented in the previous section do not indicate their casual relationships with investors' liquidity shocks. In this section, I provide causal evidence of their real impacts, discuss the channel, and examine economic forces that mitigate the transmission of liquidity shocks from investors to PE funds.

5.1 Identification Strategy

In contrast to other investors, P&C insurers face arguably exogenous liquidity shocks caused by natural disasters, which are challenging to predict in terms of timing and extent of damages. During periods with abnormal insured losses, P&C insurers face a higher cost of holding illiquid assets like private equity because they will have to keep a liquid portfolio to pay down insurance claims (Girardi, Hanley, Nikolova, Pelizzon, and Sherman, 2021; Ge and Weisbach, 2021). Therefore, funds with a higher share of P&C insurers are more intensely treated with liquidity shocks in such states of the world. Figure 5a and 6a show the temporal and cross-sectional variations exploited by my empirical design. Specifically, I estimate various forms of the following difference-in-differences (DiD) model:

$$y_{it} = \beta \times P\&C\ Insurers_i + \gamma \times P\&C\ Insurers_i \times Liquidity\ Shock_t + \boldsymbol{FEs} + \epsilon_{it} \qquad (1)$$

in which the subscript i and t denote a PE fund and each calendar quarter.[17] The outcome variable y is *Capital Called (%)* or *Number of Investments* in the corresponding quarter. *P&C Insurers* is different measures of the fund's exposure to property & casualty insurance company LPs, which 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 in the fund and the value. Insurance companies with P&C insurance divisions are considered as P&C insurers.[18] Figure 6a shows the cross-sectional distribution of the P&C insurer share. *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.

[17] 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.

[18] 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.

Standard errors ϵ are two-way 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 specifications, saturate the specification by interacting the fund manager fixed effects with the fund size dummies, based on the fund's size quintile, and the fund type dummy, based on whether the fund is a venture capital or buyout fund. Such inclusion of fixed effects in Equation (1) is necessary to address the concern that the 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 capital calls of *nearly identical* funds managed by the same fund manager, by removing confounding cross-sectional variations 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 the fund's inception. These factors are unlikely to be correlated with the fund's subsequent investment decisions. Figure 6b shows that these idiosyncratic factors generate sizable residual variation in P&C insurer share across funds. Table B2 Panel A shows the balance of 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 following Dessaint and Matray (2017):

$$y_{it} = \beta \times P\&C\ Insurers_i + \gamma_n \times P\&C\ Insurers_i \times \sum_{n=-4}^{4} Liquidity\ Shock_{t+n} + \boldsymbol{FEs} + \epsilon_{it} \quad (2)$$

in which $Liquidity\ Shock_{t+n}$ is an indicator variable equal to one for n quarters before/after the abnormal insured loss. The coefficient of interest γ_n captures the impact of investors' liquidity shocks on funds with the same exposure to P&C insurers at different quarters surrounding the period with abnormal insured losses from natural disasters (quarter Q0).

The specification includes the same set of fixed effects used in Equation (1) and two-way clusters standard errors at the fund and calendar quarter levels.

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 cash 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 there are abnormal insured losses from natural disasters.

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 from Equation (2) and the 95% confidence intervals at different

quarters surrounding the liquidity shock 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. Therefore, investors' liquidity shocks are costly to the fund manager.

5.3 Investors' Heterogeneous Illiquidity Costs

To further establish causality, I show that funds with high exposure to life insurers do not invest less during periods with abnormal insured losses from 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 from natural disasters due to the different nature of their business.

Table 5 shows the placebo tests using exposure measures *Life Insurer Exposure* and *Life Insurer Share* defined in a similar way 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 Table 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 from 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 from 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. The exposure measures are 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. We can see that none of the placebo DiD

estimates are statistically significant except the baseline estimate based on P&C insurers because natural disasters pose a unique and plausibly exogenous liquidity shock only to P&C insurers. Only P&C insurers' liabilities increase significantly after large natural disasters creating large liquidity mismatches between their liabilities and assets. The finding provides evidence that investors have heterogeneous costs of holding illiquid assets such as private equity in different states of the world because they have distinct contractual liabilities and are exposed to different economic shocks. Therefore, investor base compositions can result in 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 lead to stock market declines. Meanwhile, the government may decide to adjust interest rates following these catastrophes. Figure B5 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 federal fund rate changes are only -0.04 and 0.17 - both statistically insignificant at the 5% level.

5.4 Mechanism - Illiquidity of Private Equity

The reduced investment by PE funds following liquidity shocks to investors is not necessarily a result of LP defaults, in which investors fail to fully fund the manager's drawdowns. Fund managers may be pressured to slow down capital calls when their investors' costs of capital are high.[19] This decision is made to maintain a mutually beneficial relationship because fund managers need to come back to their investors for future fundraising due to information asymmetry and search frictions, which give investors bargaining power in PE markets (Hochberg, Ljungqvist, and Vissing-Jørgensen, 2014; Begenau and Siriwardane, 2023). My

[19]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).

findings offer a potential explanation for the empirical results presented by Robinson and Sensoy (2016). The authors find that PE funds tend to call less capital when investors' illiquidity costs are high due to a lack of liquidity in public markets.

Why do investors want to delay capital calls after they are hit by liquidity shocks? It could arise because of the so-called "denominator effect" - selling liquid assets causes overexposure in allocation to private equity, driven by either explicit or implicit investment mandates that impose restrictions on the portfolio weight of illiquid assets. This constraint typically reflects both the liquidity and diversification concerns of investors based on their liability structures and investment objectives. Recent literature on demand-based asset pricing literature has emphasized the important role of investors' investment mandates on asset prices (e.g., Koijen and Yogo, 2019; Vayanos and Vila, 2021; Bretscher, Schmid, Sen, and Sharma, 2022). At the same time, investors tend to face higher costs of external financing and potential downturns in prices of other asset classes due to selling pressure amid liquidity shocks (Ellul, Jotikasthira, and Lundblad, 2011). These factors can exacerbate their financial positions and further worsen their balance sheets. Moreover, investors might also become more risk averse because the agents managing the portfolios potentially face a higher chance of losing their jobs if their institutions become insolvent.

Therefore, investors often prefer to rebalance their portfolio towards liquid assets in response to the uncertainty created by liquidity shocks (Ge and Weisbach, 2021). Reducing capital calls from PE funds helps investors to preserve their remaining cash. Unlike mutual funds or hedge funds, PE funds are closed-end because they invest in shares of private companies which are not marketable and the investments usually have long horizons. It implies that investors cannot cash out through the redemption of their fund shares. As a result, 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 need to wait for favorable market conditions before a profitable exit if there is any (Gompers, Gornall,

Kaplan, and Strebulaev, 2020). Rushed or forced asset sales to meet distribution requests can lead to a large price discount due to illiquidity.[20]

This mechanism is supported by results in Table 6. It indicates 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 back to the investors by a PE fund as a percentage of its fund size. From Columns 1-6, the coefficient estimates of the DiD estimates 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 abnormal natural insured losses from natural disasters. Section 5.6 provides further evidence on the illiquidity channel by highlighting how a liquid secondary market for PE funds stakes can mitigate the shock transmission from investors to PE funds.

5.5 Lower Private Equity 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:[21]

$$y_i = \beta \times P\&C\ Insurer\ Share_i + \gamma \times P\&C\ Insurer\ Share_i \times Shock\ Vintage_t + \boldsymbol{FEs} + \epsilon_j \quad (3)$$

in which i and i denote a PE fund and a vintage year. The outcome variable y is a measure of PE fund returns. *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

[20] 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).

[21] 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.

the timing of such 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 7 Panel A shows that private equity funds achieve 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, which is entirely based on realized cash flows in the life of a PE fund. The 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. My results are quantitatively and qualitatively similar with an alternative measure of returns reported in Columns 4-6. *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.

As placebo tests, Panel B of Table 7 reports results of regressions that replace *P&C Insurer Share* with *Life Insurer Share* in the standalone and interacted variables. Funds with a high share of life insurers are expected to be much less affected by large natural disasters. The insignificant coefficient estimates across all columns provide additional support for causality.

The decline in realized returns of funds shown in Table 7 suggests that funding shocks negatively affect real outcomes. This adverse impact can arise due to either missed investment opportunities or worse performance of portfolio companies that become financially constrained. In the next part of the paper, I investigate the role of capital market and contracting in mitigating the transmission of liquidity shocks from PE funds' investors to themselves.

5.6 Ex Post Mitigation of Liquidity Shock Transmission

5.6.1 A Liquid Secondary Market for Private Equity Fund Stakes

As discussed in Section 5.4, the illiquidity of private equity is the key mechanism of the shock transmission when investors are hit by liquidity shocks. However, the illiquidity of PE funds' underlying assets does not necessarily imply PE fund stakes are illiquid. The existence of a liquid secondary market can alleviate this illiquidity friction and allow investors to gain liquidity by selling their PE fund stakes. Having established the causal link between investors' liquidity shocks and investment, I further investigate whether a liquid secondary market attenuates the impacts of such shocks by increasing the transferability of their illiquid PE investments.

Table 8 reports the triple-diff estimation results that are consistent with illiquidity being the driving force behind the reduced investment after investors are hit by liquidity shocks. *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 available to the fund managers for drawdowns when attractive investment opportunities arise. 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 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 partial attenuation of the liquidity shocks when it is less costly for LPs to gain liquidity from their existing illiquid positions in private equity on the secondary market. The finding is consistent with the theoretical prediction in Maurin, Robinson, and Strömberg (2022).

5.6.2 Contracting and Renegotiation on Capital Calls

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. Therefore, in-

complete contracting theory suggests that the fund manager's bargaining power can increase drawdowns 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 5.6.2, 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, 2022).

Table 9 reports triple-diff estimates that support such prediction. *Cumulative Drawdown* is a variable ranging from 1 to 5 that ranks a fund by 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* $\times$ *Liquidity Shock* $\times$ *Cumulative Drawdown* are positive and highly significant, suggesting that greater cumulative drawdowns mitigate 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 Additional Results and Robustness

5.7.1 Capital Demand

The observed cash drawdowns are the result of an equilibrium between capital supply and demand. Lower drawdowns could be attributed to decreased capital demand from fund managers due to operational disruptions caused by natural disasters. It is possible that PE funds with a higher share of P&C insurers are more likely to be located in areas with higher catastrophic risk from natural disasters. I rule out such an explanation by excluding fund-quarters of private equity firms located in states impacted by natural disasters. The results reported in Table B5 Panel A suggest 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 B5 Panel B, I only keep funds that allocate capital to 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. Taken collectively, my results indicate that the decreased investment by PE funds with significant exposure to P&C insurers following major natural disasters can be attributed to these insurers being unwilling or potentially incapable of providing capital to private equity during periods when the costs associated with holding illiquid assets are elevated.

5.7.2 Pseudo Liquidity Shocks

The inclusion of fund manager × fund type × fund size fixed effects in Equation (4) allows 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. The residual cross-sectional variation in investor base is likely idiosyncratic and the temporal variation of liquidity shocks in Figure 5a is plausibly exogenous. Alternative stories must explain why funds with a higher share of P&C insurers invest less *only* when natural disasters lead to abnormal insured losses.

To further mitigate the concern about endogenous matching between investors and funds, I conduct a placebo test by re-estimating the regressions 1000 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 above my estimate reported in Column 3 of Table 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 when natural disasters lead to abnormal insured losses. Therefore, my results are unlikely to be driven by unobservable differences across funds.

5.7.3 Subsription Lines of Credit

The recent rise of subscription lines of credit (SLCs) allows PE fund managers to borrow debt from banks and actively manage the timing of capital calls from investors (Albertus and Denes, 2023).[22] As discussed in Section 3.2, Preqin only reports cash flow that is from the equity contribution from investors but does not cover the debt contribution from lenders. 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.

Three pieces of evidence mitigate this issue. First, I re-estimate Equation (1) using alternative measures of investment by matching PE funds to each deal.[23] Table B6 indicates that funds more exposed to liquidity shocks invest less both on the intensive and extensive margin. The smaller magnitude of coefficient estimates compared to the baseline results implies that SLCs might be used to partially undo investors' liquidity shocks. Second, borrowings on SLCs are often confined to short terms with maturities typically spanning from 90 days to one year, which implies that capital needs to be called from investors in the next quarter or so to pay off the debt. However, the dynamic pattern of investment displayed in Figure 7 shows that reduced investment lasts for more than one quarter and there is no significant increase in capital calls afterward, suggesting limited use of SLCs. Third, according to Preqin (2019), SLCs are less likely to be used by venture capital funds. Table C5 shows that venture capital funds call less capital from their investors when they are hit by liquidity shocks.

