Private Company Valuations by Mutual Funds

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Abstract

Mutual funds that invest in private securities value those securities at stale prices. Prices change on average every 2.5 quarters, vary across fund families, and are revised upward dramatically at follow-on funding events. The infrequent, but dramatic price changes yield predictably large fund returns. Fund investors can exploit the stale pricing by buying (selling) before (after) the follow-on funding events (though we find little evidence of this behavior to date). Fund families can opportunistically save up and unleash dry powder (unused markup of private securities) when doing so helps their high-priority funds get to the top of league tables at year ends. Consistent with these incentives, funds near the top of league tables increase private valuations more around fourth quarter follow-on funding events than funds ranked lower.

Keywords: Mutual funds, Venture capital, Entrepreneurial firm, Private valuation, Stale prices

Historically, startup companies have funded growth by turning to seed investors, angel investors, or private capital before turning to public markets with an initial public offering (IPO). At the time of the IPO, mutual funds typically bid on shares in the IPO, receive an allocation of shares from the underwriter at the IPO offer price, and often enjoy a strong return from the offering price to the close of the first day of public trading. However, in recent years large startup companies like Uber, Airbnb, and Pinterest have chosen to remain unlisted while raising large amounts of capital by selling private securities to mutual funds often years in advance of a public IPO in what some observers have referred to as private IPOs (Brown and Wiles 2015).[1] These large private startups have become so common that the financial press has dubbed those with valuations in excess of $1 billion as "unicorns," and CB Insights reports 342 unicorns with total valuation of $1,161 billion as of January 2019.[2]

This new startup funding model leaves mutual funds holding illiquid private securities even though they must provide daily liquidity to their investors. Against this backdrop, SEC Commissioner Jay Clayton has pondered how individual investors can get access to some of the hot pre-IPO startups (Michaels 2018). Investments in mutual funds who hold these securities is an obvious vehicle, which underscores the need for a careful analysis of the pricing and dynamics of pre-IPO private securities by funds. To date there is little empirical evidence on the pricing practices of mutual funds that invest in these pre-IPO startups and behavior of investors in these funds.

This paper fills that void by analyzing a manually compiled dataset of 230 private securities (for 135 different companies) held by 204 unique mutual funds between 2010 and 2016. We identify the private security prices reported by mutual funds using quarterly filings of mutual fund holdings with the Securities and Exchange Commission (SEC). A key feature of the dataset is we identify the specific series that a mutual fund holds (e.g., Series D vs. 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

[1] Pinterest and Uber went public in April and May 2019, respectively, and Airbnb is also expected to go public in 2019.
[2] https://www.cbinsights.com/research-unicorn-companies

preference (Metrick and Yasuda, 2010). Our identification of each unique security (typically a convertible preferred stock) allows us to carefully measure variation in pricing across funds for the same security at the same point in time and rule out contract features as the source of the pricing variation. An important feature of the pricing of private securities by mutual funds is the prevalence of follow-on series offerings by private firms whereby the issuer of private securities held by mutual funds raises capital – while still remaining private – by issuing a new series of private security in a private placement on a subsequent round date. We identify 59 follow-on funding events during our 2010–2016 sample period with an average deal-over-deal price increase of 51.1%. There are only 5 down rounds, where the deal-over-deal price decreases.

Our analysis of this dataset proceeds in three steps. First, to set the stage, we provide a rich descriptive analysis of the valuation of private securities by mutual funds. We then consider two questions that arise given the valuation practices we document: Can investors capitalize on the mutual fund valuation practices? Do fund managers strategically use valuations to affect fund flows?

In our analysis of valuation practices, three main results emerge. Valuation changes are rare but generally large and positive around follow-on funding events. There is also material variation in the prices of private securities across funds, which can be traced to variation in pricing at the fund family level. Finally, private securities earn no alpha after we appropriately adjust for the stale pricing of the securities.

We find prices change infrequently by analyzing the quarterly changes in prices of private securities reported in the SEC filings. In nearly half of all security-quarters, mutual funds do not change the price of the private securities they hold (i.e., 48.6% of quarterly returns are zero). The average private security changes prices every 2.5 quarters. Private securities are often valued at a funding round deal price; 38% of all security-quarter observations are valued at a deal price. This is particularly true when there has been a follow-on deal in the most recent quarter. Of the securities issued in the new funding round, 82% are valued at the deal price at the end of the quarter following the event with most of the remaining securities valued at a 10% discount to the funding round price (perhaps a liquidity discount). Of the securities issued in earlier rounds on the same private company, almost 60% are marked to the deal price of the *new* series at the quarter end following the deal (indicating mutual funds often ignore the differences in contractual terms when pricing the different series offerings of the same firm). The large infrequent price jumps and long periods of stale valuation leave private securities earning quarterly returns that are not reliably different from public benchmarks when we appropriately adjust for the stale pricing of these securities.

We observe variation in pricing of the same security at the same time across fund families. The average price dispersion across fund families is 10.0%, which is consistent with the notion that different families have different valuation practices. To put this in perspective, two funds reporting prices of $19 and $22 for the same security would generate price dispersion of 10.3%.[3] This level of price dispersion masks large variation across security-quarters. In half of security quarters, dispersion is less than 6%, but in one out of four security-quarters, dispersion exceeds 14.3% and in one out of ten security-quarters exceeds 25%. (Two funds reporting prices of $25 and $36 generate a 25.5% dispersion measure.) In other words, individual investors can be accessing pre-IPO startups via mutual funds at significantly different valuations at a given point in time.

In contrast to this material variation in pricing across fund families, we observe virtually no variation in pricing within a fund family. For securities held by the funds within the same fund family, the mean price dispersion is a mere 0.3%. This lack of dispersion within fund families can likely be traced to the common use of family-wide valuation committees, which set standards and review pricing decisions for illiquid securities.

Investors can capitalize on these pricing dynamics. Specifically, the large valuation markups at follow-on events lead to predictable and economically large fund returns surrounding the events. This dynamic provides an incentive for investors to buy (sell) fund shares before (after) the follow-on event, though an analysis of a limited sample of daily fund flows does not find evidence of this behavior to date.

We find the returns of mutual funds that hold private securities are predictably large following the start of a follow-on deal. We define the date of the funding round as the day when the company files a restated Certificate of Incorporation in the company's home state. Average cumulative abnormal returns (*CAR*s) are 31 bps (43 bps) in the 5-day (10-day)

[3] $10.3\% = \frac{\left[(22-20.5)^2+(19-20.5)^2\right]^{1/2}}{20.5}$.

window following the funding round date for funds holding private securities. To link the strong fund returns more tightly to the markups of private securities in the wake of the new funding round, we estimate the weight of private security in each fund's overall portfolio (using quarterly holdings data) and the percentage change in the private security valuation based on the new deal price and the price reported in the quarter prior to the new deal. For example, a fund that holds 0.5% of its assets in Airbnb, currently values the security at $50, and increases the value to $100 after the announcement of the new funding round will experience a fund return of 50 bps on the day of the Airbnb markup. To test this conjecture, we regress the post-funding *CARs* of funds on the product of the private security weight in the fund's portfolio and the deal-over-valuation security price change, which as conjectured generates a reliably positive coefficient estimate (0.79 when the dependent variable is the 10-day *CAR*, *t*-stat = 2.46). The results suggest that individual investors' returns from buying mutual funds that hold private securities are significantly enhanced if they can time their purchases to occur shortly before new funding rounds.

To date, we do not find evidence that investors capitalize on these predictable return patterns. Specifically, we test if fund investors exploit stale pricing by buying (selling) funds before (after) the follow-on rounds. If investors can obtain information about the funding rounds in advance, they can time their entry into and exit out of the funds, which would predict high inflows in the period prior to the follow-on round dates and high outflows after the follow-on rounds. We find redemption fees, which were adopted in the wake of the 2003 mutual fund trading scandal and would discourage this type of timing strategy, are present in only 15% of funds that hold private securities. For a limited subsample of funds with daily flows data available from Trimtabs (22 funds and 75 fund-security events), estimates of abnormal flows are positive in the 5-day window prior to follow-on funding rounds and negative in the 5-day window afterward. However, the small sample and low power of these tests do not allow us to reject the null hypothesis that abnormal fund flows are zero around the follow-on funding round date, perhaps because the small sample renders the statistical tests insufficiently powerful. It is also possible that investors currently lack access to timely information regarding funds holding of private securities and advance knowledge about the follow-on funding rounds. We view our results as cautionary as we cannot rule out a future world in which mutual funds' positions in private securities are large, third-party data aggregators provide access to timely information, and investors time their flows to exploit predictable fund returns.

Prior research documents fund managers strategically allocate illiquid securities to high-value mutual funds and strategically value those securities toward the end of the year. Cici, Gibson, and Merrick (2011) find that bond funds mark illiquid securities in a pattern that is consistent with strategic return smoothing. There is also evidence that mutual funds and hedge funds strategically mark securities toward the end of the year (Carhart, Kaniel, Musto, and Reed 2002; Agarwal, Daniel, and Naik 2011; Ben-David, Franzoni, Landier, and Moussawi 2013; Cici, Kempf, and Puetz 2016).

In the context of our setting, we conjecture that managers of recent top-performing funds might lobby the fund families' investment valuation committees to approve swift and fuller markups of the private securities they hold before the year closes. The incentive exists because the extra boost in performance is more rewarding when you are in the more convex portion of the flow-return relation. We further conjecture that top-performing fund managers' and fund families' incentives are aligned because they each seek to maximize fund inflows and family-level fee revenues, respectively. In fact, fund families may strategically allocate the private securities to their high-value funds in the first place so that they can later utilize the valuation markups as extra boosts when doing so benefits them (and the funds) the most.

Consistent with these conjectures, we find evidence that fund families strategically allocate and value private securities. First, we find that fund families prefer to allocate private securities to high-value funds within the family such as top recent performers and high-fee funds. Second, we document that funds that have outperformed peers in the first three quarters have bigger markups on their private security holdings around follow-on funding events in the fourth quarter relative to other funds and the same funds at other times. For example, the top-20% funds have mean *CAR* of 49 bps in the 5-day window after fourth-quarter follow-on events, which is significantly larger than the *CAR* associated with follow-on rounds in the first three quarters (27 bps, *t*-stat = 2.03 for *Ho*: Difference = 0) or bottom-80% funds in the fourth quarter (2.5 bps, *t*-stat = 4.00). This is consistent with fund families having greater incentives to boost performance of affiliated funds at year end when those funds are near the top of the league tables. Finally, we document that a 30 bps boost (approximately equal to the average excess *CAR* that top-20% Q4 funds earn) has a materially greater effect on fund inflows for top-20% performers than for bottom-80% funds, affirming our interpretation of the top-20% Q4 behavior as opportunistic NAV management for the purpose of maximizing flows.

In summary, our paper is the first to provide large-scale evidence of significant time-series and cross-sectional variation in pricing of private securities by mutual funds. We document significant stale valuations of private securities and uncover predictability in fund returns when these valuations are updated infrequently at follow-on funding rounds. Investors do not (yet) appear to trade opportunistically by timing their entry into and exit from funds before and after updating of valuations. Fund families boost the yearly returns of their high performing funds by strategically marking up values of their private security holdings more at year end. Our findings inform the discussion surrounding mutual funds' investment into private securities, including issues such as disclosure and valuation of private securities when asset managers need to offer daily liquidity to their investors.

1. Related literature and our contributions

Four recent working papers study the private investments of mutual funds. Kwon, Lowry, and Qian (2019) 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 an average one or two years longer. Chernenko, Lerner, and Zeng (2017) analyze contract-level data to examine the consequences of mutual fund investments in these early-stage companies for corporate governance provisions. Huang et al. (2017) 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 valuation of private securities by individual mutual funds, nor do they study the effects of private security valuation practice on fund-level returns and flows. In a recent working paper closely related to our work, Cederburg and Stoughton (2018) also document variation in pricing across funds and argue that private equity pricing by mutual funds is procyclical with respect to fund performance, which is consistent with the prediction of a theoretical model that they develop.

Our work is related to the literature that analyzes the daily pricing of mutual funds. U.S. mutual funds typically offer an exchange of shares once per day at a price referred to as net asset value (NAV). Stale equity share prices (e.g., foreign equities or thinly traded stocks), which are reflected in a fund's net asset value, lead to predictable fund returns (Bhargava, Bose, and Dubofsky 1998; Chalmers, Edelen, and Kadlec 2001; Boudoukh et al. 2002; Zitzewitz 2006). Moreover, fund flows indicate investors capitalize on these predictable returns (Goetzmann, Ivković, and Rouwenhorst 2001; Greene and Hodges 2002). We document that private equity valuations are much less frequently updated than public equity and lead to predictable fund returns. However, in contrast to the literature on foreign and thinly traded stocks, we find no evidence of profiting by fund investors from the predictable returns. 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 can be explained by the release of public information (e.g., new funding rounds) and strategic behavior of funds.

Our work also fits into the literature on the valuation and staged funding of venture-backed firms. 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. 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 predictably strong fund returns.

