Review of Finance, 2023, 693–738
https://doi.org/10.1093/rof/rfac037
Advance Access Publication Date: 31 May 2022

Private Company Valuations by Mutual Funds*

Vikas Agarwal[1], Brad Barber[2], Si Cheng[3], Allaudeen Hameed[4], and Ayako Yasuda[2]

[1]Robinson College of Business Georgia State University, USA, [2]Graduate School of Management, UC Davis, USA, [3]Whitman School of Management, Syracuse University, USA and [4]NUS Business School, National University of Singapore, Singapore

Abstract

Mutual fund families set and report values of their private startup holdings, which affect the fund net asset value (NAV) at which investors buy/sell fund shares. We test three hypotheses related to the valuation practice: (i) information cost/access, (ii) litigation risk, and (iii) strategic NAV management. Consistent with (i), families with larger PE holdings and/or stronger information access update valuations more frequently in the absence of public information releases, their updates co-move less with other families, and their fund returns jump less at follow-on financings. We find no support for hypotheses (ii) or (iii). We also find that high-PE-exposure funds are subject to greater financial fragility.

* This research has benefitted from the comments of Manuel Adelino, Roger Edelen, Marcin Kacperczyk (editor), Byoung Uk Kang, Augustin Landier, Josh Lerner, Laura Lindsey, Clemens Sialm, Yan Xu, Chunliu (Chloe) Yang, two anonymous referees and a co-editor, and conference and seminar participants at the 2019 AFA Annual Meetings (Atlanta), the 2019 AIM Investment Conference at the University of Texas Austin, the 2019 Asian Bureau of Finance and Economic Research Annual Conference (Singapore), the 2019 FMA Annual Meetings (New Orleans), the 2019 PERC Symposium at the University of North Carolina, the 2019 Summer Institute for Finance Conference (Ningbo), the 2018 Financial Intermediation Research Society Annual Conference (Barcelona), China International Conference in Finance 2018 (Tianjin), 30th Asian FA Conference 2018 (Tokyo), UW Summer Finance Conference 2018 (Seattle), 12th Private Equity Symposium at London Business School, Academic and Practitioner Symposium on Mutual Funds and ETFs at the University of Virginia, Chinese University of Hong Kong, Securities and Exchange Commission, UC Berkeley, UC Davis, University of Illinois (Urbana–Champaign), and Waseda University. Xuan Fei, Yuan Gao, Suiheng Guo, Ming Liu, Honglin Ren, Harshini Shanker, Priti Shaw, Haifeng Wu, Yanbin Wu, Yiyang Wu, Yucheng (John) Yang, and Mengfan Yin provided valuable research assistance. V.A. would also like to thank the Centre for Financial Research (CFR) in Cologne for their continued support. S.C. acknowledges the funding from CUHK Direct Grant for Research and CUHK United College Endowment Fund Research Grant No. CA11260. A.H. is grateful for funding from NUS AcRF Tier 1 Grant R-315-000-124-115. A.Y. acknowledges the funding from UC Davis Academic Senate Committee on Research.

Keywords: Mutual funds, Venture capital, Private valuation, Stale prices, Financial fragility

JEL classification: G23, G24, G28, G32, M13

Received February 23, 2021; accepted April 20, 2022 by Editor Marcin Kacperczyk.

1. Introduction

Historically, mutual funds that focus on emerging-technology, high-growth firms have invested in shares of these firms upon their initial public offerings (IPOs) by receiving allocation of shares from the underwriter at the IPO offer price. This was a natural point of entry for mutual funds since shares they purchase would be immediately liquid, IPO firms were young with their high growth expected to continue for years after IPOs, and pre-IPO firms raised little money relative to public firms. For example, Google was founded in 1998, raised $36M in venture capital (VC) funding as a private startup, and went public in August 2004 by raising $1.7 billion. Mutual funds who purchased the stock at the IPO offer price ($85 a share) would have earned 100% on the investment within 2 months (as the stock price rose to $172.43 by late October 2004). However, "buy at IPO" has ceased to be a dominant strategy for mutual funds and other public technology investors in recent years for two reasons. First, since private startups now prefer to stay unlisted until they are much older and larger firms, IPO firms are now older and more richly valued, with less growth prospects remaining for them by the time of IPOs. Second, they now raise much larger amounts of capital as late-stage private startups, thus providing mutual funds with greater opportunities to invest in private funding rounds than they did previously. In response to these changes in startup behavior, mutual funds now participate in private funding rounds (dubbed private IPOs by practitioners) and purchase private securities that are neither liquid nor publicly tradable. For example, Fidelity participated in a $475 million Series D round for Airbnb in 2014 at $40.71 per share when Airbnb was 6-years old. By the time Airbnb went public in December 2020 as a 12-year-old company with a market capitalization of more than $100 billion, Fidelity had held the private Airbnb shares for 6 years. While this was an ultimately profitable investment (Airbnb opened trading at $146 a share), the new phenomenon of private investments by mutual funds raises a number of questions and potential concerns. In this paper, we aim to answer two such questions.

Mutual fund families set and report values of their private startup holdings daily, which affect the fund net asset value (NAV) at which investors buy/sell fund shares. This implies that the quality of private asset valuation practices by fund families can affect the fund returns that individual investors receive. The first question we therefore ask is: what determines the valuation practices by fund families investing in private securities? Are there measurable differences across fund families and are some practices more desirable for fund investors? Furthermore, to the extent that private security prices are updated with lags, the price staleness generates incentives for investors to either move into the funds to exploit low prices before appreciation or move out of the funds in anticipation of price drops. This motivates our second question: Does exposure to private investments make fund flows more sensitive to either positive or negative (anticipated) fund returns due to presence of illiquid assets and stale prices in the portfolio?

For the first question, we posit three, non-mutually exclusive hypotheses. First, information costs and access might affect the fund families' valuation practices. Private securities are inherently costlier to value given their illiquidity, lack of transaction prices, and lack of regulatory disclosure mandates. And yet open-end mutual funds are required to ascribe a value to each security to calculate the fund's daily NAV, thus necessitating an in-house valuation team dedicated to monitor any material changes in private security valuations. Ceteris paribus, fund families with larger private security exposure can budget for a higher capacity team and enjoy economies of scale in the production and processing of information about their private holdings. Also, private startups often contractually agree to disclose periodic financial and operational performance updates to investors with above-threshold percentage contribution to a funding round. Thus, fund families with large percentage stakes in a funding round are more likely to receive timely and high-quality privileged disclosure from the startups than other, less important shareholders. These observations lead to the information cost/access hypothesis: families with larger private equity (PE) holdings and/or stronger information access rely more on private information to update their valuations, leading to systematic differences in their valuation practices.

Second, litigation risk might drive the fund families' valuation practices. Redemption rights of fund shareholders sharpen the potential harm of improper valuation: if private securities in the fund portfolio are overvalued, then those redeeming fund shares will be overpaid, while those buying fund shares are overcharged. There is also an indirect transfer from remaining fund investors, since when the price correction occurs, the NAV will be reduced further to cover the overpayment to the redeeming investors.[1] We posit that fund families that fear litigation risk associated with inflated valuations and/or have greater capacity to mitigate this risk are quicker to decrease private security valuation following negative news about the security or the VC market. On the other hand, it may be difficult for courts to distinguish between inflation and optimism, making litigation risk a smaller concern.

Third, strategic incentives of fund families might influence their valuation practices. Given the well-known convex flow–performance relation, we posit that fund families are more likely to increase the valuation of private securities held in their top-performing fund portfolios at the year-end. Also, since fund managers have incentives to smooth fund returns to boost their risk-adjusted performance, we posit that fund families are more likely to increase (decrease) the valuation of private securities held in its bottom-performing (top-performing) funds. However, since private security valuation is centralized at the fund family level, when the family faces opposing strategic incentives (e.g., when the same security is held by both top- and bottom-performing funds within the family), this one-price-constraint limits the economic benefit of this type of strategic behavior.

Next, for the second question of whether the price staleness and potential wealth transfers among fund investors intensify flow–performance sensitivity when valuation updates of private security holdings are anticipated, we study two distinct scenarios. First, we test if fund investors exploit predictable positive excess fund returns around follow-on rounds of private startups by buying fund shares ahead of the issue date. Second, we test if fund investors are more prone to redeem the fund shares of high-PE-exposure funds after both the fund itself and overall VC market experience negative returns. Whereas the first scenario requires investors who do not necessarily hold current fund shares to be aware of both the mispricing in fund's private holdings and the timing of follow-on rounds—a tall

1 See Schwartz (2017) for legal analysis of investor-protection concerns that arise from mutual funds' investments in private venture-stage firms.

order—the second scenario merely requires existing fund investors to pay attention to performance of the fund and the overall VC market index in the previous quarter, which seems plausible.

We analyze a manually compiled dataset of 334 private securities (for 199 different companies) held by 235 unique mutual funds from 43 fund families between 2010 and 2018. We identify the private security prices reported by mutual funds using quarterly filings of mutual fund holdings with the US Securities and Exchange Commission (SEC). A key feature of the dataset is that we identify the specific series that a mutual fund holds (e.g., Series D versus Series E of Airbnb). Each security series represents a distinct funding event/round for the private firm; is a unique part of the firm's capital structure; and has different contractual terms such as liquidation preference, participation, and dividend preference (Metrick and Yasuda, 2010, 2021). Our identification of each unique security (typically a convertible preferred stock) allows us to carefully measure variation in pricing across fund families for the same security at the same point in time and rule out contract features as the source of the valuation differences.

To set the stage, we first show there is material variation in valuations for the same security across fund families. On average, for the same security held at the same time, the standard deviation of prices across fund families is 9.6% of the average security price. The ratio is greater than 24% for 10% of security-quarter observations in our dataset.

When we analyze the variation in valuations across fund families, we find extensive evidence in support of the information cost/access hypothesis. First, we show that families with larger PE holdings and/or stronger information access update valuations more frequently in the absence of public information releases. But unconditionally, these families do not update valuations more or less frequently than fund families with higher information costs or less information access. These results suggest that more effective private information production and processing is associated with more independent timing of valuation updates, not with more frequent re-valuations overall.

Second, valuation updates by fund families with larger PE holdings and/or stronger information access co-move less with updates made by other fund families holding the same security. Generally, co-movements among families holding a given private security are quite strong and individual families' valuations tend to revert to the average valuation among the more informed families. Thus, this finding adds to the evidence that valuation practice of families with better information cost structure or access is more independent of the peers than that of families with less information advantage.

Third, returns of mutual funds that hold private securities are predictably large after a follow-on funding round by the private startup, but the return predictability diminishes for families with larger PE holdings and families with better information access. We define the date of the funding round as the day when the company files a restated Certificate of Incorporation (reflecting the change in the capital structure of the company) in the company's home state. For funds holding the private security, average fund-level cumulative abnormal returns (*CAR*s) are 40 bps (25 bps) in the 10-day (5-day) window following the funding round date. The positive and significant *CAR* at the fund level is consistent with the view that fund families tend to keep the valuation of private securities low (and stale) until the follow-on funding dates and then make large one-time updates. The fact that *CAR*s are smaller for more informed fund families suggests that these fund families tend to use their private information to update the security valuation *before* the follow-on round dates, resulting in less stale pricing. Combined, these three results build a compelling case in support of information cost/access as a driver of the fund-family private-security valuation practice.

In contrast, we find no evidence in support of the litigation risk hypothesis. We find that families with greater assets under management or better governance practice (proxies for the awareness of or exposure to the litigation risk and/or capacity to mitigate the risk) are not quicker to decrease private security valuation when the private firms receive negative news coverage or the VC market performs poorly overall. This non-result might be because the litigation risk from inflated valuation is perceived to be small by fund families, and/or because the period we study, 2010–2018, is a long bull market with no major crashes in public or private startup funding markets.

Similarly, we do not find empirical support for the strategic behavior hypothesis. Fund families are not more likely to increase the valuation of the private securities held by their top-performing funds at the year-end than other securities. Moreover, we find no evidence of intra-year return smoothing by decreasing (increasing) the valuation of private securities held by top-performing (bottom-performing) funds. These findings suggest that strategic incentives to boost or smooth fund returns are not the main drivers of valuation practice differences across fund families.

Finally, we analyze the effects of stale pricing on fund flows and find asymmetric investor responses to expected appreciation versus de-valuation due to price staleness. No excess fund flows are associated with predictable positive excess fund returns around follow-on rounds of private startups. This suggests that investors are not taking advantage of deflated private security prices by buying fund shares before the follow-on rounds. One possible reason is that "the opportunity would be difficult to exploit because it would be hard for investors to gauge the extent of the mispricing and estimate the time frame for correction" (Schwartz, 2017). Indeed, our earlier results show that mispricing is curtailed for families with better information cost/access and thus investors have less to gain from opportunistic trading of this kind.

In contrast, we find that the flow–performance sensitivity of high-PE-exposure funds is significantly higher in quarters after both the fund and the broader VC market earn negative returns. In other words, fund investors respond more sharply to negative fund returns by redeeming the fund shares when the funds are more heavily exposed to VC-funded private startups *and* the overall VC market simultaneously performs poorly. This finding is consistent with a view that open-ended mutual fund structure, which grants redemption rights to fund investors, is inherently fragile when it holds illiquid and difficult-to-value private startup securities in a declining market. Fund investors prefer getting out of the fund before de-valuation (and getting potentially overpaid for the private securities) to getting stuck in a sinking fund where they lose twice, first from the de-valuation itself and second from having to cover the overpayment to the redeeming investors. The exit of investors in declining markets and liquidation of relatively liquid publicly listed securities, in turn, makes the private securities a bigger proportion of the fund's portfolio, amplifying the investor concern for illiquidity and future losses. Thus, stale pricing and potential fragility due to investor exits exacerbates the run risk of mutual funds holding private securities in declining markets. The asymmetric results highlight the difficulty of assessing the magnitude of this fragility risk in steady, booming market conditions, just as the sudden runs on money market funds holding securitized debt caught market participants and policymakers by surprise at the start of the 2008 Financial Crisis (e.g., Schmidt, Timmermann, and Wermers, 2016). Although there are only a few anecdotal mutual fund failures to date that resulted from a combination of large private startup equity holdings and the fund's inability to meet large redemption requests, the structural risk is apparent. The true test will come when the current tech boom ends and investors, anticipating large devaluations in the private startup holdings by mutual funds, rush to redeem their shares from high-PE-exposure funds.

In summary, our paper contributes to the literature in two ways. First, we identify information costs and access as a key driver of private startup valuation practices across fund families. Ceteris paribus, families with larger PE holdings and/or better information access make valuation decisions using better-quality private information, and thus are likely to lessen welfare loss (as well as gains) to fund investors due to stale pricing. Second, we find that high exposure to private startups increases the run risk of mutual funds when both the VC market and the fund itself perform poorly and investors respond sharply by redeeming fund shares. While some fund families are better in their "best valuation practice" of private investments, there is also an inherent fragility in all open-ended mutual funds due to the mismatch between the investors' demand for liquidity and the significant illiquidity of private startups they increasingly seek out to invest.

2. Related Literature and Our Contributions

A small but growing strand of literature studies the private investments of mutual funds. Kwon, Lowry, and Qian (2020) analyze the general rise in mutual fund participation in private markets over the last 20 years and conclude that mutual fund investments enable companies to stay private 1 or 2 years longer on average. Chernenko, Lerner, and Zeng (2021) analyze contract-level data to examine the consequences of mutual fund investments in these early-stage companies for corporate governance provisions. Huang *et al.* (2021) study the performance of private startup firms backed by institutional investors and find that they are more mature, have higher likelihoods of successful exits, and in case of IPO exits, receive lower IPO underpricing and higher net proceeds. None of these papers examine the determinants of the private securities valuation practices of fund families, nor do they study the effects of the valuation practice on fund-level returns and flows. Cederburg and Stoughton (2018) document variation in pricing across funds and argue that PE pricing by mutual funds is pro-cyclical with respect to fund performance, which is consistent with the prediction of a theoretical model that they develop. Imbierowicz and Rauch (2020) study pricing of unicorns by mutual funds and emphasize the importance of external factors, such as the valuation of peer companies, as determinants of unicorn pricing. Gornall and Strebulaev (2020b) study the dilutive impact of future financing rounds on the VC security values and compare their model predictions with values reported by mutual funds and issuers. In contrast, our paper documents that private security holdings expose mutual funds to predictable fund returns and potential wealth transfers and that valuation practices associated with better information cost structure and/or better access to information mitigate the effects. We also provide evidence that high exposure to private security holdings make open-end mutual funds subject to greater financial fragility.