While allowing PE funds to better manage cash flows, SLCs can also be costly to both fund managers and investors. By changing the timing of capital calls from investors, SLCs can be used to manipulate a fund's IRR and make performance less comparable across funds,

[22] SCLs differ from leverage buyouts (LBO) debt and venture debt in terms of the entity obligated to repay the debt and the associated collateral. See Albertus and Denes (2023) for more details.

[23] 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.

creating agency concerns (Albertus and Denes, 2023). Moreover, SLCs are often arranged as short-term debt contracts, which add fund expenses due to interest and fees, especially under a high-interest rate environment, and can also contribute to increased liquidity risk if investors' capital cannot be called in time to pay off the debt. If defaulting on SLCs, the fund's underlying assets will go to the lender.

Moreover, a theoretical argument from the Modigliani–Miller perspective is that investors could have undone their liquidity shock by borrowing to meet capital calls. The fact that investors are reluctant to do so, as shown in Table 3 and 4, suggest that there must be frictions in using leverage to finance their illiquid investments after they are hit by liquidity shocks.

5.7.4 Robustness Checks

My identification strategy relies on a plausibly exogenous capital supply shifter with a tight set of fixed effects. Combined with the placebo test results shown in Figure 9, the investment patterns around the liquidity shocks in Figure 7 provide strong causal evidence supporting the transmission of liquidity shocks from other financial markets to the private equity sector. Nevertheless, I take steps to 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 Investors' Liquidity Shocks

The findings in Section 5 suggest that the liquidity shocks faced by investors lead to reduced investment made by PE funds. If fund managers cannot draw down capital as planned, it can result in significant costs for them. First, fund managers may need to pass on investment opportunities and even have reduced capital contributions in the case LP defaults. Second, fund managers pay upfront costs from deal selection and due diligence before calling capital from investors. Third, if fund managers 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. Motivated by the ex post impacts of investors' liquidity shocks and the associated costs to the fund managers, I next examine whether the investors' liquidity shocks have any ex ante implications on investment and capital allocation of PE funds.

6.1 Measure of Ex Ante Exposure to Funding Shocks

Liquidity shocks are economic situations that create urgent demand for cash-like securities, and investors often need to sell assets to meet such demand. The discussion in Section 2.1 suggests that endowments are less likely to be hit by liquidity shocks, since they are "*equity-financed*" by donations and thus do not have any formal contractual liabilities that must be met. In contrast, other major PE investors including pension funds and insurance companies are more susceptible to short-term market fluctuations, because they are "*debt-financed*" and need to rely on investment returns to fund their *contractual liabilities* - pension benefits and insurance claims.

Therefore, I measure a fund's ex ante exposure to investors' liquidity shocks using *Endowment Share*, the percentage of investors that are endowments or foundations in the fund,[24] which is negatively correlated with a fund's liquidity risk. Figure B8a shows the cross-sectional distribution of PE funds' exposure to endowments. Funds tend to have high exposure to endowments compared to P&C insurers, even though there is large heterogeneity across funds.

My measure is supported by the patterns of Figure 10, which shows the target portfolio weight of private equity for major investors in private equity. By far, endowments have the highest allocation compared to pension funds or insurance companies.[25] For example, the median allocation of endowments is approximately 14%, while the median value is 9% (4%) for a public pension fund (insurance company).[26] This pattern is consistent with

[24] Almost all endowments and foundations in my sample are based in the US. I exclude non-US endowments and foundations from the numerator when constructing the measure.

[25] Figure B7 displays the current private equity allocation of major investors and shows the same patterns.

[26] Compared to pension funds with a predictable schedule of contractual liability, insurance companies face stochastic insurance claims. As a result, insurance companies are more vulnerable to liquidity mismatch and have a lower optimal allocation to illiquid assets, which is also reflected in the regulatory restrictions on the liquidity ratios of insurers.

endowments' illiquidity tolerance that allows them to earn more illiquidity premium in their investments. The optimal allocation to private equity is affected by other factors such as diversification. Therefore, endowments will not choose to fully allocate their portfolios to private equity.

6.2 Acceleration of Drawdowns

There are at least two economic motivations for the fund manager to invest early rather than spending the committed capital evenly in the first few years. Firstly, the fund can decrease the amount of uncalled capital, which carries the risk of not being readily available for future drawdowns in the event of liquidity shocks impacting LP investors. Secondly, early investments contribute to building collateral that can help prevent defaults by LPs, which is consistent with my empirical finding in Table 9 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).[27] Detailed variable definitions are provided in Appendix A. Standard errors are clustered at the fund level.

Table 10 reports the coefficient estimates from Equation (4). *Log(1 + Fund Age)* has a statistically negative slope across all columns, suggesting that on average PE funds tend

[27]Figure B8b shows that these idiosyncratic factors generate sizable residual variation in endowment share across funds. Table B2 Panel B shows the balance of fund characteristics between funds with high and low residualized endowment shares.

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 cash drawdowns. This observation is supported by the positive and statistically significant coefficient estimates of *Log(1 + Fund Age)* × *Endowment Share*.

Indeed, 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 10.

6.3 Investment Distortion

If accelerating drawdowns can insure against funding shocks, 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. All the agreements include "call-to-invest" provision which requires the fund manager to call only as much capital as they can promptly invest.[28] 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 may lead to suboptimal investment and thus lower fund returns.[29]

To investigate whether the acceleration of drawdowns leads to distortion of investment,

[28] 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.

[29] 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.

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 portoflio company resepctively. 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 the first year since 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 11 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 return persistence. At the fund level, certain managers consistently deliver superior returns even after risk

adjustment. 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 outcomes 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.

My findings about PE funds' ex post reduced investment and ex ante distorted investment schedules due to liquidity shocks implies that the institutional frictions faced by their investors can be another source of return persistence at both the fund and investor level. Funds with 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 awarded by higher returns (Maurin, Robinson, and Strömberg, 2022).

In terms of external validity, my results align with the higher private equity 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 funds, my findings suggest that endowments' illiquidity tolerance due to their lack of contractual liabilities can also contribute to their outperformance in private equity.[30]

[30]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 stakes, which reduces the competitive advantage of capital provided by investors that have higher illiquidity tolerance.

7 Conclusion

Due to a number of factors including shifting investments to intangibles, deregulation, as well as regulatory costs faced by public companies (e.g. Kahle and Stulz, 2017; Ewens and Farre-Mensa, 2020; Ewens, Xiao, and Xu, 2021), private equity has been playing an increasingly important role in financing businesses and supporting economic growth. This market is intermediate by PE funds that raise capital committed by various types of institutional investors including pension funds, endowments, and insurance companies, which have different funding structures and contractual liabilities.

This paper shows that investor base compositions affect real investment and capital outcomes in PE markets. Liquidity shocks experienced by investors lead to reduced investment ex post and distorted investment schedule ex ante for PE funds. Specifically, I use natural disasters as plausibly exogenous liquidity shocks to P&C insurers to provide causal evidence on reduced investment by PE funds after liquidity shocks. The transmission of shocks is mitigated by a liquid secondary market, which reduces investors' costs of holding illiquid PE fund stakes, and contracting on cash drawdowns, which act as a deterrence device to enforce cash drawdowns. Moreover, I show that funds with less capital from endowments face more distortion in the investment schedules due to higher ex ante exposure to funding shocks and stronger incentives to accelerate cash drawdowns.

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.[31] Studying the transmission of these shocks allows policymakers to identify vulnerabilities and design measures to mitigate the potential systemic risks. At

[31]For example, Bernstein, Lerner, and Mezzanotti (2019) and Johnston-Ross, Ma, and Puri (2021) show that buyout funds increase the financial stability of public companies and failed banks by providing timely financing during the 2008 financial crisis. Therefore, liquidity shocks to buyout funds' investors can prevent these funds from providing timely financing to distressed companies.

the macroeconomic level, my findings suggest that PE funding can dry up due to shocks to investors, even if there is a large amount of uncalled capital, which is often assumed to be easily accessible for investment. At last, my paper also informs the trade-off in the design of PE funds, such as the use of escrow accounts for shock-prone investors.

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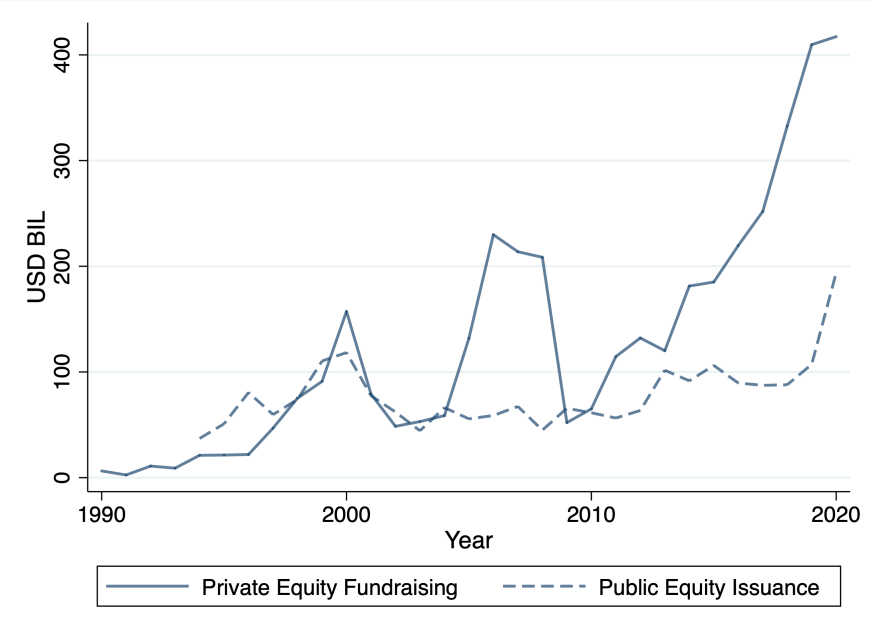


Figure 1: Expansion of Private Equity Markets

This figure shows the amount of capital raised by PE funds in the US during 1990-2021. 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 (IPOs) and seasoned equity offerings (SEOs) in the same period. The fundraising data is collected from Preqin and the equity issuance data is from the Federal Reserve Board.

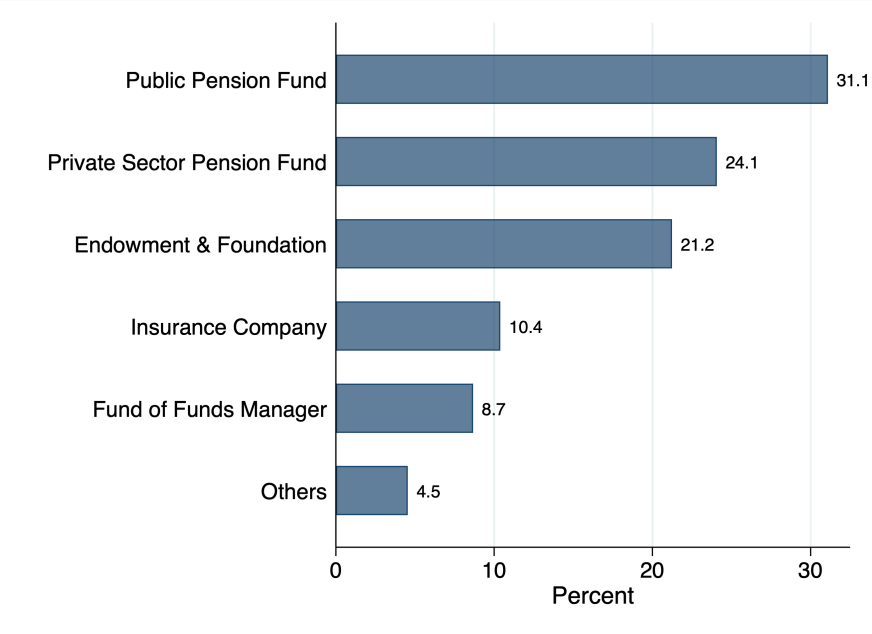


Figure 2: Institutional Types of Private Equity Investors

This figure ranks the institutional type of PE investors based on the number of PE fund investments. The sample consists of investors in US PE funds raised between 1990 and 2020. Other institutional types include family offices, sovereign wealth funds, corporate investors, banks, government agencies, and asset managers, etc.