Metrick and Yasuda (2010) and Gornall and Strebulaev (2018) develop option-pricing based valuation models, which correct for the use of convertible preferred securities 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 at the time of financing, but not applicable to how valuations of companies evolve in the absence of new rounds. Our study provides insights into the evolution of the prices of private companies over time.

Jenkinson, Sousa, and Stucke (2013), Barber and Yasuda (2017), and Brown, Gredil, and Kaplan (2018) examine the evolution of quarterly reported net asset values for private equity funds around capital campaigns to raise a follow-on fund. However, these studies use data on the quarterly valuations of the private equity fund (i.e., the *portfolio* of private companies aggregated at the fund level), not the funds' valuation of individual portfolio company holdings. This is due to data limitations on individual company/security-level valuations by private equity fund managers. These papers find that, while on average NAVs are held significantly below the values at which investment ultimately exit, some fund managers (e.g., those with low reputation) engage in NAV management during the fundraising campaigns. In related studies, Hüther (2016) and Chakraborty and Ewens (2018) report that fund managers strategically delay portfolio company write-offs until after a follow-on fund is raised. We extend this literature by documenting that mutual fund families exhibit strategic behavior with respect to exercise of their discretion over individual private security valuations.

2. Data

Our raw data on mutual fund holdings of private equity 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 private equity securities are rare before 2010, we restrict our analysis to holdings reported in 2010 and thereafter.

There are two distinct data challenges we face in constructing a clean data set of private equity security holding by mutual funds. First, neither CRSP nor SEC raw data indicate definitively whether a security held by a mutual fund is a private equity security, so we have to manually identify and verify private equity securities among mutual fund holdings. We do this by matching these fund holdings data with a list of VC-backed companies and companies that recently went public that we build separately. 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.

Second, VC-backed private companies typically issue convertible preferred securities to their investors rather than common stock. As discussed above, these securities issued at different financing rounds (called Series A, Series B, etc.) differ in their terms (Metrick and Yasuda 2010; Gornall and Strebulaev 2018). 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.

Using the matching method described in the Internet Appendix A, we carefully identify 230 securities issued by 135 companies (each security is a unique company-round pair). To measure price dispersion across mutual funds, we require that the same security be held by at least 2 mutual funds. This further reduces our sample to 170 unique securities issued by 106 companies. 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.

3. Stale Pricing of Private Companies by Mutual Funds

3.1 Descriptive Statistics

We begin the analyses by presenting evidence on the differences in the valuation of private securities across mutual funds. To illustrate the dispersion in valuation, Figure 1 provides an example of three mutual funds that hold the same private security. Fidelity Contrafund, Morgan Stanley Multicap Growth, and Thrivent Growth Stock apparently purchased Airbnb Series D securities, which were sold in April 2014 at a per share price of \$40.71. In June 2014, these three funds all report holding Airbnb at \$40.71. In December 2014, Morgan Stanley increases its valuation to \$50.41, while the other two funds continue to report \$40.71. In June 2015, shortly after Airbnb announced its Series E offering, all three funds substantially increase the reported prices. During the next year, prices reported by the three funds diverge more dramatically but converge again in September 2016 at \$105 in the wake of a Series F funding round in September 2016. While we plot three funds that hold Airbnb as an example, 32 mutual funds in our sample hold Airbnb Series D.

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 ($\overline{P_{s,q}}$):

$$DispPrc\_Avg_{s,q} = \frac{\sigma_{s,q}}{\overline{P_{s,q}}} \tag{1}$$

Since average price might be skewed by a fund that has marked the security up or down dramatically, we also scale by median price ($DispPrc\_Med_{s,q}$). As an example, a security that is held by two funds in the same quarter at prices of \$19 and \$22 would generate a *DispPrc_Avg* = 2.12/20.5 = 10.3%.

In Table 1, we present summary statistics on our sample of private companies held by at least two mutual funds in each quarter. Panel A shows that the number of funds holding the same security in a given quarter (*NumFd*) averages to 8.4, and the median number of funds is 7. While majority of mutual funds set their reporting cycles in Mar/Jun/Sep/Dec, others report their quarterly holdings and valuations in Jan/Apr/July/Oct or Feb/May/Aug/Nov cycles. To address this reporting cycle mismatches, we group funds by the ending month of their reporting cycles when calculating cross-fund dispersion, i.e., treat quarter ending on March 31, 2015 and the quarter ending on April 30, 2015 as two different quarters. As reported in Panel B, the full sample consists of 106 different firms (e.g., Uber). For these firms, there are 170 unique securities (e.g., Uber Series D, Uber Series E, etc.), which yield 2,274 security-quarter observations of price dispersion,

$DispPrc\_Avg_{s,q}$. All securities in Panel B are held by at least two funds in the same quarter ending in the same month (i.e., $NumFd \geq 2$).[4]

On average, price dispersion is 3.9% across funds in the same quarter (two funds holding the same security at prices of $35 and $37 generating a dispersion measure of 3.9%). The mean standard deviation of prices across funds is $0.72 and the average (median) security price is $16.15 ($16.23). The observed price dispersion is often zero and at times large. We observe less than 1% in 67% of security-quarters (1,522 of 2,274 security-quarters), while in 10% of security-quarters we observe price dispersion of 13% or more (90th percentile of *DispPrc_Avg* is 13.0%).

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.[5] If these practices are widespread, we expect to observe greater variation in prices across fund families but much less variation within fund families. To investigate whether this price dispersion results from variation in pricing within a particular fund family (e.g., Fidelity) or across fund families (e.g., Fidelity and T. Rowe Price), in Panel C we calculate price dispersion within a fund family. In this analysis, we require that a security be held by two funds *within the same fund family* in the same reporting month in quarter q. The analysis yields a price dispersion measure for security *s* for fund family *F* in quarter q, $DispPrc\_Avg_{F,s,q}$. Fund families in which a single fund holds a security are dropped from this analysis. However, since we have observations for multiple fund families for the same security-quarter, the number of observations (family-security-quarters) increases to 2,463. The price dispersion within fund families is negligibly small at 0.3% on average and is precisely zero for over 99% of family-security-quarters in this sample. For the remaining 1%, we cannot rule out data errors. The finding indicates that fund families impose one price per security as a general rule and that the

[4] We lose 6 firms and 11 securities because once we match on the ending month of reporting cycles, these securities are only reported by 1 mutual fund in those reporting months (though other mutual funds are concurrently holding them and reporting them in staggered reporting months).

[5] See "Here's why mutual fund valuations of private companies can vary" by Francine McKenna on marketwatch.com, published November 20, 2015: http://www.marketwatch.com/story/heres-why-mutual-fund-valuations-of-private-companies-can-vary-2015-11-20; 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: https://www.wsj.com/articles/wall-street-cop-asks-money-managers-to-reveal-silicon-valley-valuations-1481305082

documented price dispersion in Panel B occurs virtually entirely across (rather than within) fund families.

In Panel D, we present a complement to the within fund family analysis and analyze dispersion across fund families. To do so, we first calculate the average price of security *s* in quarter *q* across funds in family *F*. We then calculate price dispersion across fund families based on the standard deviation and mean of the average price for each fund family. As anticipated, price dispersion across fund families is much larger than within-family price dispersion at 10.0% on average. Building on the results reported in Panels C and D, we shift the unit of observation to fund family-security-quarter (as opposed to fund-security-quarter) in subsequent analysis wherever appropriate.

3.2 Return on Private Securities

An important feature of the pricing of private securities is the infrequent updating of the prices as suggested by the Airbnb example of Figure 1. To get a sense for 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:

$$Return\_PVT_{F,s,q} = \frac{P_{F,s,q}}{P_{F,s,q-1}} - 1 \tag{2}$$

In Table 2, Panel A, we present descriptive statistics on this quarterly return variable (*Return_PVT)* across 4,286 fund family-security-quarter observations. The average quarterly return is 3.3%, but the median return is zero and 42% of all returns are zero. To demonstrate the severity of the staleness in the prices of private securities, we compare these descriptive statistics with those for public securities (*Return_PUB*). Using 148,841 fund family-security-quarter observations for public securities held by fund families in our sample, we observe that unlike the case of private securities, the median quarterly return is 2.3%.

We further highlight the staleness issue in Panel B where we report the percentage of quarters in which the fund family does not change the reported price of the private and public securities held by it (i.e., quarterly return is zero). To do so, for each fund family-security pair, we calculate the percentage of quarters in which the private security return is precisely zero *(%Zero Return_PVT*). On average across fund-family security pairs, mutual fund families report zero returns for private securities in 48.6% of all quarters. In contrast, the incidence of zero returns for public securities *(%Zero Return_PUB*) is much lower at 0.3%. Moreover, Panel B also reports the number of quarters until the prices of private securities are updated from the acquisition price (*Qtr to Update_PVT*). It takes on average 2.5 quarters for the fund to update its acquisition price of private securities.

These results are not driven by fund family-security pairs with few quarterly observations. We repeat our analysis by imposing a condition of a minimum of three (or four) quarter holding period for each family-security pair. In untabulated results, we find that the median quarterly return for private securities continues to be zero while the mean return is largely unchanged. In addition, mutual funds still show zero returns in 46.6% using a three-quarter filter (44.5% using a four-quarter filter). In contrast, public securities still exhibit minimal incidence of zero returns (0.3% using either a three- or four-quarter filter). Finally, the number of quarters to update the prices of private securities is about the same (2.6 quarters since acquisition with either the three- or four-quarter filter). Taken together, stale pricing is much more prevalent and pronounced for private securities as compared to public securities.

3.3 Temporal Evolution of Pricing Deviation from Deal Prices

Next, we examine the time series variation in the dispersion of private security prices reported by funds. As suggested by the Aibnb example in Figure 1, price dispersion tends to decrease after a follow-on funding round when some funds may update their prices, presumably to match the new deal price. To better understand how fund families mark their private securities, we compare the prices reported by funds to deal price of the security, which serves as a natural price benchmark. We consider three primary benchmark prices for security s in quarter q, denoted as $B_{s,q}$: the deal price in the most recent funding round, the price at which the security was acquired by the family, and the average price reported by all families holding the security in the quarter. We define the price deviation as follows:

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

where $Dev_{F,s,q}$, $P_{F,s,q}$, and $B_{s,q}$ are the price deviation, price reported, and benchmark price (respectively) for security s held by fund family F in quarter q. For a given benchmark price B, *Dev* measures the percentage deviation of the reported private security prices from B. Additionally, we create an indicator variable, *Dummy*(*Dev*), that takes a value of one if the absolute value of *Dev* is above 1%. We also consider a fourth analysis that measures the extent to which mutual funds assign prices to private securities that deviate from *any* deal price. Specifically, we calculate *Dev* using the last and all prior deal prices; *Dummy(Dev)* takes a value of one if *all* of the deviations exceed 1%. The average value of *Dummy*(*Dev*) over all family-security-quarter observations is denoted as *%Dev*, and represents the proportion of families' reported prices that deviate from the benchmark price in the quarter. In unreported results, we consider defining absolute deviations only if they are above 5% (rather than 1%) and obtain qualitatively similar results.

Table 3, Panel A, reports *%Dev* results. The sample contains 139 firms (e.g., Uber), 229 securities (e.g., Uber Series C and Series D) with the corresponding benchmark deal prices during the 2010 to 2016 sample period. There are 4,763 (4,796) family-security-quarter observations of reported prices with corresponding deal prices from the most recent funding round (most recent or previous funding rounds). As shown in Panel A, last column, 62% of valuations differ by more than 1% in absolute value from the latest and any prior deal price and 63% differ by the same magnitude from the latest deal price (*%Dev* = 0.62 and 0.63, respectively). When we compare the reported security prices with the price paid by the fund for the same security at acquisition, *%Dev* is larger at 77%. In other words, more than three-quarter of the private security prices are different from the price at which they were purchased while the remaining families maintain the valuations at cost. The higher deviation from cost price relative to recent deal price suggests that part of the variation in reported security prices is related to marking to deal prices, although the new deal price does not fully eliminate the differences in reported prices.

The final benchmark price is the average of all reported security prices for the same firm held by the fund family, where we require that the family holds at least 2 securities (e.g., Uber Series C and D) of the same firm (e.g., Uber). Recall that these securities may have different contingencies and cash flow rights, so it would be reasonable to observe different prices for these securities even though they are both held on the same firm (Metrick and Yasuda 2010; Gornall and Strebulaev 2018). The requirement that the family holds multiple securities of the firm reduces the sample significantly to 39 firms and 132 securities. Panel A of Table 3 shows an average *%Dev* of 24%; fund families tend to price different securities at the same price, but we do observe some variation across securities.

To gain a deeper understanding into how follow-on deals affect valuations, we analyze the deviation in reported private security prices from the new deal price in nine quarters around a new funding round (quarter 0). In addition to the measure of percentage of fund families with reported prices deviating from the most recent deal price (*%Dev*), we split the deviation in reported prices into two groups depending on whether the reported price is above ($\%Dev^{+}$) or below ($\%Dev^{-}$) the benchmark deal price by more than 1%. For each of the two groups (above and below deal price), we also compute the median value of *Dev* conditional on whether the deviation is above or below the latest deal price ($Median\_Dev^{+}$ and $Median\_Dev^{-}$, respectively).

