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Does Family Matter?
Venture Capital Cross-Fund Cash Flows

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Abstract

Venture capital (VC) funds backed by large multi-fund families tend to perform substantially better due to cross-fund cash flows (CFCFs), a liquidity support mechanism provided by matching distributions and capital calls within a VC fund family. The dynamics of this mechanism coincide with the sensitivity of different stage projects owing to market liquidity conditions. We find that the early-stage funds demand relatively more intra-family CFCFs than later-stage funds during liquidity stress periods. We show that the liquidity improvement based on the timing of CFCF allocation reflects how fund families arrange internal liquidity provision and explains a large part of their outperformance.

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I. Introduction

The asset management industry has become more and more concentrated in recent years. In 2020, over 34 percent of assets under management (AUM) were controlled by the top 10 asset management companies.[1] As for the private equity fund industry, the 20 largest funds captured almost half (45%) of all the committed capital in 2019 compared to 29% six years ago[2]. The unexpected shock experienced during Spring 2020 at the outbreak of the ongoing COVID-19 pandemic further accelerated the capital concentration trend with fund limited partners (LPs) attracted by larger families better able to provide liquidity backup and economies of scale. Thus, when some LPs are hit by the similar liquidity stress as experienced during Spring 2020, more and more LPs are expected to tilt their preferences towards investments in larger funds and families. Given the large size of the fund families, fund managers tend to exploit their expertise and diversify the portfolio risk by setting up multiple funds to keep the current investors and attract new ones.

Abundant literature has shed light on the fund size effect, e.g., Gompers and Lerner (2000); Kaplan and Schoar (2005); Cumming (2008); Harris Jenkinson and Kaplan (2014). A series of studies have focused on whether mutual funds can benefit from being backed by a large and strong family and the mechanism behind this, e.g., Nanda, Wang and Zheng (2004); Brown and Wu (2016); Eisele, Nefedova, Parise and Peijnenburg (2020). To the best of our knowledge, we are the first to study the benefits of being part of a fund family in the venture capital (VC) fund industry where the fund setup is different to mutual funds due to liquidity constraints inherent in the closed-end fund structure. With multiple member funds managed by the same family, accompanied by different fee structures and performances, the fund management and general partners (GPs) need to determine the profit maximization on behalf of LPs and how the family level arrangements can support the member funds to perform. Hence, the fee structure design, a potential performance transfer and subsidization, as well as the intra-family liquidity provision mechanism (Kempf and Ruenzi (2008); Robinson and Sensoy (2013); Evans, Prado and Zambrana (2020)) have become additional concerns to multi-fund families. This paper addresses family benefits from a different angle by studying a new intra-family liquidity provision mechanism called cross-fund cash flows (CFCFs), a mechanism especially useful within closed-end funds investing in illiquid private assets.

Previous literature covered several varieties of intra-family liquidity provision mechanisms. Under the Investment Company Act of 1940, investment funds in the United States are prohibited from direct transactions, borrowing or lending, for instance, among affiliated funds in the same family (Almazan, Brown, Carlson and Chapman (2004); Agarwal and Zhao (2019)). An exemption, the so-called inter-fund lending program, can be granted if managers can justify an investor-centric purpose

[1]See Investment & Pensions Europe, June 2020 Top 500 Asset Management Guide
[2]See 2020 Preqin Global Private Equity & Venture Capital Report

for its application. These papers document several benefits of inter-fund lending, including funds being able to hold more illiquid and concentrated portfolios and being less susceptible to investor runs. However, the Investment Company Act of 1940 does not prohibit the intra-family liquidity provision method, which is the focus of this study as the cash flow transfer is going through fund investors.

Additionally, to achieve liquidity management goals and overall benefit maximization at the fund family level without causing legal risks, managers are keen to explore other implicit inter-fund arrangements. Gaspar, Massa and Matos (2006) examine family-level cross-subsidization with two possibilities: better allocations of underpriced IPO deals and opposite trades.

They find that intra-family subsidization positively affects the benefited fund's performance and improves the liquidity condition at the fund family level. Chaudhuri, Ivkovic and Trzcinka (2018) also observe, when studying the investment products of an asset management firm, that relatively small recent outperforming products receive cross-subsidization provided by the relatively large investment products. Other studies from Bhattacharya, Lee and Pool (2013) and Brown and Wu (2016) focus on inter-fund direct investment. Some mutual fund families employ a strategy to set up funds that only invest in funds in their own families called affiliated funds of mutual funds (AFoMFs). By playing a similar role as cross-subsidization providers, AFoMFs benefit the family at the cost of their own investment performance. The mutual funds in the family improve their performance when receiving such liquidity to prevent fire sales.

This study considers cross-fund cash flows (CFCFs), an arrangement by fund families to achieve liquidity management by matching the timing of capital calls and distributions from different member funds to occur on the same day or in the same month. The paper documents that multi-fund families frequently have cash flows in the opposite directions occurring at the same time between member funds and their investors, i.e. implicitly cash moves from one pocket to another, allowing investors to pay the capital calls with less difficulty using the received distribution, even during a liquidity crisis. Hence, following the previous literature (Gaspar, Massa and Matos (2006); Bhattacharya, Lee and Pool (2013); Agarwal and Zhao (2019)), it is appealing to study whether funds backed by a large family can perform better and suffer less when liquidity is scarce, compared to a "single child" fund. Specifically, it is expected that the dynamics of CFCFs between member funds to be positively biased towards the larger fund families and to occur more often under liquidity demanding situations. This could improve liquidity conditions at the fund family level and provide improved performance to benefited funds or even to the whole family. Investors should be more eager to invest in multiple funds of the same fund family as they would not struggle with capital calls during crisis times. Meanwhile, it is also interesting to see how these funds perform respectively when they provide and receive intra-family cash flows.

Robinson and Sensoy (2016) analyze the liquidity properties of private equity cash flows of unlisted buyout and VC funds. They find that the funds raised in a booming market underperform, and those raised in a bear market outperform in terms of absolute return. When switching to the public market equivalent (PME) relative valuation approach, the discrepancy disappears. In this study, the same methodology, following Robinson and Sensoy (2016), is utilized to check the performance effects of CFCFs. Over time, the dynamics of CFCFs is presumably largely driven by market liquidity cyclicality since CFCFs can be considered a liquidity buffer within the fund family. During a market downturn, the low liquidity situation stimulates more liquidity provision from family funds ready to distribute. Cumming, Fleming and Schwienbacher (2005) observe a strong negative relationship between the liquidity of exit markets and the likelihood of investing in new early-stage projects in the VC market. They note that private equity market investors tend to make more new investments in early-stage projects that require a longer monetizing horizon given the decreasing liquidity of exit markets. The similar relationship is expected to hold also in the case of CFCFs. This influences the average life cycle of the raised VC funds and the demand of CFCFs from different development stage projects. When the market experiences liquidity stress in terms of IPO exit opportunities, fund managers are prone to seek all possible low-cost liquidity, including internal liquidity and to utilize the limited funding in those early VC projects, which are expected to be locked up for a longer investment horizon. Early-stage projects require committed capital to be locked for a longer period, which directly postpones immediate exit requirements and implicitly eases the current liquidity risk. On the contrary, venture capitalists tend to rush to expansion or late-stage projects and expect quick investment returns by exits planned for the near future when the whole market is more liquid. Hence, higher demands are expected for CFCFs during liquidity-stressed times, especially in those early-stage projects, which absorb more liquidity under such circumstances.

This paper examines the relationship between fund performance and family structure from the perspective of intra-family liquidity provision. Being affiliated with a large multi-fund family is expected to be beneficial to VC funds. Fund managers backed by large and multi-fund families are endowed with the option of receiving liquidity from their sibling funds. It has been noted that VC funds which receive more intra-family cross-fund cash inflows can benefit from this liquidity and in relative terms outperform their peers, whilst fund families that actively arrange CFCFs among their member funds can also outperform their peers. The observed results are on the basis that funds in the family have overlapping investor pools, at least to some extent. This is reasonable since the limited liquidity supply with a closed-end fund setting, such as buyout and VC funds, might favor overlapping investor pools, as the existing investors are likely to be asked whether they want to invest in new family member funds.

Fund families pursue coordinated strategies to smooth out cash flows across their member funds. One strategy is to arrange intra-family cash flows in opposite directions (capital calls and distributions) between fund siblings and their investors on the same day. The incentive for this strategy exists when both fund families and investors benefit. When the stock market crashes, liquidity depletion can spread from the public stock market to the private equity market. Investors find it difficult to respond to capital call requests of GPs at such periods, when GPs typically prefer to execute more investments as the private equity cost is relatively low.[3,4] The paper notes that CFCFs can improve liquidity conditions in general and mitigate liquidity stress significantly in tough times. Two methods are used to study the effect of CFCFs on liquidity conditions. On the one hand, the dynamic synchronization between market liquidity and CFCFs is checked directly. Fund families are found to arrange more CFCFs during liquidity stress periods to mitigate pressure to LPs.