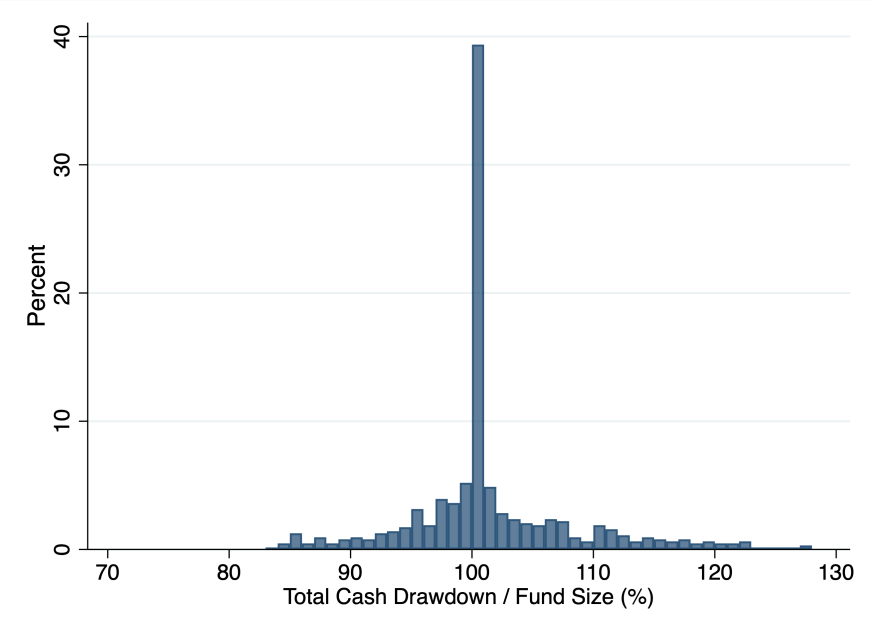
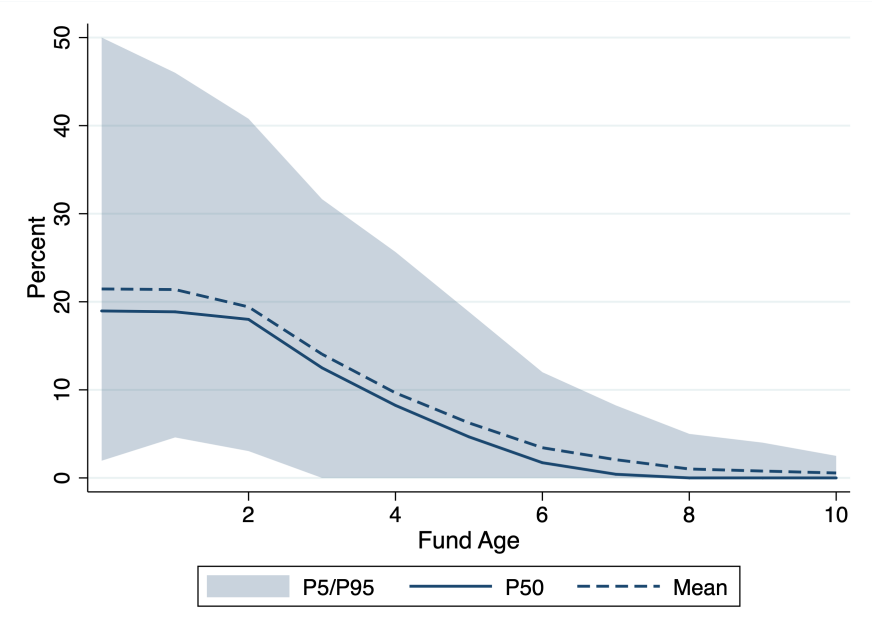
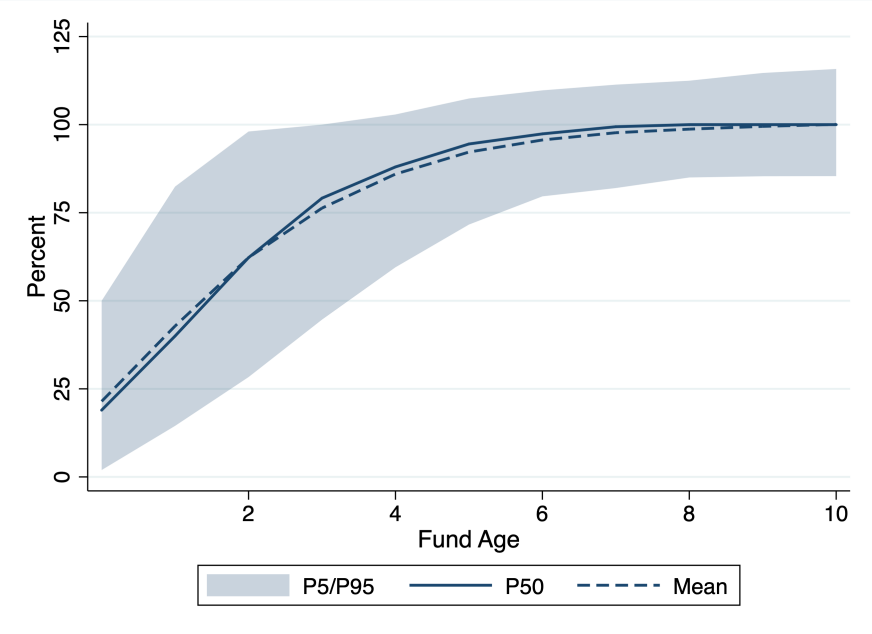


Figure 3: Cross-sectional Distribution of Total Cash Drawdowns

This figure displays the cross-sectional distribution of the total amount of cash drawdowns to PE fund size by 2021Q2. The fund size is the total amount of capital committed by investors at the fund inception. The sample consists of US PE funds raised between 1990 and 2005 so each fund has at least 15 years to draw down cash. Some funds' total cash drawdowns are more than 100% of their committed capital because of recycling provisions that allow fund managers to reinvest exit proceeds rather than distributing them back to investors. The majority of funds make capital calls that are in total close to the fund size. Figure B2 shows that the patterns are robust to subsamples by fund type, fund size, and fund sequence.



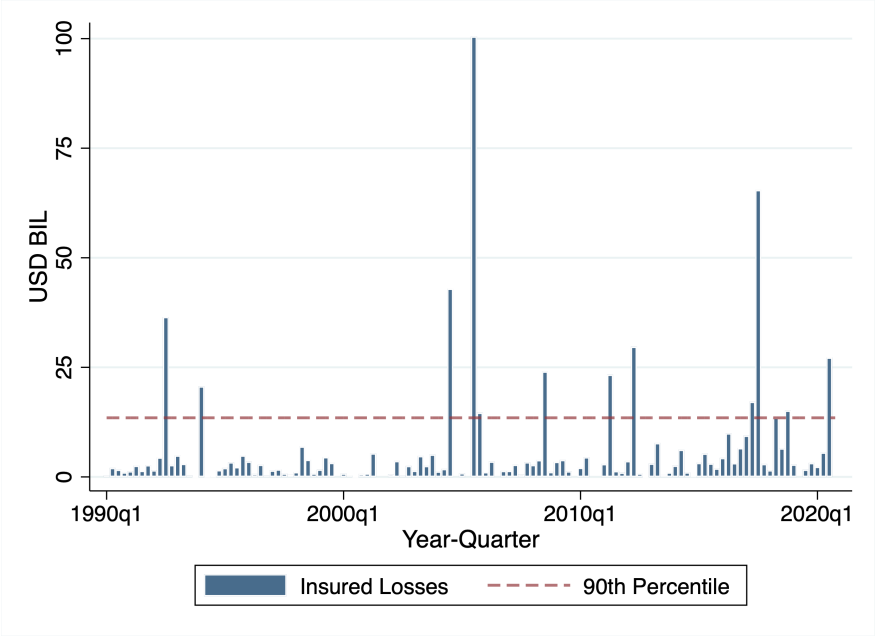
(a) Cash Drawdowns by Fund Age



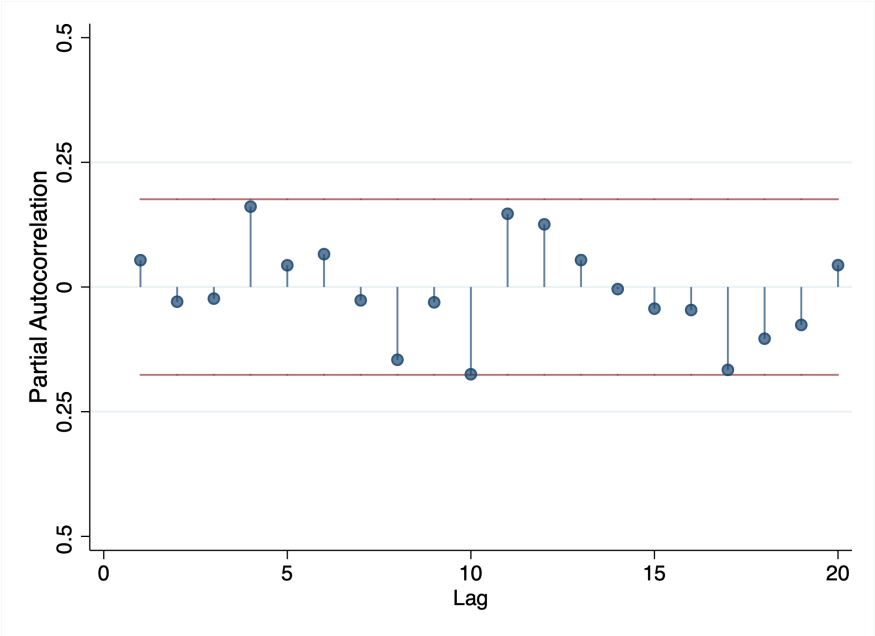
(b) Cumulative Cash Drawdowns by Fund Age

Figure 4: Life Cycle of Private Equity Fund Capital Calls

Figure 4a presents the mean, median and tails of capital calls in percentage of total committed capital by fund age in years. The sample consists of US PE funds raised between 1990 and 2005 so that each fund has at least 15 years to drawn down cash from investors by 2021Q2. The dash and solid line indicate the mean and median value.The shaded area shows 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 B3 and B4 show that the patterns are robust to subsmples by fund type, fund size and fund sequence.



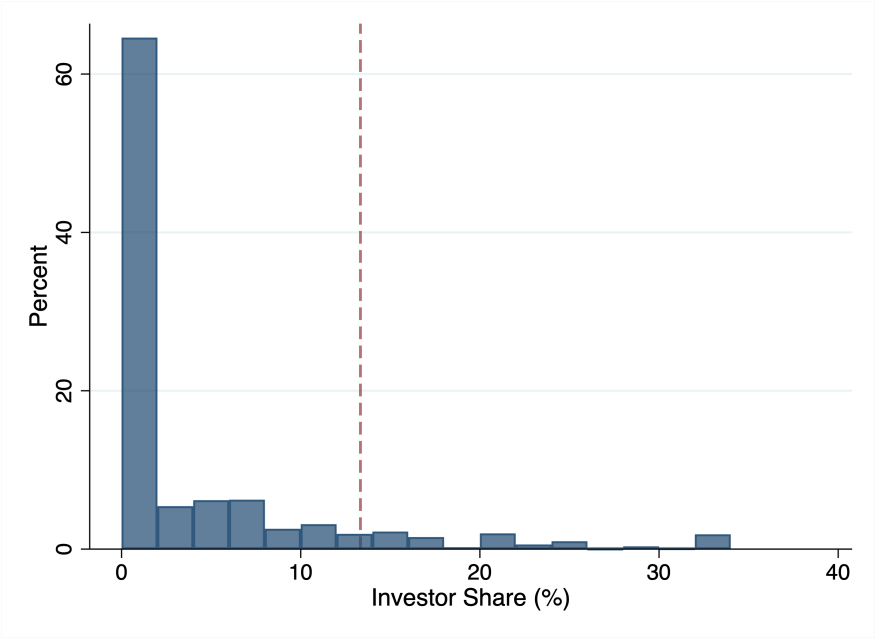
(a) Quarterly Insured Losses from Natural Disasters



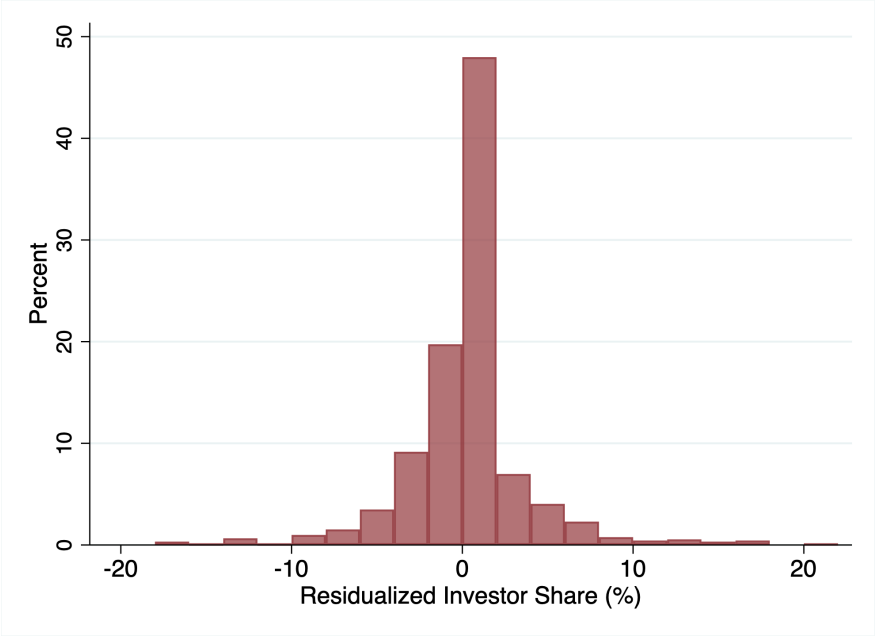
(b) Partial Autocorrelation of the Occurrence of Liquidity Shocks

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

Figure 5a shows the quarterly insured losses 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 from natural disasters, and are liquidity shocks to property & casualty insurers. Figure 5b shows the partial autocorrelation of the time series of the indicator variable *Liquidity Shock*. The red horizontal lines show the 95% confidence intervals. The Durbin-Watson statistics for the *Liquidity Shock* time series is 1.89, which cannot reject the null hypothesis of no serial correlation. These tests suggest that liquidity shocks from large natural disasters are unpredictable for P&C insurers.



