Private Company Valuations by Mutual Funds

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Abstract

We study how cross-sectional and temporal variation in valuation practice of private start-up holdings by mutual funds affects investors' access to these pre-IPO firms. Price dispersion across fund families holding the same security averages 10.0%, and is as large as 25% in some quarters. 42% of reported prices are not updated between quarters but large valuation changes occur when startups close a new funding round. Thus, follow-on rounds lead to predictably strong fund returns in the days after the event. Fund families tend to allocate private securities to their best performers and high-fee funds. Moreover, fund managers with incentives to boost periodic returns mark up their private securities more aggressively after the year-end follow-on rounds. We also find weak evidence of strategic return smoothing with lower incidence of markdowns of private securities in bear markets.

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 private companies like Uber, Airbnb, and Pinterest have chosen to remain private while raising large amounts of capital by privately selling 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). 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 the Wall Street Journal tracks 175 venture capital backed private companies with valuations in excess of $1 billion as of August 2017.[1]

This new startup funding model leaves mutual funds holding illiquid private securities. 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. For example, to date there is little empirical evidence as to whether investors accessing these pre-IPO startups through mutual funds receive consistent pricing level across different funds and over different time periods, or the pricing practice is subject to cross-sectional and temporal variation.

To fill this need, we analyze three issues that arise when mutual funds hold private securities. First, do mutual funds report different simultaneous prices for the same private security? Second, does the price updating of private securities predictably affect the daily returns of mutual funds? Third, does the discretion in valuation of private securities offer an opportunity for strategic pricing by mutual fund companies? To preview our results, we find that there is material variation in the prices of private securities across mutual funds and virtually all of this variation can be traced to variation in pricing across fund families. Valuation changes are rare, which lead to predictably large changes around follow-on funding events that are detectable in daily fund returns. Finally, we find some evidence of

[1] http://graphics.wsj.com/billion-dollar-club/

strategic valuations; funds with strong year-to-date performance are more likely to mark up private securities with follow-on funding rounds in the fourth quarter.

Valuing a private company is notoriously difficult since there is no regular exchange of shares that allow frequent updating of security prices that we observe for publicly traded stocks. It is common practice for mutual funds to value private securities held in their portfolios based on their internal valuation criteria or models, and funds can exercise considerable discretion over the reported valuation.[2] Thus, unlike public securities, it seems plausible that valuations for private companies might differ and perhaps substantially.

Since there is little information about private securities, we conjecture that mutual funds rarely update the valuations of private securities and are most likely to do so when a new funding round closes since the new funding round establishes a new valuation for the private company. The increase in the implied valuation of a company between funding rounds can be substantial. For example, the valuation of Airbnb more than doubled from $9.5 billion at the close of its Series D funding round in April 2014 to $24 billion at the close of its Series E funding round announced in June 2015.[3]

In Figure 1, we present an example of three mutual funds that hold a private security and illustrate the basic issues that we describe above. 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, the 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.

[2] Securities regulations limit the illiquid (or "Level 3") assets to 15 percent of the mutual fund holdings.
[3] Calculated as the purchase price per share times the number of fully-diluted share count, or the industry-standard post-money valuation.

To understand the pricing dynamics of private securities held by mutual funds more generally, we manually compile a dataset of 230 private securities (for 135 different companies) held by 204 unique mutual funds between 2010 and 2016.[4] To analyze price dispersion across funds, we restrict our analysis to securities that are simultaneously held by at least two funds. This further limits our sample to 170 private securities (for 106 different companies) held by 196 unique funds. For 2,274 security-quarters, we calculate a price dispersion measure across funds as the ratio of the standard deviation of prices to the mean price across families. In the average security-quarter, price dispersion is a modest 3.9%; however this understates the true extent of *effective* price variation, since this calculation blends price dispersion between funds within the same fund family as well as dispersion across funds belonging to different fund families.

On one hand, there is virtually no price dispersion within mutual fund families. When we calculate price dispersion across securities held by the funds within the same fund family, the mean price dispersion is 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 securities. On the other hand, the meaningful price variation that we do observe occurs across fund families (rather than across funds within the same family). We find that the average price dispersion across fund families grows to 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%.[5] 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 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.

[4] We treat securities issued in different rounds by the same issuer as distinct securities (e.g., Series D Airbnb vs. Series E Airbnb) differing in contractual terms such as liquidation preference, participation, and dividend preference (Metrick and Yasuda, 2010).

[5] $10.3\% = \frac{\left[(22-20.5)^2+(19-20.5)^2\right]^{1/2}}{20.5}$.

Next we analyze the determinants of pricing changes over time. After the initial acquisition date, price dispersion increases over time. A follow-on funding round, which generates a common valuation for the new-round private securities, decreases price dispersion of existing private securities. While a majority of private security values are updated following a new funding round, about 42% of funds report prices for prior-round securities that differ from the purchase price of new-round securities. 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. Public news about the company decreases price dispersion as it reduces information asymmetry across fund families.

Importantly, the reported prices of private securities are frequently stale. For each family-security-quarter observation, we calculate a quarterly return for the family-security pair based on family's reported prices for the security in the current and prior quarter, which generates 4,286 quarterly returns for family-security observations. The mean quarterly return is 3.3%, and the median is 0%. Moreover, 42% of all quarterly returns are zero (i.e., 42% of prices are not updated between quarters). Combined, these results suggest that mutual funds let the pricing of private securities go stale at times, with infrequent large jumps in prices coinciding with new funding rounds. Thus, individual investors accessing pre-IPO startups via mutual funds may pay dramatically different prices for a given security before and after the issuer's new funding round.

Does this stale pricing of private securities generate predictable fund returns? To answer this question, we analyze the returns of mutual funds that hold private securities following the official start of a new funding round, which we generally date when the company files a restated Certificate of Incorporation in the company's home state. Funding rounds for private companies are known in advance by those involved in the funding rounds and are also widely covered on websites like TechCrunch, Equidate, and Business Insider. These sources regularly report the status of funding rounds for large private companies well in advance of the close of funding.[6] We find the average cumulative

[6] For example, the Business Insider reported that Coinbase Inc. was in talks with potential investors for a funding round at a valuation of more than $1 billion on June 2, 2017. On August 10, 2017, the Business Insider reported Coinbase completed the funding round at a valuation of $1.6 billion.

abnormal returns (*CAR*s) is 31 bps (43 bps) in the five-day (ten-day) window following the funding round.