On the other hand, by arranging more CFCFs to liquidity demanding member funds, the funds themselves and fund families the funds belong to can perform relatively better than their peers due to improvements in the liquidity, allowing higher investments when prices are low and avoiding costly alternatives such as additional cash buffers and leverage. Hence, the timing of the allocation of CFCFs across the fund cycle based on market liquidity conditions is critical. A large part (between one-half to two-thirds) of the overall CFCF outperformance effect can be explained after introducing a CFCFs liquidity timing proxy, which can disentangle the effect of CFCFs allocation timing on returns from the overall performance effect.

Multiple options can be chosen to study the VC market liquidity. For example, the approach of Kaplan and Stromberg (2009) and Robinson and Sensoy (2016) could be followed to use the ratio of total committed capital to all the funds and total U.S. stock market capitalization in the same year. Franzoni, Nowak and Phalippou (2012) apply the Senior Loan Officer Opinion Survey on Bank Lending Practices to indicate the credit availability for buyout and VC investments and take the Pástor and Stambaugh (2003) traded liquidity factor as the proxy of liquidity condition. This proxy provides relevant information regarding buyout and VC market liquidity conditions. Another alternative is to use annual IPO volume as the private equity market's liquidity proxy, provided that private equity investment aims to receive investment returns after different routes to exit, including an IPO. Finally, other common liquidity measures, such as the Treasury over the eurodollar rate spread (TED Spread), the CBOE Volatility Index (VIX), the previous year market return, and NBER recessions, are utilized to check for liquidity conditions.

The remainder of this paper is organized as follows. Section 2 presents the data and summary statistics. Section 3 examines the relationship between CFCFs and fund characteristics and the impact of CFCFs on fund returns. Section 4 investigates the dynamics of CFCFs on liquidity conditions and the effect of intra-family liquidity allocation timing on fund performance, and section 5 provides the conclusion.

[3]By subscribing to a buyout or VC fund, an LP usually needs to make a total capital commitment of a specified amount in exchange for a stake in investment ownership. This total capital commitment is usually contributed to the fund over time based on the capital calls issued by the fund's GP. Default occurs when an LP fails to fund such a capital call. The Limited Partnership Agreement (LPA) for a private equity fund usually includes detailed provisions to address LP defaults and corresponding penalties, including the sale of LP interests, reallocation of capital call, compulsory redemption, liability for costs, and other remedies.

[4]The COVID-19 crisis already raised concerns for the liquidity issue on the private equity fund industry. Although the consequences remain unknown, titles such as "LP defaults 'already happening'" have started to hit the headlines (https://www.privatedebtinvestor.com/lp-defaults-already-happening-heres-why-and-what-gps-options-are/).

II. Data

The primary data source of this paper is from the private equity investment data of Preqin, which is considered the most comprehensive alternative investment data vendor worldwide. It provides buyout and venture capital (VC) fund data on three levels: cash flow transactions, fund-level data, and fund manager information. Based on Preqin VC cash flow data, 877 VC funds have been identified with 62,830 time series cash flow records, including two transaction types: capital calls and distributions at a quarterly frequency from 1982 to 2019. Capital calls are payments from limited partners (LPs) to general partners (GPs). These payments draw down the committed capital and the dry powder and are invested into companies in the investment portfolios of GPs. GPs provide distributions from exited investments as the proceeds net of fund cost, including fund management fees, carried interest profit of GPs, etc. Based on the data of fund size and family affiliation, the dynamic family size can be generated. The advantage of using the dynamic family size is that the real changes over time could be captured by excluding liquidated funds and including newly established ones at their inception. It is calculated by adding the initial values of all the family's active funds and removing the old funds that have already been liquidated at the point of calculation. This measure allows to assign the precise family size to each fund over time. The correlation between fund size and family size in this study's sample is 0.44, implying that larger fund families usually have bigger funds.

As the preliminary step for the risk-return analysis, fund performance based on cash flow data is investigated. In addition to the undiscounted absolute performance DPI (Distribution to Paid-In) and the TVPI (Total Value to Paid-In Capital), PME (Public Market Equivalent) is also generated, which is tailored based on the NASDAQ index following Robinson and Sensoy (2016). NASDAQ index return is selected as the discount factor due to the nature of VC funds' portfolio investments. A larger data sample is covered in this study than Robinson and Sensoy (2016). The complete number of VC funds with calculated PME performances in their study is 295. In contrast, in this study, the final sample contains 703 VC funds with fund size and tailored PME after winsorizing the funds with very limited cash flows, most of which are the most recently established. The same applies for the liquidated samples (195 vs 258 in this study). The main difference lies in the time horizon since we have a 10-year longer sample period, and also, the data come from Preqin. In contrast, Robinson and Sensoy (2016) rely on proprietary data from one institutional LP. Among our 703 VC fund sample, over 87% are U.S. funds, and 6.6% are European. Our sample's VC funds represent around $230 billion in committed capital in total, spanning vintage years from 1982 to 2018.

The summary statistics of VC funds in our sample are presented in Table 1. We have covered 703 VC funds, of which 258 (37%) are liquidated. The PME relative performance of liquidated and full samples are 1.14 and 1.03, respectively, which is consistent with earlier literature using the same methodology. Harris, Jenkinson and Kaplan (2014) notice that the average PME for VC funds during the 2000s is 0.91, whereas, in Robinson and Sensoy (2016), it is 1.09 for the full sample and 1.06 for the liquidated sample. As expected, in recent decades, liquidated funds are on average smaller than active funds due to the increasing VC fund size. It has been observed from the tailored PME as well that liquidated funds performed relatively better than active ones. The liquidated sample constitutes the basis to examine the fund performance based on complete actual cash flows during the whole fund life cycle. As a robustness check, the data from active funds separately and combined with liquidated funds (full sample) are covered. Table 1 Panel B shows that different stages of VC investment fund projects are almost evenly distributed between the liquidated and full samples. The categories are defined by Preqin and are consistent with the market conventions.

To measure market liquidity conditions, several alternatives exist which require additional datasets. One option is to follow the literature using public market liquidity (data from CRSP, WRDS, Fred, or Bloomberg) as the proxy, expecting indirect liquidity penetration from the public to private equity market. The other option is the annual IPO volume, on the NASDAQ, for instance, as a more relevant proxy for the VC investment market. The reason for using annual IPO volume as a VC market liquidity proxy is that private equity stakes are not frequently traded like publicly traded stocks, so the standard concepts of liquidity, such as bid-ask spreads, trading volume or return volatility, hardly applies. The aim of investing in private equity is to receive investment returns after exits. The most evaluated exit is IPO, followed by other alternatives such as mergers, private placements, recapitalization, restructuring, sales to GPs or management, trade sales, write-offs, etc. Therefore, the ease with which the investment can be exited determines the market liquidity. Thus, as an alternative, annual IPO volumes on several stock exchanges (NASDAQ, NYSE, AMEX) can be used as the private equity market's liquidity proxy, following Cumming, Fleming and Schwienbacher (2005) and employing IPO data from Jay Ritter’s website.

The dynamics of IPO volume in each year of our data sample is shown in Figure 1. The grey bar shows the annual number of IPOs, and the grey line is the market value in USD billions at the first closing date of the IPOs, both scaled on the left axis. The black dash line is the aggregate proceeds received from IPOs, also in USD billions, measured on the right axis. From Figure 1, it is observed that the VC exit opportunities became scarce after the second half of the 1990s’ boom and stayed at a low level during the internet bubble burst and the financial crisis during 2007-2008. The U.S. IPO market has not returned to flourish similarly as in the 1990s in terms of IPO numbers.

To identify CFCFs within the same fund family, a two-step identification process is implemented. The first step is to scan the capital calls and distributions occurring on the same day between different member funds, regardless of whether the flows are from newer funds to older ones or in the opposite direction. Once identified, the number of CFCFs can be calculated at the fund family level. The calls and distributions as the percentage of fund size can also be generated at the individual fund level. The second step is to relax the same-day restriction to the same month or quarter as a further robustness check.