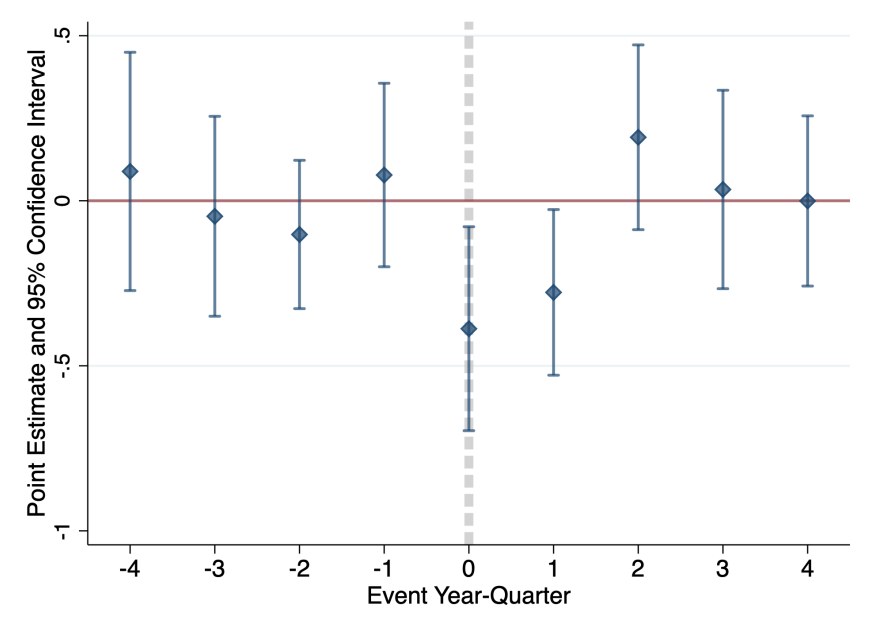
(a) P&C Insurer Share (%)



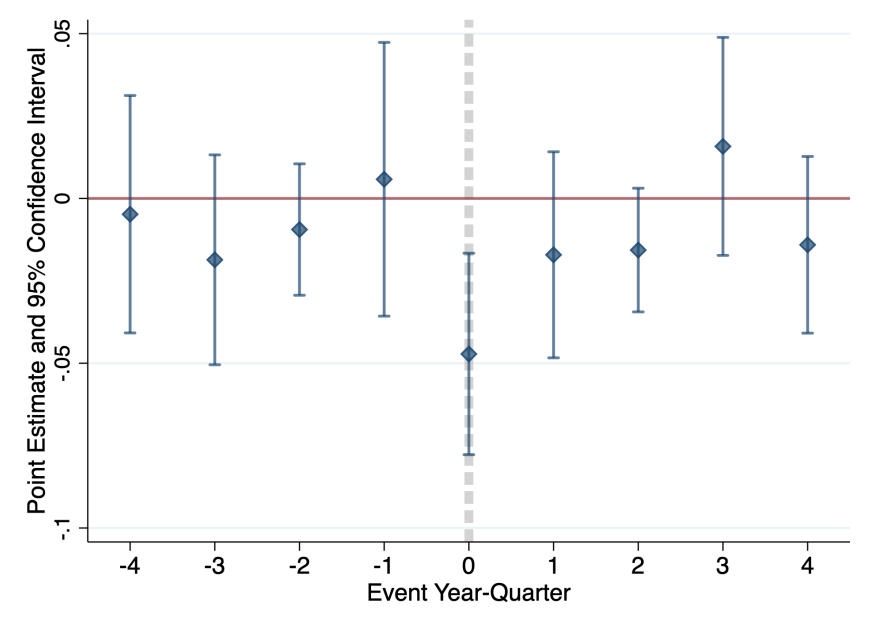
(b) Residual P&C Insurer Share (%)

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 shows the 90th percentile value (13.3%). Figure 6b shows the cross-sectional distribution of the residual property & casualty insurer share. 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 B2 reports the balance of fund characteristics.



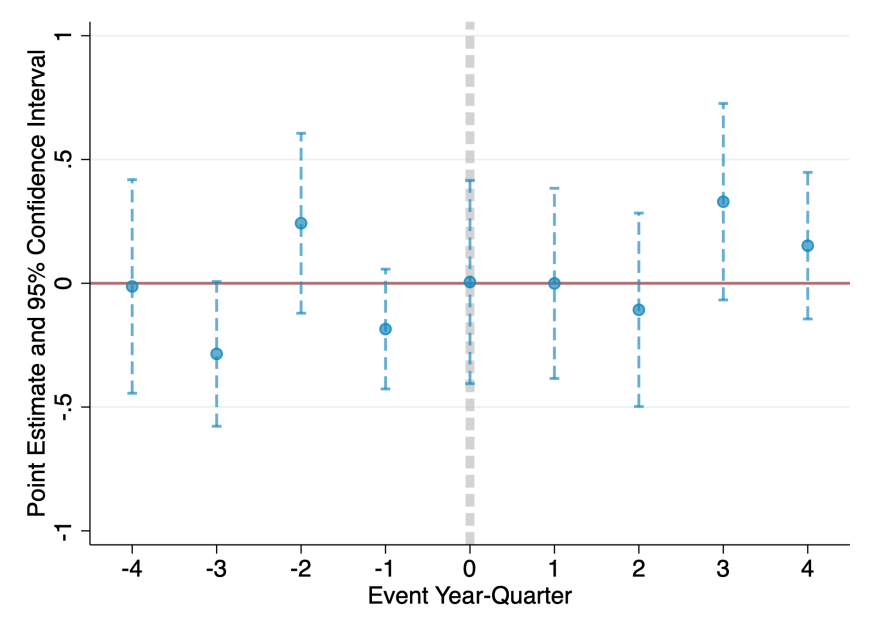
(a) Amount of Cash Drawdowns (%)



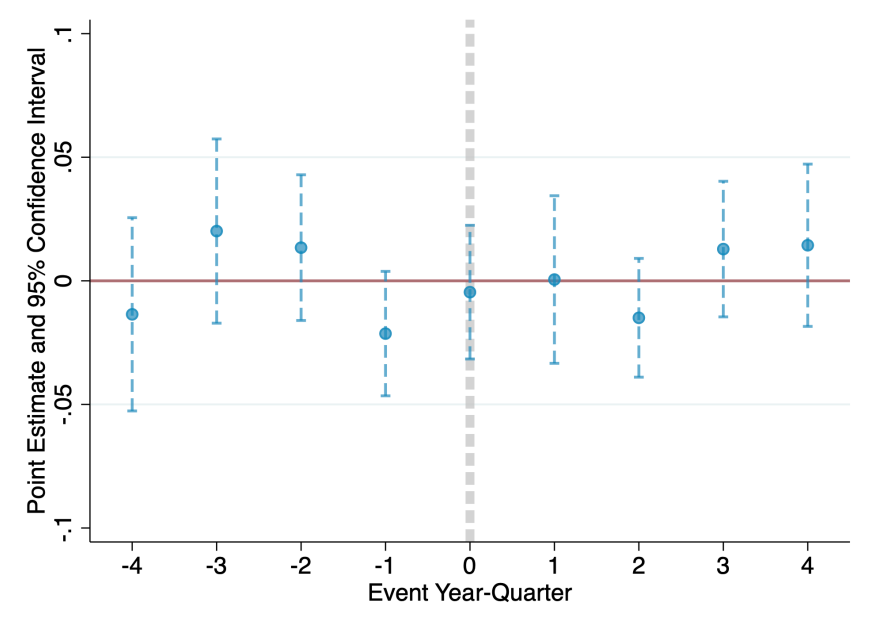
(b) Number of Investments

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

This figure plots estimates of $P\&C\ Insurers_i \times Liquidity\ Shock_{t+n}$ from Equation (2) at different quarters surrounding the period with abnormal insured losses from natural disasters (quarter Q0) and the associated two-tailed 95% confidence intervals. In Figure 7a, the outcome variable is *Capital Called (%)*, which is the quarterly amount of capital drawn down by a PE fund as a percentage of its fund size. In Figure 7b, the outcome variable is the *Number of Investments*, the number of investments made by the fund manager in the year-quarter. Year-quarter, fund age, fund manager × fund type × fund size fixed effects are included. Standard errors are two-way clustered at the fund and calendar quarter levels.



(a) Amount of Cash Drawdowns (%)



(b) Number of Investments

Figure 8: Investment Dynamics - Placebo Tests Based on Exposure to Life Insurers

This figure plots estimates of *Life Insurers*$_i$ × *Liquidity Shock*$_{t+n}$ in a regression specification similar to Equation (2) at different quarters surrounding the period with abnormal insured losses from natural disasters (quarter Q0) and the associated two-tailed 95% confidence intervals. In Figure 8a, the outcome variable is *Capital Called (%)*, which is the quarterly amount of capital drawn down by a PE fund as a percentage of its fund size. In Figure 8b, the outcome variable is the *Number of Investments*, the number of investments made by the fund manager in the year-quarter. Year-quarter, fund age, fund manager × fund type × fund size fixed effects are included. Standard errors are two-way clustered at the fund and calendar quarter levels.

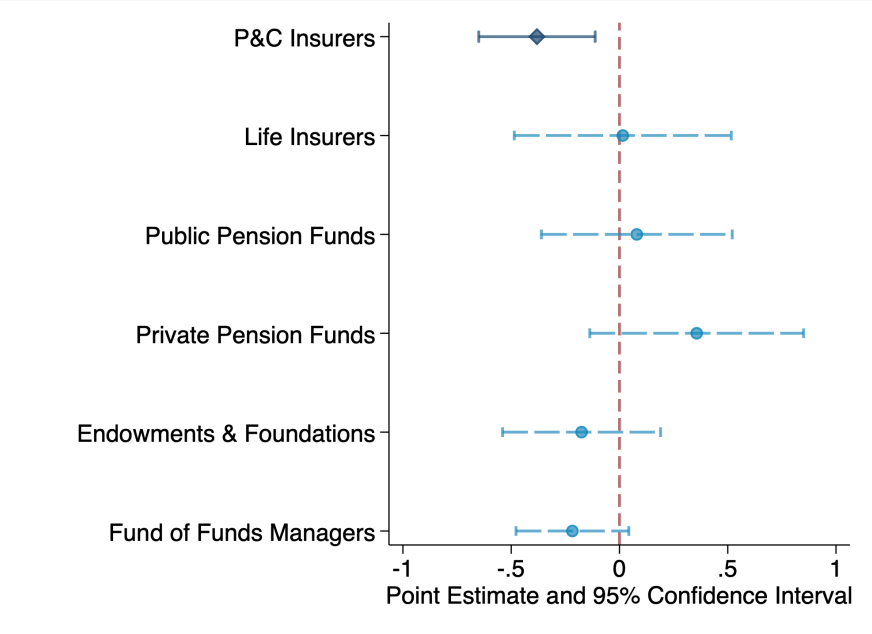


Figure 9: DiD Estimates Based on Exposures to Different Types of Investors

For Capital Called (%), this figure plots the estimated difference-in-differences (DiD) coefficients from 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. The exposure measures are defined similarly to *P&C Insurer Exposure*, an indicator variable equal to one if the fund's exposure to P&C insurers 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*. Year-quarter, fund age, fund manager × fund type × fund size fixed effects are included. Standard errors are two-way clustered at the fund and calendar quarter levels.