Our work is related to the literature that analyzes the daily pricing of mutual funds. US mutual funds typically offer an exchange of shares once per day at a price referred to as NAV. Stale equity share prices (e.g., foreign equities or thinly traded stocks), which are reflected in a fund's NAV, lead to predictable fund returns (Bhargava, Bose, and Dubofsky, 1998; Chalmers, Edelen, and Kadlec, 2001; Boudoukh *et al.*, 2002; Zitzewitz, 2006).

Recent work by Choi, Kronlund, and Oh (2022) shows that these problems associated with stale pricing are exacerbated in case of fixed income funds. Moreover, fund flows indicate that investors capitalize on these predictable returns (Goetzmann, Ivković, and Rouwenhorst, 2001; Greene and Hodges, 2002). We document that PE valuations are much less frequently updated than public equity and lead to predictable fund returns. Furthermore, we show that valuation practice differences across fund families affect the degree of return predictability. Our study is also related to the literature on the valuation of relatively illiquid assets. Cici, Gibson, and Merrick (2011) study dispersion in corporate bond valuation across mutual funds and find that such dispersion is related to bond-specific characteristics associated with liquidity and market volatility. We examine how the (time-series and cross-sectional) variation in the valuation of private securities by mutual funds is explained by the fund family information-processing resources, information access, and release of public information. Additionally, our paper is also different in that we highlight the implications of stale pricing for both mutual fund return predictability as well as fragility associated with open-end funds holding private securities.

Our work also fits into the literature on the valuation and staged funding of venture-backed firms. Limited disclosure requirements prevent researchers from observing VC valuations at the portfolio company level. Thus, Jenkinson, Sousa, and Stucke (2013); Barber and Yasuda (2017); and Brown, Gredil, and Kaplan (2019) all examine valuation practices of VC and PE funds at the fund level. These papers find that some fund managers (e.g., those with low reputation) engage in fund NAV management during the fundraising campaigns.[2] We contribute to this literature by exploiting mandatory disclosure requirements of mutual funds that enable researchers to observe quarterly valuations of individual company holdings. Our findings about information cost/access as a key driver of valuation practice differences across mutual-fund families are plausibly generalizable to valuation practice differences across VC firms. Note, however, that VC funds are closed-end and do not grant on-demand redemption rights to their investors, thus effectively preempting runs on funds by their investors. Since VC investors cannot readily trade their fund interests at the reported NAV, staleness or bias in the VC fund NAV is less consequential in terms of financial fragility than the staleness in NAV for mutual funds.

We find the follow-on round purchase price is often a reference point for the valuation of the previous round private security and, as a result, leads to predictable fund returns. Post-money valuation, the industry short hand for company valuation implied by a new VC round of financing, is defined as the purchase price per share in the new round multiplied by the fully diluted share count. This measure abstracts away from the fact that VCs and their co-investors invest in startups using complex securities, typically a type of convertible preferred stock, and that securities issued in different rounds are not identical in their investment terms. Some academic studies use post-money valuations as proxies for the company valuation. For example, Cochrane (2005) and Korteweg and Sorensen (2010) develop econometric methods that measure risk and return of VC investments at the deal level using portfolio company post-money valuations observed at the time of financing events. Gompers and Lerner (2000) find that competition for a limited number of attractive investments leads to a positive relation between capital inflows and valuations of new investments.

Metrick and Yasuda (2010, 2021) and Gornall and Strebulaev (2020a) develop option-pricing-based valuation models, which correct for the use of convertible preferred securities

2 Also see Hüther (2016) and Chakraborty and Ewens (2018).

in VC financing contracts, to estimate the implied value of VC-backed private companies. These techniques are useful when evaluating the value of the company and other existing securities issued by the company at the time of new financing rounds, but not applicable to how valuations of companies or securities evolve in the absence of new rounds. Our study provides insights into the evolution of the prices of private companies over time.

3. Data

Our raw data on mutual fund holdings of PE securities come from both CRSP Mutual Fund Database and mutual funds' SEC filings of N-CSR and N-Q forms. Because mutual funds' holdings of PE securities are rare before 2010, we restrict our analyses to holdings reported between 2010 and 2018.

Using the matching method described in Online Appendix A, we carefully identify 334 securities issued by 199 companies (each security is a unique company-round pair) held by 235 unique mutual funds from 43 fund families. There are two distinct data challenges we face in constructing a clean data set of PE security holding by mutual funds. First, neither CRSP nor SEC raw data indicate definitively whether a security held by a mutual fund is a PE security, so we must manually identify and verify PE securities among mutual fund holdings. We do this by matching these fund holdings data with a list of VC-backed companies and recently listed companies. To identify VC-backed companies, we use Thomson Reuters' One Banker database. To identify firms that recently went public, we use both Bloomberg and CRSP databases. Hence, the private securities in our final sample are not limited to those issued by VC-backed companies.

Second, VC-backed private companies typically issue convertible preferred securities to their investors rather than common stock. These securities are issued at different financing rounds (called Series A, Series B, etc.) and differ in their terms (Metrick and Yasuda, 2010; Gornall and Strebulaev, 2020a). Thus, for example, if mutual fund X holds and values a Series D preferred stock issued by Airbnb at $23/share and another mutual fund Y holds and values a Series E preferred stock issued by Airbnb at $25/share, it is not necessarily because the two funds differ in their valuation of the company as a whole, but could be because the two securities differ in their contingent claims on the company assets and therefore *should* have different valuations. Thus, to compare valuations of private securities we must identify the issuer (e.g., Airbnb) and exact Series (A, B, C, etc.) of the security. Assigning the Series to a security turns out to be a non-trivial task because security names are not standardized in mutual fund reports of their holdings. For example, mutual funds frequently only report the security by its issuer name. When measuring price dispersion, we do not compare valuations across different Series of the same company and exclude private security holdings that we cannot clearly assign to a specific round.

4. Pricing of Private Companies by Mutual Funds

In this section, we describe the cross-sectional and temporal variation in private security valuations by mutual funds. To illustrate typical pricing dynamics across fund families and over time, Figure 1 provides an example of three mutual fund families that invested in Airbnb at the same time. Airbnb issued Series D security in April 2014 at a per share price of $40.71 and three mutual-fund participants in the round—Fidelity Contrafund, Morgan Stanley Multicap Growth, and Thrivent Growth Stock—all report holding the security at

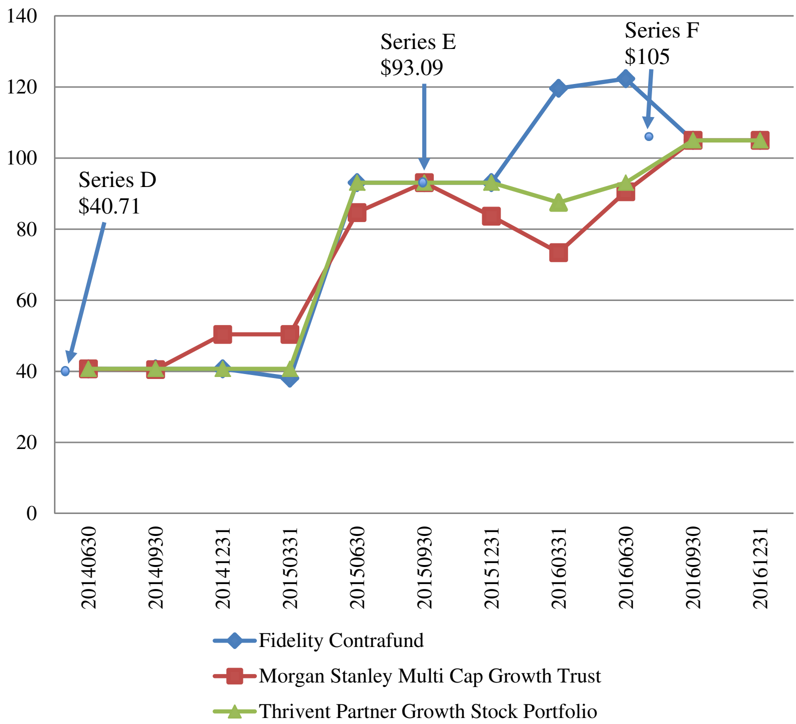

Figure 1. Airbnb Series D valuations reported by three mutual fund families. The Series D round for Airbnb was issued at $40.71 in April 2014. The lines depict the quarterly valuations for Airbnb by three mutual funds in their quarterly reports.

$40.71 (i.e., at cost) in June 2014. In December 2014, Morgan Stanley increases its valuation to $50.41, while the other two funds continue to report $40.71. In July 2015, Airbnb announces its Series E offering at $93.09 and all three funds increase their valuation of Series D holdings to $93.09 by September 2015. During the next year, prices reported by the three funds diverge substantially (e.g., $120 reported by Fidelity versus $73 by Morgan Stanley in March 2016), but converge again in September 2016 following a Series F funding round at $105 in July 2016.

The example in Figure 1 motivates us to examine three aspects of private security valuation by mutual funds. First, we establish that there is meaningful contemporaneous cross-sectional variation across mutual fund families, which suggests potential heterogeneity in valuation practices. Second, we document the frequency and timing of valuation updates in general and around key public information release events, namely follow-on rounds. Finally, we estimate how much of valuation updates by mutual funds—especially updates made in the absence of firm-specific events such as follow-on rounds—is explained by standard (public market) risk factor loadings.

4.1 Cross-Sectional Variation in Valuations

We begin the analyses by presenting contemporaneous variation in the valuation of private securities across mutual fund families.

We measure the variation in valuation across mutual funds by first calculating the standard deviation of prices across funds holding security s in quarter q ($\sigma_{s,q}$), and then scaling by average price of security s across funds in quarter q ($\overline{P_{s,q}}$)[3]:

$$\text{DispPrc\_Avg}_{s,q} = \frac{\sigma_{s,q}}{\overline{P_{s,q}}}. \tag{1}$$

We find virtually no dispersion in prices for the same security across funds *within* the same fund family (see Online Appendix Table A1, Panel C). Some fund families (e.g., Fidelity and T. Rowe Price) are known to use a centralized committee to determine values for each private company for all its funds and some families employ third-party valuation specialists.[4] The lack of variation in pricing across funds within the same fund family suggests these and similar practices yield identical pricing for a private security held across funds within a mutual fund family.

In Table I, we summarize the price dispersion *across* fund families, which is the focus of our analysis. To measure price dispersion across mutual fund families, we require that the same security be held by at least two families. This further reduces our sample to 118 unique securities issued by 69 companies. Using the average price to scale deviations, the mean price dispersion is 9.6% across fund families and is more than 24.8% at the 90th percentile of the distribution.[5] When we replace the average price with median price in the denominator of Equation (1), the cross-sectional statistics are quite similar. Thus, there is interesting and sometimes large variation in valuations across mutual fund families.[6]

4.2 Temporal Variation in Valuations

4.2.a. Infrequent valuation updates

As illustrated by the Airbnb example in Figure 1, fund families at times keep the pricing of private securities unchanged for consecutive quarters in the absence of material

3 While majority of mutual funds set their reporting cycles in March/June/September/December, others report their quarterly holdings and valuations in January/April/July/October or February/May/August/November cycles. To address these reporting cycle mismatches, we group funds by the ending month of their reporting cycles when calculating the price dispersion (i.e., treat quarter ending on March 31, 2015 and the quarter ending on April 30, 2015 as two different quarters).

4 See "Here's why mutual fund valuations of private companies can vary" by Francine McKenna on marketwatch.com, published November 20, 2015, and "Wall Street cop asks money managers to reveal Silicon Valley valuations" by Sarah Krouse and Kirsten Grind on the Wall Street Journal, published December 9, 2016.

5 As a robustness check, we repeat the analyses using the subset of securities acquired in the primary market. While there is no readily available indicator for primary market purchases, we identify them using the following criteria: (1) for securities issued before 2010, we require the first reporting date of fund holdings to be no later than the second quarter of 2010; (2) for securities issued after 2010, we require the first reporting date of fund holdings to be within 6 months after the follow-on round date. Our main findings remain unchanged: the average price dispersion within fund families is virtually zero and is much larger at 10.4% across fund families.

6 Kwon, Lowry, and Qian (2020) report that more than 50% of private securities have no variation in valuations across funds (rather than fund families), see Table 7, Panel E of their study. We find similar statistics when we calculate statistics across funds (see Online Appendix Table A1, Panel B). Thus, the lack of variation in valuations across funds within the same family masks potentially important valuation differences across fund families.

Table I. Price dispersion in private company valuations by mutual fund families

This table presents summary statistics for the price dispersion across fund families. Price dispersion (DispPrc_Avg) is computed as the standard deviation of prices across families in the same quarter ending in the same month (StdPrc) divided by the average security price across families (AvgPrc). DispPrc_Med is computed as the standard deviation divided by median price (MedPrc).

	Number of firm	Number of security	Security-quarter obs.	Mean	Std. Dev.	10%	25%	Median	75%	90%
NumFam	69	118	1,480	3.752	2.452	2	2	2	6	8
DispPrc_Avg	69	118	1,480	0.096	0.134	0.000	0.002	0.053	0.135	0.248
DispPrc_Med	69	118	1,480	0.099	0.153	0.000	0.002	0.052	0.134	0.252
StdPrc	69	118	1,480	2.138	3.733	0.000	0.076	0.873	2.561	5.279
AvgPrc	69	118	1,480	31.295	35.237	3.997	8.693	16.859	37.677	92.331
MedPrc	69	118	1,480	31.379	35.456	3.970	8.691	16.910	37.650	93.094

firm-specific events. To systematically measure how often funds update prices, we calculate a quarterly return for fund family F and security s based on the fund family's reported prices for the security in the current and prior quarters:

$$\text{Return\_PVT}_{F,s,q} = \frac{P_{F,s,q}}{P_{F,s,q-1}} - 1. \tag{2}$$

In Table II, Panel A, we present descriptive statistics on this quarterly return variable (Return_PVT) across 8,992 fund family–security–quarter observations. The average quarterly return is 3.7%, but the median return is zero and 42% of all returns are zero (not tabulated). Note that these are not daily returns, but quarterly. As a point of comparison, for public securities held by fund families in our sample, only 0.3% of quarterly returns are zero.

Similarly, when we first calculate the percentage of zero-return quarters for a given private security held by a given family and then averaging across family–security pairs, the mean is 46% (see Panel B, %Zero Return_PVT). In contrast, the mean for public security is 0.4% (%Zero Return_PUB). Panel B also reports that it takes on average 2.3 quarters for the fund to update its acquisition price of private securities (Qtr to Update_PVT).[7]

Taken together, the analysis shows that the staleness of private security pricing, where the price can stay unchanged for over 180 days on average, far exceeds the staleness of other illiquid securities held by mutual funds such as international stocks (overnight) or corporate bonds (days, sometimes weeks).

4.2.b. Valuation updates at follow-on offerings

Next, we examine the valuation changes around funding rounds. As suggested by the Airbnb example in Figure 1, price dispersion tends to decrease after a follow-on funding round when many funds update their prices, presumably by using the new deal price as a

7 In unreported analysis, we repeat our analysis by imposing a condition of a minimum of three- or four-quarter holding period for each family–security pair and find that results are unchanged. Thus, the results are not an artifact of private security holding periods being short.

Table II. Stale pricing of private securities

Quarterly return for a family–security–quarter is calculated using the reported prices by family F in quarters q and $q-1$ for security s, $(\frac{P_{F,s,q}}{P_{F,s,q-1}}-1)$. Panel A reports descriptive statistics across family–security–quarter observations for both private securities (Return_PVT) and public securities (Return_PUB). In Panel B, for each family–security pair, we calculate the percentage of quarters in which the family does not change the reported price of the security (i.e., quarterly return is zero) for private (%Zero Return_PVT) and public (%Zero Return_PUB) securities. For private securities, we also calculate the number of quarters until prices are updated from the acquisition price (Qtr to Update_PVT).