Table 2 shows the summary statistics of the identified CFCFs. The sample in Panel A are those funds without CFCFs, which are in terms of size much smaller than the ones in Panel B, the funds with CFCFs. Accordingly, the funds in Panel B are affiliated to relatively larger families. 495 of 691 (about 72%) VC funds in our data sample are involved in intra-family cash flow transmission. On average, one VC fund distributes 17 times of cash flows throughout its life cycle to its siblings on the same day when the fund manager arranges capital calls for other member funds. Cross-Fund Call% (Cross-Fund Dist.%) signifies the size of cross-fund inflows (outflows) as the percentage of the fund size from one VC or buyout fund to another VC fund (from one VC fund to another VC or buyout fund) in the same family on the same transaction date. In this, inflows from member buyout funds to the examined VC fund are also considered since the buyout and VC funds share similar attributes. The total volume of cross-fund distributions accounts for 51% of the total committed capital to a representative fund, while the percentage of cross-fund capital calls is around 21%. In this study, only cross-fund capital calls have been considered to avoid potential endogeneity issues due to reverse causality, the well-performing funds can distribute more cash flows as CFCFs.

In Section 3, the relationship between fund performance and CFCFs is first studied at the cross-sectional level, following the analysis of fund and family characteristics driving CFCFs. The Section 4 introduces time-varying dynamics to CFCFs. In studying the relationship between CFCFs and fund-family characteristics, it is started from the fund-family attributes, including the dummy variables indicating the first VC fund in the family (First), whether the family is in the largest tercile of fund families (LargeFamily) and whether the fund family recycles its distribution back to the fund committed capital (Recycled). Table 3 shows the descriptive statistics of these attributes driving CFCFs. As expected, the first fund indicator and large family size dummy exhibit the significant difference between the comparison groups, both in liquidated and full data samples. In contrast, the Recycled dummy exhibits less discrepancy.

III. Do Large-Family Funds Outperform?

It is known from Section 2 that most VC funds (72%) in our sample have intra-family cash flows. Clearly, this overlapping multi-fund strategy exists and covers a pronounced proportion of liquidity provision within VC funds. Table 2 in Section 2 illustrates the considerable size difference (61% mean-difference) between funds with and without CFCFs, significantly different from zero. In addition to the size, we also study the CFCF-related fund characteristics and provide implications for buyout and VC fund investors.

VC funds invest funding received from LPs into small private businesses and companies, which in return, provide growth potential instead of continuous cash flows. The proceeds from various exit deals (trade sales, buy-backs, IPOs, etc.) are the only returns to the VC fund investors. Fund managers implement customized investment strategies based on fund-specific prospectuses or mandates. The main strategy of private equity and VC investment vehicles is to invest in project types (stages).

Specifically, different project stages, such as early stage, expansion stage, and late stage of VC projects, provide investors with various investment horizons and growth potential.

According to the definition of development stages, early-stage projects require committed capital locked into a longer period, which directly postpones immediate exit requirements and implicitly eases current liquidity risk. On the contrary, venture capitalists often tend to rush into expansion or late-stage projects and expect quick investment returns through near future exits when the whole market liquidity is fluid. The standard liquidity concept and measurement using bid-ask spreads and volume rarely apply in the private equity and VC market due to the nature of its infrequently traded assets. Instead, the private investment market can be characterized as "hot" or "cold" by IPO clustering. Therefore, liquidity in the private equity market, in turn, can be measured by the likelihood of exit. By following Cumming, Fleming and Schwienbacher (2005), the number of annual IPOs on different stock exchanges (NASDAQ, NYSE, AMEX) has been used as the proxy for the liquidity of the VC market in this paper.

Fund managers arrange intra-family cash flows between member funds to achieve performance and liquidity improvement. The demand for CFCF increases when the market experiences downturn and external liquidity becomes more limited. We find evidence to support our conjecture that during liquidity stress periods, the early-stage funds demand relatively more intra-family CFCFs than other development-stage projects (including expansion and late stages). Figure 2 shows the relationship between CFCFs and early-stage investments. The grey shadow bar represents annual intra-family capital calls from early-stage projects over our sample period. The black shadow bar shows expansion- and late-stage investments (combined as late-stage for simplicity). The solid line shows the ratio of these two figures representing the relative proportion of early-stage CFCFs to late-stage ones. The left axis is the CFCF volume in tens of millions of USD, and the right axis is the ratio. It can be noticed that the early- versus late-stage ratio remains at the relatively high levels during the recessions such as the Internet bubble burst and post-2008 financial crisis, which intuitively shows that the early-stage VC projects demanded relatively more intra-family CFCFs during high liquidity risk periods: The mean and median PME of early-stage funds with CFCFs are 0.940 and 0.825, and those of early-stage funds without CFCFs are 0.945 and 0.680, respectively.

These initial findings are verified with regression analysis. The explanatory variable is the annual IPO volume. The dependent variable is the ratio of *CFCFs_early* over *CFCFs_late* (*CFCFs_all* as an alternative) realized during the same year. The variables *CFCFs_early* and *CFCFs_late* are calculated as the intra-family cash inflows, as a percentage of the fund size (*capital calls%*) in the early and late stages. The relative specification used here incorporates the effect of the fund size difference between the early and late stages. The regression model is represented as follows (Eq. 1a and 1b):

$$CFCFs_{early}/CFCFs_{late} = IPO_{volume} + \varepsilon \tag{1a}$$

or

$$CFCFs_{early}/CFCFs_{all} = IPO_{volume} + \varepsilon \quad (1b)$$

The regression results presented in Table 4 show the relationship between the intra-family cash flows and the stage development of the VC fund investment conditional on VC market liquidity. The negative coefficient of *Number_IPOs* (the proxy of VC market liquidity) is statistically significant. It shows that early-stage projects have 20% more CFCFs than expansion- and late-stage projects projects when the private equity market's liquidity deteriorates given a decrease of 100 IPO cases. Column (2) provides a robustness check with an alternative market liquidity proxy, Moody's Baa-Aaa corporate bond yield spread, following Franzoni, Nowak and Phalippou (2012). The result is significantly positive and emphasizes that early-stage VC projects receive relatively more internal liquidity support from fund families than other stages when there is an increase in the market liquidity risk. The results remain in the alternative model specification when all project stages are included showing the robustness of the finding.

Next, the implications of these results for LPs and VC fund industry are considered. The negative correlation between cash flows in the VC fund industry and broader market tightness makes fund investors and managers trying to seek all possibilities to ease "fire sales" of public equity or any other investments at unfavorable prices to meet capital calls during market downturns when leverage is also often more expensive. Meanwhile, the illiquid nature of VC investments motivates two decisions from fund management: to support family funds with liquidity from inside the family when broader liquidity is drying up; to secure the ongoing cash flows for a longer period to weather the market downturns. Consequently, relatively more intra-family cash flows called by ongoing VC funds are invested in early-stage projects, compared to expansion- or late-stage projects.

The macroeconomic conditions explain only a part of the cash flow variations in the VC fund industry. The rest is attributed to idiosyncrasy in specific funds at a given time point. Accordingly, what fund characteristics are associated with the sensitivity of intra-family cash flows to macro-fundamentals and how much variations can be explained by certain fund characteristics are investigated. The results are shown in Table 5. The response variable observations are fund-specific intra-family cash inflows (capital calls) as the percentage of fund size (the committed capital), as discussed before. The explanatory variables include several fund characteristics. The "*First*" is an indicator for the first buyout or VC fund affiliated to a fund family. The "*LargeFamily*" indicates whether the fund is in the largest tercile of the fund families. The "*Prev_PME*" is the previous fund performance in the same family. "*Recycled*" is an indicator of whether the fund recycles part of its distribution and returns it back to the fund to be reinvested.

The results are shown for three samples: liquidated, active and all which combines liquidated and active samples. The macroeconomic condition as measured by country- and industry-fixed effects in addition to vintage time effects are controlled across specifications (2), (3), (5), (6), (8), and (9). The vintage time-fixed effect accounts for the effect of market liquidity when the funds were established.

Columns (1), (2) and (3) present the results of liquidated VC funds, consisting of one-third of our sample. It can be seen that the cross-fund capital call% is negatively related to the first fund indicator. The first fund in a fund family is naturally less likely to receive internal cash flows since no preceding fund can provide distribution when required. This first-fund effect remains when in Column (3) the previous performance is introduced. The funds in the families with historical performance receive significantly more CFCFs in our results and show positive relation with the previous performance. The coefficient of *LargeFamily* shows a significant positive relation, which is in line with our conjecture that a larger family is more likely to support its member funds with low-cost internal liquidity. This result remains also when past performance is controlled in Column (3).