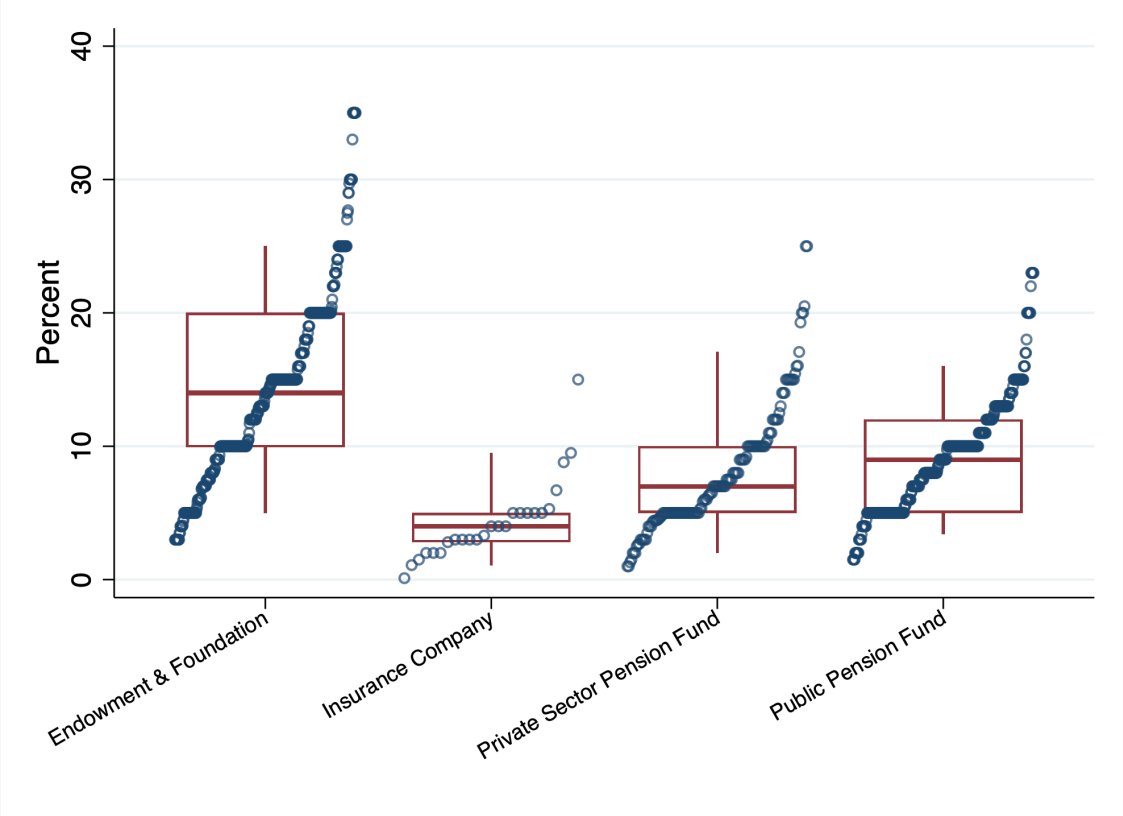


Figure 10: Target Private Equity Allocation by Investor Types

This figure shows the target private allocation of major investors in private equity. Each candlestick represents i) the quartiles in the thick body, ii) the 5th and 95th percentiles in the lower and upper shadow. The dots in front of each candlestick display the empirical distribution of investors' target private equity allocation, with each dot representing an investor. Endowments & foundations have the highest allocation to private equity. Figure B7 shows the current private equity allocation by investor types.

Table 1: Periods with Abnormal Insured Losses from 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 losses equal to or greater than the 90th percentile value of quarterly losses during 1990 and 2020. Detailed information such as insured loss, total loss and names of major disasters in the period are also reported. The calendar quarters are ranked in descending order based on the total insured loss.

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 back 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 fund's exposure to P&C insurers 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 in the 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 in the 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 the first year since 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	65805
Number of Investments	0.38	0.51	0.00	0.00	0.00	1.00	1.00	65805
Cash Distributed (%)	2.63	11.89	0.00	0.00	0.00	0.71	7.25	65805
P&C Insurer Exposure	0.09	0.28	0.00	0.00	0.00	0.00	0.00	65805
P&C Insurer Share (%)	3.89	6.70	0.00	0.00	0.00	6.06	12.50	65805
Liquidity Shock	0.13	0.34	0.00	0.00	0.00	0.00	1.00	65805
Life Insurer Exposure	0.08	0.27	0.00	0.00	0.00	0.00	0.00	65805
Life Insurer Share (%)	4.98	7.74	0.00	0.00	0.00	8.11	15.38	65805
Liquid Secondary Market	0.19	0.39	0.00	0.00	0.00	0.00	1.00	65535
High Drawdown	0.50	0.50	0.00	0.00	1.00	1.00	1.00	65805
Endowment Share (%)	16.85	16.04	0.00	0.00	13.56	25.00	40.00	65805
Fund Age (Quarters)	23.19	16.03	3.00	9.00	21.00	35.00	47.00	65805
Panel B: Fund-Company Pair Level								
IPO	0.10	0.30	0.00	0.00	0.00	0.00	1.00	37358
Successful Exit	0.18	0.39	0.00	0.00	0.00	0.00	1.00	37358
Early Investment	0.48	0.50	0.00	0.00	0.00	1.00	1.00	37358
Endowment Share (%)	23.20	22.37	0.00	5.26	19.05	33.33	52.00	37358

Table 3: Investors' Liquidity Shocks and Amount of Cash Drawdowns

This table reports results of the difference-in-differences estimations that investigate the impact of investors' liquidity shocks on the amount of cash drawn down 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. *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 fund's exposure to P&C insurers 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 in the 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	65805	65805	64675	65805	65805	64675
R^2	0.195	0.203	0.207	0.195	0.203	0.207

Table 4: Investors' Liquidity Shocks and Number of Investments

This table reports results of the difference-in-differences estimations that investigate 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 fund's exposure to P&C insurers 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 in the 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	65805	65805	64675	65805	65805	64675
R^2	0.251	0.297	0.313	0.250	0.297	0.313

Table 5: Placebo Tests - Funds' Exposure to Life Insurers

This table shows the placebo tests using funds' exposure to life insurers. 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 fund's exposure to life insurers is greater than the 90th percentile value, and zero otherwise. *Life Insurer Share* is the percentage of investors that are life insurers in the 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 Cash 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	65805	65805	64675	65805	65805	64675
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	65805	65805	64675	65805	65805	64675
R^2	0.250	0.297	0.313	0.250	0.297	0.313

Table 6: Investors' Liquidity Shocks and Amount of Cash Distributions

This table reports results of the difference-in-differences estimations suggesting that PE funds do not provide liquidity to investors through cash distributions when they are hit by liquidity shocks. 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 back 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 fund's exposure to P&C insurers 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 in the 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	65805	65805	64675	65805	65805	64675
R^2	0.041	0.061	0.079	0.041	0.061	0.079

Table 7: Investors' Liquidity Shocks and Private Equity Fund Returns

This table reports results from cross-sectional regressions that investigate the impacts of investors' liquidity shocks on private equity 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 in the 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 in the fund. Insurance companies with only life or health insurance divisions are considered as life insurers. *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 specification in Columns 1 and 4 includes 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 - Placebo Tests

	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 8: Effects of a Liquid Secondary Market for Private Equity Fund Stakes

This table reports results from the triple-diff estimations that investigate whether a liquid secondary market for PE fund stakes attenuates the impacts of investors' liquidity shocks on investments made by PE funds. A liquid secondary market allows existing investors to gain liquidity from their illiquid PE fund stakes more easily. 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 in the 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 available to the fund managers for drawdowns when attractive investment opportunities arise. 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	-0.030***	-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	0.026***	0.024**	0.024**	0.003*	0.003**	0.003*
	[0.009]	[0.009]	[0.009]	[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	65535	65535	64430	65535	65535	64430
R^2	0.195	0.203	0.207	0.251	0.298	0.314

Table 9: Mitigation of Investors' Liquidity Shocks through Cumulative Drawdowns

This table reports results from the triple-diff estimations that investigate whether greater cumulative drawdowns mitigate the transmission of investors' liquidity shocks to PE funds due to the most punitive and commonly used fund interest forfeiture provision in LP defaults. LPs stand to lose their contributed capital if they cannot meet capital calls. As a result, early investments act as collateral against LP defaults. 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 in the 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 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	65805	65805	64675	65805	65805	64675
R^2	0.200	0.216	0.225	0.258	0.308	0.324

Table 10: Investors' Liquidity Shocks and Acceleration of Cash Drawdowns

This table reports the results of the panel regression estimations that investigate the ex ante effects of investors' liquidity shocks on PE funds' investment pace. 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 in the 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 clustered at the fund level 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*	-0.008	-0.001**	-0.001	-0.000
	[0.005]	[0.005]	[0.005]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.940***	-1.871***	-1.721***	-0.217***	-0.204***	-0.160***
	[0.040]	[0.044]	[0.051]	[0.004]	[0.005]	[0.006]
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	67306	67306	66115	67306	67306	66115
R^2	0.162	0.169	0.173	0.176	0.222	0.248

Table 11: Ex Ante Effect of Investors' Liquidity Shocks on Portfolio Company Outcomes

This table investigates the ex ante effect of investors' liquidity shocks on portfolio company outcomes. 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 the first year since the fund vintage year, and zero otherwise. *Endowment Share* is the percentage of investors that are endowments or foundations in the 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	37939	37777	37939	37777
R^2	0.187	0.219	0.197	0.225

Online Appendix for

"Cash for Calls: Liquidity Shocks and Private Equity Investment"

Yingxiang Li

University of British Columbia

September 26, 2023

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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 back 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 fund's exposure to P&C insurer 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 in the 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.
Life Insurer Exposure	An indicator variable equal to one if the fund's exposure to life insurer is 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 in the 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 in the fund.
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 available to the fund managers for drawdowns when attractive investment opportunities arise.
Cumulative Drawdown	A variable ranging from 1 to 5 that ranks a fund by 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 B: 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 the first year since the fund vintage year, and zero otherwise.

Endowment Share	The percentage of investors that are endowments or foundations in the fund.
Panel C: 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