To link the strong fund returns more tightly to the markups of private securities in the wake of the new funding round, we calculate the weight of private security in each fund's overall portfolio and the percentage change in the private security valuation based on the deal-over-deal prices. For example, a fund that holds 0.5% of its assets in Airbnb when Airbnb announces a new funding round that implies a 100% company valuation increase will experience a fund return of 50 bps if the fund doubles the private security valuation when the funding commences. 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-deal valuation change, which as conjectured generates a reliably positive coefficient estimate that is close to one (0.88 when the dependent variable is the five-day *CAR*), and statistically significant (*t*-statistics = 2.51). The results suggest that individual investors' returns from buying mutual funds that hold private securities are significantly enhanced if they are able to time their purchases to occur shortly before new funding rounds. We are currently analyzing whether investors take advantage of this pricing dynamic by examining high-frequency fund flows surrounding new funding events.

Finally, we analyze whether funds strategically mark private securities. Investments in private companies afford considerable discretion to mutual fund family who at times might use this discretion to improve periodic fund returns and benefit the entire fund company. 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). We document three findings that are broadly consistent with strategic incentives influencing manager behavior. First, we find that fund families prefer to allocate private securities to high-value funds within the family such as best recent performers and high-fee funds. Second, we document that funds that have outperformed peers in the first three quarters mark up their private securities more aggressively around follow-on funding events in the fourth quarter of the year compared to those did not outperform. This is consistent with fund families having greater incentives to boost performance of affiliated funds at year end by timing their markups. Finally, we consider whether fund families use private securities to strategically "smooth" fund returns by, for example, failing to mark down private securities in a bear market. In this analysis, we document the private securities respond strongly to market-, size-, and growth-related factor returns, but with a lag of one to two quarters. We find at best weak evidence of strategic return smoothing, i.e., valuation changes are more positive in quarters with negative market returns. After controlling for responses to overall market conditions, estimates on valuation changes are economically large at 4% in these down markets, but we cannot reject the null hypothesis that valuation changes are similar in up versus down quarters due to the short time period we analyze.

Four recent working papers analyze the private investments of mutual funds. Kwon, Lowry, and Qian (2017) 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 analyze the consequences of mutual fund investments 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. In contrast to these papers, we document investors accessing pre-IPO startups through mutual funds face pricing practice that is subject to significant cross-sectional and intertemporal variation due to both stale pricing and strategic behavior. In a recent working paper closely related to our work, Cederburg and Stoughton (2018) also document stale pricing of private securities and argue that private equity pricing by mutual funds is procyclical with respect to fund performance.

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, Ivkovic, 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. 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.

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 use the follow-on round purchase price as a reference point for a new common valuation for the previous round private security and examine how mutual funds' re-valuation decisions around the follow-on funding dates lead to return predictability.

Metrick and Yasuda (2010) and Gornall and Strebulaev (2018) develop option-pricing based valuation models for estimating the implied value of VC-backed private companies that correct for the use of convertible preferred securities in VC financing contracts. 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 between 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 fund managers use considerable discretion in setting NAVs and that on average NAVs are held significantly below the values at which investment ultimately exit. 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 prices.

1. 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 investees and firms 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 some variants of convertible preferred securities to their investors, rather than common stock. These securities issued at different financing rounds (called Series A, Series B, etc.) differ in their terms, not just in their purchase prices but also in other terms such as liquidation preference, participation, dividend, etc. (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. This requires us to identify not only the issuer of the security, but also the exact Series (A, B, C, etc.) to which it belongs, and only compare securities belonging to the same Series *and* held by multiple mutual funds. 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, and/or mutual funds frequently only report the security by its issuer name.

Using the matching method described in the Internet Appendix, we 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. Note that we compare only valuations of securities with the same security ID at the same point in time to measure price dispersion; we do not compare valuations across different Series of the same company. We exclude private security holdings that we cannot clearly assign to a specific round. Thus, our sample underreports the actual exposure that mutual funds have to the private equity asset class.

2. Valuations of Private Companies by Mutual Funds

2.1 Descriptive Statistics

In this section, we present evidence on the differences in the valuation of private securities across mutual funds. Define $P_{f,s,q}$ as the price of private security *s* (e.g., Uber Series D) held by fund *f* (e.g., Fidelity Contrafund) at the end of quarter *q* (e.g., March 31, 2015). 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. In Panel A, we present summary statistics for the number of funds holding the same security in a given quarter (*NumFd*). On average, 8.4 funds hold the same security in a quarter 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. In Panel B, we present descriptive statistics for our dispersion measures for the full sample, which 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., $NumFd \geq 2$).[7]

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.[8] If this practice is widespread, we expect to observe greater variation in prices across fund families but much less variation within fund families. To investigate whether this price

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[7] 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).

[8] 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

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 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.

2.2 Time Series Variations in Price Dispersion

Next, we examine the time series variation in the dispersion of private security prices reported by funds. To understand how price dispersion evolves over time, we estimate the following panel regression:

$$DispPrc\_Avg_{s,q} = \alpha + \beta_1 QTRSinceIssue_{s,q} + \beta_2 FollowOn_{s,q} + \gamma N_{s,q} + \varepsilon_{s,q} \qquad (2)$$

where $DispPrc\_Avg_{s,q}$ refers to the dispersion in prices reported by mutual funds of security *s* in quarter *q*. The key independent variables are *QTRSinceIssue*, which is a count of number of quarters since the initial purchase, *FollowOn*, which takes a value of one upon a follow-on funding round and is zero otherwise. The vector *N* stacks other security-level variables, including *Ln(NumFd)*, the logarithm of the number of funds holding the security; and *AEV*, which is the aggregate event volume from RavenPack database and defined as a count of event volume measured over a rolling 90-day window. As controls, we include private firm fixed effects, where each firm may issue one or more private securities during our sample period.

Table 2, Model (1) reports the estimate of the regression in Equation (2). As expected, the price dispersion is increasing in the number of funds holding the security. On average, price dispersion increases modestly over time (40 bps per quarter or about 1.6% per annum). Interestingly, the coefficient on *FollowOn* is negative and statistically significant, suggesting price dispersion decreases by 4% in the quarter of a follow-on funding round. This reduction in dispersion on a new round of financing is economically large, being similar in magnitude to the unconditional mean price dispersion reported in Table 1, Panel B.