For securities held prior to a new funding round, we calculate statistics from quarter −4 to +4 and report results in Table 3, Panel B. In four quarters before the new funding round, about 97% of the reported prices are below future deal price (the median negative price deviation is 39% lower), consistent with higher deal prices in subsequent funding rounds. The price deviations fall dramatically during the new round of financing. Specifically, *%Dev* decreases from 97% in quarter −1 to 42% in quarter 0 as a majority of funds update their security value close to the new deal price. Consequently, only 34% (8%) of the family-security prices are below (above) the new deal price. This corresponds to a median deviation of 20% (23%) below (above) the new deal price. There is also a steady increase in the percentage of fund families that update their security prices to their model values, which in turn contributes to dispersion in prices over time. For example, *%Dev* increases gradually to 78% in quarter +4, with 53% (25%) reporting prices lower (higher) than the latest deal price.

Finally, we examine the variation in reported prices of private firms that first appear following a new round of financing. As shown in Panel C of Table 3, the sample contains 85 firms issuing 108 securities with new round of funding. During the quarter of new funding round (quarter 0), the deviation between reported and deal price is small at 18% (15% report prices below the deal price and 3% report higher prices). Among the funds 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 mutual funds applying a 10% discount in their fair value pricing for illiquid securities. In contrast, among family-quarters with markup in security prices above the deal price, the median markup (*Median_Dev*$^+$) is large at 18%, and remains at similar quantum over three quarters. As we move forward to four quarters after the new funding round, the reported prices diverge: *%Dev* increases to 77% in one year. In terms of the magnitude of price deviations, this converts to an economically meaningful *Median_Dev*$^+$ of 37%, and *Median_Dev*$^-$ of 15%.

In unreported results, we examine the impact of the release of public news on price dispersion, beyond information on deal price during follow-on rounds. Using news events from RavenPack database, we find that public news about the private firm significantly reduces price dispersion, consistent with news reducing asymmetric information (see Table A1 in the Internet Appendix).

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 towards the deal price during new rounds of financing, followed by price divergence over subsequent quarters.

3.4 Performance of Private Securities

In this sub-section, we evaluate the quarterly performance of the private companies held by mutual funds. Consistent with staleness in reported security prices, we find strong evidence that the changes in valuations respond to market, size and growth-related 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.

To reach these conclusions, we estimate three pooled time-series regressions using fund family-security-quarter observations:

$$\left(R_{F,s,q} - RF_q\right) = \alpha + \beta\left(R_{m,q} - RF_q\right) + \varepsilon_{F,s,q} \tag{4}$$

$$\left(R_{F,s,q} - RF_q\right) = \alpha + \sum_{l=-2,0} \beta_l\left(R_{m,q-l} - RF_{q-l}\right) + \varepsilon_{F,s,q} \tag{5}$$

$$\begin{aligned}\left(R_{F,s,q} - RF_q\right) = \alpha + \sum_{l=-2,0} \beta_l\left(R_{m,q-l} - RF_{q-l}\right) + \sum_{l=-2,0} h_l \, HML_{q-l} \\ + \sum_{l=-2,0} s_l \, SMB_{q-l} + \varepsilon_{F,s,q}\end{aligned} \tag{6}$$

where $R_{F,s,q}$ is the quarterly valuation change of a private security s in quarter q held by fund family F. For those who own shares in the mutual fund, this valuation change represents the return on the private security as the posted valuations would feed into the daily NAV of the fund. RF_q is the quarterly risk-free rate, proxied by the one-month Treasury bill rate. To address issues of cross-sectional dependence in this regression, we estimate standard errors clustering observations by quarter. In the first regression as indicated in Equation (4), we estimate a one-factor CAPM model with only the contemporaneous market risk premium, $\left(R_{m,q} - RF_q\right)$. In the second regression as indicated in Equation (5), we add lags of the market risk premium to account for the stale pricing along the lines suggested by Scholes and Williams (1977) and Dimson (1979). More closely related to our setting, Metrick and Yasuda (2010) document that appropriate adjustment for the risk of private equity funds requires the inclusion of lags of quarterly factor returns because private equity funds tend to update fund NAVs with a delay. In the third regression as indicated in Equation (6), we add size (SMB) and value (HML) factors (Fama and French 1993).[6]

The results of this analysis are presented in Table 4. Model (1) presents regression results with only a contemporaneous market factor, which illustrates a severe downwardly biased beta estimate (0.317) that is not statistically significant. Note that the alpha in this simple regression is also economically large and statistically significant at 2.9% per quarter. However, this low risk and strong abnormal fund performance is misleading and results from stale pricing. Model (2) includes lags of market returns and shows reliably positive loadings at lags of one and two quarters (consistent with sluggish valuation changes) and an alpha that is no longer statistically different from zero. In Panel B, we present the sum of the coefficients on the market risk premium, which shows a much higher and statistically significant beta of approximately 1.5. Model (3) includes size and value factors. The alpha of the private securities does not change materially, but the summed exposures in Panel B suggest the private securities are exposed to size- and growth-related factors. The results in Model (3) indicate private securities respond to market-, size-, and growth-related factors, they do so with a lag, and their performance is unremarkable after appropriately accounting for stale pricing by including lagged factors. These results are in

[6] Including additional lags of market, size, and value factors does not consistently generate reliable loadings. We also consider the liquidity factor of Pástor and Stambaugh (2003); it does not generate reliably positive loadings, nor does it qualitatively affect the conclusions of this section.

line with venture capital risk and return estimates reported in the literature that explicitly address staleness issues: Ang, Chen, Goetzmann, and Phalippou (2018) report a market beta of 1.85 and negative alpha, and Metrick and Yasuda (2010) report a market beta of 1.63 to 2.04 and an insignificant alpha in multi-factor models.

In prior analyses, we show that follow-on funding rounds generate significant changes in valuations. To determine whether the performance and exposure to common factors are sensitive to these follow-on round quarters, we introduce an indicator variable *Follow-on Dummy*, that takes a value of one if the current quarter is a quarter with a follow-on funding round and is zero otherwise. Models (4) to (6) in Table 4 show the results of the three regressions with the *Follow-on Dummy* added. The coefficients on the *Follow-on Dummy* are large (33% to 35% per quarter) and statistically significant, consistent with substantial deal-to-deal valuation changes. However, the coefficient estimates on the factor exposures and alphas are qualitatively similar to those estimated absent the *Follow-on Dummy*.

In summary, the cumulative evidence indicates that staleness in reported prices is a prominent feature of mutual fund investment in private securities. In the following sections, we examine the implication of stale pricing for investors and fund managers.

4. Do Fund Investors Capitalize on Stale Pricing?

In this section, we first examine predictability in fund returns around new rounds of financing and whether this predictability is greater when funds have more exposure to the private securities. We then investigate if fund investors exploit this predictability by purchasing fund shares before the follow-on rounds and/or selling these shares after the follow-on rounds.

4.1 Predictability in Fund Returns Around Financing Rounds

While mutual funds are required to report to the SEC only quarterly, the funds mark the net asset values (NAVs) of their individual stock holdings on a daily basis in order to compute the fund’s per share market value (the fund’s NAV). The NAV 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 valuation 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 $90.09. Mutual 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. We also expect the change in the fund's NAV to be positively related to the magnitude of the change in mutual fund valuation of the security and the weight of the private investment in the fund's overall portfolio. Indeed, this is what we find.

We examine the daily fund abnormal returns around the follow-on round of financing of the private company held by the mutual fund. For funds that hold private security *s*, the abnormal return on fund *f* on day *t* is defined as follows:

$$AR\_BMK_{f,s,t} = R_{f,t} - R_{BMK,t} \tag{7}$$

where $R_{f,t}$ ($R_{BMK,t}$) is the return on fund *f* (the fund's benchmark portfolio return) on day *t*. These fund benchmarks are based on the Lipper fund objectives obtained from the CRSP Mutual Fund Database. Denoting the follow-on round date for the issuer of private security *s* as day 0, the day 0 abnormal return for a fund *f* that holds the private security *s* is $AR\_BMK_{f,s,0}$. We compute the corresponding cumulative abnormal returns over a *k*-day window from day 0 to day *k*:

$$CAR\_BMK[0,k]_{f,s} = \left[\prod_{t=0}^{k} (1 + AR\_BMK_{f,s,t})\right] - 1 \tag{8}$$

Our empirical analysis is based on the cumulative abnormal returns averaged across fund-security pairs over the event window from day *a* to *b*, *CAR_BMK[a,b]*, and the standard errors are clustered by calendar days to account for cross-correlation in fund returns.

As reported in Panel A of Table 5, our sample consists of 476 fund-security observations, made up of 59 security-rounds with an average of 8 mutual funds holding the security. Accounting for private companies with multiple rounds of follow-on financing, the sample comprises 39 unique private companies held by 135 funds.[7] The follow-on round dates are established based on the data sources mentioned in the data section. 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,

We also split the sample into two groups by fund families. The first group consists of funds in the *Big 5* mutual fund families that most actively invest in private companies. They are Fidelity, T. Rowe Price, Hartford, American Funds, and Blackrock.[8] These 5 fund families participated in 47 of the private security rounds and account for 51 percent of the fund-security observations in our sample. The remaining funds are labeled as *Non-Big 5* fund families.

Panel A of Table 5 reports the cumulative abnormal fund returns over several windows around the follow-on funding date event. For the windows prior to the event, between day −10 and day −1, we do not observe any significant benchmark-adjusted returns. We obtain significant positive abnormal fund returns during the 3- to 10-day window after the event date. For example, for the 10-day (3-day) event window, the average *CAR_BMK* is economically significant at 43 bps (14 bps) with a *t*-stat of 2.62 (1.95).[9] The positive abnormal fund performance over the 10-day event window is significant for both the *Big 5* and *Non-Big 5* groups of mutual funds, implying that the predictability is not confined to funds heavily investing in private securities. Additionally, the impact of new funding round of private securities on overall fund returns does not persist as the *CAR*s are not different from zero beyond the 10-day post-event window. The findings on predictable abnormal fund performance are robust to adjusting daily mutual fund returns by the value-weighted market portfolio returns (i.e., *CAR_MKT*). As shown in Panel B of Table 5, we obtain similar positive abnormal returns when fund returns are

[7] The sample includes 14 companies with multiple follow-on rounds of financing, including Palantir (5 rounds), Bluearc, Nanosys, and Uber (3 rounds each), and the remaining 10 have 2 rounds each.
[8] This is based on the market value of the private-firm equity holdings as of Q2 2016, reported in Morningstar Manager Research, December 2016.
[9] In untabulated results, when we skip the event day to estimate the abnormal fund performance over [1,10] window, average *CAR_BMK* drops from 43 bps to 36 bps, indicating significant updating of private security valuations on the event day.

measured by *CAR_MKT* across event windows and sub-groups of funds. For instance, the 10-day *CAR_MKT* is economically similar at 56 bps (*t*-stat = 2.62).

In the wake of the 2003 mutual fund trading scandal, the SEC required “fund directors to consider whether to adopt a redemption fee, but the rule neither requires funds to adopt such a fee nor specifies the terms under which such a fee should be assessed.”[10] 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 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 17 of the 120 funds in the sample have redemption fees (based on data collected from funds’ N-SAR filings and prospectuses). For the 17 funds with redemption fees, the fees charged exceed the abnormal mean *CAR*s that we observe. So, we exclude these funds. For the remaining 103 funds (86% of the sample) without redemption fees, the average *CAR* (adjusted for returns on the benchmark or market portfolio) remain unchanged. As shown in Table 5, Panels C and D, the post-funding round 10-day *CAR* for funds with no redemption fee is economically large and statistically significant, between 46 to 57 bps.

Our finding is related to studies that document profitable trading opportunities in mutual funds due to stale pricing of public securities. For example, Chalmers, Edelen, and Kadlec (2001) document that non-synchronous trading of public securities held by domestic U.S. equity funds provides exploitable pricing errors in fund NAV. Bhargava, Bose, and Dubofsky (1998) show that the stale prices generate large abnormal returns in foreign equity funds. Additional evidence of stale stock prices predicting mutual fund returns is provided in Boudoukh, Richardson, Subrahmanyam, and Whitelaw (2002) and Zitzewitz (2006). We provide new evidence of trading opportunities when mutual funds invest in private securities: the valuation changes of these securities are infrequent, but lumpy and highly predictable.

4.2 Cross-Sectional Regressions of *CAR*s

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 has a big increase in a fund’s valuation after the new funding round. Since the exact weight of the private security in the fund’s portfolio

[10] https://www.sec.gov/news/press/2005-28.htm; https://www.sec.gov/rules/final/2006/ic-27504.pdf, p.16.

on the day of the new round is not available, we rely on the holdings of the security reported in the quarter before the financing round. We denote the percentage weight of each private security in a fund's portfolio as *WTPE*. Mutual funds, on average, hold 0.36% of their assets in private securities, although this weight varies significantly from 0.03% (10^{th} percentile) to 0.86% (90^{th} percentile) indicating substantial investment in private securities by some funds (figures not tabulated for brevity). We consider two measures of changes in the valuations. The first measure is the percentage change in valuation in the quarter after the new financing round, relative to the fund's prior valuation or Δ*Value.* 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 fund, labeled as *Update*. The average values of *Update* are higher compared to Δ*Value* (46% vs. 32%), which is consistent with slow updating of reported mutual fund valuations of private securities, at least by some funds, around new rounds of financing.