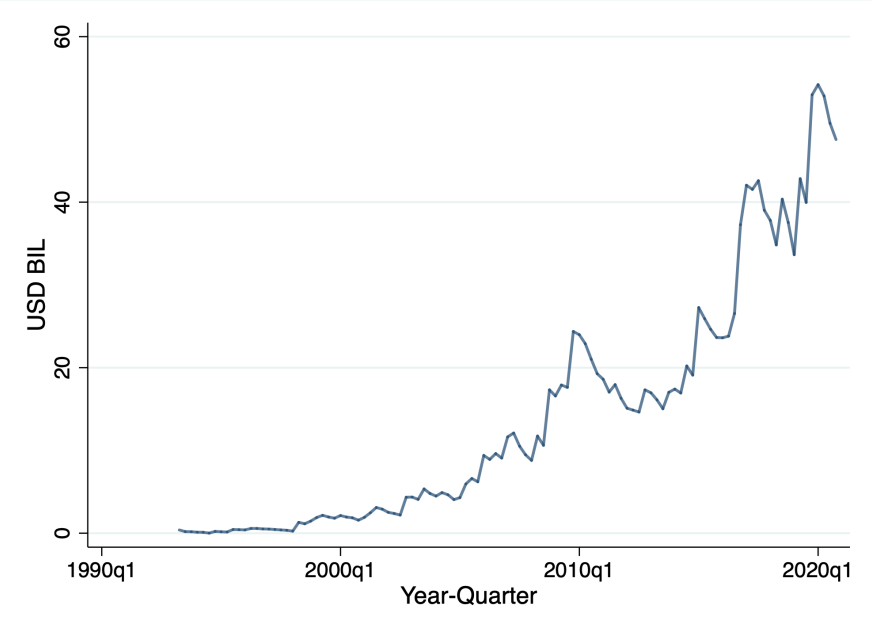
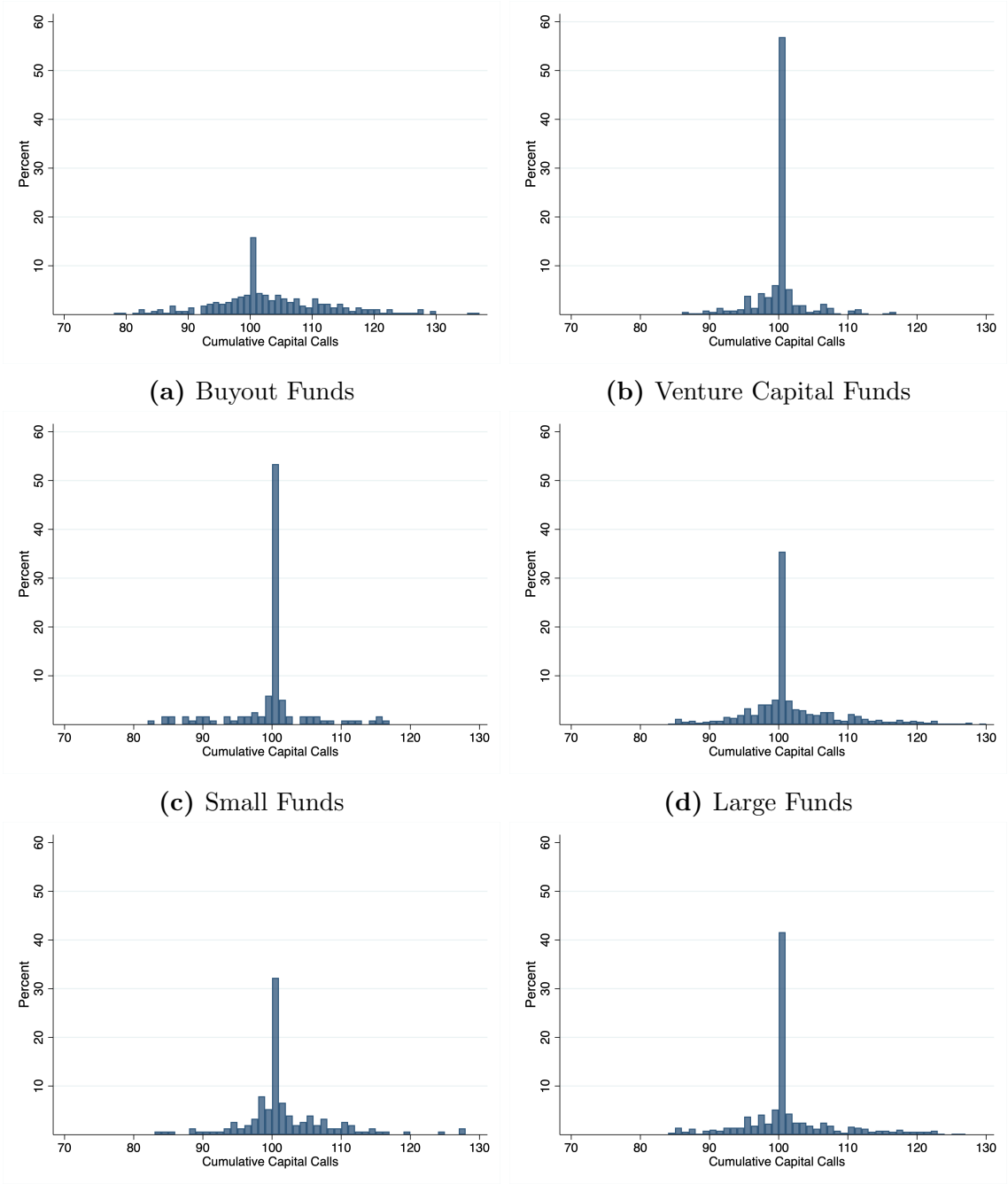


Figure B1: Liquidity of the Secondary Market for Private Equity Fund Stakes

This figure shows the liquidity of the secondary market for PE fund stakes. The solid line indicates the amount of dry powder of secondary funds in USD BIL. Dry powder is defined as the cash reserves available to the fund managers for drawdowns when attractive investment opportunities arise.



(a) Buyout Funds

(b) Venture Capital Funds

(c) Small Funds

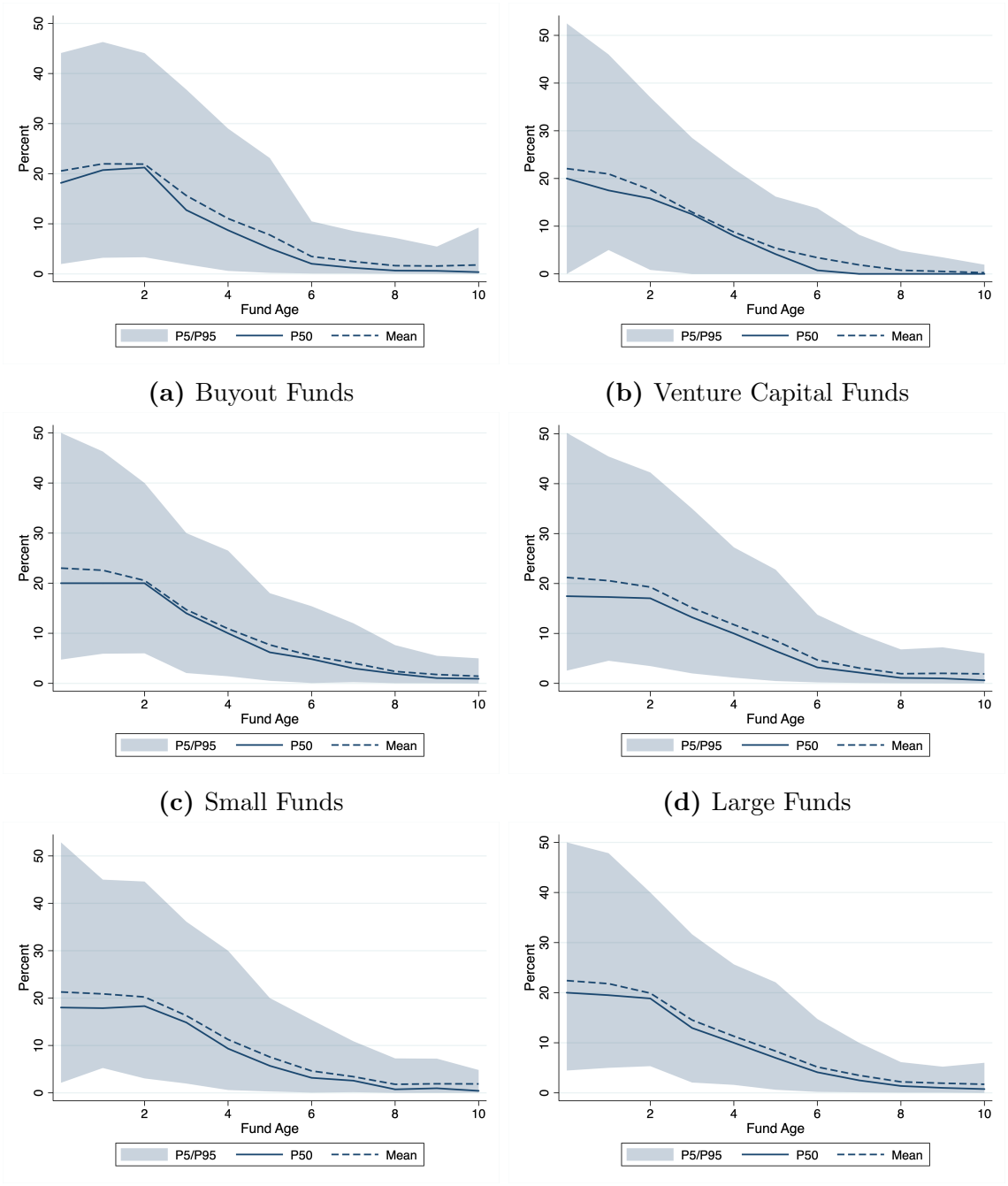
(d) Large Funds

(e) First Funds

(f) Non-First Funds

Figure B2: Cross-sectional Distribution of Total Cash Drawdowns - Subsamples

For each subsample, this figure displays the cross-sectional distribution of total amount of cash drawdowns to fund size by 2021Q2. The fund size is the total amount of capital committed by investors at the fund inception. The sample consists of US PE funds raised between 1990 and 2005 so that each fund has at least 15 years to draw down cash. The figure with the full sample is presented in Figure 3.



(a) Buyout Funds

(b) Venture Capital Funds

(c) Small Funds

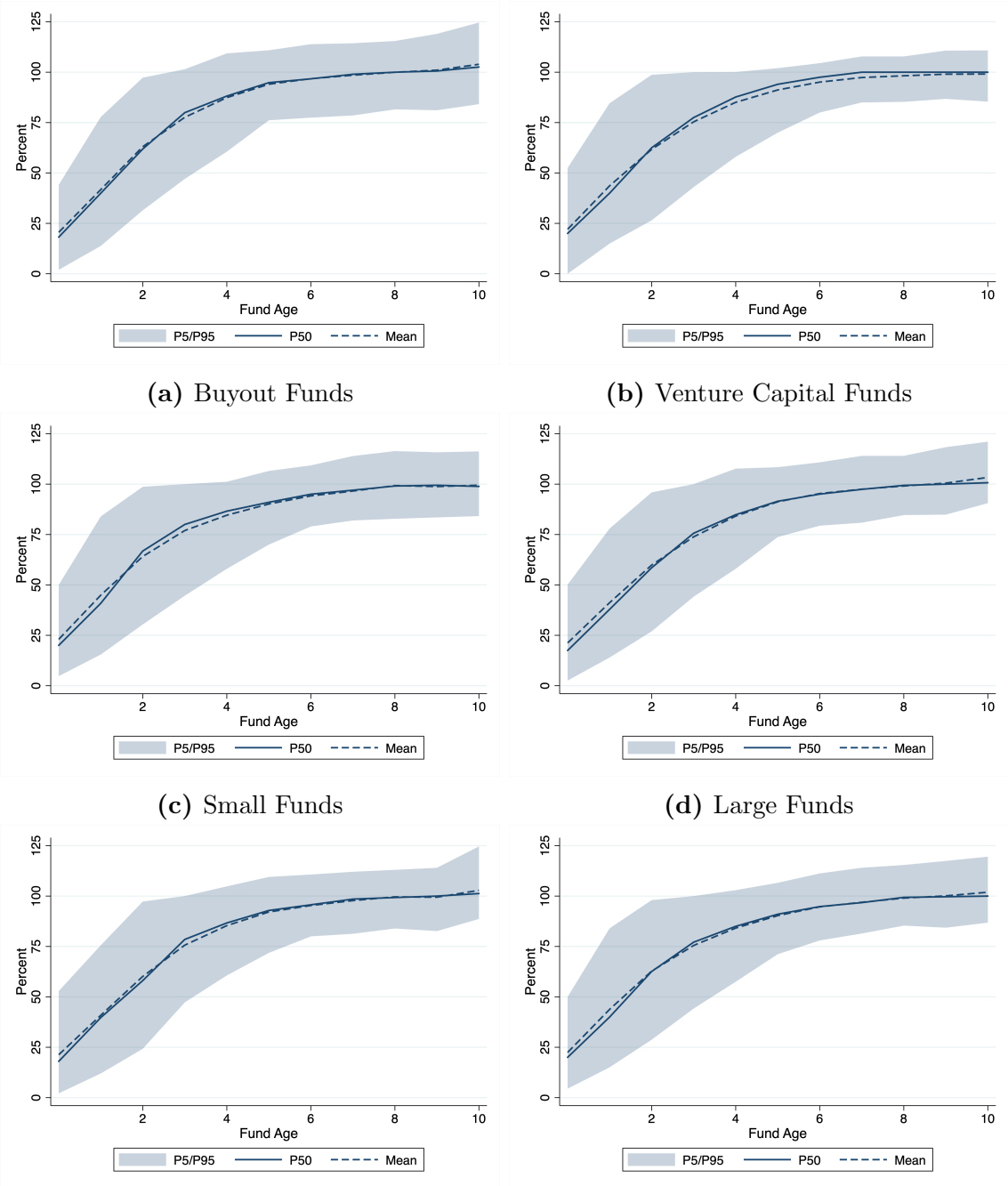
(d) Large Funds

(e) First Funds

(f) Non-First Funds

Figure B3: Cash Drawdowns by Fund Age - Subsamples

For each subsample, this figure presents the mean, median and tails of capital calls in percentage of total committed capital by fund age in years. The sample consists of US PE funds raised between 1990 and 2005 so that each fund has at least 15 years to drawn down cash from investors by 2021Q2. The dash and solid line indicate the mean and median value.The shaded area shows 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 B4: Cumulative Cash Drawdowns by Fund Age - Subsamples

For each subsample, this figure presents the mean, median and tails of cumulative capital calls in percentage of total committed capital by fund age in years. The sample consists of US PE funds raised between 1990 and 2005 so that each fund has at least 15 years to drawn down cash from investors by 2021Q2. The dash and solid line indicate the mean and median value.The shaded area shows the range between the 5th percentile and the 95th percentile. The figure with the full sample is presented in Figure 4b.