We conjecture that price dispersion decreases following news about the company, which can serve to reduce information asymmetry. To test this conjecture, we augment the baseline model to include aggregate event volume (*AEV*). Unfortunately, these data are only available for 521 security-quarter observations. In Model (2) of Table 2, we present the results of this subsample regression. The coefficient on the *AEV* variable is significantly negative. Moreover, the coefficient is economically large. For example, a one standard deviation increase in *AEV* reduces price dispersion by 1%[9] or about one-quarter of the average price dispersion. Taken together, results in Table 2 show that price dispersion increases over time, but declines with new information about the private firm such as information on deal price during follow-on rounds of financing and news about the private firm.

2.3 Stale Pricing

Another important feature of the pricing of private securities is the infrequent updating of the prices. This aspect of pricing is evident in 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:

[9] The impact of *AEV* on price dispersion is 1%, computed as -0.05×0.199, where -0.05 is the regression coefficient in Model (2) and 0.199 is the standard deviation of *AEV*.

$$Return\_PVT_{F,s,q} = \frac{P_{F,s,q}}{P_{F,s,q-1}} - 1 \quad (3)$$

In Table 3, 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 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 not zero, but equal to 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% across 18,373 fund family-security pairs. 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.

2.4 Temporal Evolution of Pricing Deviation from Deal Prices

The earlier results suggest price dispersion increases over time, but 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 four benchmark prices for security s in quarter q, denoted as $B_{s,q}$: (a) the deal price in the most recent or any of the previous funding rounds; (b) the deal price in the most recent funding round; (c) the price at which the security was acquired by the family and (d) the average price reported by all families holding the security in the quarter. We define the price deviation as follows:

$$Dev_{F,s,q} = \frac{P_{F,s,q}}{B_{s,q}} - 1 \quad (4)$$

where $Dev_{F,s,q}$ refers to the price deviation for private security *s* in quarter q as reported by the fund family *F*, $P_{F,s,q}$ refers to the price reported by the fund family *F* for security *s* in quarter q, and $B_{s,q}$ refers to the benchmark price for security *s* 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*) which takes a value of one if the absolute value of *Dev* is above 1% and is zero otherwise. 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 4, Panel A, reports *%Dev* corresponding to each of the four benchmark prices. 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 latest or 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 company (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 4 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 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 4, 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 following a new round of financing. As shown in Panel C of Table 4, 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%.

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. Stale Pricing, Private Security Funding, and Predictability of Fund Returns

3.1 Main Results

While mutual funds are required to report to the SEC only quarterly, mutual funds mark the net asset values (NAVs) of their individual stock holdings on a daily basis in order to compute the funds' 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 generally changes, and these changes are often dramatic. 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 is 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. In general, we hypothesize that there is a predictable change in the valuation of the private holdings around the start date of a follow-on funding round, which in turn generates predictable returns in the mutual fund, particularly if the private security is a relatively large holding within the mutual fund and experiences a big change in deal price. We utilize this unique feature of private equity valuations to investigate the predictability of fund returns with each new round of financing. We also expect the change in the fund's NAV to be positively related to the magnitude of the change in deal price or the change in mutual fund valuation of the security and the weight of the private investment in the fund's overall portfolio.

We start by examining 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:

$$AR\_BMK_{f,s,t} = R_{f,t} - R_{BMK,t} \tag{5}$$

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*:

$$CAR\_BMK[0,k]_{f,s} = \left[\prod_{t=0}^{k}(1 + AR\_BMK_{f,s,t})\right] - 1 \tag{6}$$

Our empirical analysis is based on the cumulative abnormal returns averaged across fund-security pairs, *CAR_BMK[0,k]*, and the standard errors that are clustered by calendar days (filing date of follow-on security-round) to account for cross-correlation in fund returns surrounding a common security funding date.

As reported in Panel A, 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.[10] The follow-on round dates are established based on the filing dates of COIs and supplemented with information from the SEC filings and supplemental data sources as 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. This filter assures that the funds we analyze hold the private security on the date of the funding round. It should be noted that we do not require that the fund participates in the new round of financing. Hence, we only delete funds that do not continue to hold the same original-round private security (that they held prior to the follow-on round event) in the post event window. These filters give us a sample of 135 funds holding at least one private security before and after the follow-on round.

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.[11] 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 second group comprising the other fund families (*Non-Big 5* fund families) account for 235 fund-security observations (see Panel A, Table 5).

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. This is what we would expect if the adjustment for benchmark returns accounts for

[10] The sample includes 14 companies with multiple follow-on rounds of financing, including Palantir (5 rounds), Bluearc, Nanosys, and Uber (3 rounds), and the remaining 10 have 2 rounds each.
[11] This is based on the market value of the private-firm equity holdings as of Q2 2016, reported in Morningstar Manager Research, December 2016.

much of the variation in fund returns in the pre-event window. The *CAR_BMK[0,k]* in the post-event window is positive for the full sample as well as the two groups of fund families. For example, for the 3-day event window, the average *CAR_BMK[0,3]* is a significant 14 bps (*t*-statistics = 1.95) and the abnormal returns increase as we expand the event window. Specifically, the *CAR_BMK[0,5]* and *CAR_BMK[0,10]* are economically and statistically significant at 31 bps and 43 bps, respectively.

Panel A also reports the post-event returns for the two sub-groups of funds. Funds in the *Big 5* group frequently invest in private securities and earn significant abnormal returns over the three event windows. The benchmark-adjusted cumulative abnormal returns for the *Big 5* funds over the 5- and 10-day windows are large and significant at 20 bps and 30 bps, respectively. The benchmark-adjusted returns within the funds in *Non-Big 5* group are somewhat larger in magnitude and significance during the 5- and 10-day windows at 43 bps and 56 bps, respectively. In addition, we do not observe significant *CAR*s beyond 10 days.

In Panel B of Table 5, we adjust fund returns by the value-weighted market portfolio returns (instead of the benchmark returns), denoted by *CAR_MKT*. The results on abnormal returns around the new round of financing of private securities are robust to using the market returns to adjust the fund returns. For the full sample in Panel B, we obtain economically and statistically significant *CAR_MKT* over the 3-, 5- and 10-day event windows of 22 bps, 41 bps and 56 bps, respectively. The market-adjusted fund returns within the two sub-groups of *Big 5* and *Non-Big 5* fund families are similar to those based on benchmark-adjusted returns. Overall, we find strong evidence of predictable positive abnormal returns for the funds holding private securities when the issuers of the private securities raise new capital.