	Number of security	Obs.	Mean	Std. Dev.	10%	25%	Median	75%	90%
Panel A: Family–security–quarter return characteristics									
Return_PVT	334	8,992	0.037	0.279	−0.151	−0.005	0.000	0.044	0.219
Return_PUB	6,677	248,823	0.030	0.236	−0.178	−0.070	0.026	0.118	0.222
Panel B: Family–security return characteristics									
%Zero Return_PVT	334	763	0.461	0.304	0.038	0.250	0.455	0.667	1.000
Qtr to Update_PVT	334	763	2.334	1.975	1	1	2	3	5
%Zero Return_PUB	6,677	26,628	0.004	0.057	0.000	0.000	0.000	0.000	0.000

benchmark. To better understand how fund families benchmark private securities, we compare the prices of security s in quarter q to three primary benchmark prices: (i) the deal price in the most recent *and* any of the previous funding rounds (Any Prior Deal Price), (ii) the deal price in the most recent funding round (Latest Deal Price), and (iii) the price at which the security was acquired by the family (Acquisition Price). For each of the benchmarks, we examine how often the reported prices deviate from the benchmark prices by more than 1% (%Dev).

Table III, Panel A, reports the %Dev results. We find that in 62% of the reporting quarters, fund families report prices that are different from any of the prior deal prices. This corresponds, for example, to Morgan Stanley valuing Airbnb Series D at $73.41 in March 2016, which deviates from any of the prior deal prices for Series A–E (with the latest funding round being Series E in July 2015). In contrast, in 38% of the times, mutual funds report prices that match one of the prior deal prices. Furthermore, we find that in 35% of the reporting quarters, mutual funds report prices that match the latest deal price, since %Dev for Latest Deal Price is 65%. Similarly, %Dev of 80% for Acquisition Price implies that in 20% of the reporting quarters, mutual funds report valuation that equals the cost of acquisition (which could also be the latest deal price). This corresponds, for example, to Trivent still holding Airbnb at $40.71 in December 2014, 8 months after the initial acquisition. Lastly, if a mutual fund family simultaneously holds multiple securities issued by the same firm (e.g., Series D and Series E of Airbnb), how often do their valuations of the securities deviate from each other? We report this statistic in the last row of Panel A, as %Dev using the average of reported prices of all securities as the benchmark and requiring at least two securities to be held by fund families. We find that %Dev is 27%, that is, in 73% of reporting quarters the multiple securities are held at the same valuation.

Table III. Deviation from deal price around follow-on rounds

For each family–security–quarter, price deviation is calculated using the reported price by family F in quarter q for security s, $P_{F,s,q}$, and the benchmark price for the same security, $B_{s,q}$ ($\text{Dev}_{F,s,q} = \frac{P_{F,s,q}}{B_{s,q}} - 1$). DumDev is an indicator variable that equals one if the absolute value of Dev is above 1% and zero otherwise. DumDev^{+} is an indicator variable that equals one if Dev is above 1% and zero otherwise, and DumDev^{-} is an indicator variable that equals one if Dev is below -1% and zero otherwise. Panel A employs four sets of benchmark price in private security valuation, including the deal price in the most recent and any of the previous funding rounds (Any Prior Deal Price), the deal price in the most recent funding round (Latest Deal Price), the price at which the security was acquired by the family (Acquisition Price), and the average price reported by all families holding a security in a quarter (Family-Firm Average Price), and reports the number of price deviation, the total number of family–security–quarter observations, as well as the percentage of price deviation. In Panel B, for each family–security pair, we compute the price deviation of early round security valuation from the new round deal price, over nine quarters around the new round. We report the percentage of price deviations, as well as the median price deviation in the subset of positive and negative deviations, respectively. Panel C reports similar statistics for private securities issued in the new round.

	Number of firm	Number of security	$\sum$ DumDev	Number of family–security–quarters	%Dev
Panel A: Deviation of security valuation					
Any Prior Deal Price	186	326	5,660	9,132	62%
Latest Deal Price	186	326	5,894	9,132	65%
Acquisition Price	182	314	7,227	9,086	80%
Family-Firm Average Price	63	204	1,377	5,193	27%

Event quarter	Number of firm	Number of security	Number of family	Number of family–security–quarters	%Dev	$\%\text{Dev}^{+}$	$\%\text{Dev}^{-}$	Median Dev^{+}	Median Dev^{-}
Panel B: Deviation of early round security valuation from the new round deal price									
−4	50	90	35	292	99%	10%	89%	0.589	−0.339
−3	58	105	37	332	98%	8%	90%	0.580	−0.336
−2	62	113	39	369	98%	10%	88%	0.440	−0.310
−1	63	116	40	393	90%	14%	76%	0.190	−0.308
0	70	140	41	484	39%	8%	31%	0.232	−0.159
1	64	124	41	452	54%	13%	40%	0.210	−0.130
2	59	114	40	424	53%	21%	32%	0.190	−0.167
3	52	102	35	388	65%	28%	37%	0.232	−0.207
4	46	89	30	362	78%	36%	42%	0.212	−0.208
Panel C: Deviation of new round security valuation from the new round deal price									
0	156	207	40	440	14%	3%	12%	0.163	−0.100
1	150	198	39	419	32%	14%	19%	0.169	−0.100
2	132	178	38	386	46%	24%	23%	0.292	−0.100
3	119	161	38	353	66%	40%	26%	0.263	−0.138
4	107	146	35	310	76%	43%	34%	0.372	−0.127

These statistics confirm that latest follow-on deal prices are particularly important benchmarks for fund families. To gain a deeper understanding into pricing dynamics around follow-on round dates, we define price deviation from the follow-on round price as

$$\mathrm{Dev}_{F,s,q} = \frac{P_{F,s,q}}{B_{s,q}} - 1, \tag{3}$$

where $P_{F,s,q}$ is the reported price for security s held by fund family F in quarter q and $B_{s,q}$ is the latest follow-on round price, and trace both the average size of this deviation and as well as %Dev for four quarters before and four quarters after the follow-on round quarters. In doing so, we split the deviation in reported prices into two groups depending on whether the reported price is above or below the benchmark.

For securities held prior to a new funding round, we calculate statistics from quarter –4 to +4 and report results in Table III, Panel B. In quarter –4, 89% of the reported prices are below the future deal price (%Dev^-) and the median Dev^- is –0.34, implying the securities are valued substantially below the new fund round price. Interestingly, %Dev^- decreases from 88% in quarter –2 to 76% in quarter –1, suggesting that a critical minority of fund families use private information to update valuations ahead of the upcoming new funding round. As expected, %Dev decreases dramatically from 90% to 39% in quarter 0 as the majority of fund families update their security value to match the new deal price. After the new funding round, %Dev gradually increase again, reaching 78% in quarter +4, suggesting that three out of four fund families choose a price deviating from the deal price a year after the deal.

We also report the same deviation statistics for securities newly purchased at the time of the fund rounds in Panel C of Table III. In quarter 0, %Dev^+ and %Dev^- are 3% and 12%, respectively. Among the families reporting lower prices, the median "discount" (Median Dev^-) is –10%, which persists for up to three quarters. We conjecture that the lower valuation is consistent with some funds applying a 10% discount in their fair value pricing for illiquid securities.[8] In contrast, among family-quarters with markup in security prices above the deal price, the median markup (Median Dev^+) is large at 0.16 and gradually increases over time. As we move forward to quarter +4, %Dev increases to 76%. In terms of the magnitude of price deviations, this converts to an economically meaningful Median Dev^+ of 0.37 and Median Dev^- of –0.13.

Overall, the analyses indicate economically large differences in the prices reported by the cross section of mutual fund families. Moreover, these price deviations evolve over time, with some convergence toward the deal price during new rounds of financing, followed by price divergence over subsequent quarters.[9]

4.3 Are Private Security Valuations Explained by Standard Public Market Factors?

In this subsection, we examine how much standard public market factors such as market, size, and growth affect the private security valuations by mutual funds. Note that we

8 Untabulated results suggest that among the families reporting lower prices in quarter 0, 73% could be attributed to a 10% discount (measured within a close range between 9.9% and 10.1%).

9 Our findings are robust to (i) restricting our sample to the subset of securities acquired in the primary market and (ii) excluding securities with subsequent funding rounds in the post-event window (quarter +1 to +4). For brevity, these results are not tabulated.

exclude exit values of investments from our analysis, since we focus on valuation practices by fund families. Specifically, we regress the fund family–security–quarter percentage valuation changes (less the risk-free rate) of private companies held by mutual funds on the three common factors in Fama and French (1993): market, size, and value factors. We add lagged factor returns to account for stale pricing along the lines suggested by Scholes and Williams (1977) and Dimson (1979).[10]

Consistent with staleness in reported security prices, we find strong evidence that the changes in valuations respond to market, size, and value factors with a lag, and the exposure to these factors explains the average private security returns after we account for the slow updating of prices. For example, regressing the percentage change in private security valuations on a contemporaneous market factor yields an implausibly low market beta of 0.28 (see Online Appendix Table A3, Model 1). Including two quarterly lags of the market factor and summing coefficients yield a beta estimate of 1.255 (see Online Appendix Table A3, Model 2). These results are more in line with venture capital risk estimates reported in the literature that explicitly address staleness issues: Ang *et al.* (2018) report a market beta of 1.85 and negative alpha, and Metrick and Yasuda (2021) report a market beta of 1.47–1.85 and an insignificant alpha in multi-factor models.

Importantly, the *R*-squareds from the regressions of the percentage change in private security valuations on a public market factors yield low *R*-squareds ($<7\%$), which indicates valuation changes are largely driven by idiosyncratic factors leaving much room for discretion—the focus of our analysis.

5. Determinants of Valuation Practice Differences across Fund Families

Having shown that (i) security valuation varies significantly across fund families and (ii) both public information releases (e.g., follow-on rounds) and market factors interact meaningfully with temporal pricing dynamics, we now investigate potential explanations for why fund families may vary in their practice of updating the values of private securities. We expect that variation in both family and security characteristics influences the ability and incentives of fund families to update their valuations. Using a cost–benefit framework, we postulate three non-mutually exclusive hypotheses that reflect the differential costs and benefits faced by fund families. First, we examine if the updating behavior of fund families is influenced by differences in information costs and access to information. Second, we consider litigation risk as a potential determinant for valuation practice differences. Finally, we evaluate if valuation practices reflect strategic motives of the fund families.

10 See Anson (2007), Woodward (2009), and Metrick and Yasuda (2021) for methods similar to ours in assessing risk and return in private equity using index returns and lagged factors. See Kaplan and Sensoy (2015) and Korteweg (2019) for a review of other empirical methods to assess risk and returns in private equity. Also see Cochrane (2005); Kaplan and Schoar (2005); Korteweg and Sorensen (2010); Driessen, Lin, and Phalippou (2012); Franzoni, Nowak, and Phalippou (2012); Jegadeesh, Kräussl, and Pollet (2015); Korteweg and Nagel (2016); and Ang *et al.* (2018), among others. In addition, including additional lags of market, size, and value factors does not consistently generate significant loadings. We also consider the liquidity factor of Pástor and Stambaugh (2003) and the momentum factor of Carhart (1997); they do not generate reliable loadings, nor do they qualitatively affect the conclusions of this subsection.

5.1 Information Production Effectiveness and Access

Fund families incur cost in producing and processing information about the pricing of private securities. We expect fund families with larger PE holdings to be more effective in PE-related information production, since they can budget more dedicated internal resources, hire more experienced and specialized investment professionals, and spread the fixed cost across more PE investments. We consider two proxies for the extent of investment in private securities by fund families: the total dollar amount of private firm holdings and the total number of private firms held. Both proxies capture the importance of private securities in the family's portfolio. We expect families with larger PE holdings to rely more on private information to update their valuations, due to their superior economies of scale in information production.

We also postulate that fund families with greater access to privileged information about private companies should rely more on private information, leading to timely valuation updates even in the absence of public information. A major investor in a particular funding round typically negotiates rights to acquire information and/or receive financial statements from portfolio companies on an ongoing basis as part of their investor rights agreement.[11] Mutual funds participating as lead or key investors in a VC round thus are likely to receive privileged information from portfolio companies that other non-major investors (including those who purchased shares in secondary transactions) do not receive.[12] If this channel creates a wedge in information flows between major investors and others, we expect major investors' valuation update timing to differ from those of non-major investors.

To explore if the updating of private security prices is related to information production costs and access to information, we estimate the following panel regression:

$$\mathrm{DumUpd}_{F,s,q} = \alpha + \beta_1 \mathrm{Char}_{F,s,q-1} + \beta_2 \left(\mathrm{Char}_{F,s,q-1} \times \mathrm{News}_{s,q}\right) + \mu_{s,q} + \varepsilon_{F,s,q}, \qquad (4)$$

where $\mathrm{DumUpd}_{F,s,q}$ refers to an indicator variable that equals 1 if a fund family F revises its valuation of security s in quarter q, and zero otherwise. $\mathrm{Char}_{F,s,q-1}$ is a vector of family or family–security characteristics in quarter $q-1$, including (1) Ln(PE Value), the logarithm of the total dollar amount of private firms in the family's portfolio; (2) Ln(PE Number), the logarithm of the total number of private firms in the family's portfolio; and (3) %Firm

11 For example, a sample VC term sheet available on the NVCA website includes the following "Information Rights" boilerplate language:
Information Rights: Any Major Investor ... will be granted access to Company facilities and personnel during normal business hours and with reasonable advance notification. The Company will deliver to such Major Investor (i) annual, quarterly, [and monthly] financial statements, and other information as determined by the Board of Directors; [and] (ii) thirty days prior to the end of each fiscal year, a comprehensive operating budget forecasting the Company's revenues, expenses, and cash position on a month-to-month basis for the upcoming fiscal year; and (iii) promptly following the end of each quarter an up-to-date capitalization table. A "Major Investor" means any Investor who purchases at least $[______] of Series A Preferred.
See https://nvca.org/model-legal-documents/for a full sample term sheet.

12 Some fund families with large private equity holdings, such as Fidelity and T. Rowe Price, are known to often lead a funding round for late-stage startups with unicorn status. See, for example, Foldy (2021) for a VC round in Rivian led by T. Rowe Price and participated by Fidelity. In our sample, Fidelity and T. Rowe Price on average hold 29% and 19% of a funding round, respectively, suggesting their high likelihood of being major investors. In contrast, John Hancock Group has an average 2% and MassMutual has 0.15% of a funding round.

Round Size, defined as the total dollar amount of each private firm in a family's portfolio, scaled by the deal size of the corresponding funding round. Ln(PE Value) and Ln(PE Number) proxy for the amount of PE investment by fund families (information costs), and %Firm Round Size proxies for a key investor status of a fund family in a round (information access). $News_{s,q}$ refers to two proxies for news event about private firm, including (1) Ln(AEV), defined as the logarithm of the aggregate event volume from RavenPack database, which measures the count of public news releases over a rolling 91-day window and (2) High AEV, defined as an indicator variable that equals one if the aggregate event volume is in the top tercile across all private firms and zero otherwise. Our information cost/access hypothesis posits that families with better information cost structure or access are more likely to use their private information to update prices (relative to other families) in the absence of public information. To test this hypothesis, we add the interaction of information proxies with "News." Crucially, we further include security-quarter-fixed effects ($\mu_{s,q}$) to focus on the differences in valuation updates across fund families for the same security at the same time. The standard errors are clustered by quarter to account for cross-correlation in family–security characteristics.

We report the results in Table IV. Unconditionally, we do not find evidence of differences in the updating of private securities across fund families with varying information production costs or access to information. As shown in Models (1)–(3), the regression coefficients (β_1) associated with the information proxies are positive, but none are statistically significant, suggesting that the unconditional probability of updating PE prices, on average, is not associated with information costs or access. More importantly, we find that families with better information cost structure or access depend less on public news releases to update private security prices (significantly negative regression coefficients β_2 in Models (4)–(6)). Specifically, Models (4) and (5) show that families with large investments in private securities (in terms of dollar amount and the number of private firms held) are more likely to update prices (relative to families with low PE investments) when there is lesser amount of public news releases. This implies that families with better information cost structure rely mostly on private information to update PE prices.[13] Similarly, families that are key investors in a private firm do not update more frequently (Model (3)) but rely less on public release of information about the company than non-key investors in their valuation decisions (Model (6)). The latter result is consistent with the idea that key investors in a firm are partly conditioning their valuation updates on privileged information they receive from the issuer companies. For example, key-investor fund families may update their security valuations in advance of follow-on rounds because they become aware of upcoming funding events sooner (via direct updates from the portfolio company or more vigilant monitoring of the company) than non-key-investor fund families who learn of the news when it becomes public. Key-investor fund families would also learn about negative performance of the company sooner than non-key-investor fund families and thus act faster to devalue the securities they hold.