The dummy variable "*Recycled*" indicates the existence of recallable distribution. When some capital has been distributed but is being recalled by the GP, the dummy "*Recycled*" equals one; otherwise, it is zero. It could be seen that the coefficients are significantly positive in the active data sample and remain positive in the group of sample including all the VC funds, conveying that those funds that recycle their distributed capital tend to have more demand in liquidity, and in turn, need more cash inflows from inside the family.[5]

Overall, the results shown in Table 5 are similar across all subsamples. Other fund-specific attributes, such as primary geographic focus, region, and industry focus, do not provide significant variations in the demand of CFCFs within fund families. Given the outperformance of benefited funds receiving CFCFs within families, the family size matters as shown by the significantly positive coefficient of *LargeFamily*. Bigger families are more able to provide support to its member funds providing practical implications to LPs when screening their VC investments. After controlling for the size of the family, the experience of the fund manager and fund family account for an essential proportion of variations, as measured by the number of funds, that investors may need to focus on. The result is robust in our unreported analysis with scalar numbers of fund series instead of dummy variables. Experienced fund families tend to know better when and how to utilize low-cost internal liquidity to ease the negative impact of changes in the market conditions. Other fund characteristics, including capital recycling, primary geographic focus, and industry focus, also provide limited information to VC fund investors to choose CFCFs favoured funds.

According to the definition of CFCFs in Section 2, funding inflows and outflows within the fund family can occur simultaneously and circulate through the fund life span. Normally, a member fund acts as an intra-family liquidity receiver in its early stage. Later when a part of the underlying assets have been exited, it can distribute the proceeds to its sibling funds via overlapping investor base. CFCFs are included in our performance model as the main independent variable. The empirical results are presented in Table 6. It exhibits cross-sectional fund-level OLS regression results on liquidated VC

[5]Private Equity News reveals that the recycled capital fund tends to be small funds; however, this is not supported by our data. No evidence of size discrepancy between funds with and without recycled capital is found. https://www.penews.com/articles/small-funds-and-the-joy-of-recycling-20190531

funds and depicts the relationship between fund performance and CFCFs as well as other fund characteristics.[6] The cash flow data of liquidated VC funds have been carefully winsorized by controlling for extreme outliers and unqualified cash flows.[7] The major outcome from Table 6 Panel A is that VC funds receiving CFCFs from the other member funds in the same family generally outperform others in Column (2) by 0.49 in terms of PME, where the cross-fund capital call indicator CFCF Call Dummy equals 1 if there are cross-fund cash inflows to the examined fund and otherwise it is zero. This outcome is verified by including the fund size effect and vintage year fixed effect following Kaplan and Schoar (2005). This controls any size-related performance effect in the data.

Furthermore, to understand the impact of CFCF volume on the fund performance, Columns (3) and (4) replace the CFCF dummy with the CFCF volume. One hundred percent more CFCF capital call as the percentage of the total fund committed capital contributes around 0.8 PME return, which is statistically significant at 5% confidence level. Here, the *Cross-Fund Call%* mentioned in Section 2 stands for the size of cross-fund inflows (received distribution) as the percentage of the fund size from other VC or buyout fund in the same family to the VC fund on the same transaction date. Inflows from member buyout funds to the examined VC fund are considered since the buyout and VC funds share similar attributes. However, the results remain the same if only VC funds are included as shown by unreported robustness check. All these results verify our conjecture that funds receiving more intra-family cross-fund cash inflows (capital calls) are expected to benefit from this arrangement and outperform their peers.

Table 6 Panel A reveals three additional findings. First, the results disclose a linear relation between PME and log fund size in model specifications (1) to (7). A negative loading on the quadratic term can also be observed, indicating a concave shape in the size-performance relationship. This is consistent with the results from Kaplan and Schoar (2005) and Robinson and Sensoy (2016). Second, the result shows performance persistence in Column (6), where *Prev_PME* stands for the previous VC fund's performance managed by the same family and *Prev_PME_dummy* equals 1 if the fund's past performance exists and 0 otherwise. After controlling for the vintage fixed effect, the result stays positive in Column (5). Third, to give a better picture of the current results, the relation between CFCFs and past fund performance in Panel B is shown. The dependent variable is *Cross-Fund Call%,* and the independent variables are *Prev_PME* and *Prev_PME_dummy*. The positive relationship in the first column indicates that the fund family are able to subsidize the current fund through CFCF if its previous fund performed well. This is expected as the LPs are more likely to invest in the future funds when the past performance has been satisfactory enabling the fund management to arrange CFCFs when timing

[6] As a robustness check, the same regression is performed but including also still active funds. This sample covers also recently established funds. Note however, that a complete overview of their performance cannot be established as future cash flows are still expected.

[7] The data are winsorised by controlling for extreme outliers (e.g. excluding funds with PME larger than 10) and unqualified cash flows (e.g. excluding funds with TVPI equals 0, meaning there are no distributions or residual value in the cash flow data to this fund). The results are qualitatively similar without the winsorisation.

the cash flows. The second column of Panel B shows the Tobit model exhibiting the relationship between CFCFs and past performance with lower-bound censored data at 0 for those funds without cross-fund cash inflows. This specification shows that positive relationship is robust to potential biases in OLS specification due to funds that are not involved in CFCFs.

Robustness checks (shown in the Appendix) are also performed with the sample of active funds and all VC funds sample. The results confirm that the CFCF performance effect shown in Table 6 is robust.

IV. The Dynamics of CFCFs on Liquidity Conditions

CFCFs as an internal liquidity support mechanism is expected to benefit funds and their families due to the associated liquidity improvements. We conjecture that the effect of CFCFs on fund performance is largely derived from the relative liquidity ease during liquidity depletion. This section provides empirical evidence on this linkage.

Private equity investments provide less diversification benefit than it was understood earlier as it is significantly exposed to the same liquidity factor as the public market and other asset classes (e.g., Franzoni, Nowak and Phalippou (2012); Ang, Chen, Goetzmann and Phalippou (2018); Kondor and Vayanos (2019)). Such synchronization between public market liquidity and private equity investors' capital constraints fund managers with the difficulty of refinancing their investments when the market liquidity is drying up. The fund GPs have to either liquidate part of their portfolios at unfavorable prices or accept higher borrowing costs if they use leverage in these stressful times, translating into underperformance of the fund. CFCFs, however, provide them with an alternative low-cost channel when needed to ease liquidity tightness and improve ultimate performance when exiting. The equilibrium requires decent fund performance to keep up investor interest in the ensuing funds, making them the CFCF providers for future follow-ups. However, if the current performance cannot meet expectations, no investors or funding flows occur to new funds, and consequently, CFCFs will dry up.

The buffering provided by CFCFs is needed more during illiquid times, and therefore we expect to see negative relationship between liquidity and CFCFs. Table 7 shows the OLS regression results of the relationship between intra-family cash flows and public market liquidity. The dependent variable is the cross-fund capital calls as the percentage of the fund size, based on the quarterly cross-sectional data from 1996 to 2018, where earlier years are excluded due to data scarcity (only few quarterly data points exist before 1996). This relative measure is used to disentangle the fund size effect on liquidity levels. The independent variables are public market liquidity indicators in the odd columns. Their corresponding lag terms are in the even columns, including the Pastor-Stambaugh liquidity index (P&S liquidity index), the Senior Loan Officer Opinion Survey on Bank Lending Practices (Loan credit tightness), the Chicago Board Options Exchange's CBOE Volatility Index (VIX), the interest rates difference on interbank loans and short-term U.S. government debt (TED), and Moody's Baa-Aaa corporate bond yield spread (Bond yield spread). The Pastor-Stambaugh liquidity index captures the unexpected aggregated innovations in market liquidity which is a positive liquidity measure and the rest indicators are illiquidity measures. The Federal Reserve's Senior Loan Officer Opinion Survey on Bank Lending Practices instead provides non-price related credit covenant information to indicate the credit availability for private equity investments. The remaining indicators are included as robustness checks. It can be clearly observed that the demand for CFCF calls is consistently and positively related to those liquidity tightening indices, although the coefficients of bond yield spread and TED spread are not significant but still remain positive. The result also shows a significant negative relationship to the Pastor-Stambaugh liquidity condition as expected. Hence, fund families tend to arrange relatively more CFCFs when the aggregated public market liquidity decreases and when credit issuers tighten the credit availability. All the results stay robust, considering liquidity conditions with a one-quarter time-lag effect, noted in the even columns. As a next step, the extent member funds can benefit from intra-family cash flows considering the liquidity cyclicality is examined.

Given the nature of imbalanced cash flows throughout the life of private equity investments, the focus is here on the yield-to-maturity (YTM) fund performance. Using this measure, this section studies intra-family cash flows as the funding liquidity channel linking public market conditions and VC fund performance.