3.2 Portfolio Sorts on Economic Significance of Private Equity Returns

Following the evidence of strong predictability in fund returns around new round of financing, we test if the predictability is greater when funds have greater exposure to the private securities. We expect a greater fund exposure when the private security experiences bigger valuation change at the new financing round and when the security is more heavily weighted in the fund's portfolio. Since the exact weight of the private security in the fund's portfolio on the day of the new round is not available, we rely on the holdings (and portfolio weight) of the security last reported by the fund in the quarter before the financing round. We denote the percentage weight of each private security in a fund's portfolio as *WTPE*. We consider three measures of changes in the valuations of private securities in each new round of financing, where the valuation is based on the deal price or the security value reported by the mutual fund. The first measure is the percentage change in the deal price of the new round of financing relative to the deal price in the previous round, denoted as Δ*Deal*. The second measure, Δ*Value*, represents the percentage change in the mutual fund's valuation of the private security reported in the quarter after the new financing round, relative to the fund's valuation in the quarter before the new round. The final 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*. Intuitively, we expect a positive relation between the predictability of fund returns around the new security financing round and the product of the change in security valuation and the fund's investment weight in private securities. Bigger valuation changes in the private securities where funds hold a substantial fraction of their portfolios should have a larger impact on the fund's NAV, thereby contributing more to the predictability in fund's overall portfolio returns.

Panel A1 of Table 6 reports the distribution of Δ*Deal*. Our sample consists of 60 observations of Δ*Deal* and the average percentage change in deal price is a large 51% and is positively skewed. There is also substantial variation in Δ*Deal* with a value of 133% at the 90th percentile, declining to −11% at the 10th percentile. Not surprisingly, most of the deals take place at higher prices in subsequent rounds since private firms are less likely to issue new securities in a follow-on round at a lower valuation. In addition to the percentage change in the deal price, we also need to consider the percentage weight of each private security in a fund's portfolio (*WTPE*) to determine the effect of the change in deal price on a fund's overall return. After all, if a fund holds an insignificant proportion of a private security in its portfolio, it will not make much dent in the fund-level returns despite a big valuation change. Therefore, we take the product of the percentage change in deal price and the investment weight of each private security (Δ*Deal* × *WTPE*). Panel A2 reports the distribution of *WTPE* across fund-security observations: the average percentage holding of private securities is 0.36%, varying from 0.03% (10th percentile) to 0.86% (90th percentile). Interestingly, the product of Δ*Deal* and *WTPE* has a non-trivial mean of 0.18%. To put this in perspective, the average private security experiences an average of 51% increase in in deal price, and this translates to an average increase in the fund overall value by 0.18% on the event date. At the extreme 90th percentile, the equivalent increase in fund overall value arising from the change in deal price is economically bigger at 0.40%.

Panel A2 of Table 6 also presents the distribution pattern for the other two measures of changes in valuation of private securities around the new round of financing: Δ*Value* and *Update*. The change in private security values based on the figures reported by mutual funds, Δ*Value*, displays less dispersion. Δ*Value* has a lower mean and standard deviation and is less positively skewed than Δ*Deal*. The interquartile range for Δ*Value* is also smaller than that for Δ*Deal*. Similarly, the product of valuation change reported by mutual funds and the weight of private securities in the funds' portfolios, Δ*Value* × *WTPE*, is less dispersed, with a mean of 0.10%, standard deviation of 0.30% compared to the mean of 0.18% and standard deviation of 0.32% for Δ*Deal* × *WTPE*. A greater dispersion of Δ*Deal* compared to Δ*Value* is consistent with mutual funds at least partially updating their private security valuations between financing rounds. The distribution based on *Update*, the percentage change in the deal price at the new round relative to the last valuation reported by the mutual fund, is similar to the distribution of Δ*Value*, except that we observe less negative *Update* values. For example, the 25th and the 10th percentile value of *Update* (Δ*Value*) is 19% and −1.0% (0.0% and −1.3%), respectively. Moreover, the mean (46%) and standard deviation (51%) of *Update* is also higher than that for Δ*Value* at 32% and 45%, respectively. Similar observations apply when we compare the distribution of *Update* × *WTPE* and Δ*Value* × *WTPE*. The higher values of *Update* compared to Δ*Value* is consistent with slow updating of reported mutual fund valuations of private securities, at least by some funds, around new rounds of financing.

We next examine if the strength of predictability in fund returns varies with the product of the percentage change in deal price and the investment weight of each private security (Δ*Deal* × *WTPE*). To that end, Panel B1 of Table 6 reports the cumulative abnormal returns (*CAR*s) around the follow-on funding event at the fund-security level for the terciles based on Δ*Deal* × *WTPE*. We average the *CAR*s across fund-securities in each of the "Low", "Medium", and "High" Δ*Deal* × *WTPE* tercile groups and cluster the standard errors by calendar day (filing date of follow-on security-round). Our analysis is based on *CAR*s relative to both the fund's benchmark portfolio returns (*CAR_BMK*) and value-weighted market index returns (*CAR_MKT*), as reported in Table 5. Results in Panel B1 strongly support our hypothesis of greater predictability in fund returns when funds hold a greater proportion of those private securities that experience a bigger valuation change during follow-on funding. *CAR*s for 3-, 5-, and 10-day windows after the event date 0 are all higher for the "High" group, regardless of whether we use the fund's benchmark returns or value-weighted market returns to estimate *CAR*s. In contrast, there is little evidence of predictability for the "Low" group, especially when the inference is based on *CAR_BMK*. There is also a monotonic increase in the magnitude of *CAR*s for all three post-event windows from "Low" to "High" group. Moreover, the economic magnitude of predictability is large. For example, for the "High" group, *CAR_BMK* ranges from 24 bps to 75 bps over 3- to 10-day window after the event date of follow-on funding.

In Panels B2 and B3 of Table 6, we report the results when the *CAR*s around the follow-on round are grouped into terciles using the alternative two metrics for valuation changes: Δ*Value* × *WTPE* and *Update* × *WTPE*. The findings are qualitatively similar to the *CAR* results based on Δ*Deal* × *WTPE* in Panel B1. Over the three event windows of 3-, 5- and 10-days, we find significant *CAR*s (measured by *CAR_BMK*) between 20 bps to 57 bps for the "High" Δ*Value* × *WTPE* tercile observations. In contrast, the *CAR*s over the three event windows are statistically and economically weaker for the "Low" Δ*Value* × *WTPE* tercile. However, the contrast between "High" and "Low" Δ*Value* × *WTPE* terciles becomes less precise as we expand the window to 10 days. When we compare the *CAR*s across "High", "Medium" and "Low" terciles based on *Update* × *WTPE,* the differences becomes less striking.