To further gauge the economic significance, we define News as an indicator variable, that is, High AEV (when there is relatively more public news about the private firm) and report the results in Models (7)–(9). In the absence of large amount of public news releases, a

13 We focus on PE holdings to capture the PE-related information production and processing. While PE holdings could be correlated with family size, unreported results confirm robustness of our findings after controlling for the (logarithm of) family's TNAs.

Table IV. Regression of private company valuations: Information costs and access

This table presents the results of the following panel regressions with security–quarter-fixed effects and the corresponding *t*-statistics with standard errors clustered by quarter:

$$\text{DumUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,s,q-1} + \beta_2 (\text{Char}_{F,s,q-1} \times \text{News}_{s,q}) + \mu_{s,q} + \varepsilon_{F,s,q},$$

where $\text{DumUpd}_{F,s,q}$ refers to an indicator variable that equals one if a fund family *F* revises its valuation of security *s* in quarter *q* and zero otherwise. $\text{Char}_{F,s,q-1}$ is a vector of family or family–security characteristics, including Ln(PE Value), defined as the logarithm of the total dollar amount of private firms in a family's portfolio; Ln(PE Number), defined as the logarithm of the total number of private firms in a family's portfolio; and %Firm Round Size, defined as the total dollar amount of each private firm in a family's portfolio, scaled by the total deal size of the corresponding funding rounds. $\text{News}_{s,q}$ refers to two proxies for news event, including Ln(AEV), defined as the logarithm of the aggregate event volume from RavenPack, which measures the count of public news releases over a rolling 91-day window; and High AEV, defined as an indicator variable that equals one if the aggregate event volume is in the top tercile across all firms and zero otherwise. $\mu_{s,q}$ are security–quarter-fixed effects. Online Appendix B provides the detailed definitions of each variable. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Ln(PE Value)	0.004			0.015***			0.028***		
	(1.30)			(3.34)			(2.83)		
Ln(PE Number)		0.002			0.034***			0.120***	
		(0.24)			(3.84)			(5.91)	
%Firm Round Size			0.035			0.228***			0.376***
			(0.52)			(2.79)			(3.25)
Ln(PE Value) × Ln(AEV)				−0.009***					
				(−3.82)					
Ln(PE Number) × Ln(AEV)					−0.026***				
					(−3.72)				
%Firm Round Size × Ln(AEV)						−0.521***			
						(−4.30)			

(continued)

Table IV. Continued

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Ln(PE Value) × High AEV							−0.014**		
							(−2.43)		
Ln(PE Number) × High AEV								−0.071***	
								(−5.83)	
%Firm Round Size × High AEV									−0.317***
									(−3.90)
Security × Quarter FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
R-squared	0.706	0.705	0.699	0.707	0.708	0.701	0.707	0.711	0.700
Obs.	3,493	3,493	2,942	3,493	3,493	2,942	3,493	3,493	2,942

one-standard-deviation increase in Ln(PE Value) (Ln(PE Number), %Firm Round Size) is related to a 12% (21%, 7%) higher likelihood to update (scaled by the sample mean of DumUpd), highlighting the information advantage of these families.[14] During periods of high public information releases (i.e., High AEV periods), the differences in the updating behavior across families decline substantially, by 50–84%, as shown in the interactions.[15] Our results suggest that information costs have a sizable impact on families' updating behavior, especially among more opaque firms.

As a robustness check, we exclude security-quarters with follow-on funding rounds to ensure that the public news releases are not entirely driven by new funding rounds. Our findings in Table IV remain unchanged (see Online Appendix Table A4). These results suggest that more effective private information production is associated with more independent timing of valuation updates, not with more frequent re-valuation overall.

5.1.a. Leaders and followers in updating

Our findings indicate that fund families with low cost function—that is, better information cost structure or access—update their valuation of private securities at different times from other families. This raises the question of whether low-cost function families take the lead in updating of prices, while other families are slower in updating and follow the prices set by the low-cost function leaders, at a lag. Our investigation of this prediction involves two sets of tests. First, we check if there is a significant co-movement in the changes in valuation of a security across families in each period, and more importantly, we ask if the valuation changes made by low-cost function families co-move less with the valuation changes reported by other families. If families with low cost function mostly rely on private information that is not available to their high-cost counterparts, we expect to see less co-movement between low-cost families and other families. Second, we examine if families adjust their valuations in a mean-reverting way. In the context of our information cost/access hypothesis, we consider the price set by low-cost families as the benchmark price and test if fund families who deviate from the benchmark price revise their prices to reduce the deviation in the subsequent quarter, that is, follow the more informed leader. We also examine if the leader–follower pattern varies across families with low versus high information costs, and conjecture that low-cost families are less likely to be a follower due to their information advantage. We conduct the tests using the following panel regression:

$$\begin{aligned} \mathrm{RET}_{F,s,q} = \alpha &+ \beta_1 \mathrm{OTHRET}_{F,s,q} + \beta_2 \mathrm{DEV}_{F,s,q-1} + \beta_3 \mathrm{Char}_{F,s,q-1} \\ &+ \beta_4 \left(\mathrm{Char}_{F,s,q-1} \times \mathrm{OTHRET}_{F,s,q}\right) + \beta_5 \left(\mathrm{Char}_{F,s,q-1} \times \mathrm{DEV}_{F,s,q-1}\right) + \mu_s + \varepsilon_{F,s,q}, \end{aligned} \tag{5}$$

where $\mathrm{RET}_{F,s,q}$ is the return of security s in quarters q based on the reported prices by family F, and $\mathrm{OTHRET}_{F,s,q}$ is the equal-weighted average returns of other families holding the same security in the same quarter. $\mathrm{Dev}_{F,s,q-1}$ refers to signed percentage price deviation from the mean price reported by low-cost families. For example, we identify fund families with above-median investment in PE (High PE Value) and calculate an average

14 We compute the economic magnitude as $0.028 \times 2.696/0.621 = 12\%$, where 0.028 is the regression coefficient in Model (7), 2.696 is the standard deviation of Ln(PE Value) (Online Appendix Table A2), and 0.621 is sample mean of DumUpd (Online Appendix Table A2).

15 For example, the difference is $|-0.014|/0.028 = 50\%$ in Model (7) and $|-0.317|/0.376 = 84\%$ in Model (9).

end-of-quarter price for a security across these fund families as a benchmark price. We then calculate the signed percentage price deviation (DEV_High PE Value) as the fund family's security valuation relative to the benchmark. In all observations, we exclude family *F*'s valuation from the calculation of the benchmark valuation if family *F* is a high-PE-value family. There are similar calculations for price deviations relative to fund families with above-median number of PE investments (Dev_High PE Number) and with above-median investment in funding rounds (Dev_High %Round Size). $Char_{F,s,q-1}$ is a vector of family or family–security characteristics, including Ln(PE Value), Ln(PE Number), and %Firm Round Size, as defined in Equation (4). Online Appendix B provides the detailed definitions of each variable. We further include security-fixed effects (μ_s) to focus on the valuation changes over time and cluster the standard errors by quarter.

We tabulate the results in Table V. Several findings are worth noting. First, we find a positive and significant β_1 coefficient across all specifications, indicating a strong contemporaneous co-movement in private security returns reported by all families.[16] Second, the β_2 coefficient is significantly negative across all specifications, suggesting that fund families follow other low-cost families in valuing the private securities. When families deviate from the benchmark price, they tend to revise their prices to converge to the benchmark price in the subsequent quarter.

Importantly, we find that the funds with low information costs or superior access report valuations that correlate less strongly with others. Specifically, in Models (2), (4), and (6), the interaction between the contemporaneous return of others (OTHRET) and measures of information costs or access (Ln(PE Value), LN(PE Number), %Firm Round Size) yield coefficient estimates (β_4) that are significantly negative. In other words, low-cost families' valuations tend to move more independently from the valuation changes of other families, and high-cost families tend to have correlated price updates, consistent with their reliance on common public information. In contrast, families with low information production costs or special access to privileged information use their private information, hence have valuation changes that are more idiosyncratic and deviate from the prices reported by others. This is consistent with our previous finding that low-cost families rely less on public news releases to update private security prices.

Finally, we find some, albeit weaker, evidence suggesting that low-cost families are less likely to be followers, as reflected in a positive β_5 coefficient when information cost/access is measured by High %Round Size (Model (6)). The two measures of information costs based on intensity of PE investment (High PE Value or Number) also yield positive point estimates but they are not statistically significant. Overall, we find that price updates reported by fund families with low information costs co-move less with updates by other families. Additionally, when fund families' own prices deviate from those of other low-cost families, they tend to revise their prices toward the benchmark, except for families who are key investors in the private firm.

5.1.b. Predictability in fund returns around financing rounds

While mutual funds are required to report to the SEC only quarterly, the funds need to mark the valuations of individual stock holdings daily in order to compute the fund's NAV.

16 If all funds update valuations in the same quarter, we would expect the coefficient on OTHRET to be 1.0 in a univariate regression of RET on OTHRET. In untabulated results from such a regression, we find the estimated coefficient of 0.828 to be reliably less than 1.0 ($t = 4.98$, $P < 0.01$), which indicates meaningful variation in updating practices across fund families.

Table V. Regression of private company returns: Leader–follower relation

This table presents the results of the following panel regressions with security-fixed effects and the corresponding *t*-statistics with standard errors clustered by quarter:

$$\text{RET}_{F,s,q} = \alpha + \beta_1\text{OTHRET}_{F,s,q} + \beta_2\text{DEV}_{F,s,q-1} + \beta_3\text{Char}_{F,s,q-1} + \beta_4(\text{Char}_{F,s,q-1} \times \text{OTHRET}_{F,s,q}) + \beta_5(\text{Char}_{F,s,q-1} \times \text{DEV}_{F,s,q-1}) + \mu_s + \varepsilon_{F,s,q},$$

where $\text{RET}_{F,s,q}$ is the return of security *s* in quarters *q* based on the reported prices by family *F*, and $\text{OTHRET}_{F,s,q}$ is the equal-weighted average returns of other families holding the same security in the same quarter. $\text{Dev}_{F,s,q-1}$ refers to three proxies for price deviation, including DEV_High PE Value, DEV_High PE Number, and DEV_High %Round Size, defined as price deviation from other high-PE-value families, high-PE number families, and high-round-size families, respectively. $\text{Char}_{F,s,q-1}$ is a vector of family or family–security characteristics, including Ln(PE Value), Ln(PE Number), and %Firm Round Size. μ_s are security-fixed effects. Online Appendix B provides the detailed definitions of each variable. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
OTHRET	0.836***	1.031***	0.841***	1.053***	0.791***	0.875***
	(25.30)	(46.02)	(25.76)	(37.07)	(15.34)	(17.59)
DEV_High PE Value	−0.162***	−0.233***				
	(−6.03)	(−3.25)				
Ln(PE Value)		0.003**				
		(2.62)				
Ln(PE Value) × OTHRET		−0.050***				
		(−5.95)				
Ln(PE Value) × DEV_High PE Value		0.014				
		(1.26)				
DEV_High PE Number			−0.162***	−0.263***		
			(−5.60)	(−3.28)		
Ln(PE Number)				0.006**		
				(2.31)		
Ln(PE Number) × OTHRET				−0.105***		

(continued)

Table V. Continued

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
				(−4.51)		
Ln(PE Number) × DEV_High PE Number				0.039		
				(1.49)		
DEV_High %Round Size					−0.114***	−0.150***
					(−4.56)	(−3.88)
%Firm Round Size						0.047
						(1.02)
%Firm Round Size × OTHRET						−1.099***
						(−4.47)
%Firm Round Size × DEV_High %Round Size						0.322*
						(1.75)
Security FE	Y	Y	Y	Y	Y	Y
R-squared	0.607	0.622	0.613	0.624	0.546	0.557
Obs.	4,765	4,765	4,614	4,614	3,133	3,133

The valuations of publicly traded stocks are based on the daily closing market prices of the securities in the fund's portfolio. However, for private security holdings, funds determine the fair value of the security based on a valuation method, which is often determined by a valuation committee for the fund family. With each new round of financing, the pricing of a private security changes, and often dramatically. For example, the purchase price per share of Airbnb Series D is $40.71 in April 2014, while the purchase price in July 2015 for a follow-on round of Airbnb Series E more than doubled to $93.09. Funds holding Airbnb Series D are expected to significantly revise the valuation of their Airbnb holdings around the Series E funding date. Since funds do not update the valuations frequently, when there are new funding rounds—typically at significantly higher prices—we expect predictable changes in funds' valuations, which in turn generates predictability in fund returns.[17]

We examine the daily abnormal fund returns around the follow-on round of financing of the private company held by the mutual funds in the family. Since our earlier analysis indicates that the valuation of private securities is done at the family level with little within-family variation in valuation, we conduct the analysis aggregated at the family level. For each round of financing for private security s, the abnormal return on fund family F on day t is defined as

$$\text{AR\_BMK}_{F,s,t} = R_{F,s,t} - R_{\text{BMK},t}, \tag{6}$$

where $R_{F,s,t}$ is the average fund return for family F on day t, computed as the equal-weighted average of fund returns for funds belonging to the family and holding early round private securities, that is, securities previously issued by the same company now issuing security s. $R_{\text{BMK},t}$ is the equal-weighted average of fund benchmark returns for the same set of funds and fund benchmark is based on the Lipper fund objectives obtained from the CRSP Mutual Fund Database. Our empirical analysis is based on the CARs for each family over the follow-on funding round event window from day a to day b, $\text{CAR\_BMK}[a,b]_{F,s}$, which is computed as

$$\text{CAR\_BMK}[a,b]_{F,s} = \left[\prod_{t=a}^{b}(1 + \text{AR\_BMK}_{F,s,t})\right] - 1. \tag{7}$$

We report the average cumulative abnormal *fund* returns, which are averaged across families and follow-on events, that is, $\text{CAR\_BMK}[a,b]$, and the standard errors are clustered by calendar days to account for cross-correlation in fund returns. For example, the 10-day cumulative abnormal fund returns after the follow-on funding round date from day 0 (the filing date of the follow-on round for private securities) to day 10 is the average CAR across all families and is represented by $\text{CAR\_BMK}[0,10]$.

As presented in Panel A of Table VI, our sample consists of 251 family–security–event observations, made up of 96 follow-on round events with an average of 3 fund families holding a security previously issued by the same company. Accounting for private companies with multiple rounds of follow-on financing, the sample comprises fifty-seven unique

17 While we use the term predictability, most investors' ability to take advantage of the predictability of fund returns will be limited because investors would need timely access to information on the timing of funding rounds, fund holdings, and security valuations. Specifically, investors need to forecast when a given private startup would likely raise its next funding round, find which mutual funds hold the firm's securities from previous rounds, and whether the valuation at which the securities are held is low relative to the new round price. Section 6.1 further examines fund flows around financing rounds.

private companies held by thirty-seven families (and 156 funds).[18] To be included in the sample, we require that each mutual fund holds a private security prior to a follow-on round of financing by its issuer and that the fund reports holding the same private security in the first quarterly report after the new round of financing. We do not require the fund to participate in the new round of financing.

Panel A of Table VI reports the cumulative abnormal fund returns over several windows around the follow-on funding event. For the windows prior to the event, between day −10 and day −1, we do not observe any significant benchmark-adjusted CARs. We obtain significant positive abnormal fund returns during the 3-day to 10-day window after the event date. For example, for the 3-day (5-day, 10-day) event window, the average CAR is economically significant at 13 bps (25 bps, 40 bps) with a *t*-stat. of 2.48 (3.41, 4.09).[19] Additionally, the impact of a new funding round of private securities on overall fund returns does not persist as the CARs are not different from zero beyond the 10-day post-event window. Results are qualitatively similar if (i) we compute abnormal fund returns by subtracting fund returns from market portfolio returns rather than returns on the benchmark portfolio and (ii) we report the results at fund–security level instead of family–security level, that is, we compute CARs for each fund–security pair and then average across all fund–security pairs. Taken together, we provide new evidence of return predictability when mutual funds invest in private securities: the valuation changes of these securities are infrequent, but lumpy and highly predictable.