As shown above, CFCFs appear to occur more often when public market liquidity conditions are not favorable. Thus, we anticipate that the funds with more CFCFs during liquidity-strained times can perform better than their peers, which not only anchors the results from Section 3 that funds with more CFCF outperform but also has another meaning that this effect is more distinct when combined with liquidity timing. More detailed, in this section we provide evidence that a part of the outperformance shown in Section 3 due to the CFCFs comes from the intra-family liquidity allocation timing according to the market liquidity conditions. To build an indicator to reveal this relationship using the available data, an interactive measurement is formed that combines the distribution of intra-family capital calls in fund-level data and the corresponding contemporary market liquidity conditions at the time-series level, named as CFCF liquidity timing. It is defined as the aggregated market liquidity tightness indicators weighted by the distribution of the CFCF capital call% for each fund. The liquidity tightness indicators include the aforementioned P&S liquidity index, the Senior Loan Officer Opinion Survey on Bank Lending Practices, Moody’s Baa-Aaa spreads, VIX, and TED. The P&S liquidity index is converted into a reciprocal of its exponential term to be consistent with other liquidity tightness indicators. The CFCF liquidity timing aims to disentangle the effect of CFCF timing over dynamic market liquidity conditions on fund returns from the overall CFCF performance effect. The CFCF liquidity timing indicator is defined as shown in the following Eq. 2.

$$CFCF\ liquidity\ timing_i = \sum_{t=1}^{T} (Pct_{CFCF_{it}} * Ind_{liquidity\ tightness_t}), \quad (2)$$

where $t\epsilon[1,T]$ is the time interval, the frequency of which depends on the corresponding liquidity indicators, and i is the fund indicator. *CFCF liquidity timing* measures the distribution of the fund CFCFs, expressed as the percentage of the fund's total CFCFs, on liquidity conditions where $Pct_{CFCF_{it}}$ is the percentage of the cross-fund capital call% at time t over the total CFCFs of fund i. $Ind_{liquidity\ tightness_t}$ is the contemporaneous indicator of market liquidity conditions. Due to the data frequency of different market liquidity indicators, for instance, VIX and TED are reported daily, Moody's Baa-Aaa spreads, and the P&S liquidity index are reported monthly, and the Senior Loan Officer Opinion Survey on Bank Lending Practices is reported quarterly, the cross-fund capital calls based on corresponding time intervals are grouped. Figure 3 depicts an example of the CFCF liquidity timing distribution of a representative fund. The black dashed line is the market liquidity condition measured by VIX, and the grey bar stands for the percentage of the cross-fund capital call% ($Pct_{CFCF_{it}}$) of our representative fund in each quarter of its life span. In this example, the cash flow data shows 5 quarters containing CFCFs. Following the definition of CFCF liquidity timing (Equation 2), we weight the market liquidity indicator (VIX) based on the distribution of $Pct_{CFCF_{it}}$. The summation of CFCF liquidity timing over the fund life span is the fund-specific CFCF liquidity timing indicator, capturing the liquidity stress concentration of CFCFs for each VC fund.

To disentangle the effect of CFCF liquidity allocation timing over the dynamic market liquidity condition on fund returns from the influence of overall CFCF effect, the model specification is updated, as shown in Table 6, Column (3), by introducing the CFCF liquidity timing indicator as an extra explanatory variable. The results are presented in Table 8. Column (3) of Table 6 is copied into the first column of this Table as the benchmark. The following specifications correspond to alternative liquidity condition measures. It can be observed that, except for the insignificant positive CFCF liquidity timing effect measured by loan credit tightness, all coefficients of CFCF liquidity timing measures are significantly positive. Our empirical results show liquidity timing plays an important role in fund performance attribution of CFCFs. Based on the results in Column (2) to (6) of Table 8, the CFCF liquidity timing absorbs around half to two-thirds of the CFCF performance effect. Except in Column (3), where the CFCF liquidity timing indicator is measured by the Senior Loan Officer Opinion Survey on Bank Lending Practices, the coefficients of cross-fund capital call% weaken to become insignificant but remain positive. Note that the specification utilizing Senior Loan Officer Opinion Survey on Bank Lending Practices has less variation in market liquidity due to less frequent data, potentially explaining the lower statistical significance. Across all specifications in Table 8, the vintage time fixed effect is included to control the fund life duration against the dynamic market liquidity cyclicality.

A significant portion of the CFCF effect is derived from its liquidity timing. It can be explained by the timing at which this internal liquidity is allocated to balance the market dynamics. By arranging more CFCFs during market liquidity strained periods, the fund family could manage the liquidity exposures of the funds and weather the difficult times with low-cost liquidity support available within its family. Controlling liquidity risk is crucial for financial institutions and notably for those with large exposure to illiquid private underlying assets. This paper shows that a multi-fund family can achieve overall liquidity management and profit maximization utilizing internal liquidity support through CFCF allocation mechanism.

V. Conclusion

The size endowment in the investment fund industry plays an increasingly important role as the industry develops. Portfolio diversification, strategy implementation, fee structure competency and reputation visibility, all of these issues require investment agencies to become larger and more liquid. As a non-trivial pricing factor, the liquidity risk premium must be considered in the fund investors' selection model. This study's findings contribute to the existing literature by exploring an uncovered intra-family liquidity provision and provide investors with a new insight to target fund selection. Keeping other conditions the same, larger VC funds backed by a powerful multi-fund family have more chances of obtaining subsidization or receiving low-cost liquidity from within the family, especially in difficult times with market liquidity stress. This gives fund management the option of smoothing the distribution of limited committed capitals and dry powder dynamics and possibly generating alpha for investors. In this study, evidence to support this hypothesis has been found, and it also provides the complete picture of the effect of CFCFs on VC funds.

Larger families are naturally capable of providing internal cash flows from one member fund to another sibling, with 16 percent more of cross-fund capital call% for the funds in the largest tercile of the family size distribution. In terms of the fund and manager's experience, the cross-fund capital call% is significantly positively correlated to the number of funds in one family, confirmed by the previous fund performance as an alternative controller. The result also implies that past well-performing funds can distribute more in the future as CFCFs create reverse causality. The equilibrium requires decent fund performance to keep up investor interest in the ensuing funds, making them the CFCF providers for future follow-ups. However, if current performance cannot meet expectations, no investors or funding flows to new funds exist, and consequently, CFCFs will dry up.

When focusing on detailed fund strategies for project stage selection, the result is significantly positive. It emphasizes that the early-stage VC projects receive relatively more internal liquidity support from fund families than other stage projects when the whole market liquidity risk increases. The reason behind this is that the negative correlation between cash flows in the VC fund industry and broader market tightness makes fund investors and managers try to seek all possibilities to ease “fire sale” public equity or any other investments at unfavorable prices to meet capital calls during market downturns when leverage is also often more expensive. Meanwhile, the illiquid nature of VC investments motivates two decisions from fund management: to support family funds with liquidity from within the family when broader liquidity dries up; to secure the ongoing cash flows for a longer period to weather the market downturns. Consequently, relatively more intra-family cash flows called into ongoing VC funds are invested in early-stage projects than expansion- or late-stages.

After examining the attributes of CFCFs and linking them with the fund performance matrix, it has been noted that funds receiving more intra-family cross-fund cash inflows (capital calls) benefit from this arrangement and outperform their peers. One hundred percent more CFCF capital call as the percentage of total fund committed capital contributes around 0.8 PME return. This overall outperformance can be partly attributed to the CFCF allocation by fund families at the right time. By allocating more cross-fund capital calls to member funds during liquidity stress periods, the family exploits this low-cost liquidity provision and smooths the capital call distribution, which subsequently favors the final performance of funds. Such CFCF allocation timing accounts for half to two-thirds of the CFCF performance effect.

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Table 1. Sample Statistics

This table presents the summary statistics for the venture capital (VC) funds in our sample. The fund size is the fund's total committed capital and is based on millions of US dollars. The total committed capital is the aggregated amount of capital committed to our sample funds. The full sample includes all VC funds, while funds in the liquidated sample have a completed life span that distributed all proceeds to limited partners (LPs), and therefore have no active cash flow transactions. In the last column, following Robinson and Sensoy (2016), the public market equivalent (PME) is tailored to the NASDAQ index during the same sample period. Panel B presents the distribution of different-stage projects in both the liquidated and the full VC sample. The categories are defined by the data vendor Preqin and are consistent with public market conventions.