In summary, findings in Table 6 show that investors can predict future fund returns when funds adjust the typical stale valuations of private securities at the time of follow-on funding by issuers, especially when there are bigger changes in the deal price during subsequent funding events and for those securities that have larger weights in a fund's portfolio. Although we find qualitatively similar results when valuation changes are measured using the figures reported by mutual funds, the event window fund abnormal returns across funds grouped by their investment amount and changes in private security valuations are more striking using changes in deal prices.

3.3 Cross-Sectional Regressions of *CAR*s

The above findings show that returns on funds holding private securities are predictable around the follow-on funding event by the issuers and that the predictability is stronger when fund *f* holds a larger share of security *s* in their portfolio ($WTPE_{f,s}$) and when the change in the security valuation, e.g., change in deal price ($\Delta Deal_s$) is large. We check for the robustness of the finding in the context of a regression model. Using the cumulative abnormal returns on fund *f* holding security *s* over *k* days following the event date, $CAR\_BMK[0,k]_{f,s}$, we estimate the following regression model, regressed over all fund-security observations:

$$CAR\_BMK[0,k]_{f,s} = \alpha + \beta \Delta Deal_s \times WTPE_{f,s} + \varepsilon_{f,s} \quad (7)$$

Under the hypothesis that the overall fund performance is significantly related to the performance of the private securities held, particularly around the follow-on funding event, 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 7: benchmark-adjusted *CAR*s (*CAR_BMK*) are reported in Panel A and market-adjusted *CAR*s (*CAR_MKT*) in Panel B (see Models (1), (4) and (7)). Consistent with the cumulative evidence so far, we find a strong positive relation between fund performance and the change in the valuation of the private securities held. For example, using the 5-day event window [0,5], the cross-sectional variation in the abnormal (benchmark- or market-adjusted) fund returns corresponds to the change in valuations arising from its private equity investments, indicated by the point estimate of β close to 1.0 in Model (4). Similarly, the β estimates in Model (7) are around 1.0 when *CAR_BMK* or *CAR_MKT* is estimated over a 10-day event window. When we reduce the event window to 3 days, the β estimates are significantly positive but smaller in magnitude, consistent with the idea that many funds may not be updating their valuations immediately after the funding round.

For completeness, we also report the regression results when changes in private security valuations are anchored on values reported by the funds in the quarter prior to the funding round. Specifically, we estimate regression in Equation (7), where the independent variable is $\Delta Value \times WTPE$ ($Update \times WTPE$) and report the results in Models (2), (5) and (8) (Models (3), (6) and (9)) in Table 7. The β estimates over the 3-day event window are similar across all valuation measures: they are significantly positive but are smaller than 1.0. However, the regression coefficient is significantly positive and closer to 1.0 only when *CAR* is measured relative to the fund benchmark portfolios over the 10-day event window.

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. Analysis of Mutual Fund Families' Incentives to Hold Private Securities

4.1 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 specialize in certain investment styles (e.g., growth funds). Second, fund families aiming to maximize the overall family profits may favor those 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:

$$Allocation_{f,s,q} = \alpha + \beta_1 RETBMK_{f,q-1} + \beta_2 Dollar\ Fee_{f,q-1} + \beta_3 Experience_{f,q-1} + \gamma_1 M_{f,q-1} + \gamma_2 N_{s,q-1} + \varepsilon_{f,s,q} \quad (8)$$

where $Allocation_{f,s,q}$ refers to two proxies for the private security allocation within fund family, i.e., $PctShr_{f,s,q}$ 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, and 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 allocation of security s in quarter q and zero otherwise. $RETBMK_{f,q-1}$ refers to the cumulative benchmark-adjusted return of fund *f* in the past year (from quarter $q-4$ to $q-1$), and $Dollar\ Fee_{f,q-1}$ refers to 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 $q-1$, i.e., $PE_{f,q-1}$ and $Ln(PE\ Experience)_{f,q-1}$. $PE_{f,q-1}$ refers to an indicator variable that equals one if fund *f* has invested in private equities in the past and zero otherwise, and $Ln(PE\ Experience)_{f,q-1}$ 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 private firms are likely to receive early allocation and accumulate more experience (selection channel). In contrast, 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 the *Ln(Fund TNA)*, defined as the logarithm of the fund TNA; *Ln(Fund Age)*, defined as the logarithm of the number of months since fund inception; *Expense Ratio*, defined as the annualized fund expense ratio; 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. Only the main variables are tabulated for brevity.

We report the results in Table 8, Models (1) to (4) for *PctShr* and Models (5) to (8) 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 family receive allocation given a new round, implying a potential competition to obtain the private security shares. Models (1) to (2) of Table 8 suggest that funds with prior experience in private security investments receive

5.2% more allocation, consistent with some funds specializing in such securities. Controlling for the persistence in new round allocations, funds with superior past performance and high dollar fees receive bigger allocation of the new security. The economic effect is sizable. In Model (1), for instance, a one standard deviation increase in the benchmark-adjusted return (dollar fee) is associated with a 0.51% (1.5%) increase in percentage shares allocated,[12] and this accounts for 33% (97%) of the sample mean (the average *PctShr* is 1.55%). In Models (3) and (4), the level of *RETBMK* and *Dollar Fee* are no longer significant when these variables are interacted with *Experience*, while the interaction effects are positive and statistically significant. This indicates that past performance and fee revenue mostly matter for funds that already hold private securities, and do not determine the first-time allocation of the securities. Finally, we examine the likelihood of a fund receiving an allocation, and obtain similar results in Models (5) to (8). In Model (5), a one standard deviation increase in the benchmark-adjusted return (dollar fee) is associated with a 1.64% (2.52%) 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-security pairs in sample receive an allocation.

Overall, the empirical evidence suggests that funds are allocated 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 will further investigate such strategic behavior in the next section.

4.2 Strategic Marking of Private Securities to Improve Periodic Fund Returns

Investments in private companies afford considerable discretion to mutual fund family who at times might use this discretion to improve periodic fund returns and benefit

[12] The impact of benchmark-adjusted return on shares allocation is 0.51%, computed as 0.094% × 5.474, where 0.094% is the regression coefficient in Model (1) and 5.474 is the standard deviation of *RETBMK*. Similarly, the impact of dollar fee on shares allocation is 1.5%, computed as 28.802% × 0.052, where 28.802% is the regression coefficient in Model (1) and 0.052 is the standard deviation of *Dollar Fee*.

the entire fund company. For example, if follow-on round events occur towards the end of the calendar year, fund families may strategically decide to aggressively mark up the value of existing security holdings before the end of the year to boost the current year returns, or to take a big bath and delay marking up the security until the beginning of next year. We conjecture that if affiliated funds have outperformed their peers in the first three quarters, mutual fund families have the strongest incentives to aggressively 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) and the spillovers in cash inflows between funds within a family (Nanda, Wang, and Zheng, 2004).