5.1.c. Cross-sectional regressions of CARs

We next test the hypothesis that the predictability in a fund's return is stronger when it holds a large stake in a private company that gets a big increase in the fund family's valuation after the new funding round. We consider two measures of changes in valuations. The first measure is the percentage change in the valuation of the previously issued private security in the quarter after the new financing round relative to the family's prior valuation, that is, change from family's valuation before the new round to "family's valuation after the new round," labeled as ΔValue. The second measure is the percentage change in the deal price of the new round of financing relative to the last valuation reported by the family, that is, change from family's valuation before the new round to the "new round deal price," labeled as "Update."[20] The average value of Update is higher compared with ΔValue (42% versus 30%), which is consistent with slow updating of valuations of private securities, at least by some families, around new rounds of financing.

Following our analyses in Section 5.1.b, we examine the link between change in family valuations for early round securities and abnormal fund returns among those funds

18 The sample includes twenty-six companies with multiple follow-on rounds of financing, including Palantir (five rounds), Moderna and Vroom (four rounds each), AppNexus, Honest, Nanosys, Pinterest, Uber, and WeWork (three rounds each), and the remaining seventeen companies have two rounds each.

19 In untabulated results, when we skip the event day to estimate the abnormal fund performance over [1, 10] window, the average benchmark-adjusted CAR drops to 33 bps, indicating significant updating of private security valuations on the event day.

20 For example, suppose the new round deal price is $14, the family's valuation as of the last quarter before the new round was $10, and the family's valuation after the new round is $13. Then Update = (14–10)/10 = 40%, whereas ΔValue = (13–10)/10 = 30%.

Table VI. Mutual fund returns around follow-on financing round of PE holdings

For each round of financing for a private security s (that counts as a follow-on round), the abnormal return on family F on day t is defined as $\text{AR\_BMK}_{F,s,t} = R_{F,s,\,t} - R_{\text{BMK},t}$, where $R_{F,s,t}$ is the average fund return for family F on day t, computed as the equal-weighted average of fund returns for funds belonging to the family and holding early round private securities, that is, securities previously issued by the same company now issuing security s. $R_{\text{BMK},t}$ is the equal-weighted average of fund benchmark returns for the same set of funds. We exclude funds that do not hold the same early round private securities after the follow-on round. The CARs from day a to day b is $\text{CAR\_BMK}[a,b]_{F,s} = \left[\prod_{t=a}^{b}(1+\text{AR\_BMK}_{F,s,t})\right] - 1$ and we then average $\text{CAR\_BMK}[a,b]_{F,s}$ across families and follow-on events to obtain $\text{CAR\_BMK}[a,b]$. In particular, day 0 refers to the round date for private security s. Panel A reports the number of events, families, average number of families per event, and family-event observations, as well as the average benchmark-adjusted CARs across all family events. Standard errors are clustered by calendar days (filing date of follow-on security-round). Panel B presents the results of the following cross-sectional regressions (across families and private securities) and the corresponding t-statistics with standard errors clustered by calendar days (filing date of follow-on security-round): $\text{CAR\_BMK}[0,k]_{F,s} = \alpha + \beta(\Delta\text{Value}_{F,s} \times \text{WTPE}_{F,s}) + \varepsilon_{F,s}$, where $\text{CAR\_BMK}[0,k]_{F,s}$ refers to the benchmark-adjusted CARs of family F holding early round securities over from day 0 to day k, and k takes the value of 3, 5, or 10. $\Delta\text{Value}_{F,s}$ refers to the percentage change in the valuation by family F of the early round private security reported in the quarter after the new financing round, relative to the family's valuation in the quarter before the new round, and $\text{WTPE}_{F,s}$ refers to the investment weight of family F in the early round security according to the latest holdings, computed as the equal-weighted average of fund-level percentage investment weight, that is, the investment value of the security in the fund relative to the fund's TNA, across all funds that hold the security in the family. If a family invests in multiple early round securities, we first compute $\Delta\text{Value}_{F,s} \times \text{WTPE}_{F,s}$ for each round then sum up across all early round holdings prior to the follow-on financing round. $\Delta\text{Value}_{F,s}$ is further replaced with $\text{Update}_{F,s}$, defined as the percentage change in the deal price of the new round of financing of the private security s relative to the last valuation reported by family F. Panel C reports similar statistics of the following cross-sectional regressions: $\left|\text{CAR\_BMK}[0,k]_{F,s}\right| = \alpha + \beta_1 \text{Char}_{F,s} + \varepsilon_{F,s}$, where $\left|\text{CAR\_BMK}[0,k]_{F,s}\right|$ is the absolute value of $\text{CAR\_BMK}[0,k]_{F,s}$ and $\text{Char}_{F,s,q}$ is a vector of family or family–security characteristics, including Ln(PE Value), Ln(PE Number), and %Firm Round Size. We further exclude family–security observations with security weights ($\text{WTPE}_{F,s}$) below 0.1%. Online Appendix B provides the detailed definitions of each variable. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

Panel A: Benchmark-adjusted CAR on funds around follow-on round

Number of event	Number of family	Families per event	Family-event obs.	CAR							
				[−10, −1]	[−5, −1]	[−3, −1]	[0, 3]	[0, 5]	[0, 10]	[11, 15]	[16, 20]
96	37	3	251	0.116	−0.002	−0.031	0.134**	0.254***	0.398***	0.034	0.034
				(1.36)	(−0.02)	(−0.49)	(2.48)	(3.41)	(4.09)	(0.54)	(0.58)

Table VI. Continued

	[0, 3]		[0, 5]		[0, 10]	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel B: Benchmark-adjusted CAR on funds after follow-on round regressed on change in valuation and fund holding						
ΔValue × WTPE	0.395**		0.755***		1.395***	
	(2.32)		(2.84)		(4.50)	
Update × WTPE		0.288*		0.582**		1.153***
		(1.77)		(2.30)		(3.39)
Constant	0.107*	0.106*	0.203***	0.198**	0.303***	0.287***
	(1.92)	(1.83)	(2.69)	(2.48)	(3.06)	(2.76)
R-squared	0.019	0.012	0.043	0.029	0.090	0.071
Obs.	251	251	251	251	251	251

Panel C: Absolute benchmark-adjusted CAR on funds after follow-on round regressed on family and family–security characteristics

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Ln(PE Value)	−0.017*			−0.028**			−0.028**		
	(−1.92)			(−2.41)			(−2.12)		
Ln(PE Number)		−0.074**			−0.103***			−0.117***	
		(−2.48)			(−2.96)			(−3.83)	
%Firm Round Size			−0.246**			−0.222			−0.630***
			(−2.39)			(−1.37)			(−2.71)
Constant	0.482***	0.565***	0.432***	0.699***	0.796***	0.598***	0.891***	1.017***	0.832***
	(7.28)	(6.23)	(9.13)	(7.51)	(6.68)	(7.41)	(7.23)	(7.76)	(7.39)
R-squared	0.010	0.042	0.010	0.014	0.042	0.004	0.010	0.036	0.022
Obs.	179	179	179	179	179	179	179	179	179

belonging to family F and holding early round securities over k days following the new funding date, that is, $\text{CAR\_BMK}[0,k]_{F,s}$. We estimate the following cross-sectional regression:

$$\text{CAR\_BMK}[0,k]_{F,s} = \alpha + \beta(\Delta\text{Value}_{F,s} \times \text{WTPE}_{F,s}) + \varepsilon_{F,s}, \quad (8)$$

where $\text{WTPE}_{F,s}$ is the equal-weighted average of fund-level percentage investment weight of early round security (computed as the investment value of the security in the fund relative to the fund's TNA) across all funds that hold the security in the family. Since the exact weight of the private security in the fund's portfolio on the day of the new round is not available, we rely on the latest holdings of the security reported prior to the financing round. Mutual funds, on average, hold 0.3% of their assets in the individual private securities we study, although this weight varies significantly from 0.05% (10th percentile) to 0.74% (90th percentile) indicating substantial investment in private securities by some funds.[21]

Under the hypothesis that the abnormal fund-level performance is related to the changes in family's valuation of private securities, we expect a positive β coefficient. Moreover, if we have accurate estimates of the private security weight and the change in valuation of the private security, the β coefficient should equal one. For example, a fund that allocates 1% of portfolio weight to Airbnb Series D and increases the valuation of the security by 50% should experience an abnormal return of 0.5%.

The estimate of the above regression model is presented in Panel B of Table VI. The results are similar when change in valuation is measured by ΔValue × WTPE (Models (1), (3), and (5)) or Update×WTPE (Models (2), (4), and (6)). Consistent with our expectations, we find a strong positive relation between fund performance and the changes in the valuation of the private security. For example, using the 5-day event window, the cross-sectional variation in the abnormal returns corresponds to 58–76% of the change in private security valuations, indicated by the β estimates in Models (3) and (4).

As shown in Table IV, the valuation practice is related to family characteristics depicting information costs and access to information. Intuitively, if mutual fund families have adjusted their valuations prior to the new funding round based on privileged information, there is less room to update at the follow-on round and we expect to observe lower absolute CARs. Since the abnormal performance is mechanically related to private security weight, we focus on funds that have sufficiently large investments in the private security related to the funding round to leave a footprint in fund returns. Specifically, we estimate the following cross-sectional regression:

$$\left|\text{CAR\_BMK}[0,k]_{F,s}\right| = \alpha + \beta_1 \text{Char}_{F,s} + \varepsilon_{F,s}, \quad (9)$$

where $\left|\text{CAR\_BMK}[0,k]_{F,s}\right|$ is the absolute value of $\text{CAR\_BMK}[0,k]_{F,s}$, defined as in Equation (8). $\text{Char}_{F,s,q}$ refers to Ln(PE Value), Ln(PE Number), and %Firm Round Size, defined as in Equation (4). We exclude family–security observations with security weights ($\text{WTPE}_{F,s}$ in Equation (8)) below 0.1% (approximately 30% of the sample).

The results are tabulated in Panel C of Table VI. We find strong evidence that families with larger investments in private firms and holding a larger percentage in a funding round

21 Note that $\text{WTPE}_{F,s}$ measures the investment weight on each security and does not reflect the total PE holdings in fund portfolios, because mutual funds can invest in multiple private securities.

display significantly lower absolute abnormal returns in nearly all event windows after the new funding round, consistent with their low information production costs, better access to information, and independent updating behavior using private information. These results suggest that fund families with better information cost structure and with privileged access to information update prices prior to the new round of financing, resulting in less return predictability around follow-on rounds.[22]

In summary, our findings indicate that mutual fund valuation of private securities is frequently stale and this leads to large price changes and fund return predictability around key corporate events such as follow-on rounds. Valuation practice is not uniform across fund families and families with better information cost structure and/or stronger information access display more frequent updating in the absence of public news releases and less return predictability around follow-on rounds. Overall, the results in Tables IV–VI build a compelling case in support of information cost/access as a driver of the fund families' valuation practice for private securities.

5.2 Litigation Risk

In addition to the costs of information production and access, litigation risk could also be a concern for mutual fund families when valuing private securities (see Houge and Wellman, 2005, for a list of mutual fund companies implicated in the market timing and late trading scandal due to stale valuation). Mutual fund managers are fiduciaries of the funds they manage and the fund shareholders and should employ fair value pricing. Redemption rights of fund shareholders further sharpen the potential harm of improper valuation: if private securities in the fund portfolio are overvalued then those redeeming fund shares will be overpaid and those buying fund shares are overcharged, leading to a wealth transfer. As a result, fund families could be exposed to litigation risk for having private firm valuations that depart from the "true" values.

On the one hand, families with higher litigation risk are more likely to update valuations per fair value accounting standards. Specifically, larger families and families with better internal monitoring are likely to be more concerned with the litigation risk (because they have greater reputation capital at stake and deeper pockets) and/or have greater capacity to mitigate this risk (through good governance). In addition, litigation risk varies over time and could spike following times of negative events, because stale and inflated valuations could lead to runs on the funds and significant wealth transfers. Therefore, we conjecture that families with greater litigation risk are more likely to lower their valuations during periods of adverse events.

On the other hand, the litigation risk may not be a primary concern for the following reasons. First, under the current securities laws and accounting rules, it may be difficult for courts to distinguish between inflation and optimism for venture-stage firm valuation. Second, our sample period covers a long bull market with no major crashes in public or private startup funding markets; hence, the litigation risk from inflated valuations could be small.

22 As robustness checks, we consider (1) an alternative cutoff for security weight of 0.15% (approximately the sample median) and (2) a subsample excluding family–security observations with $|\Delta\text{Deal} \times \text{WTPE}|$ below 0.05%, based on the 0.1% cutoff for WTPE used in Table VI, Panel C and an average ΔDeal of approximately 50%. Our main results (not tabulated) remain unchanged.

To test the litigation risk hypothesis, we estimate the following panel regression:

$$\text{SignUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,q-1} + \beta_2 \left(\text{Char}_{F,q-1} \times \text{CSS}_{s,q}\right) + \mu_{s,q} + \varepsilon_{F,s,q}, \tag{10}$$

where $\text{SignUpd}_{F,s,q}$ takes a value of 1 if a fund family F increases its valuation of security s in quarter q, –1 if a fund family reduces its valuation of a security, and 0 otherwise. $\text{Char}_{F,q-1}$ is a vector of family characteristics that proxy for the awareness of the litigation risk and/or capacity to mitigate the risk, including (1) Ln(Family TNA), defined as the logarithm of the family's TNA and (2) Monitoring, defined as the composite monitoring score, computed as the first principal component of director ownership, board size, and board independence.[23] $\text{CSS}_{s,q}$ is the composite sentiment score from RavenPack database and proxies for the negative news at the firm level. We further consider adverse events at the market level and replace $\text{CSS}_{s,q}$ with NegVC_{q-1}, defined as an indicator variable that equals one if the Cambridge Associates VC index return is negative in quarter –1 and zero otherwise. We employ contemporaneous news sentiment but lagged VC index return because the latter cannot be observed in real time. Online Appendix B provides the detailed definitions of each variable. The panel regressions include security-quarter-fixed effects ($\mu_{s,q}$) and we cluster the standard errors by quarter.

We report the results in Panel A of Table VII. First, the family size and governance variables yield insignificant coefficient estimates (β_1) across all specifications, suggesting that, in general, families with larger assets under management or better governance practice do not adjust their valuations differently from other families. Second, we do not observe different valuation practices across families following adverse events at both the firm level and market level, such as bad news about the firm (Models (1) and (2) that use CSS) and negative VC market returns (Models (3) and (4) that use NegVC).

Note that the effect on valuation increase and decrease could be asymmetric and our working hypothesis focuses on the downward revisions. We replace $\text{SignUpd}_{F,s,q}$ in Equation (10) with $\text{NegUpd}_{F,s,q}$, defined as an indicator variable that equals one if a fund family reduces its valuation of a security and zero otherwise. We tabulate the results in Panel B of Table VII. Again, we find that families with greater litigation risk are not more likely to mark down their private securities in response to adverse events.[24] Thus, litigation risk does not appear to be a strong determinant of the family valuation practice.

5.3 Strategic Valuation of Private Securities

Finally, we turn to the strategic behavior of mutual fund managers as an explanation of differences in valuation practices. On the one hand, the absence of daily market prices, illiquidity, and the resulting stale prices of private securities provide mutual fund families

23 Prior work documents that directors with more ownership in their funds (e.g., Chen, Goldstein, and Jiang, 2008; Cremers *et al.*, 2009) and independent board members (Yermack, 2004; Khorana, Tufano, and Wedge, 2007) are likely to provide better monitoring. In addition, Coles, Daniel, and Naveen (2008) show that large boards are associated with higher firm value for complex firms with greater advising requirements.

24 In addition, we examine how litigation risk affects the valuation updates in the absence of follow-on funding rounds. Specifically, we employ similar regression specifications as in Table IV and further include the two proxies for the litigation risk. In untabulated results, we do not find evidence indicating that litigation risk leads to less frequent re-valuation in the absence of follow-on funding rounds.