Panel A	Fund Size ($m)	Tailored PME
Liquidated Sample		
Number of Funds	258	258
Mean	201.85	1.14
Median	160.00	0.72
Std. Dev.	158.16	1.79
Total Committed Capital	52,076	
Full Sample		
Number of Funds	703	703
Mean	327.34	1.03
Median	227.00	0.83
Std. Dev.	354.23	1.22
Total Committed Capital	230,118	

Panel B	Liquidated Sample	Full Sample
Early Stage	24.42%	24.75%
Early Stage: Seed	1.55%	3.13%
Early Stage: Start-up	2.71%	3.70%
Expansion/Late Stage	7.75%	10.10%
Venture (General)	63.57%	58.32%

Table 2. Cross-fund Cash Flow Statistics

This table presents summary statistics of the VC funds and cross-fund cash flows (CFCFs) in our sample. The fund size is the committed capital of the fund in millions of US dollars. The family size is the aggregated committed capital of all the active funds affiliated to the same fund family, which is dynamic over time. The number of CFCFs is the number of opposite directional cash flows (capital calls and distributions) among member funds that occur on the same transaction date. Cross-Fund Dist.% and Cross-Fund Call% are the respective volume of CFCFs (distributions and calls) as the fund size percentage.

Panel A: Funds w/o CFCFs

	Fund Size ($m)	Family Size ($m)
Mean	230	691
Median	150	150
Std. Dev.	296	5,329
Min.	1	1
Max.	2,500	73,879
Number of Funds	196	
Liquidated	83	
Active	113	

Panel B: Funds w/ CFCFs

	Fund Size ($m)	Family Size ($m)	No. of CFCFs	Cross-Fund Dist.%	Cross-Fund Call%
Mean	370	1,060	17	51%	21%
Median	275	500	11	23%	11%
Std. Dev.	370	2,181	16	96%	23%
Min.	7	7	1	0%	0%
Max.	2,800	34,820	65	1058%	87%
Number of Funds	495				
Liquidated	167				
Active	328				

Table 3. Fund Family Characteristics

This table shows the descriptive statistics of VC fund characteristics that drive cross-fund cash flows (CFCFs) in our sample. The first dummy is an indicator for the first buyout or VC fund in a fund family. LargeFamily is an indicator of whether the fund is in the largest tercile of the family size distribution. Recycled is an indicator of whether the fund recycles its distribution and returns it to fund investments. Cross-Fund Call% is the volume of CFCFs (capital calls) as the percentage of the fund size.

Cross-Fund Call%	Liquidated						All					
	First		LargeFamily		Recycled		First		LargeFamily		Recycled	
	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
Mean	0.5%	13.4%	22.7%	5.6%	9.1%	12.0%	0.5%	17.1%	33.8%	9.4%	14.8%	14.9%
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	16.5%	78.0%	78.0%	77.2%	77.2%	78.0%	16.5%	86.5%	86.5%	77.2%	85.5%	86.5%
Std. Dev	2.6%	21.1%	23.3%	15.2%	17.2%	20.7%	2.0%	22.6%	25.1%	17.3%	21.4%	21.9%
Number of Funds	39	211	84	166	54	196	92	599	154	537	126	565

Table 4. Relationship between CFCFs and Early-Stage Projects

This table shows the regression results of the relationship between the intra-family cash flows and the stage development of VC fund investment under conditioned liquidity. The explanatory variables are annual IPO volume (Number_IPOs) from 1995 to 2019 (data obtained from Jay Ritter' website) and Moody's Baa-Aaa corporate bond yield spread. The dependent variable is the ratio of CFCFs_early over CFCFs_late (CFCFs_all as an alternative). The variables CFCFs_early and CFCFs_late are calculated as the intra-family cash inflows as a percentage of the fund size (capital calls%) of the early and late (including expansion) stages, respectively. Due to the employed relative term, the fund size difference between the early and late stages of the final results is controlled. The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable			
	Early/Late ratio		Early/All ratio	
	(1)	(2)	(3)	(4)
Number_IPOs	−0.002*		−0.0004**	
	(0.001)		(0.0001)	
Ln (Yield Spread)		1.621**		0.236***
		(0.586)		(0.078)
Constant	2.199***	1.797***	0.684***	0.601***
	(0.345)	(0.179)	(0.043)	(0.024)
Observations	25	25	25	25
R^2	0.125	0.250	0.253	0.287
Adjusted R^2	0.087	0.217	0.221	0.256
Residual Std. Error	0.939	0.869	0.118	0.115
F-Statistic	3.289*	7.653**	7.800**	9.264***

Table 5. Relationship between CFCFs and Fund Characteristics

This table shows the OLS regression results of the relationship between intra-family cash flows and VC fund characteristics. The dependent variable is cross-fund capital calls as a percentage of the fund size (Cross-Fund Call%). The explanatory variables include several indicators. The "First" is an indicator of the first buyout or VC fund in a fund family. The "LargeFamily" indicates whether the fund is in the largest tercile of the family size distribution. The "Prev_PME" is the previous fund performance a. "Recycled" is an indicator of whether the fund recycles its distribution and returns it to fund investments. We also control for macroeconomic condition, country- and industry-fixed effects across specifications (2), (3), (5), (6), (8), and (9), where the vintage time-fixed effect is considered as a proxy of macroeconomic conditions, to account for the effect of the market condition on liquidity when the funds were introduced. The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable: Cross-Fund Call%								
	Liquidated			Active			All		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
First	−0.076**	−0.042	-0.023	−0.105***	−0.118***	−0.081***	−0.108***	−0.107***	−0.074***
	(0.033)	(0.032)	(0.030)	(0.027)	(0.028)	(0.026)	(0.022)	(0.022)	(0.021)
LargeFamily	0.156***	0.165***	0.128**	0.290***	0.300***	0.264***	0.226***	0.228***	0.199***
	(0.025)	(0.026)	(0.025)	(0.021)	(0.021)	(0.020)	(0.018)	(0.018)	(0.017)
Recycled	−0.0002	−0.014	−0.015	0.035	0.048*	0.043**	0.011	0.015	0.015
	(0.028)	(0.028)	(0.025)	(0.023)	(0.024)	(0.022)	(0.019)	(0.019)	(0.018)
Prev_PME			0.046**			0.074***			0.061***
			(0.007)			(0.010)			(0.006)
Constant	0.073***			0.107***			0.111***		
	(0.017)			(0.012)			(0.010)		
Vintage, region, and industry FE	NO	YES	YES	NO	YES	YES	NO	YES	YES
Observations	250	250	250	441	441	441	691	691	691
R^2	0.182	0.529	0.602	0.360	0.629	0.676	0.245	0.536	0.597
Adjusted R^2	0.172	0.467	0.548	0.355	0.605	0.654	0.241	0.509	0.572
Residual Std. Error	0.182	0.168	0.154	0.181	0.176	0.165	0.190	0.185	0.172
F-Statistic	18.257***	8.568***	11.086***	81.869***	26.047***	30.730***	74.143***	19.347***	24.080***

Table 6. Effect of CFCFs on Fund Performance

Panel A shows the cross-sectional fund level of the OLS regression results. The independent variables include fund size, cross-fund capital call dummy (CFCF Call Dummy), cross-fund capital call amount as a percentage of the fund size (Cross-Fund Call%), previous fund performance (Prev_PME), previous fund performance dummy (Prev_PME_dummy), and vintage year-fixed effect variable. The dependent variable is the PME tailored with respect to the NASDAQ index for model specifications 1 to 6. Panel B shows the relationship between CFCFs and fund family past performances based on the OLS and Tobit models with lower bound censored data at 0 for those funds without CFCFs. The dependent variable is Cross-Fund Call%, and the independent variables are Prev_PME and Prev_PME_dummy. The sample includes all liquidated VC funds that are winsorized by controlling for extreme outliers (e.g., the funds with PMEs larger than 10) and unqualified cash flows (e.g., the fund with TVPI equals 0, indicating no distribution or residual value cash flow data subject to this fund). The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Panel A Dependent Variable						
	PME					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (Fund Size)	0.951*	1.039*	0.930*	0.929	0.971*	1.279**
	(0.569)	(0.554)	(0.563)	(0.564)	(0.561)	(0.537)
Ln $(\text{Fund Size})^2$	−0.075	−0.094	−0.078	−0.078	−0.083	−0.137**
	(0.059)	(0.058)	(0.059)	(0.059)	(0.059)	(0.056)
CFCF Call Dummy		0.491***				
		(0.132)				
Cross-Fund Call%			0.839**	0.799*	0.626	0.744*
			(0.344)	(0.436)	(0.442)	(0.427)
Prev_PME_dummy				0.026	−0.081	−0.175
				(0.176)	(0.184)	(0.183)
Prev_PME					0.095*	0.123**
					(0.049)	(0.051)
Constant	−1.689	−1.732	−1.564	−1.555	−1.640	−1.972
	(1.637)	(1.592)	(1.619)	(1.624)	(1.615)	(1.261)
Vintage FE	YES	YES	YES	YES	YES	NO
Observations	250	250	250	250	250	250
R^2	0.244	0.288	0.264	0.264	0.276	0.073
Adjusted R^2	0.152	0.198	0.171	0.167	0.177	0.054
Residual Std. Error	0.935	0.909	0.925	0.927	0.921	0.988
F-Statistic	2.654***	3.196***	2.829***	2.720***	2.787***	3.822***