We examine this conjecture by calculating 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 fourth quarter of the year, sorted by the fund's performance rank as of the end of the third quarter (top 20% vs. bottom 80%)[13]. The results are presented in Table 9. Panel A, which uses *CAR*s based on the fund's benchmark returns, shows that among the top 20% funds, the average *CAR* associated with follow-on rounds in the fourth quarter of the calendar year is 49 bps (72 bps) for the 5-day (10-day) window, which was significantly larger than the *CAR* associated with follow-on rounds in the first three quarters (27 bps and 34 bps, respectively) and the *t*-statistics for the difference is significant at 2.03 (2.73). 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 difference-in-differences is positive and statistically significant for all three windows. The results presented in Panel B using market-return-adjusted *CAR* are qualitatively similar.

To summarize, our preliminary analysis suggests that mutual fund families with greater incentives to boost periodic fund returns mark up their private securities more aggressively after the year-end follow-on round events, which is consistent with strategic NAV management.

[13] 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 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%.

4.3 Valuation Changes across Market Conditions

In prior sections, we show that funds are slow to change private security valuations over time. It is natural to wonder 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. In this section, we consider the temporal variation in valuation changes to see if valuation changes respond to market conditions generally and whether there is evidence that the performance is smoothed across bear and bull markets. To preview our results, we find strong evidence that valuations respond to market conditions (and size- and growth-related factors), they do so with a lag, but there is at best weak evidence that private securities valuation changes generate positive alphas in bear markets.

To reach these conclusions, we build our analysis on three pooled time-series regressions using fund family-security-quarter observations:

$$\left(R_{F,s,q} - RF_q\right) = \alpha + \beta\left(R_{m,q} - RF_q\right) + \varepsilon_{F,s,q} \tag{9}$$

$$\left(R_{F,s,q} - RF_q\right) = \alpha + \sum_{l=-2,0} \beta_l\left(R_{m,q-l} - RF_{q-l}\right) + \varepsilon_{F,s,q} \tag{10}$$

$$\begin{aligned}\left(R_{F,s,q} - RF_q\right) = \alpha + \sum_{l=-2,0} \beta_l\left(R_{m,q-l} - RF_{q-l}\right) + \sum_{l=-2,0} h_l\, HML_{q-l} \\ + \sum_{l=-2,0} s_l\, SMB_{q-l} + \varepsilon_{F,s,q}\end{aligned} \tag{11}$$

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 (9), 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 (10), 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 the risk of private equity funds requires the inclusion of lags of quarterly factor returns because private equity funds tend to update the net asset values of the funds with delay. In the third regression as indicated in Equation (11), we add size (SMB) and value (HML) factors.[14]

The results of this analysis are presented in Table 10. Column 1A 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 performance is misleading and results from stale pricing. Column 2A 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. Column 3A 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 of columns 1A to 3A 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 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.

To test the conjecture that funds engage in return smoothing by, for instance, delaying the downward valuation of private securities in a bear market, we include an indicator variable *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. If funds smooth returns over time, this indicator variable would be reliably positive. Columns 1B to 3B show the results of the three regressions with the key *Down Market Dummy* added. In all

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[14] Including additional lags of market, size, and value factors do 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.

three specifications, the estimated coefficient is positive (and economically large at > 4% per quarter in models 1B and 2B), but imprecisely estimated; we cannot reject the null hypothesis that private security valuation changes are similar in bull and bear markets.

In prior analyses, we show that follow-on funding rounds generate significant changes in valuations. To determine whether the tests for asymmetry in market conditions are sensitive to these follow-on round quarters, we introduce a second 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. Columns 1C to 3C show the results of the three regressions with both the *Down Market Dummy* and *Follow-on Dummy* added. The coefficients on the *Follow-on Dummy* are large (33% to 35% per quarter) and statistically significant, which is consistent with our prior evidence that the deal-to-deal valuation changes are quite large. However, the coefficient estimates on the key *Down Market Dummy* are similar to those estimated absent the *Follow-on Dummy*. In summary, while the estimated alpha in bear markets is positive and at times economically large, we lack the power to reject the null hypothesis that the valuation changes are similar across bear and bull markets.

5. Conclusion

In this paper, we investigate the valuation of private companies held by mutual funds in their portfolio. We document three intriguing empirical findings related to these holdings. First, we find large differences in the valuation of the same private security reported by these mutual funds. 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. When we trace the dispersion in prices over time, we observe that the price dispersion increases with the passage of time as some funds update their prices based on news about the company or their own internal valuation models while other funds value the investment at stale prices. Interestingly, the price dispersion decreases after a follow-on round of financing for the same company, consistent with many funds using the deal price of the new round to update their valuations of the existing private securities they hold.

Second, we find that the infrequent updating of the prices of the private securities generates predictable mutual fund returns. Specifically, we find that these mutual funds display large abnormal fund returns immediately after a follow-on funding round for the private securities held. Follow-on funding rounds typically involve significant changes in the deal prices and imminence of these new rounds is often rumored or known in advance. 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. Moreover, the abnormal fund returns are positively related to the weight of the private security in the fund's overall portfolio and the percentage change in the private security valuation based on the deal-over-deal prices. For example, for funds that hold a larger percentage of the private securities whose valuation changes are also large, the average cumulative abnormal mutual fund returns in the 5-day (10-day) window following a new funding round increases to 53 (75) bps.

Third, we provide evidence that mutual fund families are strategic in their use of discretion in marking their private securities. Specifically, the abnormal fund returns 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. The result is consistent with the "leaning for the tape" behavior documented in other settings for mutual funds. We also find weak evidence in favor of return smoothing by funds with lower incidence of markdowns of private securities in bear markets.

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. Our empirical 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.

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Internet Appendix

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 versus 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 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. Firms	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. 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; *FollowOn*, 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 the security. The regressions also control for private firm fixed effects.