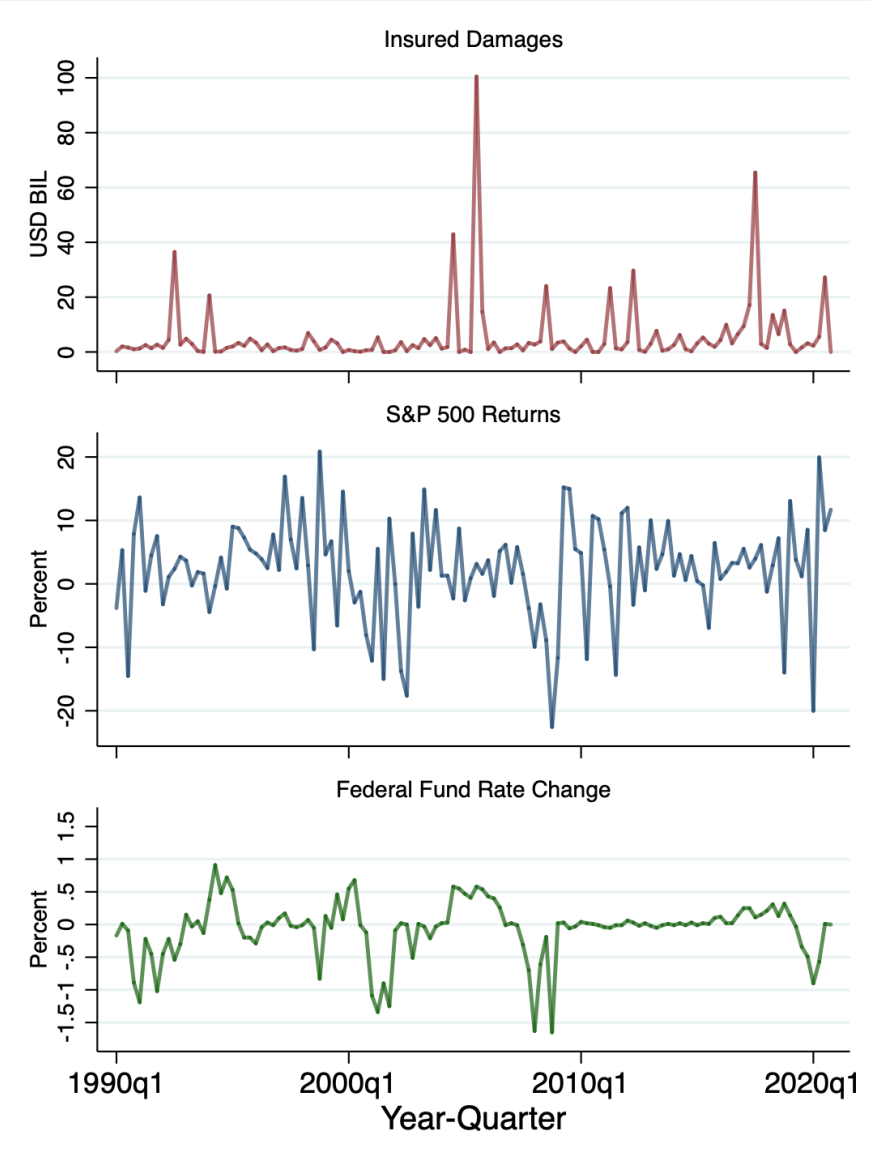
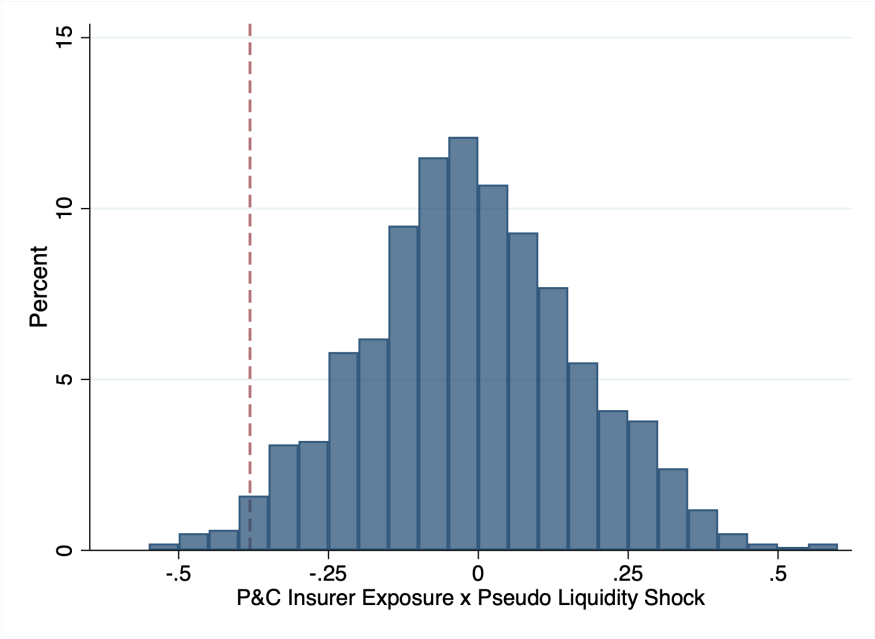
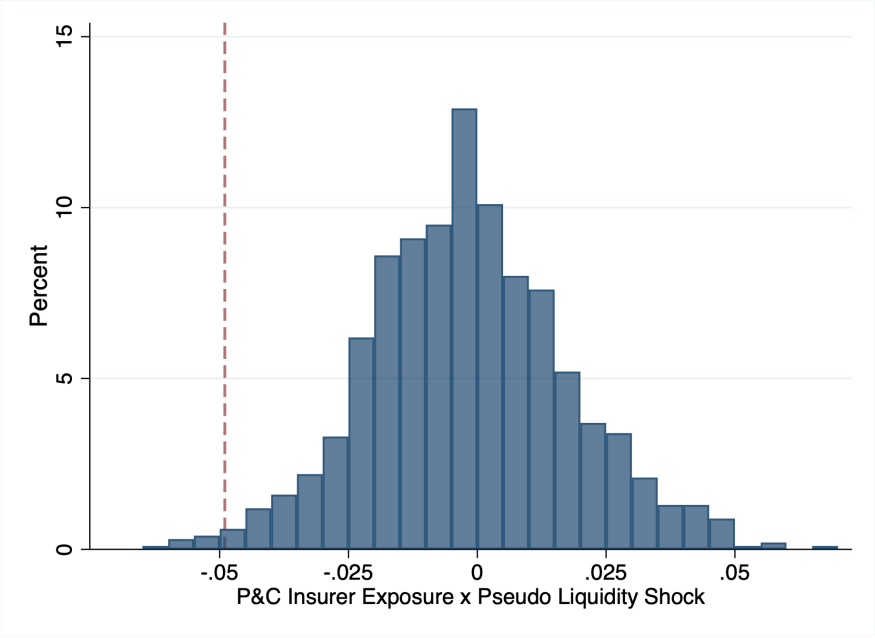


Figure B5: Time Series of Insured Losses and Marco Economic Shocks

This figure shows the quarterly time series of insured damages, S&P 500 returns, and changes in the federal fund effective rate. The correlations of insured damages with S&P 500 returns and federal fund rate changes are -0.04 and 0.17 and statistically insignificant at the 5% level.



(a) *Capital Called (%)*



(b) *Number of Investments*

Figure B6: Distributions of DiD Coefficients Estimated With Pseudo Liquidity Shocks

This figure plots the histogram of estimated DiD coefficients from 1000 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 estimate *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 the subtitles. 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.

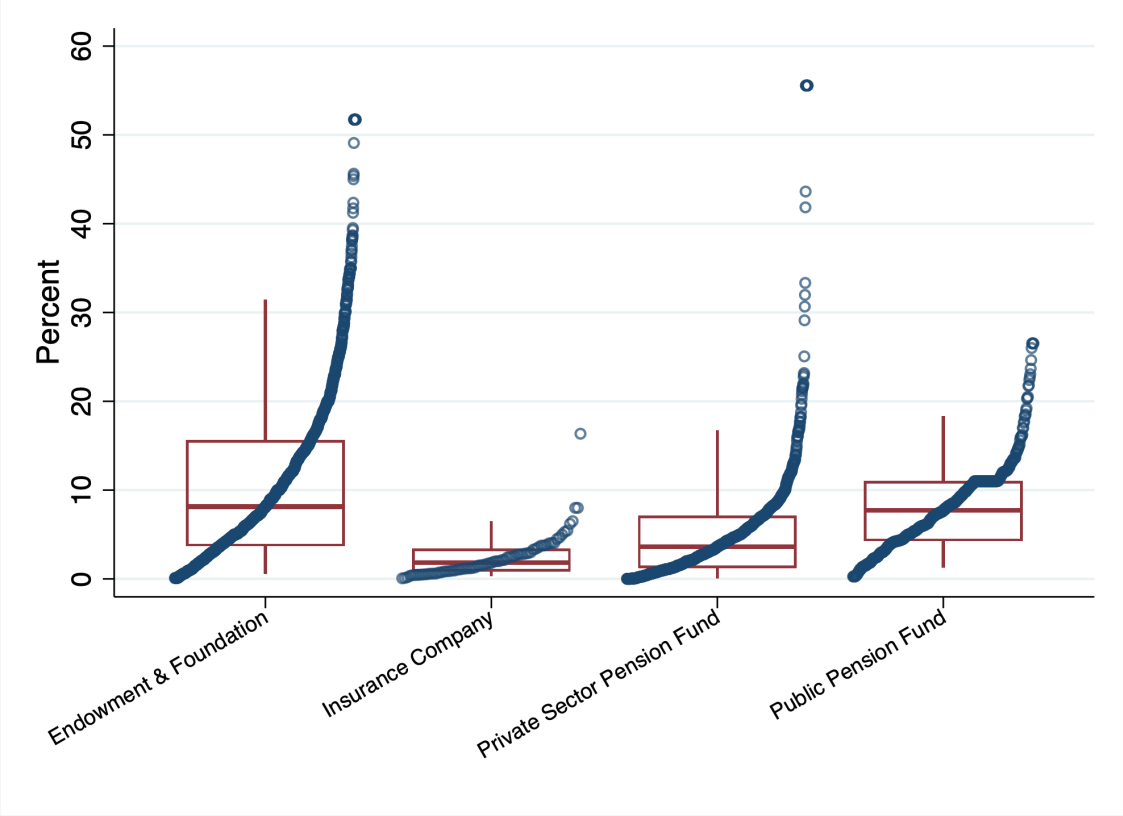
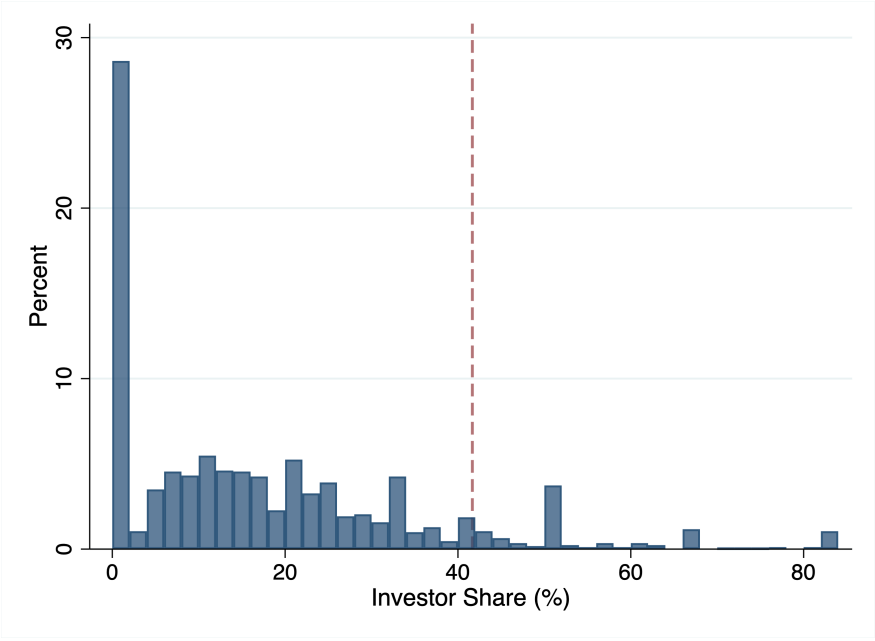
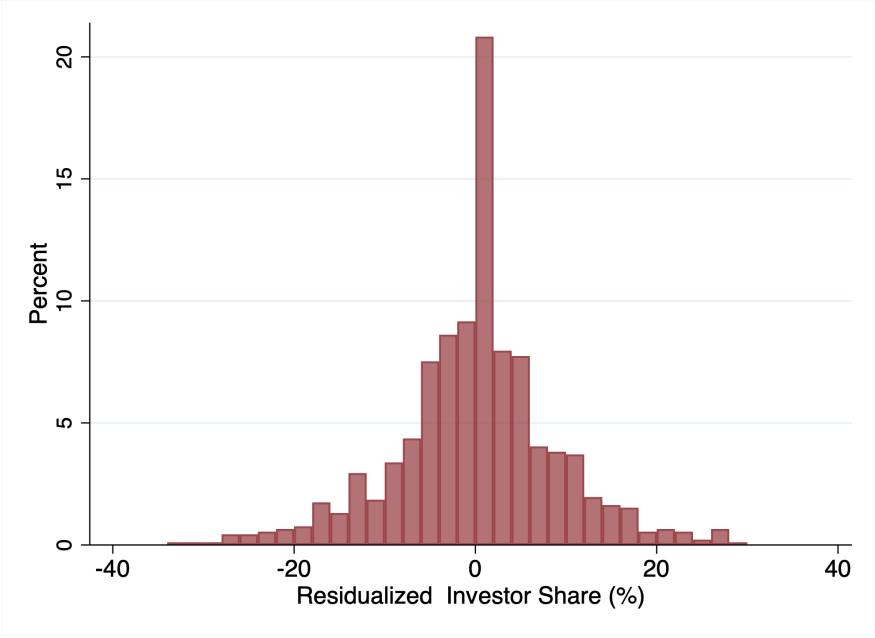