Panel B Dependent Variable		
	Cross-Fund Call%	
	OLS	Tobit
Intercept 1	0.008	−0.10***
	(0.012)	(0.03)
Intercept 2		−1.18***
		(0.08)
Prev_PME	0.025***	0.10***

	(0.007)	(0.01)
Prev_PME_dummy	0.232***	
	(0.022)	
Log Likelihood		−105.70
DF		497
Observations	250	250
R^2	0.461	
Adjusted R^2	0.457	
Residual Std. Error	0.147	
F-Statistic	105.719***	

Table 7. Relationship between CFCFs and Liquidity Condition

This table shows the OLS regression results of the relationship between intra-family cash flows and public market liquidity. The dependent variable is cross-fund capital calls as the fund size percentage, based on the quarterly cross-sectional data from 1996 to 2018. We control for the sample scarcity in earlier periods (few quarterly data points exist before 1996). The independent variables are public market liquidity indicators in the odd columns. Their corresponding lag terms are in the even columns, including the Pastor-Stambaugh liquidity index (P&S liquidity index), the Senior Loan Officer Opinion Survey on Bank Lending Practices (Loan credit tightness), the Chicago Board Options Exchange's CBOE Volatility Index (VIX), the interest rates difference on interbank loans and short-term U.S. government debt (TED), and Moody's Baa-Aaa corporate bond yield spread (Bond yield spread). The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable									
	Cross-Fund Call%									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
P&S liquidity index	−6.163***									
	(2.288)									
P&S liquidity index_1		−5.793**								
		(2.282)								
Loan credit tightness			0.003*							
			(0.002)							
Loan credit tightness_1				0.004**						
				(0.002)						
Bond yield spread					0.260					
					(0.200)					
Bond yield spread_1						0.295				
						(0.198)				
TED							0.089			
							(0.229)			
TED_1								0.181		
								(0.227)		
VIX									0.038***	
									(0.010)	

VIX_1										0.039***
										(0.010)
Constant	−1.292***	−1.306***	−1.270***	−1.276***	−1.566***	−1.613***	−1.352***	−1.410***	−2.077***	−2.110***
	(0.080)	(0.080)	(0.085)	(0.084)	(0.214)	(0.212)	(0.138)	(0.137)	(0.221)	(0.219)
Observations	92	91	92	91	92	91	92	91	92	91
R^2	0.075	0.068	0.031	0.047	0.018	0.024	0.002	0.007	0.132	0.143
Adjusted R^2	0.064	0.057	0.020	0.036	0.008	0.013	−0.009	−0.004	0.123	0.133
Residual Std. Error	0.767	0.764	0.785	0.773	0.790	0.782	0.797	0.789	0.743	0.733
F-Statistic	7.254***	6.446**	2.832*	4.366**	1.692	2.226	0.150	0.635	13.719***	14.820***

Table 8. Effect of CFCF Liquidity Timing on Fund Performance

This table shows the OLS regression results of the relationship between the CFCF liquidity timing over the dynamics of the public market conditions and VC fund performance. The dependent variable is the tailored PME with respect to the NASDAQ index for model specifications 1 to 6. The independent variables are fund size, cross-fund capital call amount as a percentage of the fund size (Cross-Fund Call%), CFCF liquidity timing measured by public market liquidity indicators, including the Pastor-Stambaugh liquidity index (P&S liquidity index), the Senior Loan Officer Opinion Survey on Bank Lending Practices (Loan credit tightness), the Chicago Board Options Exchange's CBOE Volatility Index (VIX), the interest rates difference on interbank loans and short-term U.S. government debt (TED), and Moody’s Baa-Aaa corporate bond yield spread (Bond yield spread). The P&S liquidity index is converted into a reciprocal of its exponential term to be consistent with other liquidity tightness indicators. The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable					
	PME					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (Fund Size)	0.930*	1.024*	0.923	1.012*	0.973*	1.117**
	(0.563)	(0.555)	(0.563)	(0.554)	(0.558)	(0.546)
Ln (Fund Size)^2	–0.078	–0.093	–0.078	–0.091	–0.086	–0.104*
	(0.059)	(0.058)	(0.059)	(0.058)	(0.058)	(0.057)
Cross-Fund Call%	0.839**	0.179	0.791**	0.368	0.392	0.148
	(0.344)	(0.408)	(0.347)	(0.376)	(0.399)	(0.374)
CFCF liquidity timing						
P&S liquidity index		0.460***				
		(0.159)				
Loan credit tightness			0.006			
			(0.006)			
Bond yield spread				0.438***		
				(0.152)		
TED					0.514**	
					(0.237)	
VIX						0.027***
						(0.007)
Vintage FE	YES	YES	YES	YES	YES	YES
Observations	250	250	250	250	250	250
R^2	0.264	0.291	0.268	0.291	0.279	0.315
Adjusted R^2	0.171	0.197	0.171	0.197	0.184	0.224
Residual Std. Error	0.925	0.910	0.924	0.910	0.917	0.894
F-Statistic	2.829***	3.111***	2.776***	3.110***	2.938***	3.483***

Figure 1. IPO Volume in U.S. Stock Exchanges from 1995 to 2019

This figure shows the dynamics of IPO volume in three major U.S. stock exchanges (NASDAQ, NYSE, AMEX) during our sample period from 1995 to 2019. The grey bar is the annual number of IPOs, and the grey line is the market value in USD billions at the first closing date of the IPOs, both scaled on the left axis. The black dashed line is the aggregate proceeds received from IPOs in USD billions measured on the right axis. The data come from Jay Ritter's website.

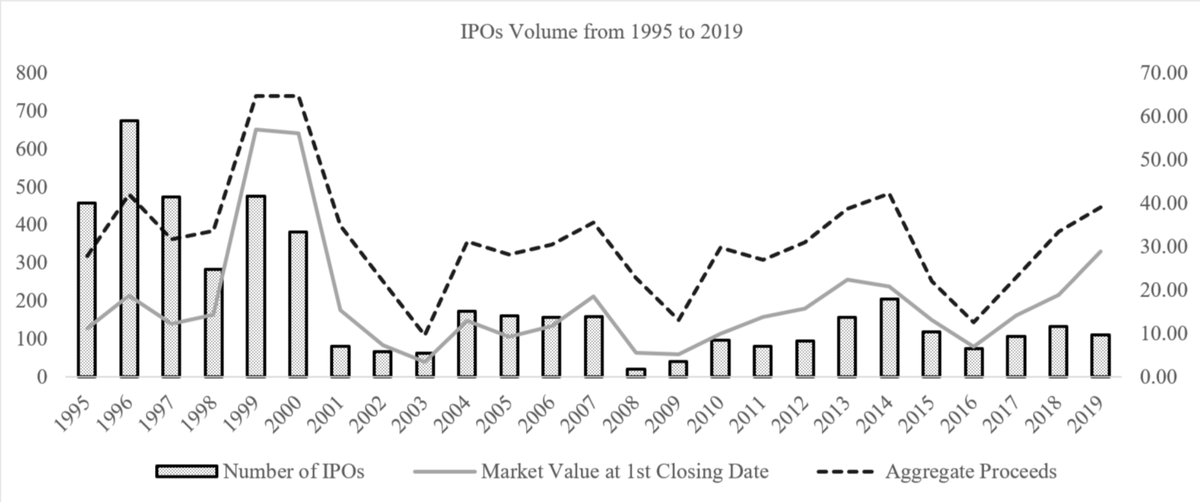


Figure 2. CFCF Volume and Early to Later Stages Ratio

This figure shows the relationship between CFCFs and early-stage investment. The grey shadow bar represents intra-family capital calls from early-stage projects over our sample period, while the black shadow bar shows late-stage investments (incl. expansion). The solid line shows the relative proportion of early-stage CFCFs to late-stage ones. The left axis is the CFCF volume in tens of millions of USD, and the right axis is the ratio ranging from 0.39 to 4.34.