To examine the link between change in valuations and abnormal returns of fund *f* holding security *s* over *k* days following the new funding date, we regress $CAR\_BMK[0,k]_{f,s}$, on Δ*Value* × *WTPE*:

$$CAR\_BMK[0,k]_{f,s} = \alpha + \beta \Delta Value_{f,s} \times WTPE_{f,s} + \varepsilon_{f,s} \tag{9}$$

Under the hypothesis that the fund abnormal performance is significantly related to the changes in fund's valuation of private securities, we expect a positive coefficient, β. Moreover, if we have reasonable 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 holds 1% of Airbnb Series D and increases the valuation of the holding by 50% should experience an abnormal return of 0.5% in the fund return.

The estimate of the above regression model is presented in Table 6: benchmark-adjusted *CAR*s are reported in Panel A and market-adjusted *CAR*s in Panel B. The results are similar when change in valuations is measured by Δ*Value*×*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. For example, using the 10-day event window [0,10], the cross-sectional variation in the abnormal (benchmark- or market-adjusted) fund returns corresponds to the change in private security valuations, indicated by the point estimate of β close to 1.0 in Models (5) and (6). When we reduce the event window to 3 and 5 days, the β estimates are significantly positive but smaller in magnitude, consistent with the idea that some funds may not be updating their valuations immediately after the funding round. Also, any measurement error in the independent variable will downwardly bias estimates of the regression coefficient.

Overall, our findings suggest that changes in the valuation of private equities can have material effect on mutual fund returns, although their holdings tend to be small relative to the overall assets under management. Two factors contributing to this finding are: (i) follow-on rounds of securities issued by the private firms are often priced at a steep step up relative to the previous round issue price; and (ii) funds tend to keep the private securities at stale prices (i.e., near cost) until the next follow-on round events.

4.3 Fund Flows around Follow-on Rounds

If stale pricing and sizable markups lead to predictably large abnormal 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. Moreover, since redemption fees deprive investors of quick profit-making trading opportunities, any flow patterns hypothesized above would be stronger for mutual funds without redemption fees. Thus, we separately analyze funds without redemption fees.

We zoom into a subset of funds covered by Trimtabs that provides the daily flow data (i.e., 22 funds with 75 fund-security observations or 16% of observations in Table 5)[11], and measure abnormal fund flows around follow-on round dates using two distinct

[11] 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 (2018). 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

measures. Our first measure, the benchmark-adjusted abnormal flow of fund f holding security s on day t is defined as:

$$AF\_BMK_{f,s,t} = Flow_{f,t} - Flow_{BMK,t} \tag{10}$$

where $Flow_{f,t}$ is the percentage flow of fund f on day t, computed as the ratio of dollar flow to prior day's total net asset (TNA), and $Flow_{BMK,t}$ 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:

$$Z_{f,t} = \frac{Flow_{f,t} - \overline{Flow_f}}{\sigma_f} \tag{11}$$

where $Flow_{f,t}$ is the percentage flow of fund f on day t, $\overline{Flow_f}$ is the average daily flow of fund f in the same year, and σ_f is the standard deviation of daily flow of fund f in the same year. 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 average flows over the past year.

In Table 7, we report the benchmark-adjusted flows in Panel A and the z-score in Panel B for the whole sample. While the fund flows are generally more positive (negative) before (after) the follow-on round dates, the results are generally not statistically significant, perhaps because of the low power due to limited sample. In Panels C and D, we report results for funds without redemption fees and results are similar.

Furthermore, our inability to detect opportunistic trading by investors could be due to investors not yet being aware of such profitable trading opportunities and/or not possessing necessary information to time their mutual fund investments. If investors intend to exploit the stale pricing of private securities held by mutual funds and the subsequent mark up around follow-on rounds, they need to know funds' positions in private securities and latest valuations of those securities, as well as the date (or at least the time range) of a new funding round. This requires intensive search on the SEC EDGAR (Electronic Data Gathering, Analysis and Retrieval) system to identify the funds holding private securities and access information on funds' quarterly portfolio holdings. Moreover, current regulation allows for a delay of up to 60 days in funds' disclosing their holdings, which

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.

imposes another hurdle in implementing the timing strategy. Additionally, investors would need to track the new funding rounds on various websites such as TechCrunch, Equidate, and Business Insider to ascertain when prices are likely to be updated. Finally, investors need to know the timing of the update of private security value held by the fund. Together, these challenges likely make it too difficult for most fund investors to profit from infrequent updating of private security prices.

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 private equity have redemption fees. As the size of private equity markets is expected to keep growing, it is possible that mutual funds will hold significantly larger proportion of their portfolios in the future. Investors' behavior might change as the relative weights of private equity securities in mutual fund portfolios and thus the potential gain from these trades increase and the information required to execute these trades become more accessible over time (e.g., via entry by third-party data aggregators).

5. Do Managers Capitalize on Stale Pricing?

Having examined whether mutual fund investors exploit stale pricing by timing their buy (sell) trades into (out of) mutual funds holding private securities, now we turn to the behavior of mutual fund managers. The illiquidity and resulting stale pricing practices of private securities provide mutual fund managers with wider reporting discretion than with their public security holdings.

Two features of the institutional setting are worth noting. First, fund managers with private security holdings know precisely when the opportunities to exploit (i.e., follow-on funding events for companies whose earlier-round securities they already own) arise and how much discretion they have to mark up (or down) the security, because as existing investors in the startups they receive real-time information about upcoming follow-on funding events and are even positioned to approve the pending deal. This is in contrast to fund investors, who have to overcome information asymmetry in order to exploit the profitable trading opportunities.

Second, we also document in earlier section that private security valuation appears to be set at the fund family level and there is little dispersion in valuation across funds within a fund family. This is likely a result of a common practice in which a family-level valuation committee has the final say in setting the valuation of illiquid securities. While to the best of our knowledge it is not illegal for individual fund managers within a fund family to hold illiquid securities at different valuations at a given point in time, doing so carries investor litigation risk, so the fund families appear to impose a common valuation across all of their affiliate funds in most cases. In such a setting, it is plausible that fund managers lobby the family-level valuation committee to manage valuation of their private security holdings in ways that maximize their fund's inflows. Given their own incentives to maximize family fee revenues, fund families in turn may choose to strategically set the valuation of private securities in ways that benefit their high-value funds the most – e.g., boosting their recent top performing funds' returns at year ends so as to catapult them to the top of league tables. In other words, fund families may exploit stale pricing by selectively unleashing the dry powder (unused markup of private securities) when it is in the families' best interest to do so.

To shed light on the extent to which mutual fund families strategically manage private security valuation, we examine the following two questions. First, how do fund families allocate their newly bought private securities among their affiliated funds? Do they prioritize high-value funds such as recent top performers and high-fee funds, or do they evenly spread the securities across many divergent groups of funds? This question sets the stage for the main question: Do fund families upwardly manage their security valuation when doing so pushes up the ranking of their top-performing funds in the league tables near the year end? We study this question by a diff-in-diff comparison of *CAR*s around follow-on round dates and quarterly valuation changes for top-20% performers vs. bottom-80% performers, and in first three quarters vs. the fourth quarter of the year.

5.1 Fund Families' Allocation Decisions

In this sub-section, we investigate how mutual fund families allocate private securities among funds within the family. First, fund families may prioritize allocations to funds skilled at investing in startups or that specialize in certain investment styles (e.g., growth funds). Second, fund families aiming to maximize the overall family profits may favor high family value funds, i.e., high past performers or high fee funds (e.g., Gaspar, Massa, and Matos 2006). To understand the determinants of within family allocations, we estimate the following cross-sectional regressions:

$$
\begin{aligned}
Allocation_{f,s,q} &= \alpha + \beta_1 RETBMK_{f,q-1} + \beta_2 Dollar\ Fee_{f,q-1} \\
&\quad + \beta_3 Experience_{f,q-1} + \gamma_1 M_{f,q-1} + \gamma_2 N_{s,q-1} + \varepsilon_{f,s,q}
\end{aligned}
\tag{12}
$$

where $Allocation_{f,s,q}$ refers to two proxies for the private security allocation within a fund family ($PctShr_{f,s,q}$ and $DumShr_{f,s,q}$). $PctShr_{f,s,q}$ is computed as the number of security *s* shares allocated to fund *f* in quarter q divided by the total number of security *s* shares acquired by the family in the same quarter when security *s* is issued in a new funding round in quarter q. $DumShr_{f,s,q}$ refers to an indicator variable that equals one if fund *f* receives an allocation of security *s* in quarter *q* and zero otherwise. $RETBMK_{f,q-1}$ is the cumulative benchmark-adjusted return of fund f in the past year (from quarter *q–4* to *q–1*). $Dollar\ Fee_{f,q-1}$ is the dollar fee amount of fund *f* in quarter *q–1*, computed as fund total net assets (TNA) multiply by the expense ratio. $Experience_{f,q-1}$ refers to two proxies for fund experience in private equity investment in periods up to end of quarter *q–1* ($PE_{f,q-1}$ and $Ln(PE\ Experience)_{f,q-1}$). $PE_{f,q-1}$ is an indicator variable that equals one if fund *f* has invested in private equities in the past. $Ln(PE\ Experience)_{f,q-1}$ is the logarithm of the number of months since the first investment in private equity by fund *f*. Fund experience incorporates the appropriate investment styles for private startups, and serves as a reasonable proxy for managerial skill in private equity investment. For instance, skilled fund managers with sophisticated knowledge and expertise in pre-IPO firms are likely to receive early allocation and accumulate more experience (selection channel). Alternatively, more experienced funds could turn out to be more skilled as they learn and improve over time (learning channel). The vector *M* stacks all other fund-level control variables, including *Ln(Fund Age)*, defined as the logarithm of the number of months since fund inception; and *Turnover*, defined as the annualized fund turnover ratio. The vector *N* stacks security-level control variables, including *Ln(Deal Size)*, defined as the logarithm of the deal size of the new funding round; and *NumFam*, defined as the number of mutual fund families participating in the new round. We consider all fund families participating in a new funding round and all active equity mutual funds within those families. We also include family-quarter fixed effects to focus on the within-family variation in fund characteristics. The standard errors are clustered at the fund level to address the potential autocorrelation in fund characteristics.

We report the results in Table 8, Models (1) to (5) for *PctShr* and Models (6) to (10) for *DumShr*. Several findings are noteworthy. In unreported results, we find that on average 2 fund families participate in a new funding round, and the shares are allocated to 2.7 funds within family. Only 8% of funds within a family receive an allocation given a new round, implying a potential competition to obtain the private security shares. Model (1) of Table 8 suggests that high family value funds such as those with superior past performance and high dollar fees receive bigger allocation of the new security. Model (2) further investigates funds' prior experience in private security investments and shows that experienced funds (*PE=1*) receive 5.2% more allocation, consistent with some funds specializing in such securities. More importantly, high family value funds receive bigger allocation after controlling for the persistence in new round allocations. The economic effect is sizable. In Model (2), for instance, a one standard deviation increase in the benchmark-adjusted return (dollar fee) is associated with a 0.53% (1.47%) increase in percentage shares allocated,[12] and this accounts for 34% (95%) of the sample mean (the average *PctShr* is 1.55%). In Model (4), the level of *RETBMK* and *Dollar Fee* are no longer significant when these variables are interacted with *PE*, while the interaction effects are positive and statistically significant. This indicates that past performance and fee revenue matter in allocation to funds that already hold private securities. When we replace *PE* with *Ln(PE Experience)* in Models (3) and (5), we continue to find bigger allocations to high value funds. Finally, we examine the likelihood of a fund receiving an allocation and obtain similar results in Models (6) to (10). In Model (7), a one standard deviation increase in the benchmark-adjusted return (dollar fee) is associated with a 1.64% (2.70%) increase in the likelihood of a fund receiving an allocation. Meanwhile, prior experience in private equity investment increases the likelihood to receive new allocation by 13%. This represents a drastic increase compared to an unconditional probability of 3.9% —i.e., 3.9% of all fund-

[12] The impact of benchmark-adjusted return on shares allocation is 0.53%, computed as 0.096% × 5.474, where 0.096% is the regression coefficient in Model (2) and 5.474 is the standard deviation of *RETBMK*. Similarly, the impact of dollar fee on shares allocation is 1.47%, computed as 28.288% × 0.052, where 28.288% is the regression coefficient in Model (2) and 0.052 is the standard deviation of *Dollar Fee*.

security pairs in sample receive an allocation. As a robustness check, unreported results show that our findings remain intact if we further control for the level of fund TNA and expense ratio in addition to dollar fee. Moreover, if we replace dollar fee with fund TNA and expense ratio, we find that large funds and high fee funds receive more allocation in general. However, the expense ratio is no longer significant once we control for the PE experience, potentially due to the lack of cross-sectional variation in expense ratio among experienced funds in similar investment styles.