Table VII. Regression of private company valuations: Litigation risk

In Panel A, Models (1) and (2) present the results of the following panel regressions with security–quarter-fixed effects and the corresponding *t*-statistics with standard errors clustered by quarter:

$$\text{SignUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,q-1} + \beta_2 (\text{Char}_{F,q-1} \times \text{CSS}_{s,q}) + \mu_{s,q} + \varepsilon_{F,s,q},$$

where $\text{SignUpd}_{F,s,q}$ takes a value of 1 if a fund family *F* increases its valuation of security *s* in quarter *q*, -1 if a fund family reduces its valuation of a security, and 0 otherwise. $\text{Char}_{F,q-1}$ is a vector of family characteristics, including Ln(Family TNA), defined as the logarithm of the family's TNA; and Monitoring, defined as the composite monitoring score. $\text{CSS}_{s,q}$ is the composite sentiment score from RavenPack. Models (3) and (4) report similar statistics when we replace $\text{CSS}_{s,q}$ with NegVC_{q-1}, defined as an indicator variable that equals one if the Cambridge Associates VC index return is negative in the previous quarter and zero otherwise. Panel B reports similar statistics when we replace the dependent variable with $\text{NegUpd}_{F,s,q}$, defined as an indicator variable that equals one if a fund family reduces its valuation of a security and zero otherwise. $\mu_{s,q}$ are security–quarter-fixed effects. Online Appendix B provides the detailed definitions of each variable. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

	Model 1	Model 2	Model 3	Model 4
Panel A: Signed valuation change of private companies (SignUpd)				
Ln(Family TNA)	−0.540		0.004	
	(−0.67)		(0.57)	
Monitoring		1.819		−0.005
		(0.88)		(−0.21)
Ln(Family TNA) × CSS	1.057			
	(0.66)			
Monitoring × CSS		−3.539		
		(−0.87)		
Ln(Family TNA) × NegVC			0.012	
			(0.59)	
Monitoring × NegVC				0.021
				(0.25)
Security × Quarter FE	Y	Y	Y	Y
R-squared	0.681	0.663	0.660	0.630
Obs.	3,493	2,202	4,440	2,960
Panel B: Valuation decrease of private companies (NegUpd)				
Ln(Family TNA)	0.383		0.005	
	(0.91)		(1.07)	
Monitoring		0.966		0.021
		(0.97)		(1.58)
Ln(Family TNA) × CSS	−0.740			
	(−0.90)			
Monitoring × CSS		−1.891		
		(−0.96)		
Ln(Family TNA) × NegVC			−0.005	
			(−0.47)	
Monitoring × NegVC				−0.016
				(−0.35)
Security × Quarter FE	Y	Y	Y	Y
R-squared	0.695	0.685	0.664	0.637
Obs.	3,493	2,202	4,440	2,960

with wider reporting discretion than with their public security holdings. As a result, fund families may exploit this discretion to improve periodic fund returns and maximize family-level fee revenues. On the other hand, implementing strategic valuation may not be easy at the fund family level because the same private security could be held by different funds with opposing strategic incentives. In addition, the potential litigation risk due to mispricing could further mitigate the strategic incentives. Therefore, whether such strategic behavior prevails in the valuation of private securities remains an empirical question.

First, fund families with interim performance near the top of the league table might strategically mark securities up toward the end of the year to boost the yearly returns ("leaning for the tape"), because they are expected to gain the most from doing so given the convexity in the fund flow–performance relation, that is, the top-performing funds disproportionally attract more inflows than the mediocre or poor performers (Sirri and Tufano, 1998).[25] To test the "leaning for the tape" behavior, we estimate the following panel regression:

$$\text{SignUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,s,q-1} + \beta_2 \text{Char}_{F,s,q-1} \times \text{YEND}_q + \mu_{s,q} + \lambda_{F,q} + \varepsilon_{F,s,q}, \tag{11}$$

where $\text{SignUpd}_{F,s,q}$ is defined as in Equation (10) and $\text{Char}_{F,s,q-1}$ is a vector of family–security characteristics, including Top (Bottom), defined as an indicator variable that equals one if the security is held by at least one top-ranked (bottom-ranked) fund in a family and zero otherwise; and %Top TNA (%Bottom TNA), defined as the fund TNA-weighted average of Top (Bottom) across all funds holding the security in a family.[26] A top-ranked (bottom-ranked) fund is a fund that belongs in the top (bottom) quintile across all funds based on cumulative benchmark-adjusted returns in the previous three quarters, following Sirri and Tufano (1998). YEND_q is an indicator variable that equals one if quarter q is the fourth quarter of a calendar year and zero otherwise. Online Appendix B provides the detailed definitions of each variable. The panel regressions include security-quarter ($\mu_{s,q}$) and family-quarter ($\lambda_{F,q}$) fixed effects and we cluster the standard errors by quarter.

We report the results in Models (1)–(4) of Table VIII. First, fund families are not more likely to increase the valuation of the private securities held by their top-performing funds at the year-end than other securities, as reflected in the insignificant Top×YEND and %Top TNA×YEND coefficients. Second, we find some weak evidence that families with poorly performing funds mark down the corresponding private security holdings in the fourth quarter compared with other families (Model (2)), suggesting that they shift the performance to the next year.

In addition, fund families might strategically value illiquid securities to smooth returns over the course of the year ("return smoothing"). Return smoothing makes the fund appear less risky and hence improves its risk-adjusted performance such as Sharpe ratio. For instance, Cici, Gibson, and Merrick (2011) find that bond funds mark illiquid securities in a pattern that is consistent with strategic return smoothing. To test the "return smoothing" behavior, we estimate the following panel regression:

$$\text{SignUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,s,q-1} + \mu_{s,q} + \lambda_{F,q} + \varepsilon_{F,s,q}, \tag{12}$$

where $\text{SignUpd}_{F,s,q}$ is defined as in Equation (10) and $\text{Char}_{F,s,q-1}$ is a vector of family–

25 An extensive literature documents that mutual funds and hedge funds strategically mark securities toward the end of the year, for example, Carhart *et al.* (2002); Agarwal, Daniel, and Naik (2011); Ben-David *et al.* (2013); Hu *et al.* (2014); and Cici, Kempf, and Puetz (2016).

26 We consider TNA-weighted performance because fund families' incentives are more aligned with large funds that generate more fee revenues.

Table VIII. Regression of private company valuations: Strategic behavior

This table presents the results of the following panel regressions with security–quarter- and family–quarter-fixed effects and the corresponding *t*-statistics with standard errors clustered by quarter:

$$\text{SignUpd}_{F,s,q} = \alpha + \beta_1 \text{Char}_{F,s,q-1} + \beta_2(\text{Char}_{F,s,q-1} \times \text{YEND}_q) + \mu_{s,q} + \lambda_{F,q} + \varepsilon_{F,s,q},$$

where $\text{SignUpd}_{F,s,q}$ takes a value of 1 if a fund family *F* increases its valuation of security *s* in quarter *q*, -1 if a fund family reduces its valuation of a security, and 0 otherwise. $\text{Char}_{F,s,q-1}$ is a vector of family–security characteristics, including Top (Bottom), defined as an indicator variable that equals one if the security is held by at least one top-ranked (bottom-ranked) fund in a family and zero otherwise; High Positive (Low Negative), defined as an indicator variable that equals one if the security is held by at least one high-positive-return (low-negative-return) fund in a family and zero otherwise; and %Top TNA (%Bottom TNA, %High Positive TNA, %Low Negative TNA), defined as the fund TNA-weighted average of Top (Bottom, High Positive, Low Negative) across all funds holding the security in a family. YEND_q is an indicator variable that equals one if quarter *q* is the fourth quarter of a calendar year and zero otherwise. $\mu_{s,q}$ and $\lambda_{F,q}$ are security–quarter and family–quarter-fixed effects, respectively. Online Appendix B provides the detailed definitions of each variable. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Top × YEND	−0.020	−0.018				
	(−0.19)	(−0.16)				
Bottom × YEND		−0.151*				
		(−1.72)				
Top	−0.019	−0.019				
	(−0.28)	(−0.28)				
Bottom		0.087				
		(1.49)				
%Top TNA × YEND			−0.356	−0.359		
			(−1.66)	(−1.64)		
%Bottom TNA × YEND				−0.024		
				(−0.21)		
%Top TNA			0.077	0.079		
			(0.91)	(0.93)		
%Bottom TNA				0.024		
				(0.45)		
High Positive					0.026	
					(0.50)	
Low Negative					0.025	
					(0.46)	
%High Positive TNA						0.059
						(0.99)
%Low Negative TNA						0.107
						(1.44)
Security × Quarter FE	Y	Y	Y	Y	Y	Y
Family × Quarter FE	Y	Y	Y	Y	Y	Y
R-squared	0.763	0.764	0.764	0.764	0.763	0.763
Obs.	4,580	4,580	4,580	4,580	4,547	4,547

security characteristics, including High Positive (Low Negative), defined as an indicator variable that equals one if the security is held by at least one high-positive-return (low-negative-return) fund in a family and zero otherwise; and %High Positive TNA (%Low Negative TNA), defined as the fund TNA-weighted average of High Positive (Low Negative) across all funds holding the security in a family. A high-positive-return (low-negative-return) fund is ranked in the top tercile across funds with positive (negative) cumulative benchmark-adjusted returns in the previous 12 months, following Cici, Gibson, and Merrick (2011). Online Appendix B provides the detailed definitions of each variable. We further include security-quarter ($\mu_{s,q}$) and family-quarter ($\lambda_{F,q}$) fixed effects and cluster the standard errors by quarter.

We report the results in Models (5) and (6) of Table VIII. Fund families with more positive (negative) performance in the last 12 months are not more likely to decrease (increase) the valuation of private securities. Overall, we do not find evidence indicating strategic updating practices by mutual fund families in the form of either boosting fund returns at the year-end or smoothing fund returns over the course of the year.

6. Implications of Private Security Valuation for Fund Investors

In this section, we turn to our second question: Does exposure to private investments make fund flows more sensitive to either positive or negative (anticipated) fund returns due to presence of illiquid assets and stale prices in the portfolio? We proceed in two parts. First, we investigate if positive return predictability of funds holding private securities around follow-on funding rounds is associated with abnormal fund inflows. Second, we examine if mutual funds holding private securities are more vulnerable than traditional mutual funds to investor runs and financial fragility during periods of downturns in the PE market because of correlated redemptions by fund investors.

6.1 Fund Flows around Financing Rounds

If stale pricing and sizable markups lead to predictably large abnormal positive fund returns around follow-on round events, do investors in mutual funds exploit this by purchasing (selling) funds before (after) the follow-on rounds? We address this question by examining the net fund flows around follow-on round events.

If investors have sufficient information about upcoming follow-on round events and the holdings of private securities by mutual funds, they might capitalize on this information by buying the mutual funds with large stakes in private companies ahead of the follow-on round dates and selling them after the events. If this behavior is common, we would expect abnormally high inflows in days leading up to the follow-on round dates and high outflows in the days after the follow-on rounds. Conversely, if investors are aware of any upcoming public release of negative information by the company, they might sell the mutual funds with stakes in the private company ahead of such events and buy them after the events. While this latter scenario is worth investigating, during the sample period most of the private companies in the sample experienced markups in follow-on rounds.[27] So we are interested in whether mutual funds attract inflows before follow-on rounds (i.e., positive information events) in this subsection. In contrast, in the next subsection, we examine the

27 Among the ninety-six follow-on rounds in our sample, seventy-nine are up rounds, eleven are flat rounds, and six are down rounds.

impact of poor performance in the overall VC market on flow–performance sensitivity of funds holding private securities.

We use a subset of funds covered by Trimtabs that provides the daily flow data[28] and measure abnormal fund flows around follow-on round dates using two distinct measures. For each round of financing for a private security s, our first measure, the benchmark-adjusted abnormal flow of fund f on day t is defined as:

$$AF\_BMK_{f,s,t} = Flow_{f,s,t} - Flow_{BMK,t}, \tag{13}$$

where $Flow_{f,s,t}$ is the percentage flow of fund f on day t, computed as the ratio of dollar flow to prior day's TNA. We require fund f to hold early round private securities, that is, securities previously issued by the same company now issuing security s, both before and after the follow-on round. $Flow_{BMK,t}$ is the lagged TNA-weighted average flow across funds in the fund's benchmark category on day t. Our second measure is the z-score for fund f on day t, defined as

$$Z_{f,s,t} = \frac{Flow_{f,s,t} - \overline{Flow}_f}{\sigma_f}, \tag{14}$$

where $Flow_{f,s,t}$ is defined as in Equation (13), $\overline{Flow}_f$ and σ_f refer to the average daily flow, and standard deviation of daily flow of fund f during the [t–180, t–31] window, respectively. Thus, the first measure captures contemporaneous deviation of fund f's flows from that of its cohorts, whereas the second measure captures deviation of fund f's flows from its own historical average flows.

In Table IX, we report the benchmark-adjusted flows in Panel A and the z-score in Panel B for the whole sample. We do not find statistically significant fund flows around the follow-on round dates, perhaps because investors are not yet aware of such trading opportunities and/or do not possess necessary information to time their mutual fund investments (e.g., timely information on funds' positions in private securities and valuations of those securities, and the timing and expected outcome of new funding rounds). It is also possible that gains from trading on stale pricing may not be large enough due to the relatively small holdings of private securities in mutual funds' portfolios.[29]

While the positive abnormal returns after the funding rounds provide opportunities for fund investors to time their trades, perhaps mutual funds impose redemption fees to

28 Other papers that use the Trimtabs data include Chalmers, Edelen, and Kadlec (2001); Edelen and Warner (2001); Greene and Hodges (2002); Rakowski (2010); Kaniel and Parham (2017); and Agarwal, Jiang, and Wen (2022). For robustness, we repeat our analysis using monthly flows and do not find evidence of significant abnormal flows in the months surrounding a follow-on offering, though monthly flows may not be sufficiently granular to detect unusual activities. Daily flows more precisely identify abnormal investor response in the days around follow-on round dates, which is not feasible with monthly flows.

29 Of the 156 funds that invest in private securities with follow-on funding rounds, 60 are covered by Trimtabs. The Trimtabs-covered funds have higher investment weight in private securities (0.40% for Trimtabs-covered funds versus 0.27% for non-covered funds) and display higher 10-day benchmark-adjusted CARs after the funding round event date (0.54% for covered funds versus 0.30% for non-covered funds). Since the subset of funds in Trimtabs have bigger markups following the funding rounds, our findings suggest that investors do not time their investments around these funding events in general.

Table IX. Mutual fund flows around follow-on financing round of PE holdings

In Panel A, for each round of financing for a private security s (that counts as a follow-on round), the abnormal flow of fund f on day t is defined as $\text{AF\_BMK}_{f,s,t} = \text{Flow}_{f,s,t} - \text{Flow}_{\text{BMK},t}$, where $\text{Flow}_{f,s,t}$ is the percentage flow of fund f on day t, computed as the ratio of dollar flow to prior day's TNA. We require fund f to hold early round private securities, that is, securities previously issued by the same company now issuing security s, both before and after the follow-on round. $\text{Flow}_{\text{BMK},t}$ is the lagged TNA-weighted average flow across funds in the fund's benchmark category on day t. In Panel B, the z-score for fund f on day t is defined as $Z_{f,s,t} = (\text{Flow}_{f,s,t} - \overline{\text{Flow}}_f)/\sigma_f$, where $\text{Flow}_{f,s,t}$ is defined as above, $\overline{\text{Flow}}_f$ and σ_f refer to the average daily flow and standard deviation of daily flow of fund f during the $[t-180, t-31]$ window, respectively. Denoting the round date for private security s as day 0, we first compute the average abnormal flows (or z-score) over a k-day window for each fund, then average across fund-event pairs. Standard errors are clustered by calendar days (filing date of follow-on security-round). The number of events, funds, average number of funds per event, and fund-event observations are reported. Panels C and D report similar statistics on benchmark-adjusted flow and z-score when we only include funds that do not charge redemption fees at the time of the follow-on round.