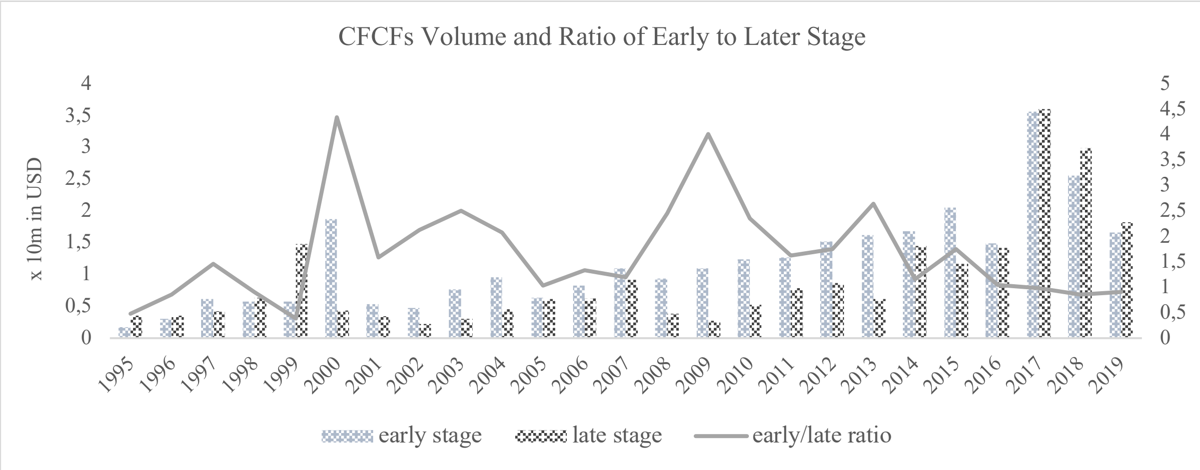
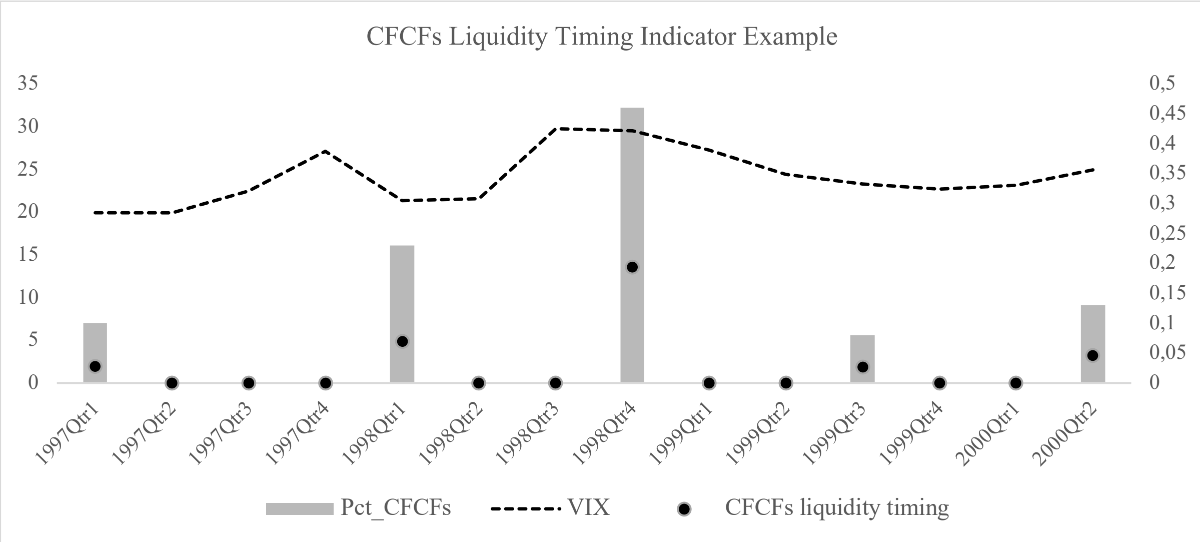


Figure 3. Example of CFCF Liquidity Timing Indicator

This figure depicts an example of the CFCF liquidity timing distribution of a representative fund. The black dashed line is the market liquidity condition measured by the VIX, and the grey bar is the percentage of cross-fund capital call% ($Pct_{CFCF_{it}}$) of the representative fund in each quarter of its life span. Assuming that the cash flow data show five quarters containing CFCF, and according to the definition of CFCF liquidity timing, we weight the market liquidity indicator (VIX) based on the distribution of $Pct_{CFCF_{it}}$. The summation of CFCF liquidity timing over the fund's life span is then the fund-specific CFCF liquidity timing indicator, capturing the liquidity stress concentration of CFCFs for each VC fund.



Appendix

Table A1. Effect of CFCFs on Active VC Fund Performance

This table shows the cross-sectional fund-level OLS regression results. The independent variables include fund size, cross-fund capital call dummy (CFCF Call Dummy), cross-fund capital call amount as a percentage of the fund size (Cross-Fund Call%), previous fund performance (Prev_PME), previous fund performance dummy (Prev_PME_dummy), and the vintage year-fixed effect variable. The dependent variable is the tailored PME with respect to the NASDAQ index for model specifications 1 to 6. The sample includes all active VC funds winsorized by controlling for extreme outliers (e.g., funds with PMEs larger than 10) and unqualified cash flows (e.g., funds with TVPI equal to 0, indicating no distribution or residual value cash flow data subject to this fund). The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable					
	PME					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (Fund Size)	–0.121	–0.134	–0.116	–0.118	–0.132	–0.143
	(0.188)	(0.189)	(0.188)	(0.188)	(0.188)	(0.181)
Ln $(\text{Fund Size})^2$	0.011	0.011	0.008	0.008	0.009	0.008
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.017)
CFCF Call Dummy		0.071				
		(0.075)				
Cross-Fund Call%			0.262	0.207	0.175	0.280
			(0.166)	(0.198)	(0.200)	(0.191)
Prev_PME_dummy				0.046	0.005	–0.064
				(0.089)	(0.098)	(0.095)
Prev_PME					0.047	0.067
					(0.047)	(0.045)
Constant	1.525*	1.588*	1.573*	1.540*	1.576*	1.459***
	(0.861)	(0.863)	(0.860)	(0.863)	(0.863)	(0.480)
Observations	441	441	441	441	441	441
R^2	0.072	0.074	0.077	0.078	0.080	0.017
Adjusted R^2	0.016	0.016	0.019	0.018	0.018	0.006
Residual Std. Error	0.694	0.694	0.693	0.693	0.693	0.697
F-Statistic	1.283	1.268	1.335	1.293	1.283	1.524

Table A2. Effect of CFCFs on All VC Fund Performance

This table shows the cross-sectional fund-level OLS regression results. The independent variables include fund size, cross-fund capital call dummy (CFCF Call Dummy), cross-fund capital call amount as a percentage of fund size (Cross-Fund Call%), previous fund performance (Prev_PME), previous fund performance dummy (Prev_PME_dummy), and the vintage year-fixed effect variable. The dependent variable is the tailored PME with respect to the NASDAQ index for model specifications 1 to 6. The sample includes all VC funds winsorized by controlling for extreme outliers (e.g., funds with PMEs larger than 10) and unqualified cash flows (e.g., funds with TVPI equal to 0, indicating no distribution or residual value cash flow data subject to this fund). The asterisks *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

	Dependent Variable					
	PME					
	(1)	(2)	(3)	(4)	(5)	(6)
Ln (Fund Size)	0.147	0.121	0.161	0.159	0.129	0.133
	(0.189)	(0.187)	(0.188)	(0.188)	(0.187)	(0.183)
Ln (Fund Size)^2	−0.008	−0.010	−0.013	−0.013	−0.010	−0.008
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
CFCF Call Dummy		0.213***				
		(0.067)				
Cross-Fund Call%			0.415***	0.369*	0.286	0.419**
			(0.157)	(0.189)	(0.190)	(0.188)
Prev_PME_dummy				0.036	−0.049	−0.108
				(0.082)	(0.087)	(0.088)
Prev_PME					0.089***	0.104***
					(0.032)	(0.033)
Constant	0.459	0.585	0.479	0.490	0.560	0.722
	(0.924)	(0.918)	(0.920)	(0.921)	(0.916)	(0.471)
Observations	691	691	691	691	691	691
R^2	0.124	0.138	0.134	0.134	0.144	0.031
Adjusted R^2	0.075	0.087	0.083	0.082	0.091	0.024
Residual Std. Error	0.796	0.790	0.792	0.792	0.789	0.817
F-Statistic	2.507***	2.738***	2.648***	2.582***	2.733***	4.450***

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