Overall, the empirical evidence suggests that funds are allocated with new private securities primarily because they already invest in private startups. Among these funds, fund families favor high family value funds, i.e., high past performers and high fee funds. The priority given to high family value funds could be related to the strategic behavior of mutual fund families. For instance, high past performers are more likely to be ranked close to the top performers across all funds and benefit from the discretionary pricing of private securities. We further investigate such strategic behavior in the next sub-section.

5.2 Diff-in-Diff Analysis of CARs and Valuation Changes around Follow-on Rounds

Investments in private companies afford considerable discretion to mutual fund families who at times might use this discretion to improve periodic fund returns. For example, if follow-on round events occur towards the end of the calendar year, fund families may strategically time the mark up of existing (earlier-round) security holdings before the end of the year to boost the current year returns, or to delay marking up the security until the beginning of next year. We conjecture that funds that have outperformed their peers in the first three quarters have the strongest incentives to mark up the value of existing private securities around follow-on round events in the fourth quarter because they are expected to gain the most from doing so given the convexity in the fund flow-performance relation (Sirri and Tufano 1998).

We examine this conjecture by calculating the difference-in-differences (DID) in two ways. First we compare the *CAR*s after follow-on rounds in quarter 4 (Q4) to the *CAR*s during the first three quarters of the year (Q1-Q3), sorted by the fund's performance rank as of the end of the third quarter (top 20% vs. bottom 80%).[13] We restrict the analysis to

[13] Following Sirri and Tufano (1998), we initially sorted all sample mutual funds into top 20%, middle 60%, and bottom 20%, but the bottom 20% group contained only 8 funds that met the screening criteria for this

funds that hold securities with follow-on events in both Q1-Q3 and Q4 so that we are observing the changing behavior of the same funds across quarters, conditional on where they fall in the league tables entering Q4. The results from abnormal return analysis are presented in Table 9. Panel A presents *CAR*s based on benchmark-adjusted *CAR*s; Panel B presents *CAR*s based on market-adjusted *CAR*s. In Panel A, the top-20% funds have mean 5-day (10-day) *CAR* of 49 (72) bps around fourth-quarter follow-on events. Both *CAR*s are significantly larger than the *CAR* associated with follow-on rounds in the first three quarters (22 bps with *t*-stat for the difference = 2.03 for the 5-day *CAR*, and 38 bps with *t*-stat for the difference = 2.73, respectively). This is in sharp contrast to the bottom-80% funds for which there is no evidence that markup is more aggressive in the fourth quarter; if anything, the opposite is true. The DID (Top − Bottom) is positive and statistically significant for all three windows, ranging from 51 bps to 87 bps. The results presented in Panel B using market-return-adjusted *CAR*s are qualitatively similar.

In our second analysis, we examine the quarterly security valuation changes for the same set of funds in Q4 relative to Q1-Q3. We focus on the valuation changes multiplied by the weight of the private security in the fund's portfolio (*WTPE*) since this variable maps directly into the incremental effect that the valuation change will have on the mutual fund's return. In Panel A of Table 10, we present results for the percentage valuation change from quarter *q−1* to *q*, $\left[\left({V_q}/{V_{q-1}}\right)-1\right]\times WTPE$, the log version of the valuation change $ln\left({V_q}/{V_{q-1}}\right)\times WTPE$, and the weights invested in private securities (*WTPE*). We find that the top 20% funds in Q4 have significantly larger valuation changes than the same funds in Q1-Q3 (0.28% vs. 0.15%). In contrast, we do not observe a significant difference in the markup behavior of bottom 80% funds from Q4 to Q1-Q3 (0.12% vs. 0.10%). The DID (Top − Bottom) of 0.109% is significant at the 10% level. The results are similar when we compare the log version and yield a DID of 0.074% (We do observe greater weights in the private securities held by top 20% funds, but these weights are similar across quarters and the DID is a very small and insignificant 0.002).

analysis – i.e., the fund had securities issued by at least 1 firm that had a follow-on round in the first three quarters, and at least 1 firm that had a follow-on round in the last quarter. Since this group was too small, we combined it with the middle 60%.

In Panel B of Table 10, we decompose the log valuation change into three components:

$$ln\left({V_q}\Big/{V_{q-1}}\right) \times WTPE$$
$$= \left[ln\left({V_q}\Big/{DEAL_s}\right) + ln\left({DEAL_s}\Big/{DEAL_{s-1}}\right) - ln\left({V_{q-1}}\Big/{DEAL_{s-1}}\right)\right] \times WTPE \quad (13)$$

$DEAL_s$ is the deal price for the s^{th} follow-on offering for a company (which occurs in quarter q), and $DEAL_{s-1}$ is the deal price for the prior deal. Thus, the decomposition consists of three components: (1) the end-of-quarter valuation relative to the deal in quarter q, $\ln\left({V_q}\Big/{DEAL_s}\right)$, (2) the deal-over-deal price change, $\ln\left({DEAL_s}\Big/{DEAL_{s-1}}\right)$, and (3) the valuation at the beginning of quarter q relative to the prior deal price, which measures how much the fund has marked up the security since the prior deal, $\ln\left({V_{q-1}}\Big/{DEAL_{s-1}}\right)$. Note that the DID for the log valuation change of 0.074 in Panel A consists of the three components, respectively (i.e., 0.074 = (0.016) + (–0.006) – (–0.064)).

The decomposition results of Panel B, Table 10, indicate most of the difference that we observe in the valuation change of top 20% in Q4 can be traced to the third component, i.e., the low markup of securities entering Q4, and to a lesser degree to the first component, or the quick full markup of securities by the end of Q4. In the first component, $\ln\left({V_q}\Big/{DEAL_s}\right)$, we observe that valuation prices in quarter q is significantly below the deal price in quarter q for the bottom 80% funds as well as the top 20% funds in the first three quarters, whereas valuation prices for the top 20% funds in Q4 is fully matched to the deal price in quarter q, suggesting immediate full markup employed by the 20% funds in Q4. However, the DID (Top-Bottom) is not significant and magnitude is modest (0.016). In the second component, $\ln\left({DEAL_s}\Big/{DEAL_{s-1}}\right)$, we observe the top 20% either hold larger security holdings (*WTPE*) or have better deals than the bottom 80% but this is true in all quarters and the DID between the top 20%/bottom 80% is immaterial (−0.006). However, the third component, $\ln\left({V_{q-1}}\Big/{DEAL_{s-1}}\right)$, indicates top 20% funds enter the fourth quarter with securities that are marked up less than what we observe in Q1-Q3 and this DID is significant (–0.064, *t*-stat = –2.77). This is consistent with fund families anticipating follow-on deals in the fourth quarter (as existing investors they receive real time updates from the startup company of its funding prospects as well as their remaining cash) save up their unused markups for unleashing in the fourth quarter if the securities are held by their recent top-performing funds. Alternatively, mutual funds are more conservative in pricing the private securities if they generate superior concurrent performance on their entire portfolios in the first three quarters. Either way, the result is that they have more "dry powder" coming into Q4 to strategically time the markup at year ends.

Note that the behavior of marking up securities in Q4 is merely shifting returns from prior or future quarters to Q4. The incentive exists because the extra boost in performance is more rewarding when you are in the more convex portion of the flow-return relation. To get a sense for the economic magnitude of this effect, we regress monthly fund flows on lagged annual benchmark-adjusted return for the fund and that return interacted with a dummy variable for a fund being in the top 20% (with controls for fund style, log TNA, annual return standard deviation, and fees). The resulting coefficient on the benchmark-adjusted return is 0.013, while the interaction of top-20% and the return yields a coefficient of 0.010 (for a total effect of 0.023). Thus, a 30-bps increase in returns in a top 20% year would imply greater flows by $0.010 \times 0.3 = 0.3\%$ compared to a 30-bps return increase in a bottom 80% year. This analysis affirms our interpretation of the top-20% Q4 behavior as opportunistic NAV management for the purpose of maximizing flows.[14]

To summarize, our analysis suggests that mutual fund families opportunistically unleash the dry powder (un-used markup of private securities) to boost the year-end performance of their recent top performers when these high-priority funds' private security holdings experience follow-on rounds near the year end. The fund families are likely richly

[14] In light of prior literature such as Cici, Gibson, and Merrick (2011), we also examine whether funds engage in return smoothing by failing to mark down private company valuations in a bear market, which would result in a performance boost for the fund in these down markets. Specifically, we add a *down market dummy* that takes a value of one if the market risk premium in the current quarter is less than zero and is zero otherwise to the six models shown in Table 4. If funds smooth returns over time, this indicator variable would be reliably positive. The results are reported in Internet Appendix Table A2. In all six specifications, the estimated coefficient is positive (and economically large at > 4% per quarter in Models (1) to (2) and Models (5) to (6), but imprecisely estimated; we cannot reject the null hypothesis that private security valuation changes are similar in bull and bear markets.

rewarded from their actions by the sharply higher flows that these funds attract when their year-end performance is pushed to the top of the league table.

6. Conclusion

We provide novel empirical evidence on the valuation of private companies held by mutual funds and examine the potential strategic behavior of investors and fund families. Our analysis highlights emerging issues that should be considered as we allow mutual funds, which are the primary investment vehicle for many individual investors, to hold more difficult-to-value private securities.

We find the valuations of private securities are frequently stale, changing on average once every 2.5 quarters. When new securities on the private company are issued, the deal prices in these offerings serve as a valuation anchor for *both* the newly issued security and securities issued in earlier funding rounds. In 38% of all fund-security-quarter observations, the prices of private securities are posted at a deal price. This number jumps to 82% when the security was part of a deal in the most recent quarter.

We observe large differences in the valuation of the same private security reported by different fund families. The average dispersion (standard deviation) in the prices across multiple fund families holding a private security is 10.0%, which translates to about $3 for a security priced at $19. In 10% of quarters, this price dispersion exceeds 25%. In contrast to the dispersion observed at the fund family level, we observe virtually no dispersion in prices across funds within the same family, perhaps because valuation committees assure similar valuations across funds within the same family. Since private security valuations feed directly into the daily NAVs that determine investors' transaction prices, the differences in prices across fund families indicate mutual fund investors are buying into these private securities at different prices.

These pricing dynamics, generally stale prices with infrequent but large markups, provide a trading opportunity for investors. Investors might capitalize on the stale pricing by buying funds in the days prior to a large markup in the private security. A natural place where this markup is likely to occur is around a follow-on series offering, which are generally accompanied by large deal-over-deal price changes (averaging 51% in our sample). This large deal-over-deal price increase leaves a discernable footprint in fund returns. Defining the new funding round date as the event day, we find the average cumulative abnormal fund return is an economically and statistically significant 31 bps (43 bps) in the 5-day (10-day) window following the funding round. Consistent with these returns being linked to the private securities, we show that the post-funding abnormal returns are positively related to estimates of the economic significance of the impact of the valuation change on fund returns (i.e., quarter-end weight in the private security times the ratio of the deal price to the most recently observed security valuation).

Investors might capitalize on these pricing dynamics by buying funds in the days prior to a follow-on funding event and selling the funds afterward. Despite this opportunity, we do not find evidence that investors currently capitalize on these pricing dynamics in an analysis of daily fund flows for a limited subsample of funds (22 funds and 75 fund-security events). Despite observing generally positive (negative) flows in the 5-day window before (after) the event, we cannot reject the null hypothesis that the abnormal flows are zero. We may lack power to reject the null because we have a limited sample size. It is also possible investors lack easy and quick access to information on the identity of funds holding private securities, funds' positions in these securities and the timing of new funding rounds. As more private companies seek large funding rounds from mutual fund companies, it is likely that more funds will hold private securities and the holdings of private securities will become economically large. Consequently, information about private security positions of funds may become more readily available to fund investors, offering them opportunities to profit from significant stale pricing of private securities. Viewed from this perspective, our results provide a warning about a potential timing opportunity.

Finally, we provide evidence that fund families are strategic in the allocation of private securities to funds and the valuation of those securities. Fund families tend to allocate private securities to high value funds, such as those with strong recent performance or high fees. Furthermore, we find funds near the top of the league tables have greater valuation markups around fourth quarter follow-on events. Specifically, the abnormal fund returns and valuation changes following the follow-on fund events are larger when follow-on fund events occur near the calendar year-end, *and* if the funds holding the private securities performed in the top 20% among their peers in the first three quarters of the year. This result suggests funds near the top of league tables might be more vigilant in assuring fund families approve swift valuation markups for the securities they hold before the year closes. These results are consistent with the "leaning for the tape" behavior documented in other settings for mutual funds.

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Table 1. Price dispersion in private company valuations by mutual funds, 2010 to 2016

Panel A presents summary statistics for the number of funds that hold the same security in a given quarter (*NumFd*). Panel B presents summary statistics for the price dispersion measures. Price dispersion (*DispPrc_Avg*) is computed as the standard deviation of prices across funds in the same quarter ending in the same month (*StdPrc*) divided by the average security price across funds (*AvgPrc*). *DispPrc_Med* is computed as the standard deviation divided by median price (*AvgMed*). Panel C calculates price dispersion within fund families, which yields multiple observations for the same security in the same quarter. Panel D calculates price dispersion across fund families (average price is first calculated within the fund family to generate a price dispersion measure). The sample period is from 2010 to 2016.