	Model 1	Model 2
QTRSinceIssue	0.004***	0.005**
	(3.20)	(2.31)
FollowOn	-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 3. Stale pricing of private securities

Quarterly return for a family-security-quarter is calculated using the reported prices by family F in quarter 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 4. 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 or any of the previous funding rounds (Latest or 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 the security in the 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. Firms	No. Security	∑ Dummy (Dev)	No. Family-Security-Quarters	%Dev
Panel A: Deviation of Security Valuation					
Latest or 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. Firms	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 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. Denoting the follow-on round date for private security s as day 0, the cumulative abnormal returns (*CAR*s) over a k-day window from day 0 to day k is: $CAR\_BMK[0,k]_{f,s} = \left[\prod_{t=0}^{k}(1 + AR\_BMK_{f,s,t})\right] - 1$, and we then average $CAR\_BMK[0,k]_{f,s}$ across fund-security pairs to obtain $CAR\_BMK[0,k]$. *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. The *CAR*s for pre-event windows are from days $-k$ to -1 are also 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.

	No. Security	No. Funds	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)

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

Table 6. Funds' exposure to private securities and predictability in fund returns

Panel A presents the cross-sectional distribution of the percentage change in valuation of private security, the investment weight on private security, as well as the product of the two variables. Δ*Deal* refers to the percentage change in the deal price of the new round of financing relative to the deal price in the previous round, $\Delta Value$ refers to the percentage change in the mutual fund's valuation of the private security reported in the quarter after the new financing round, relative to the fund's valuation in the quarter before the new round, and *Update* refers to the percentage change in the deal price of the new round of financing relative to the last valuation reported by the fund. Panel B reports the cumulative abnormal returns (*CAR*s) around the follow-on funding event at the fund-security level for the terciles based on $\Delta Deal \times WTPE$, $\Delta Value \times WTPE$, and $Update \times WTPE$. *CAR*s are averaged across securities in each tercile portfolio and standard errors are clustered by calendar days (filing date of follow-on security-round) for computing the *t*-statistics. *CAR*s are computed relative to both the fund's benchmark portfolio returns and value-weighted market index returns, and referred to as *CAR_BMK* and *CAR_MKT*, respectively. Event windows are 3-, 5-, and 10-days around the event date 0 of follow-on funding round date.

Panel A: Quantile Distribution							
Rank	Mean	Std. Dev.	Quantile Distribution				
			10%	25%	Median	75%	90%
Panel A1: Security Level (in %)							
ΔDeal	51.076	65.022	-11.038	13.747	37.849	101.622	133.149
Panel A2: Fund-Security Level (in %)							
ΔValue	32.491	45.241	-1.316	0.000	20.082	43.331	106.177
Update	45.584	50.605	-1.021	18.972	32.191	60.056	112.363
WTPE	0.364	0.538	0.027	0.082	0.188	0.441	0.859
ΔDeal × WTPE	0.181	0.316	0.011	0.028	0.087	0.217	0.397
ΔValue × WTPE	0.096	0.296	-0.001	0.000	0.031	0.142	0.307
Update × WTPE	0.125	0.285	0.000	0.019	0.058	0.196	0.347

Table 6—Continued

Rank	No. Security	No. Funds	Funds per Security	Fund-Security Obs.	CAR_BMK [−10, −1]	CAR_BMK [−5, −1]	CAR_BMK [−3, −1]	CAR_BMK [0, 3]	CAR_BMK [0, 5]	CAR_BMK [0, 10]	CAR_MKT [−10, −1]	CAR_MKT [−5, −1]	CAR_MKT [−3, −1]	CAR_MKT [0, 3]	CAR_MKT [0, 5]	CAR_MKT [0, 10]
Panel B: CAR around Follow On Round																
Panel B1: CAR around Follow On Round (Sort by ΔDeal × WTPE)																
Low	44	66	4	164	0.014	-0.028	-0.039	0.081	0.143	0.181	0.190	-0.031	-0.005	0.102	0.202	0.383**
					(0.11)	(-0.28)	(-0.58)	(0.93)	(1.66)	(1.66)	(0.89)	(-0.20)	(-0.04)	(0.64)	(1.53)	(2.38)
Med	31	85	5	162	0.314**	0.093	0.066	0.081	0.218**	0.365**	0.471**	0.212	0.128	0.188	0.348**	0.542***
					(2.65)	(1.13)	(1.00)	(0.85)	(2.22)	(2.60)	(2.40)	(1.32)	(1.02)	(1.22)	(2.58)	(3.01)
High	22	89	7	158	-0.055	0.006	0.054	0.244*	0.529**	0.748*	0.058	0.127	0.065	0.348**	0.607**	0.744
					(-0.22)	(0.04)	(0.41)	(2.04)	(2.15)	(1.90)	(0.18)	(0.82)	(0.42)	(2.36)	(2.14)	(1.49)
Panel B2: CAR around Follow On Round (Sort by ΔValue × WTPE)																
Low	36	78	5	172	0.254**	0.082	0.065	0.058	0.191*	0.378**	0.421**	0.119	0.103	0.077	0.236	0.506**
					(2.48)	(1.01)	(1.13)	(0.66)	(1.71)	(2.55)	(2.60)	(0.84)	(0.97)	(0.49)	(1.46)	(2.63)
Med	42	77	4	169	0.034	-0.064	-0.057	0.087	0.180	0.238	0.082	-0.075	-0.090	0.161	0.298*	0.494**
					(0.23)	(-0.62)	(-0.75)	(0.89)	(1.53)	(1.64)	(0.36)	(-0.43)	(-0.69)	(1.00)	(1.74)	(2.31)
High	27	84	6	169	-0.064	-0.029	0.025	0.200**	0.367**	0.569*	0.066	0.060	0.026	0.300**	0.411**	0.536
					(-0.24)	(-0.20)	(0.24)	(2.09)	(2.26)	(2.01)	(0.18)	(0.30)	(0.18)	(2.23)	(2.24)	(1.55)
Panel B3: CAR around Follow On Round (Sort by Update × WTPE)																
Low	44	72	4	165	0.077	-0.014	-0.034	0.170**	0.294**	0.426**	0.217	-0.019	-0.024	0.219	0.378*	0.604**
					(0.56)	(-0.15)	(-0.64)	(2.13)	(2.26)	(2.63)	(1.04)	(-0.13)	(-0.25)	(1.50)	(2.01)	(2.64)
Med	33	85	5	161	0.288**	0.112	0.093	0.062	0.257*	0.338*	0.481**	0.238	0.164	0.193	0.452**	0.611**
					(2.46)	(1.11)	(1.25)	(0.55)	(1.88)	(1.91)	(2.58)	(1.44)	(1.36)	(1.01)	(2.30)	(2.43)
High	26	87	6	158	-0.092	-0.028	0.022	0.169*	0.332***	0.520**	0.021	0.089	0.049	0.219*	0.319**	0.444
					(-0.38)	(-0.20)	(0.20)	(1.86)	(2.94)	(2.16)	(0.06)	(0.51)	(0.36)	(1.84)	(2.55)	(1.48)