Number of events	Number of fund	Funds per event	Fund-event obs.	[−30, −1]	[−20, −1]	[−10, −1]	[−5, −1]	[−3, −1]	[0, 3]	[0, 5]	[0, 10]	[0, 20]	[0, 30]
Panel A: Benchmark-adjusted fund flow around follow-on round													
48	60	4	203	−0.010	−0.010	−0.012	−0.013	−0.016	−0.017	−0.011	0.002	−0.001	−0.010
				(−0.86)	(−0.76)	(−0.88)	(−0.63)	(−0.80)	(−1.17)	(−0.80)	(0.06)	(−0.09)	(−0.89)
Panel B: z-score on fund flow around follow-on round													
48	60	4	203	0.024	0.016	0.005	−0.010	−0.012	0.019	0.003	−0.169	−0.091	−0.087
				(0.73)	(0.37)	(0.09)	(−0.14)	(−0.15)	(0.35)	(0.06)	(−1.02)	(−0.96)	(−1.09)
Panel C: Benchmark-adjusted fund flow around follow-on round (funds without redemption fee)													
37	42	4	140	0.001	0.001	0.001	0.017	0.011	0.001	0.006	0.023	0.010	−0.001
				(0.17)	(0.11)	(0.14)	(1.15)	(0.79)	(0.05)	(0.40)	(0.65)	(0.53)	(−0.07)
Panel D: z-score on fund flow around follow-on round (funds without redemption fee)													
37	42	4	140	0.040	0.026	0.018	0.080	0.103	0.073	0.023	−0.171	−0.109	−0.111
				(0.98)	(0.56)	(0.31)	(1.19)	(1.37)	(1.15)	(0.41)	(−0.75)	(−0.86)	(−1.03)

discourage opportunistic short-term trading (Greene, Hodges, and Rakowski, 2007). This does not seem to be the case. Redemption fees in mutual funds that hold private securities are rare; only eighteen of the sixty funds in the sample have redemption fees (based on data collected from funds' N-SAR filings and prospectuses). Funds can also discourage timing by investors either by explicitly forbidding or imposing sanctions against such practices.

For the funds with redemption fees, the fees charged exceed the abnormal mean CARs that we observe. So, we exclude these funds and repeat our analysis in Panels C and D of Table IX. Untabulated results suggest that the post-funding round 10-day (5-day) CAR_BMK for funds with no redemption fee is economically large and statistically significant at 51 bps (34 bps). However, we do not find evidence showing that investors time their investments around the follow-on rounds. Our findings remain unchanged if we conduct similar analysis at family-event level (untabulated for brevity).

Despite little evidence of timing by fund investors around financing rounds, we estimate wealth transfer between incoming investors (buyers) and investors redeeming from the funds (sellers). Since most of the CARs after follow-on rounds are positive, sellers of the mutual funds right before the follow-on rounds experience a wealth loss, whereas both existing investors and new buyers experience a wealth gain. We measure the loss to sellers as the cumulative dollar outflows in the 30-day period before the follow-on rounds, multiplied by the 10-day CAR after the follow-on rounds.[30] We estimate the average fund-level loss to sellers before the follow-on round to be \$0.25 million and the loss increases to \$2.5 million at the 90th percentile. Note that, while similar wealth transfer mechanisms have been studied in other contexts such as stale valuation of funds investing in international stocks, the situation surrounding private holdings is distinct because mutual fund managers can neither buy more of (nor dispose) the private securities as a response to the fund inflow (outflow). If there is a net inflow (outflow) before the follow-on round, this dilutes (inflates) the gain of the existing investors. Thus, the intensity of buying (inflow) before the follow-on rounds determines the breakdown of the wealth gain between existing investors and new buyers in a way that diverges from the previously studied mechanism (see, e.g., Greene and Hodges, 2002).[31]

In sum, with the small sample we are able to analyze, we do not find compelling evidence of opportunistic trading by investors and perhaps as a consequence, few of the funds holding PE have redemption fees. One possible reason is that "the opportunity would be difficult to exploit because it would be hard for investors to gauge the extent of the mispricing and estimate the time frame for correction" (Schwartz, 2017). Indeed, our earlier results show that mispricing is curtailed for families with better information cost/access and thus investors have less to gain from opportunistic trading of this kind. It is also possible that, as

30 One caveat is that we only observe daily net flow from Trimtabs. Therefore, we use the monthly redemption amount from funds' N-SAR filings. We compute the daily dollar outflows as the redemption amount in a month divided by the number of days in the month. Cumulative dollar outflows are obtained by summing up the daily dollar outflows over the [t–30, t–1] window prior to the follow-on round. Wealth transfer is estimated as the cumulative dollar outflows multiplied by the 10-day CAR after the follow-on rounds. Finally, we compute the wealth transfer for each fund at the time of a new funding round, then average across all fund–security observations to obtain the sample mean.

31 Note that we only consider the outflows from existing investors as a wealth transfer, as the effect of dilution is likely to be small.

the size of PE markets is expected to keep growing, mutual funds will hold a higher proportion of their portfolios in private securities in the future. Investors' behavior might change as the relative weights of PE securities in mutual fund portfolios rise, the potential gains from these trades increase, and the information required to execute these trades become more accessible over time (e.g., via entry of third-party data aggregators).

6.2 Financial Fragility and PE Investment

In addition to wealth transfer between incoming and outgoing investors in funds holding private securities, another welfare consequence can be related to the potential run risk associated with such funds. As mentioned earlier, there are a couple of examples of fragility in open-end mutual funds that had substantial investments in private securities. The US-based mutual fund, Firsthand Technology Value Fund, that invested in private securities was forced to convert to a closed-end fund in April 2011 after a large reduction in its NAV.[32] More recently, in the summer of 2019, the multi-billion pound UK mutual fund LF Woodford Equity Income Fund had to suspend withdrawals as continued poor performance of its public stock holdings and outflows left the fund holding a large proportion of its portfolio in illiquid, early-stage private securities. Woodford fund flows turned negative in 2017 following a period of bad performance, but the fragility of the liquidity mismatch did not become apparent until 2019. The fund was forced to unwind the private securities at as deep as 43% discount of the pre-suspension valuation. Thus, it was indeed forced to make costly and unprofitable trades and hurt the investors whose assets were frozen, but after a prolonged period of outflows.[33]

Motivated by these examples, we examine if mutual funds holding private securities are more vulnerable than traditional mutual funds to investor runs and financial fragility during periods of downturns in the PE market because of correlated redemptions by fund investors. In our setting, strategic complementarities among investors can arise as follows. Private security valuation is updated slowly (due to high cost of information collection and processing) and this staleness creates an opportunity for mutual fund investors to "get out" by selling their fund shares before the securities are marked down by funds and avoid the loss. Investors also have an opportunity to "jump in" by buying the fund shares before private securities are marked up and pocket the gain, for example, before the follow-on rounds, though we posit and verify that there is an asymmetry in that investors are more eager to avoid the loss than to capture the gain. When the fund's previous-period return is negative and the overall VC market previous-period return is negative—both of which are public information—the prospect of further loss from markdowns of private securities becomes salient to the fund investors. As investors exit the fund following the downturn and managers need to sell relatively liquid public securities, the private securities become a bigger proportion of the fund's portfolio, which amplifies the investor concern for illiquidity and future losses. Therefore, we conjecture that this combination of events could lead to higher flow–performance sensitivity in funds holding private securities.[34]

32 https://firsthandfunds.com/index.php?fuseaction=funds.tvfqx.

33 See Walker and Smith (2019), "Neil Woodford: The inside story of his rise and dramatic fall", *The Financial Times*.

34 See Chen, Goldstein, and Jiang (2010), for example, for other mechanisms of strategic complementarities arising in mutual fund setting.

To account for potential heterogeneity between fund families that invest in private securities and those that do not, we focus here on funds *within* mutual fund families that invest in private securities. Specifically, we compare the flow–performance sensitivity among funds affiliated with families that have access to private security investment but differing in their holdings of private securities. To further allay any endogeneity concerns regarding the specific types of funds that choose to hold private securities, we entropy–balance match the PE mutual funds (i.e., mutual funds with PE investment) with non-PE mutual funds on observable fund and family characteristics each year, including fund liquidity (Illiq), defined as an indicator variable that equals one if a fund is in small-cap or mid-cap style and zero otherwise; fund flow (Flow); benchmark-adjusted fund return (RETBMK); the logarithm of fund TNA (Ln(Fund TNA)); the logarithm of the number of months since fund inception (Ln(Fund Age)); the annualized fund expense ratio (Expense Ratio); the annualized fund turnover ratio (Turnover); the standard deviation of monthly fund returns in a quarter (RETVOL); and the logarithm of family TNA (Ln(Family TNA)). The entropy balancing is a preprocessing method where the covariate distribution of the control group (the non-PE fund sample) is reweighted using a pre-specified set of sample moments (see Hainmueller, 2012 and Hainmueller and Xu, 2013 for detailed discussion of the matching method and its advantages). This approach allows us to reweight the control units to ensure that differences between the PE and non-PE sample in these fund and family characteristics do not drive our results. In this regard, it is especially important that our results are not spuriously produced by the higher illiquidity of the public portion of the fund portfolios, as in the Chen, Goldstein, and Jiang's (2010) mechanism. For example, fund managers that invest heavily in private startup securities may hold overall riskier portfolios that invest in less proven, emerging technology stocks. Therefore, we use the illiquidity proxy used by Chen, Goldstein, and Jiang (2010), that is, a fund is considered as illiquid if its investment style is in small-cap or mid-cap equities, as one of the matching variables in our entropy–balance matching procedure. We report the matching results in Online Appendix Table A5 and confirm that PE funds and matched non-PE funds display identical fund and family characteristics that are used for matching.

We estimate the following panel regression using a *matched* sample of PE and non-PE mutual funds:

$$\begin{aligned}\text{Flow}_{f,q} = {} & \alpha + \beta_1^{\text{Neg}}\text{NegPerf}_{f,q-1} + \beta_2^{\text{Neg}}\left(\text{NegPerf}_{f,q-1} \times \text{High PE}_{f,q-1} \times \text{NegVC}_{q-1}\right) \\ & + \beta_3^{\text{Neg}}\left(\text{NegPerf}_{f,q-1} \times \text{High PE}_{f,q-1}\right) + \beta_4^{\text{Neg}}\left(\text{NegPerf}_{f,q-1} \times \text{NegVC}_{q-1}\right) \\ & + \beta_5^{\text{Neg}}\left(\text{NegPerf}_{f,q-1} \times \text{Illiq}_{f,q-1}\right) + \beta_1^{\text{Pos}}\text{PosPerf}_{f,q-1} \\ & + \beta_2^{\text{Pos}}\left(\text{PosPerf}_{f,q-1} \times \text{High PE}_{f,q-1} \times \text{NegVC}_{q-1}\right) \\ & + \beta_3^{\text{Pos}}\left(\text{PosPerf}_{f,q-1} \times \text{High PE}_{f,q-1}\right) + \beta_4^{\text{Pos}}\left(\text{PosPerf}_{f,q-1} \times \text{NegVC}_{q-1}\right) \\ & + \beta_5^{\text{Pos}}\left(\text{PosPerf}_{f,q-1} \times \text{Illiq}_{f,q-1}\right) + \gamma M_{f,q-1} + \mu_F + \lambda_q + \varepsilon_{f,q},\end{aligned} \tag{15}$$

where $\text{Flow}_{f,q}$ refers to the investor flows of fund f in quarter q. $\text{NegPerf}_{f,q-1}$ ($\text{PosPerf}_{f,q-1}$) equals the benchmark-adjusted return when it is negative (positive) and zero otherwise. $\text{High PE}_{f,q-1}$ is an indicator variable that equals one if the investment weight in private securities is in the top quintile across all PE mutual funds and zero otherwise.[35] NegVC_{q-1} is an indicator variable that equals one if the VC index return is negative and zero

35 For perspective, high-PE funds hold 2.7% private securities on average and the PE allocation increases to 3.4% at the 75th percentile and 5.7% at the 90th percentile. In addition, the average

otherwise. The vector M stacks all other fund-level and family-level control variables, including the High PE, High PE×NegVC, Illiq, Lag(Flow), Ln(Fund TNA), Ln(Fund Age), Expense Ratio, Turnover, RETVOL, and Ln(Family TNA). We also include family (μ_F)- and quarter (λ_q)-fixed effects and the standard errors are clustered at the family level.

The coefficient of interest is β_2^{Neg}, which captures the incremental flow–performance sensitivity for high PE mutual funds during periods of VC market downturns and poor mutual fund performance. We expect β_2^{Neg} to be positive because poor performance of high PE mutual funds should induce investors to withdraw their capital before the securities are marked down by mutual funds and thus avoid the loss, particularly following periods of stress in the venture capital market which we proxy by NegVC_{q-1}.

We report the results in Panel A of Table X. We proxy VC index returns by Cambridge Associates VC index.[36] For brevity, we suppress reporting the estimated coefficients for control variables. As shown in Model (1), β_2^{Neg} is positive and significant (0.670). Thus, PE mutual funds experience higher levels of outflows relative to entropy-matched non-PE mutual funds when they experience poor performance (NegPerf < 0) and VC market is also faring badly. In contrast, PE mutual fund flows are not significantly affected by any of the interactions of positive fund performance with high PE holdings and negative VC market performance. In Model (2), we also include an interaction of fund's illiquidity measure with negative fund returns (NegPerf×Illiq) to ensure that the interaction effect we document is driven by the triple interaction of (i) high level of private security holdings, (ii) negative fund return in the previous period, and (iii) negative VC market return in the previous period. As in Chen, Goldstein, and Jiang (2010), we find the coefficient on NegPerf×Illiq to be positive and significant (0.339), suggesting that illiquid funds experience greater flow–performance sensitivity compared with their liquid peers. More importantly, even after controlling for the effect of fund illiquidity on the flow–performance relation, β_2^{Neg} estimate is slightly smaller in magnitude but continues to be positive and significant (0.606).

In Panel B, we calculate the total flow effect when PE mutual funds have poor performance and in poor VC markets by summing the coefficients on the NegPerf variables (the direct effect and three interactions). The overall flow–performance sensitivity amounts to 0.682 and 0.418 in Models (1) and (2), respectively, for high PE mutual funds with negative performance during VC market downturns. In contrast, the overall flow–performance sensitivity for high PE mutual funds is not statistically different from zero when either the fund or the VC market exhibits positive performance. This asymmetry in the flow–performance sensitivity suggests that highly illiquid private security holdings amplify the sensitivity of fund flows to poor performance when the VC market declines, consistent with correlated redemptions and fragility following bad states in the PE market.[37]

Collectively, these findings highlight one of the disadvantages of the open-end mutual fund structure when it comes to investing in illiquid private securities. During bad times in the PE investment sector, funds holding more PE securities are subject to greater outflows

weight of private security holdings among high-PE funds increased from 1.5% in the pre-2015 period to 3.5% in the post-2015 period.

36 Our main results also hold when we use the Thomson Reuters VC Research index.

37 In untabulated results, we find both retail and institutional investors of high PE mutual funds display run-like behavior during VC market downturns. For this analysis, we classify fund share classes into retail and institutional based on the methodology in Chen, Goldstein, and Jiang (2010) and construct matched samples within each subsample, again using the previously described entropy balancing approach.

Table X. Flow–performance sensitivity

Panel A presents the results of the following panel regressions with family- and quarter-fixed effects and the corresponding *t*-statistics with standard errors clustered by family:

$$\begin{aligned}\text{Flow}_{f,q} = {} & \alpha + \beta_1^{\text{Neg}}\text{NegPerf}_{f,q-1} + \beta_2^{\text{Neg}}(\text{NegPerf}_{f,q-1} \times \text{High PE}_{f,q-1} \times \text{NegVC}_{q-1}) \\ & + \beta_3^{\text{Neg}}(\text{NegPerf}_{f,q-1} \times \text{High PE}_{f,q-1}) + \beta_4^{\text{Neg}}(\text{NegPerf}_{f,q-1} \times \text{NegVC}_{q-1}) \\ & + \beta_5^{\text{Neg}}(\text{NegPerf}_{f,q-1} \times \text{Illiq}_{f,q-1}) + \beta_1^{\text{Pos}}\text{PosPerf}_{f,q-1} \\ & + \beta_2^{\text{Pos}}(\text{PosPerf}_{f,q-1} \times \text{High PE}_{f,q-1} \times \text{NegVC}_{q-1}) \\ & + \beta_3^{\text{Pos}}(\text{PosPerf}_{f,q-1} \times \text{High PE}_{f,q-1}) + \beta_4^{\text{Pos}}(\text{PosPerf}_{f,q-1} \times \text{NegVC}_{q-1}) \\ & + \beta_5^{\text{Pos}}(\text{PosPerf}_{f,q-1} \times \text{Illiq}_{f,q-1}) + \gamma M_{f,q-1} + \mu_F + \lambda_q + \varepsilon_{f,q},\end{aligned}$$

where $\text{Flow}_{f,q}$ refers to the investors flows of fund *f* in quarter *q*. NegPerf (PosPerf) equals the benchmark-adjusted return when it is negative (positive) and zero otherwise. High $\text{PE}_{f,q-1}$ is an indicator variable that equals one if fund investment weight in private equities is in the top quintile and zero otherwise. NegVC_{q-1} is an indicator variable that equals one if the Cambridge Associates VC index return is negative and zero otherwise. $\text{Illiq}_{f,q-1}$ is an indicator variable that equals one if fund investment style is in small-cap equities or mid-cap equities and zero otherwise. The vector *M* stacks all other fund-level and family-level control variables, including the High PE, High PE × NegVC, Illiq, Lag(Flow), Ln(Fund TNA), Ln(Fund Age), Expense Ratio, Turnover, RETVOL, and Ln(Family TNA) (untabulated for brevity). μ_F and λ_q are family- and quarter-fixed effects, respectively. We focus on mutual fund families that invest in private equities and implement an entropy balancing approach to match the PE funds (i.e., funds with PE investment) with non-PE funds on observable fund and family characteristics each year. Panel B reports the overall flow–performance sensitivity for high PE funds during periods of negative and positive VC index returns, respectively, as well as the corresponding *F*-statistics. *, **, and ***, significant at the 10%, 5%, and 1% level (respectively).