Figure B7: Current Private Equity Allocation by Investor Types

This figure shows the current private allocation of major investors in private equity. Each candlestick represents i) the quartiles in the thick body, ii) the 5th and 95th percentiles in the lower and upper shadow. The dots in front of each candlestick display the empirical distribution of investors' current private equity allocation, with each dot representing an investor. Endowments & foundations have the highest allocation to private equity. Figure 10 shows the target private equity allocation by investor types.



(a) Endowment Share (%)



(b) Residual Endowment Share (%)

Figure B8: Share of Endowments at the Fund Level

Figure B8a 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 shows the 90th percentile value (41.7%). Figure B8b shows the cross-sectional distribution of the residual endowment share. 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 endowment share. Table B2 reports the balance of fund characteristics.

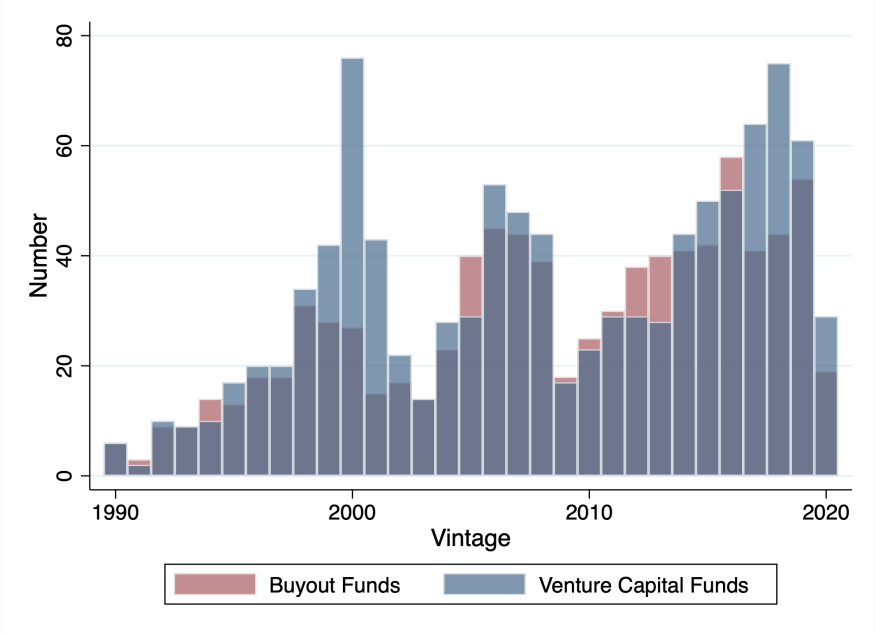


Figure B9: Distribution by Vintage and Fund Type

This figure shows the sample distribution of PE funds by vintage and fund type.

Table B1: Private Equity Fund Characteristics - Sample Representativeness

This table compares PE fund characteristics of the full sample and the sample with cash flow and investor data in Preqin. The PE funds examined are PE funds, excluding funds of funds, secondary funds, and co-investment funds, raised between 1990 and 2020 covered by Preqin. *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). Detailed variable definitions are provided in Appendix A. ***, **, and * indicate 1%, 5%, and 10% significance levels.

	Full Sample Mean	Analysis Sample Mean	Difference	t-stats
Buyout Fund	0.20	0.48	-0.28	-24.75***
Target Size ($ MIL)	202.65	1206.95	-1004.30	-34.29***
Fund Size ($ MIL)	216.48	1082.14	-865.66	-36.59***
Fund Sequence	2.17	4.11	-1.94	-31.77***
CA	0.33	0.30	0.03	2.15**
NY	0.19	0.22	-0.03	-3.19***
MA	0.07	0.13	-0.06	-7.76***
IL	0.04	0.08	-0.03	-5.77***
TX	0.05	0.04	0.01	1.31

Table B2: Balance of Fund Characteristics

This table presents PE fund characteristics of funds assigned to the first and last decile groups 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 PE funds examined are PE funds, excluding funds of funds, secondary funds, and co-investment funds, raised between 1990 and 2020 covered by Preqin. *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 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 in the 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: Capital Calls and Investors' Funding Costs

This table reports OLS regression results that show private equity 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 clustered at the 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	-0.395***		-0.389***		-0.400***	
	[0.105]		[0.110]		[0.119]	
Term Spread		-0.165***		-0.162***		-0.158***
		[0.042]		[0.047]		[0.049]
Fund Age FE	✓	✓	✓	✓	✓	✓
Observations	68272	68272	31772	31772	36500	36500
R^2	0.171	0.171	0.152	0.152	0.195	0.195

Table B5: Ruling Out Alternative Explanations - Reduced Capital Demand

This table reports regression results that rule out reduced capital demand as an alternative explanation. Panel A excludes fund-quarters in states affected by natural disasters. Panel B restricts 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 in the fund and the value. 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 company 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	31730	31727	31166	31730	31727	31166
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	37696	37695	37094	37696	37695	37094
R^2	0.227	0.236	0.239	0.275	0.323	0.337

Table B6: 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 restrict 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 fund's exposure to P&C insurers 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 in the 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	48953	48953	48952	48953	48953	48952
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	49579	49579	48952	49579	49579	48952
R^2	0.179	0.326	0.373	0.178	0.326	0.373

C Appendix: Robustness Checks

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 variations 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.

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 Funds Raised in the Early Period. Figure B9 reports the fund distribution by vintage and fund type. To alleviate the concern that early-vintage funds are different from the rest due to selection issue caused by poorer data coverage in the earlier period, I exclude funds raised before 2002. It also mitigate the concern that the Internet Bubble might drive my findings. Table C6 indicates that my findings remain robust.

Exclude the Period when Hurricane Katrina Happened. Table C7 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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	47152	65800	47152	65800
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	-0.011		0.000	
	[0.009]		[0.001]	
Log(1 + Fund Age)	-1.879***	-0.715***	-0.186***	0.052***
	[0.067]	[0.084]	[0.009]	[0.008]
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 Age FE	✓	✓	✓	✓
Fund Manager × Fund Type × Fund Size FE	✓		✓	
Fund Manager × Year-Quarter FE	✓		✓	
Fund FE		✓		✓
Observations	48243	67306	48243	67306
R^2	0.469	0.191	0.513	0.312
Adjusted R^2	0.173	0.168	0.242	0.293

Table C2: Restrict to First Five Years

This table reports robustness checks excluding fund-quarters after the 5 years since 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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	31124	31124	30426	31124	31124	30426
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*	-0.015*	-0.002***	-0.002***	-0.002***
	[0.007]	[0.008]	[0.008]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-0.873***	-0.850***	-0.749***	-0.021***	-0.021***	-0.003
	[0.085]	[0.087]	[0.091]	[0.007]	[0.007]	[0.007]
Log(1 + Fund Age) × Endowment Share	0.005*	0.006*	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	31825	31825	31088	31825	31825	31088
R^2	0.050	0.066	0.071	0.053	0.140	0.161

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

This table reports robustness checks restricting to PE funds with more 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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	41084	41084	40718	41084	41084	40718
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**	-0.013*	-0.014*	-0.002**	-0.001	-0.001
	[0.007]	[0.008]	[0.009]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.964***	-1.886***	-1.668***	-0.230***	-0.215***	-0.159***
	[0.052]	[0.058]	[0.068]	[0.006]	[0.007]	[0.008]
Log(1 + Fund Age) × Endowment Share	0.005**	0.005**	0.004*	0.001**	0.000*	0.000
	[0.002]	[0.003]	[0.003]	[0.000]	[0.000]	[0.000]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	41854	41854	41471	41854	41854	41471
R^2	0.170	0.175	0.180	0.185	0.223	0.251

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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	30899	30899	30592	30899	30899	30592
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	-0.009	-0.007	-0.018*	0.000	0.001	-0.001
	[0.008]	[0.009]	[0.009]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.852***	-1.808***	-1.621***	-0.187***	-0.181***	-0.141***
	[0.057]	[0.063]	[0.075]	[0.006]	[0.006]	[0.008]
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	31678	31678	31354	31678	31678	31354
R^2	0.132	0.139	0.144	0.159	0.195	0.222

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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	34904	34904	34081	34904	34904	34081
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
	[0.006]	[0.006]	[0.007]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-2.033***	-1.936***	-1.804***	-0.254***	-0.232***	-0.185***
	[0.054]	[0.060]	[0.071]	[0.007]	[0.008]	[0.009]
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	35626	35626	34759	35626	35626	34759
R^2	0.203	0.211	0.215	0.200	0.254	0.279

Table C6: Exclude Funds Raised in the Early Period

This table reports robustness checks excluding PE funds raised before 2002. The full 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 in the fund and the value. 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 in the 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. Reported in brackets, standard errors are two-way clustered at the fund and company levels in Panel A and clustered at the fund level in Panel B. ***, **, 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	-0.001	-0.009	-0.009	-0.002***	-0.001	-0.000
	[0.002]	[0.007]	[0.014]	[0.001]	[0.001]	[0.001]
P&C Insurer Share × Liquidity Shock	-0.027***	-0.027***	-0.027***	-0.002**	-0.002*	-0.002**
	[0.008]	[0.008]	[0.008]	[0.001]	[0.001]	[0.001]
Year-Quarter FE	✓	✓	✓	✓	✓	✓
Fund Age FE	✓	✓	✓	✓	✓	✓
Fund Manager FE		✓			✓	
Fund Manager × Fund Type × Fund Size FE			✓			✓
Observations	40931	40931	40177	40931	40931	40177
R^2	0.160	0.172	0.178	0.208	0.264	0.279

Panel B: Ex Ante Effects

	Capital Called (%)			Number of Investments		
	(1)	(2)	(3)	(4)	(5)	(6)
Endowment Share	-0.016***	-0.009	-0.005	-0.000	0.000	0.001
	[0.006]	[0.006]	[0.007]	[0.001]	[0.001]	[0.001]
Log(1 + Fund Age)	-1.824***	-1.740***	-1.578***	-0.162***	-0.154***	-0.124***
	[0.054]	[0.060]	[0.069]	[0.005]	[0.006]	[0.007]
Log(1 + Fund Age) × Endowment Share	0.005**	0.005**	0.004*	0.000	0.000	0.000
	[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	42432	42432	41617	42432	42432	41617
R^2	0.131	0.141	0.146	0.153	0.204	0.223

Table C7: Exclude the Period When Hurricane Katrina Happened (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 fund's exposure to P&C insurers 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 in the 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	65218	65218	64092	65218	65218	64092
R^2	0.194	0.202	0.207	0.250	0.297	0.313