	No. Firm	No. Security	Security-Quarter Obs.	Mean	Std. Dev.	10%	25%	Median	75%	90%
Panel A: Security-Quarters (Full Sample)										
NumFd	106	170	1,359	8.435	6.547	2	3	7	11	18
Panel B: Security-Quarters (with same ending month) (Full Sample)										
DispPrc_Avg	106	170	2,274	0.039	0.084	0.000	0.000	0.000	0.049	0.130
DispPrc_Med	106	170	2,274	0.040	0.090	0.000	0.000	0.000	0.048	0.128
StdPrc	106	170	2,274	0.719	2.034	0.000	0.000	0.000	0.440	1.900
AvgPrc	106	170	2,274	16.153	23.367	2.566	4.581	8.467	16.730	32.390
MedPrc	106	170	2,274	16.232	23.547	2.565	4.581	8.432	16.860	33.300
Panel C: Within Family, Family-Security-Quarters (with the same ending month)										
NumFd	98	154	2,463	2.970	1.483	2	2	3	3	5
DispPrc_Avg	98	154	2,463	0.003	0.031	0.000	0.000	0.000	0.000	0.000
DispPrc_Med	98	154	2,463	0.003	0.030	0.000	0.000	0.000	0.000	0.000
StdPrc	98	154	2,463	0.029	0.310	0.000	0.000	0.000	0.000	0.001
AvgPrc	98	154	2,463	17.592	23.155	2.835	4.911	9.775	18.997	40.713
MedPrc	98	154	2,463	17.597	23.155	2.835	4.911	9.776	18.970	40.713
Panel D: Across Families, Security-Quarters (with the same ending month)										
NumFam	50	84	860	3.103	1.510	2	2	2	4	5
DispPrc_Avg	50	84	860	0.100	0.133	0.000	0.002	0.060	0.143	0.246
DispPrc_Med	50	84	860	0.103	0.155	0.000	0.002	0.058	0.143	0.251
StdPrc	50	84	860	1.895	3.600	0.000	0.028	0.705	2.046	4.817
AvgPrc	50	84	860	21.937	27.808	3.299	5.991	14.000	22.737	47.149
MedPrc	50	84	860	22.064	28.311	3.298	5.991	14.000	22.698	48.772

Table 2. 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 and public securities. For private securities, we also calculate the number of quarters until prices are updated from the acquisition price.

	No. Security	Obs.	Mean	Std. Dev.	10%	25%	Median	75%	90%
Panel A: Family-Security-Quarter Return Characteristics									
Return_PVT	229	4,286	0.033	0.257	-0.162	-0.015	0.000	0.044	0.229
Return_PUB	6,416	148,841	0.026	0.217	-0.188	-0.073	0.023	0.119	0.227
Panel B: Family-Security Return Characteristics									
%Zero Return_PVT	229	474	0.486	0.332	0.000	0.200	0.467	0.750	1.000
Qtr to Update_PVT	229	474	2.485	1.976	1	1	2	3	5
%Zero Return_PUB	6,416	18,373	0.003	0.052	0	0	0	0	0

Table 3. 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 and the benchmark price for the same security, ($Dev_{F,s,q} = \frac{P_{F,s,q}}{B_{s,q}} - 1$). $Dummy(Dev)$ is an indicator variable that equals one if the absolute value of *Dev* is above 1% and zero otherwise. $Dummy(Dev^{+})$ is an indicator variable that equals one if *Dev* is above 1% and zero otherwise, and $Dummy(Dev^{-})$ 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.

	No. Firm	No. Security	∑ Dummy (Dev)	No. Family-Security-Quarters	%Dev
Panel A: Deviation of Security Valuation					
Any Prior Deal Price	139	229	2,972	4,796	0.620
Latest Deal Price	139	229	3,008	4,763	0.632
Acquisition Price	137	224	3,560	4,653	0.765
Family-Firm Average Price	39	132	588	2,413	0.244

Event Quarter	No. Firm	No. Security	%Dev	%Dev^{+}	%Dev^{-}	Median Dev^{+}	Median Dev^{-}
Panel B: Deviation of Early Round Security Valuation from the New Round Deal Price							
−4	22	38	1.000	0.029	0.971	0.100	-0.387
−3	26	45	1.000	0.026	0.974	0.124	-0.317
−2	30	55	0.993	0.075	0.918	0.143	-0.312
−1	33	59	0.967	0.119	0.848	0.206	-0.281
0	36	71	0.418	0.077	0.341	0.226	-0.202
1	35	70	0.561	0.118	0.443	0.164	-0.134
2	32	61	0.558	0.179	0.379	0.186	-0.211
3	27	56	0.639	0.294	0.344	0.280	-0.309
4	25	49	0.778	0.247	0.531	0.269	-0.208
Panel C: Deviation of New Round Security Valuation from the New Round Deal Price							
0	85	108	0.184	0.034	0.150	0.184	-0.100
1	80	103	0.345	0.118	0.227	0.160	-0.100
2	73	93	0.478	0.248	0.230	0.199	-0.100
3	66	84	0.671	0.430	0.242	0.347	-0.131
4	56	72	0.773	0.436	0.337	0.367	-0.147

Table 4: Quarterly private company alphas

This table presents the results of a pooled regression of fund family-security-quarter percentage valuation changes (less the risk-free rate) of private companies held by mutual funds on factor returns (market risk premium, size, and value factors of Fama and French, 1993) and market condition (follow-on funding quarter for the company). Three models are estimated: (1) a one-factor market model with no lags, (2) a one-factor market model with two lags, and (3) a three-factor model with two lags of market, size, and value factors. Models 1 to 3 present a single alpha estimate. Models 4 to 6 include an indicator variable *Follow-on Dummy*, that equals one in quarters when the company engages in a follow-on funding round and zero otherwise. Standard errors are clustered by quarter.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: Coefficient Estimates and Regression Statistics						
Alpha	0.029**	0.005	0.014	0.009	-0.015	-0.005
	(2.23)	(0.38)	(0.94)	(0.73)	(-1.22)	(-0.33)
Follow-on Dummy				0.351***	0.350***	0.333***
				(4.94)	(5.18)	(5.01)
MKTRET	0.317	0.440**	0.567**	0.403**	0.525***	0.562***
	(1.62)	(2.21)	(2.61)	(2.11)	(2.94)	(2.78)
$MKTRET_{t-1}$		0.604***	0.663**		0.601***	0.630***
		(3.33)	(2.41)		(3.99)	(2.80)
$MKTRET_{t-2}$		0.467*	0.252		0.455**	0.282
		(1.88)	(1.09)		(2.17)	(1.44)
HML			-0.700***			-0.596***
			(-5.29)			(-4.30)
HML_{t-1}			-0.038			-0.012
			(-0.15)			(-0.05)
HML_{t-2}			-0.360			-0.158
			(-1.04)			(-0.54)
SMB			0.530**			0.506**
			(2.31)			(2.24)
SMB_{t-1}			0.119			0.097
			(0.37)			(0.35)
SMB_{t-2}			1.067***			0.796***
			(3.25)			(2.86)
R-squared	0.004	0.025	0.051	0.092	0.112	0.129
Observations	4,322	4,322	4,322	4,322	4,322	4,322
Panel B: Summed Factor Exposures						
Market Beta	0.317	1.511***	1.482**	0.403**	1.581***	1.474***
	(1.62)	(3.33)	(2.64)	(2.11)	(4.16)	(3.19)
HML Tilt			-1.098**			-0.766*
			(-2.54)			(-1.91)
SMB Tilt			1.717***			1.399***
			(4.44)			(3.62)

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 5. Mutual fund returns around follow-on financing found of private equity holdings

For each round of follow-on financing for a private security s, the abnormal return on fund f on day t is defined as $AR\_BMK_{f,s,t} = R_{f,t} - R_{BMK,t}$, where $R_{f,t}$ ($R_{BMK,t}$) is the return on fund f (the fund's benchmark portfolio) on day t. The cumulative abnormal returns (*CAR*s) from day a to day b is: $CAR\_BMK[a,b]_{f,s} = \left[\prod_{t=a}^{b}(1 + AR\_BMK_{f,s,t})\right] - 1$, and we then average $CAR\_BMK[a,b]_{f,s}$ across fund-security pairs to obtain $CAR\_BMK[a,b]$. In particular, day 0 refers to the follow-on round date for private security s. *CAR*s based on the value-weighted market index returns are analogously defined and reported in Panel B. Standard errors are clustered by calendar days (filing date of follow-on security-round). The number of securities, funds, average number of funds per security and fund-security observations are reported. *Big 5* refers to the sub-sample of mutual fund families that most actively invest in private companies, comprising of Fidelity, T. Rowe Price, Hartford, American Funds, and Blackrock. *Non-Big 5* refers to all funds excluding the *Big 5* funds. We exclude funds that do not hold the security s after the follow-on round. Panels C and D report similar statistics on benchmark-adjusted *CAR*s and market-adjusted *CAR*s when we only include funds that do not charge redemption fees at the time of the follow-on round.

	No. Security	No. Fund	Funds per Security	Fund-Security Obs.	CAR [−10, −1]	[−5, −1]	[−3, −1]	[0, 3]	[0, 5]	[0, 10]	[11, 15]	[16, 20]
Panel A: Benchmark-adjusted CAR (CAR_BMK) around Follow On Round												
All Funds	59	135	8	476	0.095	0.043	0.037	0.141*	0.311***	0.429**	-0.129	-0.042
					(0.73)	(0.55)	(0.62)	(1.95)	(2.70)	(2.62)	(-1.43)	(-0.54)
Big 5	47	50	5	241	0.187	0.095	0.037	0.123	0.197**	0.300***	-0.055	0.009
					(1.32)	(0.95)	(0.47)	(1.48)	(2.56)	(2.84)	(-0.67)	(0.09)
Non-Big 5	32	85	7	235	0.000	-0.011	0.036	0.159	0.428**	0.561*	-0.205	-0.093
					(0.00)	(-0.11)	(0.49)	(1.56)	(2.33)	(1.95)	(-1.41)	(-0.96)
Panel B: Market-adjusted CAR (CAR_MKT) around Follow On Round												
All Funds	59	135	8	476	0.256	0.128	0.072	0.224*	0.405***	0.558**	-0.139	-0.020
					(1.33)	(1.11)	(0.77)	(1.94)	(2.84)	(2.62)	(-1.12)	(-0.19)
Big 5	47	50	5	241	0.332	0.168	0.038	0.293*	0.396***	0.516***	-0.150	-0.004
					(1.58)	(1.10)	(0.30)	(1.93)	(2.98)	(3.08)	(-1.05)	(-0.03)
Non-Big 5	32	85	7	235	0.178	0.086	0.108	0.154	0.414**	0.601*	-0.128	-0.037
					(0.64)	(0.71)	(1.12)	(1.27)	(2.05)	(1.71)	(-0.73)	(-0.33)
Panel C: Benchmark-adjusted CAR (CAR_BMK) around Follow On Round (Funds without Redemption Fee)												
All Funds	49	103	8	398	0.085	0.045	0.054	0.191**	0.363***	0.461**	-0.126	-0.014
					(0.60)	(0.60)	(0.94)	(2.59)	(2.82)	(2.51)	(-1.26)	(-0.17)
Big 5	44	39	5	214	0.187	0.126	0.055	0.199***	0.258***	0.354***	-0.019	0.055
					(1.45)	(1.57)	(0.88)	(2.80)	(3.95)	(3.77)	(-0.22)	(0.62)
Non-Big 5	24	64	8	184	-0.033	-0.049	0.052	0.180	0.486**	0.586	-0.251	-0.093
					(-0.14)	(-0.46)	(0.62)	(1.50)	(2.19)	(1.68)	(-1.49)	(-0.79)
Panel D: Market-adjusted CAR (CAR_MKT) around Follow On Round (Funds without Redemption Fee)												
All Funds	49	103	8	398	0.220	0.123	0.081	0.284**	0.461***	0.571**	-0.119	0.037
					(1.06)	(1.10)	(0.92)	(2.52)	(2.97)	(2.36)	(-0.92)	(0.34)
Big 5	44	39	5	214	0.284	0.193	0.059	0.364***	0.452***	0.538***	-0.087	0.095
					(1.43)	(1.55)	(0.60)	(2.89)	(4.07)	(3.71)	(-0.72)	(0.71)
Non-Big 5	24	64	8	184	0.145	0.042	0.106	0.189	0.472*	0.609	-0.156	-0.031
					(0.43)	(0.30)	(1.00)	(1.37)	(1.92)	(1.39)	(-0.75)	(-0.22)

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 6. Regression of abnormal mutual fund returns on its exposure to private securities

Panel A presents the results of the following cross-sectional regressions (across funds and private securities) and the corresponding *t*-statistics with standard errors clustered by calendar days (filing date of follow-on security-round):

$CAR\_BMK[0,k]_{f,s} = \alpha + \beta \Delta Value_{f,s} \times WTPE_{f,s} + \varepsilon_{f,s}$,

where $CAR\_BMK[0,k]_{f,s}$ refers to the cumulative abnormal returns (adjusted for the fund benchmark portfolio returns) of fund f holding private security s over from day 0 to day k, where day 0 is the follow-on funding round date, and k takes the value of 3, 5, or 10. $\Delta Value_{f,s}$ refers to the percentage change in the valuation by fund f of the private security s reported in the quarter after the new financing round, relative to the fund's valuation in the quarter before the new round, and $WTPE_{f,s}$ refers to the investment weight of fund f in security s according to the latest holdings. $\Delta Value_{f,s}$ is further replaced with $Update_{f,s}$, 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 fund f. Panel B reports similar statistics when $CAR\_BMK[0,k]_{f,s}$ is replaced with $CAR\_MKT[0,k]_{f,s}$, defined as cumulative abnormal returns adjusted by the value-weighted market index returns.