	Model 1	Model 2
Panel A: Coefficient estimates and regression statistics		
NegPerf	0.365***	0.282***
	(4.26)	(3.09)
NegPerf × High PE × NegVC	0.670**	0.606**
	(2.28)	(2.05)
NegPerf × High PE	−0.285*	−0.365*
	(−1.90)	(−1.96)
NegPerf × NegVC	−0.068	−0.105
	(−0.34)	(−0.50)
NegPerf × Illiq		0.339*
		(1.92)
PosPerf	0.556***	0.580***
	(5.65)	(5.04)
PosPerf × High PE × NegVC	0.134	0.158
	(0.24)	(0.30)
PosPerf × High PE	−0.269	−0.234
	(−0.82)	(−0.66)
PosPerf × NegVC	0.061	0.064
	(0.17)	(0.18)
PosPerf × Illiq		−0.103
		(−0.49)

(continued)

Table X. Continued

	Model 1	Model 2
Controls	Y	Y
Family FE	Y	Y
Quarter FE	Y	Y
R-squared	0.209	0.209
Obs.	16,835	16,835
Panel B: High PE fund total flow sensitivity in different fund return (NegPerf or PosPerf) and VC market conditions (NegVC or PosVC)		
NegPerf × High PE × NegVC	0.682***	0.418**
$(\sum_{i=1}^{4} \beta_i^{\text{Neg}})$	[15.84]	[4.51]
NegPerf × High PE × PosVC	0.080	−0.084
$(\beta_1^{\text{Neg}} + \beta_3^{\text{Neg}})$	[0.44]	[0.20]
PosPerf × High PE × NegVC	0.482	0.569
$(\sum_{i=1}^{4} \beta_i^{\text{Pos}})$	[0.69]	[0.75]
PosPerf × High PE × PosVC	0.287	0.346
$(\beta_1^{\text{Pos}} + \beta_3^{\text{Pos}})$	[0.82]	[0.83]

when the funds perform poorly. Given the rapid growth of mutual fund participation in private markets and enhanced mandated disclosure of illiquid investments of mutual funds, economically large increases in the holdings of private securities by mutual funds could pose systemic risk arising from investor runs and financial fragility.

7. Conclusion

We provide novel empirical evidence on mutual fund family practices in the valuation of private companies they hold and examine the financial fragility associated with their holdings of private securities. Our analysis highlights emerging issues that should be considered as we allow mutual funds, which are the primary investment vehicles for many individual investors, to hold more difficult-to-value private securities.

We observe large differences in the valuation of the same private security reported by different fund families. We examine the variation in valuation practices across families using a cost–benefit framework and posit three, non-mutually exclusive hypotheses. We find strong evidence in favor of the first hypothesis related to information cost/access. We find that families with better information cost structure (larger PE holdings) and/or stronger information access (holding high percentage of the funding round) rely more on their private information to update valuations, leading to systematic differences in valuations. The valuation updates by these more informed families are also more independent: they co-move less with the updates of other families holding the same private security. Finally, we find that mutual funds holding private securities register significant fund-level CARs after the follow-on funding round date. These CARs reflect stale private security prices that get a large one-time update after the follow-on rounds. The CARs for fund families with better information access is lower, consistent with the view that more informed families use their private information to update the security values before the follow-on round. In contrast, we find no support for the litigation risk or strategic behavior hypotheses.

Finally, we find that flow–performance sensitivity is exacerbated when funds have high PE exposure and both the fund and the VC market performed poorly in the previous period. This is suggestive of stronger strategic complementarities and financial fragility faced by investors when mutual funds have high exposure to PE securities. At the time of our writing, we are observing an unprecedented growth in mutual funds' participation in the private funding market, which itself is contributing to a record-breaking growth in the size of the VC market itself.[38] A major down move in prices can significantly impact the mutual fund NAVs and potentially lead to investor runs on open-end funds holding private and highly illiquid securities. In a cautionary tale of liquidity mismatch gone awry, the shattered UK Woodford Equity Income Fund was forced to liquidate and in the end sold its private securities at a discount as deep as 43% of the pre-closure valuation. So while some fund families are better than others in their "best valuation practice" of private investments, there is also an inherent fragility in all open-ended mutual funds due to the mismatch between the investors' demand for liquidity and the significant illiquidity of private startups they increasingly seek out to invest.

Supplementary Material

Supplementary data are available at *Review of Finance* online.

References

Agarwal, V., Daniel, N. D., and Naik, N. Y. (2011): Do hedge funds manage their reported returns?, *Review of Financial Studies* 24, 3281–3320.

Agarwal, V., Jiang, L., and Wen, Q. (2022): Why do mutual funds hold lottery stocks?, *Journal of Financial and Quantitative Analysis* 57, 825–856.

Ang, A., Chen, B., Goetzmann, W. N., and Phalippou, L. (2018): Estimating private equity returns from limited partner cash flows, *Journal of Finance* 73, 1751–1783.

Anson, M. J. P. (2007): Performance measurement in private equity: another look, *Journal of Private Equity* 10, 7–21.

Barber, B. M. and Yasuda, A. (2017): Interim fund performance and fundraising in private equity, *Journal of Financial Economics* 124, 172–194.

Ben-David, I., Franzoni, F., Landier, A., and Moussawi, R. (2013): Do hedge funds manipulate stock price?, *Journal of Finance* 68, 2383–2434.

Bhargava, R., Bose, A., and Dubofsky, D. A. (1998): Exploring international stock market correlations with open-end international mutual funds, *Journal of Business Finance & Accounting* 25, 765–773.

Boudoukh, J., Richardson, M., Subrahmanyam, M., and Whitelaw, R. F. (2002): Stale prices and strategies for trading mutual funds, *Financial Analysts Journal* 58, 53–71.

Brown, G. W., Gredil, O. R., and Kaplan, S. N. (2019): Do private equity funds manipulate reported returns?, *Journal of Financial Economics* 132, 267–297.

38 For example, Stanfill, Stanford, and Cook (2020) estimates nontraditional capital availability of roughly $250 to $340 billion (which includes mutual funds, hedge funds, PE funds, and corporate VC) worldwide as of 2020, which doubles the amount of capital available to global venture-backed companies. In other words, $0.50 out of every dollar that VC-backed companies receive is estimated to come from non-VC source in 2020–2021.

Carhart, M. M. (1997): On persistence in mutual fund performance, *Journal of Finance* 52, 57–82.

Carhart, M. M., Kaniel, R., Musto, D. K., and Reed, A. V. (2002): Leaning for the tape: evidence of gaming behavior in equity mutual funds, *Journal of Finance* 57, 661–693.

Cederburg, S. and Stoughton, N. (2018): Discretionary NAVs. Unpublished working paper.

Chakraborty, I. and Ewens, M. (2018): Managing performance signals through delay: evidence from venture capital, *Management Science* 64, 2875–2900.

Chalmers, J. M., Edelen, R. M., and Kadlec, G. B. (2001): On the perils of financial intermediaries setting security prices: the mutual fund wild card option, *Journal of Finance* 56, 2209–2236.

Chen, Q., Goldstein, I., and Jiang, W. (2008): Directors' ownership in the U.S. mutual fund industry, *Journal of Finance* 63, 2629–2677.

Chen, Q., Goldstein, I., and Jiang, W. (2010): Payoff complementarities and financial fragility: evidence from mutual fund outflows, *Journal of Financial Economics* 97, 239–262.

Chernenko, S., Lerner, J., and Zeng, Y. (2021): Mutual funds as venture capitalists? Evidence from unicorns, *Review of Financial Studies* 34, 2362–2410.

Choi, J., Kronlund, M., and Oh, J. Y. J. (2022): Sitting bucks: stale pricing in fixed income funds, *Journal of Financial Economics* 145, 296–317.

Cici, G., Gibson, S., and Merrick, J. J. Jr. (2011): Missing the marks? Dispersion in corporate bond valuations across mutual funds, *Journal of Financial Economics* 101, 206–226.

Cici, G., Kempf, A., and Puetz, A. (2016): The valuation of hedge funds' equity positions, *Journal of Financial and Quantitative Analysis* 51, 1013–1037.

Cochrane, J. H. (2005): The risk and return of venture capital, *Journal of Financial Economics* 75, 3–52.

Coles, J. L., Daniel, N. D., and Naveen, L. (2008): Boards: does one size fit all?, *Journal of Financial Economics* 87, 329–356.

Cremers, M., Driessen, J., Maenhout, P., and Weinbaum, D. (2009): Does skin in the game matter? Director incentives and governance in the mutual fund industry, *Journal of Financial and Quantitative Analysis* 44, 1345–1373.

Dimson, E. (1979): Risk measurement when shares are subject to infrequent trading, *Journal of Financial Economics* 7, 197–226.

Driessen, J., Lin, T. C., and Phalippou, L. (2012): A new method to estimate risk and return of nontraded assets from cash flows: the case of private equity funds, *Journal of Financial and Quantitative Analysis* 47, 511–535.

Edelen, R. M. and Warner, J. B. (2001): Aggregate price effects of institutional trading: a study of mutual fund flow and market returns, *Journal of Financial Economics* 59, 195–220.

Fama, E. F. and French, K. R. (1993): Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3–56.

Foldy, B. (2021): Electric-truck maker Rivian raises $2.65 billion ahead of first vehicle launch, *The Wall Street Journal*. https://www.wsj.com/articles/electric-truck-maker-rivian-raises-2-65-billion-ahead-of-first-vehicle-launch-11611075656

Franzoni, F., Nowak, E., and Phalippou, L. (2012): Private equity performance and liquidity risk, *Journal of Finance* 67, 2341–2373.

Goetzmann, W. N., Ivković, Z., and Rouwenhorst, K. G. (2001): Day trading international mutual funds: evidence and policy solutions, *Journal of Financial and Quantitative Analysis* 36, 287–309.

Gompers, P. and Lerner, J. (2000): Money chasing deals? The impact of fund inflows on private equity valuations, *Journal of Financial Economics* 55, 281–325.

Gornall, W. and Strebulaev, I. (2020a): Squaring venture capital valuations with reality, *Journal of Financial Economics* 135, 120–143.

Gornall, W. and Strebulaev, I. (2020b): A valuation model of venture capital-backed companies with multiple financing rounds. Unpublished working paper.

Greene, J. T. and Hodges, C. W. (2002): The dilution impact of daily fund flows on open-end mutual funds, *Journal of Financial Economics* 65, 131–158.

Greene, J. T., Hodges, C. W., and Rakowski, D. A. (2007): Daily mutual fund flows and redemption policies, *Journal of Banking and Finance* 31, 3822–3842.

Hainmueller, J. (2012): Entropy balancing for causal effects: a multivariate reweighting method to produce balanced samples in observational studies, *Political Analysis* 20, 25–46.

Hainmueller, J. and Xu, Y. (2013): Ebalance: a Stata package for entropy balancing, *Journal of Statistical Software* 54, 1–18.

Houge, T. and Wellman, J. (2005): Fallout from the mutual fund trading scandal, *Journal of Business Ethics* 62, 129–139.

Hu, G., McLean, D., Pontiff, J., and Wang, Q. (2014): The year-end trading activities of institutional investors: evidence from daily trades, *Review of Financial Studies* 27, 1593–1614.

Huang, S., Mao, Y., Wang, C., and Zhou, D. (2021): Public market players in the private world: implications for the going-public process, *Review of Financial Studies* 34, 2411–2447.

Hüther, N. (2016): Raising funds on performance: Are private equity returns too good to be true? Unpublished working paper.

Imbierowicz, B. and Rauch, C. (2020): The pricing of private assets: Mutual fund investments in 'unicorn' companies. Unpublished working paper.

Jegadeesh, N., Kräussl, R., and Pollet, J. M. (2015): Risk and expected returns of private equity investments: evidence based on market prices, *Review of Financial Studies* 28, 3269–3302.

Jenkinson, T., Sousa, M., and Stucke, R. (2013): How fair are the valuations of private equity funds. Unpublished working paper.

Kaniel, R. and Parham, R. (2017): WSJ Category Kings—The impact of media attention on consumer and mutual fund investment decisions, *Journal of Financial Economics* 123, 337–356.

Kaplan, S. N. and Schoar, A. (2005): Private equity performance: returns, persistence, and capital flows, *Journal of Finance* 60, 1791–1823.

Kaplan, S. N. and Sensoy, B. A. (2015): Private equity performance: a survey, *Annual Review of Financial Economics* 7, 597–614.

Khorana, A., Tufano, P., and Wedge, L. (2007): Board structure, mergers, and shareholder wealth: a study of the mutual fund industry, *Journal of Financial Economics* 85, 571–598.

Korteweg, A. (2019): Risk adjustment in private equity returns, *Annual Review of Financial Economics* 11, 131–152.

Korteweg, A. and Nagel, S. (2016): Risk-adjusting the returns to venture capital, *Journal of Finance* 71, 1437–1470.

Korteweg, A. and Sorensen, M. (2010): Risk and return characteristics of venture capital-backed entrepreneurial companies, *Review of Financial Studies* 23, 3738–3772.

Kwon, S., Lowry, M., and Qian, Y. (2020): Mutual fund investments in private firms, *Journal of Financial Economics* 136, 407–443.

Metrick, A. and Yasuda, A. (2010): *Venture Capital and the Finance of Innovation*, 2nd edition, John Wiley & Sons, Hoboken, New Jersey.

Metrick, A. and Yasuda, A. (2021): *Venture Capital and the Finance of Innovation*, 3rd edition, John Wiley & Sons, Hoboken, New Jersey.

Pástor, L. and Stambaugh, R. F. (2003): Liquidity risk and expected stock returns, *Journal of Political Economy* 111, 642–685.

Rakowski, D. (2010): Fund flow volatility and performance, *Journal of Financial and Quantitative Analysis* 45, 223–237.

Schmidt, L., Timmermann, A., and Wermers, R. (2016): Runs on money market mutual funds, *American Economic Review* 106, 2625–2657.

Scholes, M. and Williams, J. (1977): Estimating betas from nonsynchronous data, *Journal of Financial Economics* 5, 309–327.

Schwartz, J. (2017): Should mutual funds invest in startups? A case study of Fidelity Magellan fund's investments in unicorns (and other startups) and the regulatory implications, *North Carolina Law Review* 95, 1341–1402.

Sirri, E. R. and Tufano, P. (1998): Costly search and mutual fund flows, *Journal of Finance* 53, 1589–1622.

Stanfill, C., Stanford, K., and Cook, D. (2020): Shadow capital in venture investing, PitchBook Analyst Note.

Walker, O. and Smith, P. (2019): Neil Woodford: The inside story of his rise and dramatic fall, *The Financial Times*.

Woodward, S. E. (2009): Measuring risk for venture capital and private equity portfolios. Unpublished working paper, Sand Hill Econometrics.

Yermack, D. (2004): Remuneration, retention, and reputation incentives for outside directors, *Journal of Finance* 59, 2281–2308.

Zitzewitz, E. (2006): How widespread was late trading in mutual funds?, *American Economic Review* 96, 284–289.