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

Table 7. 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): $CAR\_BMK[0,k]_{f,s} = \alpha + \beta \Delta Deal_s \times WTPE_{f,s} + \varepsilon_{f,s}$,
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 0 is the follow-on funding round date, and k takes the value of 3, 5, or 10. $\Delta Deal_s$ refers to the percentage change in deal price per share of security s on the follow-on round date, and $WTPE_{f,s}$ refers to the investment weight of fund f in security s according to the latest holdings. $\Delta Deal_s$ is further replaced with $\Delta Value_{f,s}$, defined as 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 $Update_{f,s}$, 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	Model 7	Model 8	Model 9
Panel A: Benchmark-adjusted CAR (CAR_BMK)									
ΔDeal × WTPE	0.306***			0.882**			1.373***		
	(3.09)			(2.51)			(3.09)		
ΔValue × 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	0.079	0.086	0.136*	0.204*	0.243**	0.181	0.319**	0.326**
	(1.02)	(1.16)	(1.18)	(1.96)	(1.92)	(2.24)	(1.61)	(2.20)	(2.18)
R-squared	0.023	0.034	0.032	0.117	0.024	0.022	0.140	0.043	0.042
Obs	482	508	482	484	510	484	484	510	484
Panel B: Market-adjusted CAR (CAR_MKT)									
ΔDeal × WTPE	0.306**			0.853**			1.121**		
	(2.63)			(2.26)			(2.06)		
ΔValue × 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	0.155	0.135	0.158	0.230**	0.274*	0.342**	0.353**	0.459**	0.489**
	(1.19)	(1.18)	(1.28)	(2.24)	(1.95)	(2.36)	(2.25)	(2.41)	(2.40)
R-squared	0.010	0.021	0.016	0.061	0.013	0.008	0.056	0.013	0.010
Obs	482	508	482	484	510	484	484	510	484

*, **, *** - 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 4 and *DumShr* in Models 5 to 8. *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 TNA)*, *Ln(Fund Age)*, *Expense Ratio*, and *Turnover*, and the vector *N* stacks security-level control variables, including *Ln(Deal Size)* and *NumFam*.

Dep. Var. =	PE Allocation (in %)				PE Allocation (Dummy)			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
RETBMK	0.094***	0.096***	0.011	0.004	0.003***	0.003***	0.000	0.000
	(3.11)	(3.18)	(0.73)	(0.27)	(3.85)	(3.81)	(1.05)	(1.16)
Dollar Fee	28.802***	26.515***	-2.084	4.065	0.486**	0.436**	-0.092	0.019
	(2.85)	(2.66)	(-0.21)	(0.39)	(2.19)	(1.98)	(-0.70)	(0.12)
PE	5.228***		3.383***		0.130***		0.088***	
	(4.96)		(3.48)		(7.21)		(5.20)	
Ln(PE Experience)		1.547***		1.062***		0.037***		0.027***
		(4.50)		(3.80)		(6.62)		(5.45)
RETBMK × PE			0.489***				0.015***	
			(2.87)				(6.11)	
RETBMK × Ln(PE Experience)				0.176***				0.005***
				(3.18)				(6.02)
Dollar Fee × PE			35.235**				0.651**	
			(2.23)				(2.54)	
Dollar Fee × Ln(PE Experience)				6.894*				0.126*
				(1.66)				(1.93)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Family-Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.115	0.111	0.126	0.123	0.165	0.156	0.188	0.178
Obs	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 CARs after follow-on rounds between follow-on rounds that take place during the first 3 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. Panel A presents the results using CARs adjusted by the fund's benchmark returns; Panel B presents the results using CARs adjusted by the value-weighted market index returns.

CAR around Follow On Round Filing Date Sorted by Fund Performance											
Rank of Fund Performance	No. Funds	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)
TMB			-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)
TMB			-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: 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. Models 1A-3A present a single alpha estimate. Models 1B-3B 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 1C-3C 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.

	(1A)	(2A)	(3A)	(1B)	(2B)	(3B)	(1C)	(2C)	(3C)
Panel A: Coefficient Estimates and Regression Statistics									
Alpha	0.029**	0.005	0.014	0.011	-0.013	0.008	-0.010	-0.033*	-0.016
	(2.23)	(0.38)	(0.94)	(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	0.317	0.440**	0.567**	0.624*	0.736**	0.632***	0.711**	0.824***	0.699***
	(1.62)	(2.21)	(2.61)	(1.81)	(2.40)	(2.68)	(2.20)	(2.87)	(2.80)
$MKTRET_{t-1}$		0.604***	0.663**		0.622***	0.664**		0.619***	0.632***
		(3.33)	(2.41)		(3.39)	(2.40)		(4.03)	(2.77)
$MKTRET_{t-2}$		0.467*	0.252		0.433*	0.256		0.421**	0.292
		(1.88)	(1.09)		(1.84)	(1.12)		(2.15)	(1.50)
HML			-0.700***			-0.683***			-0.560***
			(-5.29)			(-5.18)			(-3.99)
HML_{t-1}			-0.038			-0.014			0.040
			(-0.15)			(-0.05)			(0.16)
HML_{t-2}			-0.360			-0.371			-0.180
			(-1.04)			(-1.10)			(-0.63)
SMB			0.530**			0.562**			0.571**
			(2.31)			(2.11)			(2.29)
SMB_{t-1}			0.119			0.106			0.070
			(0.37)			(0.34)			(0.25)
SMB_{t-2}			1.067***			1.016**			0.687**
			(3.25)			(2.63)			(2.25)
R-squared	0.022	0.043	0.069	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	4,322	4,322	4,322
Panel B: Summed Factor Exposures									
Market Beta	0.317	1.511***	1.482**	0.624*	1.791***	1.553***	0.711**	1.865***	1.623***
	(1.62)	(3.33)	(2.64)	(1.81)	(3.48)	(2.80)	(2.20)	(4.09)	(3.28)
HML Tilt			-1.098**			-1.068**			-0.701*
			(-2.54)			(-2.35)			(-1.73)
SMB Tilt			1.717***			1.684***			1.328***
			(4.44)			(4.47)			(3.69)

*, **, *** - 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.