CAR After Follow On Round Regressed on Change in Valuation and Fund Holding						
	[0, 3]		[0, 5]		[0, 10]	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: Benchmark-adjusted CAR (CAR_BMK)						
∆Value × WTPE	0.375***		0.432***		0.788**	
	(3.49)		(3.74)		(2.46)	
Update × WTPE		0.384***		0.410***		0.812**
		(3.51)		(3.33)		(2.44)
Constant	0.079	0.086	0.204*	0.243**	0.319**	0.326**
	(1.16)	(1.18)	(1.92)	(2.24)	(2.20)	(2.18)
R-squared	0.034	0.032	0.024	0.022	0.043	0.042
Obs	508	482	510	484	510	484
Panel B: Market-adjusted CAR (CAR_MKT)						
∆Value × WTPE	0.455***		0.429***		0.550**	
	(4.44)		(3.09)		(2.13)	
Update × WTPE		0.422***		0.333*		0.520*
		(3.49)		(1.73)		(1.69)
Constant	0.135	0.158	0.274*	0.342**	0.459**	0.489**
	(1.18)	(1.28)	(1.95)	(2.36)	(2.41)	(2.40)
R-squared	0.021	0.016	0.013	0.008	0.013	0.010
Obs	508	482	510	484	510	484

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 7. Mutual fund flows around follow-on financing found of private equity holdings

In Panel A, for each round of follow-on financing for a private security s, the abnormal flow of fund f on day t is defined as $AF\_BMK_{f,s,t} = Flow_{f,t} - Flow_{BMK,t}$, where $Flow_{f,t}$ is the percentage flow of fund f on day t, computed as the ratio of dollar flow to prior day's total net asset (TNA). $Flow_{BMK,t}$ 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 $Z_{f,t} = (Flow_{f,t} - \overline{Flow_f})/\sigma_f$, where $Flow_{f,t}$ is the percentage flow of fund f on day t, $\overline{Flow_f}$ is the average daily flow of fund f in the same year, and σ_f is the standard deviation of daily flow of fund f in the same year. Denoting the follow-on 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-security pairs. Standard errors are clustered by calendar days (filing date of follow-on security-round). The number of securities, funds, average number of funds per security and fund-security observations are reported. We exclude funds that do not hold the security *s* after the follow-on round. 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.

No. Security	No. Fund	Funds per Security	Fund-Security 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 Flow around Follow On Round													
31	22	2	75	0.098	0.095	0.086	0.059	0.048	-0.033	-0.002	-0.026	-0.025	-0.049
				(1.42)	(1.36)	(1.30)	(1.57)	(1.35)	(-0.64)	(-0.06)	(-0.40)	(-0.52)	(-1.07)
Panel B: Z-Score on Flow around Follow On Round													
31	22	2	75	0.010	0.017	0.014	0.045	0.039	0.025	-0.002	-0.025	-0.026	-0.036*
				(0.63)	(0.86)	(0.62)	(1.22)	(0.95)	(0.54)	(-0.04)	(-0.46)	(-0.91)	(-1.87)
Panel C: Benchmark-adjusted Flow around Follow On Round (Funds without Redemption Fee)													
20	17	3	59	0.093	0.088	0.078	0.070*	0.057	-0.068	-0.013	-0.041	-0.031	-0.029
				(1.19)	(1.23)	(1.16)	(2.01)	(1.66)	(-0.85)	(-0.29)	(-0.56)	(-0.65)	(-0.75)
Panel D: Z-Score on Flow around Follow On Round (Funds without Redemption Fee)													
20	17	3	59	0.002	-0.005	-0.007	0.048	0.031	-0.026	-0.029	-0.062	-0.046	-0.033
				(0.09)	(-0.25)	(-0.32)	(1.07)	(0.78)	(-0.91)	(-1.14)	(-1.32)	(-1.63)	(-1.41)

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 8. Regression of within family allocation of private equity shares on fund characteristics

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

$$Allocation_{f,s,q} = \alpha + \beta_1 RETBMK_{f,q-1} + \beta_2 Dollar\ Fee_{f,q-1} + \beta_3 Experience_{f,q-1} + \gamma_1 M_{f,q-1} + \gamma_2 N_{s,q-1} + \varepsilon_{f,s,q},$$

where $Allocation_{f,s,q}$ refers to two proxies for the allocation of new security s to fund f within the family in quarter q, i.e., *PctShr* in Models 1 to 5 and *DumShr* in Models 6 to 10. *PctShr* is defined as the number of shares allocated to fund f divided by the total number of shares acquired by the family, and *DumShr* refers to an indicator variable that equals one if a fund receives allocation and zero otherwise. $RETBMK_{f,q-1}$ refers to the cumulative benchmark-adjusted return of fund f from quarter $q-4$ to $q-1$, $Dollar\ Fee_{f,q-1}$ refers to the dollar fee amount of fund f in quarter $q-1$, $Experience_{f,q-1}$ refers to two proxies for fund experience in private equity investment, i.e., *PE*, defined as an indicator variable that equals one if fund has invested in private equities in the past and zero otherwise, and *Ln(PE Experience)*, defined as the logarithm of the number of months since the first investment in private equity by the fund. The vector *M* stacks all other fund-level control variables, including the *Ln(Fund Age)* and *Turnover*, and the vector *N* stacks security-level control variables, including *Ln(Deal Size)* and *NumFam*.

Dep. Var. =	*PctShr*: PE Allocation (in %)					*DumShr*: PE Allocation (Dummy)				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
RETBMK	0.115***	0.096***	0.099***	0.016	0.009	0.003***	0.003***	0.003***	0.000	0.000
	(2.89)	(3.15)	(3.22)	(1.19)	(0.64)	(3.88)	(3.88)	(3.82)	(1.44)	(1.49)
Dollar Fee	42.047***	28.288***	27.203***	6.462	12.478*	0.520***	0.520***	0.503***	0.152*	0.278**
	(4.97)	(3.45)	(3.41)	(1.04)	(1.72)	(2.92)	(2.92)	(2.87)	(1.82)	(2.19)
PE		5.167***		3.627***		0.130***	0.130***		0.096***	
		(4.92)		(3.82)		(7.19)	(7.19)		(5.63)	
Ln(PE Experience)			1.540***		1.134***			0.038***		0.029***
			(4.50)		(4.07)			(6.64)		(5.85)
RETBMK × PE				0.488***					0.015***	
				(2.83)					(6.12)	
RETBMK × Ln(PE Experience)					0.177***					0.005***
					(3.15)					(6.02)
Dollar Fee × PE				29.910**					0.491**	
				(2.11)					(2.01)	
Dollar Fee × Ln(PE Experience)					5.429					0.078
					(1.44)					(1.22)
Ln(Fund Age)	0.172	0.339	0.278	0.351	0.281	-0.006	-0.006	-0.007	-0.005	-0.007
	(0.61)	(1.12)	(0.96)	(1.25)	(1.05)	(-1.02)	(-1.02)	(-1.30)	(-1.21)	(-1.54)
Turnover	0.773**	0.594*	0.613*	0.543	0.594*	0.015**	0.015**	0.015**	0.014**	0.015**
	(2.02)	(1.67)	(1.70)	(1.56)	(1.67)	(2.17)	(2.17)	(2.21)	(2.30)	(2.38)
Ln(Deal Size)	0.000	0.000	0.000	0.000	0.000	0.005*	0.005*	0.005*	0.005*	0.005*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(1.90)	(1.90)	(1.90)	(1.90)	(1.90)
NumFam	-0.003	-0.003	-0.003	-0.003	-0.003	0.000	0.000	0.000	0.000	0.000
	(-0.05)	(-0.05)	(-0.05)	(-0.05)	(-0.05)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Family-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.080	0.114	0.110	0.124	0.121	0.165	0.165	0.155	0.186	0.176
Obs	18,145	18,145	18,145	18,145	18,145	18,145	18,145	18,145	18,145	18,145

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 9. Difference in differences of CARs after follow-on rounds sorted by Q1-3 fund performance

This table presents the difference-in-differences of *CAR*s after follow-on rounds between follow-on rounds that take place during the first three quarters of the year vs. follow-on rounds that happen in the 4th quarter of the year, sorted by the fund's performance rank as of the end of the third quarter. The sample consists of funds holding private securities with follow-on rounds in both the first three quarters and the fourth quarter of a calendar year. Panel A presents the results using *CAR*s adjusted by the fund's benchmark returns; Panel B presents the results using *CAR*s adjusted by the value-weighted market index returns.

CAR around Follow On Round Filing Date Sorted by Fund Performance											
Rank of Fund Performance	No. Fund	Fund-Year Obs.	[0, 3]			[0, 5]			[0, 10]		
			Q1-3	Q4	Q4 − Q1-3	Q1-3	Q4	Q4 − Q1-3	Q1-3	Q4	Q4 − Q1-3
Panel A: Benchmark-adjusted CAR (CAR_BMK)											
Bottom 80%	36	51	0.260***	-0.059	-0.319***	0.315***	0.025	-0.290**	0.573***	0.080	-0.493**
			(2.94)	(-0.95)	(-2.84)	(4.05)	(0.31)	(-2.54)	(3.82)	(0.88)	(-2.59)
Top 20%	25	33	0.106	0.536***	0.430***	0.269***	0.492***	0.223*	0.343***	0.724***	0.382**
			(1.60)	(6.93)	(4.23)	(3.94)	(5.80)	(2.03)	(4.45)	(5.45)	(2.73)
Top − Bottom			-0.154	0.595***	0.749***	-0.046	0.467***	0.513***	-0.230	0.644***	0.874***
			(-1.39)	(6.02)	(4.95)	(-0.44)	(4.00)	(3.23)	(-1.37)	(4.00)	(3.71)
Panel B: Market-adjusted CAR (CAR_MKT)											
Bottom 80%	36	51	0.306***	0.096	-0.211	0.329***	0.104	-0.225*	0.580***	0.222**	-0.358**
			(3.86)	(0.95)	(-1.45)	(3.97)	(1.05)	(-1.72)	(4.70)	(2.30)	(-2.06)
Top 20%	25	33	0.256***	0.850***	0.594***	0.516***	0.675***	0.159	0.576***	0.849***	0.272
			(3.70)	(10.69)	(4.98)	(7.31)	(8.59)	(1.44)	(5.29)	(7.99)	(1.69)
Top − Bottom			-0.050	0.755***	0.805***	0.187*	0.571***	0.384**	-0.004	0.627***	0.630***
			(-0.47)	(5.90)	(4.28)	(1.72)	(4.53)	(2.25)	(-0.02)	(4.37)	(2.66)

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table 10. Percentage weighted valuation changes for top performing funds in Quarter 4

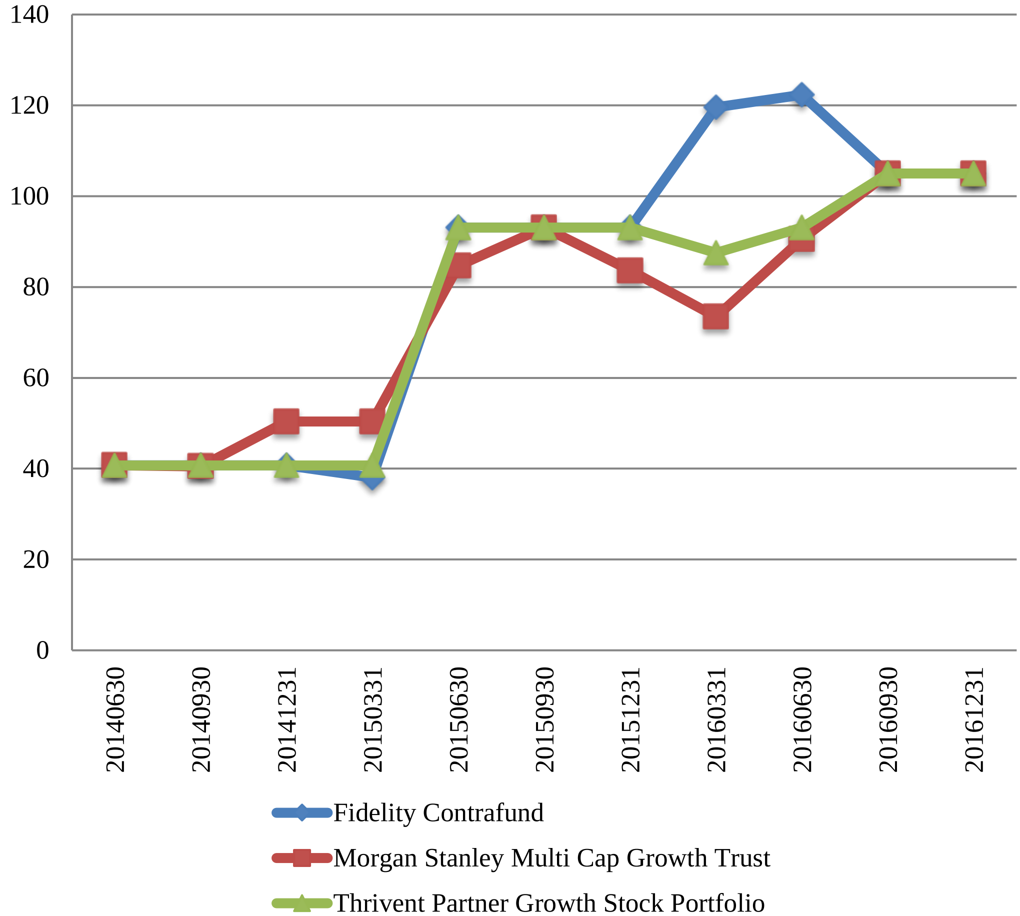
The sample consists of funds holding private securities with follow-on rounds in both the first three quarters and the fourth quarter of a calendar year. The table presents means across securities (aggregated by fund and then averaged across funds) for fund-securities with a follow-on funding round conditional on quarter (quarter 1-3 vs. quarter 4) and fund performance rank in the first three quarters (top 20% vs. bottom 80%). Panel A presents the mean change in valuation from the end of the prior quarter to the current quarter multiplied by the weight of the security in the fund's portfolio ($(V_q/V_{q-1} - 1) \times WTPE$), the log version of the valuation change ($\ln(V_q/V_{q-1}) \times WTPE$), and the weights held in the security ($WTPE$). Panel B presents a decomposition of the log valuation change: $\ln(V_q/V_{q-1}) \times WTPE = [\ln(V_q/DEAL_s) + \ln(DEAL_s/DEAL_{s-1}) - \ln(V_{q-1}/DEAL_{s-1})] \times WTPE$. $DEAL_s$ is the deal price of the follow-on round in quarter q, and $DEAL_{s-1}$ is the price of the prior deal in the security sequence. Thus, $V_q/DEAL_s$ measures the valuation at which the early-round security is held relative to the follow-on deal price in quarter q; $DEAL_s/DEAL_{s-1}$ measures the markup in deal prices between the two rounds; and $V_{q-1}/DEAL_{s-1}$ measures the valuation at which the early-round security is held relative to its original deal price in quarter q–1.

Rank of Fund Performance	No. Funds	Fund-Year Obs.	Q1-3	Q4	Q4 − Q1-3	Q1-3	Q4	Q4 − Q1-3	Q1-3	Q4	Q4 − Q1-3
Panel A: Weighted Valuation Changes in Q4 vs. Q1-3											
			$(V_q/V_{q-1} - 1) \times WTPE$			$\ln(V_q/V_{q-1}) \times WTPE$			$WTPE$		
Bottom 80%	36	51	0.104**	0.121***	0.017	0.076**	0.099***	0.023	0.291***	0.375***	0.084**
			(2.23)	(8.10)	(0.43)	(2.41)	(8.27)	(0.88)	(6.07)	(9.75)	(2.26)
Top 20%	25	33	0.154***	0.280***	0.126***	0.120***	0.217***	0.097***	0.629***	0.715***	0.086
			(4.40)	(5.83)	(2.74)	(4.27)	(5.96)	(2.96)	(5.18)	(5.78)	(1.57)
Top − Bottom			0.050	0.159***	0.109*	0.044	0.118***	0.074*	0.338**	0.341**	0.002
			(0.86)	(3.16)	(1.79)	(1.05)	(3.08)	(1.75)	(2.59)	(2.63)	(0.03)
Panel B: Log Decomposition of Weighted Valuation Changes											
			$\ln(V_q/DEAL_s) \times WTPE$			$\ln(DEAL_s/DEAL_{s-1}) \times WTPE$			$\ln(V_{q-1}/DEAL_{s-1}) \times WTPE$		
Bottom 80%	36	51	-0.022***	-0.024***	-0.002	0.101***	0.130***	0.029	0.003	0.007	0.003
			(-4.85)	(-4.51)	(-0.32)	(3.23)	(11.63)	(1.07)	(0.63)	(0.68)	(0.33)
Top 20%	25	33	-0.029**	-0.015	0.014	0.197***	0.219***	0.022	0.048***	-0.013	-0.061***
			(-2.72)	(-1.48)	(0.89)	(6.34)	(7.05)	(0.66)	(3.08)	(-0.71)	(-2.91)
Top − Bottom			-0.007	0.010	0.016	0.095**	0.089**	-0.006	0.045***	-0.019	-0.064***
			(-0.58)	(0.86)	(0.95)	(2.16)	(2.70)	(-0.15)	(2.71)	(-0.95)	(-2.77)

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Figure 1. Airbnb Series D valuations reported by three mutual funds

The Series D round for Airbnb closed at $40.71 on April 16, 2014. The lines depict the quarterly valuations for Airbnb by three mutual funds in their quarterly reports.



Internet Appendix

Appendix A

To identify private equity securities, we proceed as follows.

1. We start with all unique security names without CUSIP reported in the CRSP Mutual Fund Database. There are initially 308,133 unique security names without CUSIP. We eliminate securities that are unlikely to be U.S. private equity using keywords in security names (e.g., "bond", "coupon", "7%", "Put" "Forex" "Mortgage"). This reduces the number of unique security names to 27,127.
2. We create a union of VC investment data from Thomson Reuters and the IPO data from Bloomberg and CRSP to generate a list of VC-backed companies.
3. We match U.S. active equity mutual funds in the CRSP Mutual Fund investment data with the VC-backed company list on issuer company name by using fuzzy name matching.

The above matching process provides us with a sample of mutual fund investments in VC-backed, pre-IPO companies. We next need to identify the specific security (e.g., Airbnb Series C vs. Airbnb Series D) held by each mutual fund. To do so, we proceed as follows:

1. We start from the list of VC-backed companies held by mutual funds and use the company names as keywords to search through mutual funds' SEC filings (N-CSR and N-Q forms). For those filings with positive hits, we manually collect holdings information on *all* restricted and illiquid securities. In particular, we collect information on fund name, reporting date, security name, security type, number of shares, value of holdings, acquisition date, and acquisition cost. Mutual funds group their portfolio investment into sub-categories (such as common stock, preferred stock, and convertible preferred stock), and report them in the "Statement of Investments" in the SEC filings. The investment category together with any additional Series information included in the security name (e.g., "Series E Preferred Security") are collected to identify security type. In addition, some mutual funds also report acquisition date and acquisition cost for restricted and illiquid securities in the SEC filings; this information is not available in CRSP but is crucial for us to identify Series name as described later. This comprehensive data collection also expands the sample of private firms, and our final sample is not limited to the original coverage of VC-backed companies.
2. Separately, we create a dataset of VC funding rounds for VC-backed companies that identifies the round investment date, per share purchase price, and Series name. We collect this data mainly from the company's Certificate of Incorporation documents (COIs) accessed via Genesis' Private Company Insight database, and supplement it with other sources such as S-1 filings for companies that subsequently went public, company press releases, and TechCrunch, PitchBook, and SharePost

databases. Each observation in this dataset is a distinct security (e.g., Uber Series E), and we assign a unique security ID to each observation of this dataset ("security ID master file"). Typically, the purchase price per share is different across rounds (e.g., Series E's purchase price is different from Series D, which is also different from Series C, etc.). This becomes crucial in our ability to assign a specific round to a security, as described below in point 5.

3. We merge the CRSP holding data with the SEC filing data, by fund name, company name, and reporting date. When a fund holds multiple Series from the same company at the same time, we further match by Series name (if available in both CRSP and SEC), number of shares and its value. We also manually check the quality of the merged sample and reconcile the two databases to the extent possible. One thing to notice is that this match is not always one-to-one. For instance, CRSP reports an aggregate position of "Uber", while SEC filing indicates that the fund actually holds multiple securities of Uber the company including Series D and Series E convertible preferred stock. When the number of shares and value of those individual Series (e.g., "Uber Series D" and "Uber Series E") sum up to the aggregate amount in CRSP (e.g., "Uber"), we replace CRSP data with the Series-specific information from SEC filings.
4. Next, we analyze the security name and extract information about the Series name in the CRSP-SEC merged sample. If the CRSP mutual fund holding data or SEC filing clearly identifies the Series name (e.g., "Uber Series F Preferred" and "Uber P/P Ser F"), then we assign this investment a security ID uniquely associated with that company *and* that round.
5. For remaining security holdings that do not clearly identify the Series name (e.g., it is listed simply as "Uber"), we rely on the acquisition date and acquisition cost from the SEC filings. Specifically, we match the SEC filing data and the security ID master file (described above in point #2). If the acquisition cost per share matches the per share purchase price of a particular funding round, and the acquisition date approximately matches the round investment date (in the same quarter), then we assign this investment a security ID uniquely associated with that company and that round.
6. Finally, we adjust the number of shares and per share purchase price for stock splits. We obtain the dates and split ratios from COIs, S-1 filings, and press.

Table A1. Time series variation in price dispersion of private securities

This table presents the results of a panel regression where the dependent variable is the price dispersion of private security s in quarter q across mutual funds, which is measured as the standard deviation of prices divided by the mean price across mutual funds in quarter q. Independent variables include *QTRSinceIssue*, the number of quarters since the initial purchase; *Follow-on Dummy*, an indicator variable that equals one upon a follow-on funding round and zero otherwise; *AEV* is the aggregate event volume from RavenPack, which measures the count of news events over a rolling 91-day window; *Ln(NumFd)*, the logarithm of the number of funds holding a security. The regressions also control for private firm fixed effects.

	Model 1	Model 2
QTRSinceIssue	0.004***	0.005**
	(3.20)	(2.31)
Follow-on Dummy	-0.040***	-0.051***
	(-5.81)	(-3.60)
AEV		-0.050***
		(-3.25)
Ln(NumFd)	0.042***	0.022**
	(4.25)	(2.53)
Firm FE	Yes	Yes
R-squared	0.443	0.362
Obs	1,952	521

*, **, *** - significant at the 10, 5, and 1% level (respectively).

Table A2: Quarterly private company alphas by market condition

This table presents the results of a pooled regression of fund family-security-quarter percentage valuation changes (less the risk-free rate) of private companies held by mutual funds on factor returns (market risk premium, size, and value factors of Fama and French, 1993) and market conditions (down market or follow-on funding quarter for the company). Three models are estimated: (1) a one-factor market model with no lags, (2) a one-factor market model with two lags, and (3) a three-factor model with two lags of market, size, and value factors. All models include an indicator variable *Down Market Dummy* that equals one if the market risk premium in the current quarter is less than zero and zero otherwise. Models 4 to 6 further include an indicator variable *Follow-on Dummy*, that equals one in quarters when the company engages in a follow-on funding round and zero otherwise. Standard errors are clustered by quarter.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Panel A: Coefficient Estimates and Regression Statistics						
Alpha	0.011	-0.013	0.008	-0.010	-0.033*	-0.016
	(0.46)	(-0.63)	(0.45)	(-0.51)	(-1.82)	(-0.87)
Down Market Dummy	0.047	0.045	0.013	0.047	0.046	0.028
	(1.10)	(1.16)	(0.38)	(1.26)	(1.37)	(0.91)
Follow-on Dummy				0.351***	0.350***	0.334***
				(4.92)	(5.17)	(5.01)
MKTRET	0.624*	0.736**	0.632***	0.711**	0.824***	0.699***
	(1.81)	(2.40)	(2.68)	(2.20)	(2.87)	(2.80)
$MKTRET_{t-1}$		0.622***	0.664**		0.619***	0.632***
		(3.39)	(2.40)		(4.03)	(2.77)
$MKTRET_{t-2}$		0.433*	0.256		0.421**	0.292
		(1.84)	(1.12)		(2.15)	(1.50)
HML			-0.683***			-0.560***
			(-5.18)			(-3.99)
HML_{t-1}			-0.014			0.040
			(-0.05)			(0.16)
HML_{t-2}			-0.371			-0.180
			(-1.10)			(-0.63)
SMB			0.562**			0.571**
			(2.11)			(2.29)
SMB_{t-1}			0.106			0.070
			(0.34)			(0.25)
SMB_{t-2}			1.016**			0.687**
			(2.63)			(2.25)
R-squared	0.025	0.045	0.069	0.111	0.131	0.145
Observations	4,322	4,322	4,322	4,322	4,322	4,322
Panel B: Summed Factor Exposures						
Market Beta	0.624*	1.791***	1.553***	0.711**	1.865***	1.623***
	(1.81)	(3.48)	(2.80)	(2.20)	(4.09)	(3.28)
HML Tilt			-1.068**			-0.701*
			(-2.35)			(-1.73)
SMB Tilt			1.684***			1.328***
			(4.47)			(3.69)

*, **, *** - significant at the 10, 5, and 1% level (respectively).