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Access to Private Equity and Real Firm Activity: Evidence from PIPEs

JAMES R. BROWN and IOANNIS V. FLOROS*

Abstract

We study how access to private equity financing affects real firm activities using a broad panel of publicly traded U.S. firms that raise external equity through private placements (PIPEs) between 1995 and 2008. The public firms relying on PIPEs are generally small, high-tech firms that cannot finance investment internally and likely face severe external financing constraints; PIPEs are by far the most important source of finance for these firms. We show that firms use PIPE inflows to maintain extremely high R&D investment ratios and to build substantial cash reserves. We also use GMM techniques that control for firm-specific effects and the endogeneity of the decision to raise private equity and find that PIPE funding has a substantial impact on corporate investment in cash reserves and R&D, and a smaller but significant impact on investment in non-cash working capital, but little impact on fixed investment or acquisitions. Our estimates indicate that R&D investment initially increases by $0.20-$.25 for each dollar of private equity flowing into the firm, and that PIPE funds initially invested in cash ultimately go to R&D. These findings offer direct evidence that access to private equity finance has an important effect on the key input that drives innovation at the firm- and economy-wide levels.

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I. Introduction

How important is access to private equity financing for real corporate activities? Despite extensive interest in the private equity industry, most evidence on private equity's real impact is based on aggregate comparisons of private equity activity (e.g., LBOs and venture capital activity) and real outputs (e.g., patent grants) across countries or industries (e.g., Kortum and Lerner (2000); Lerner, Sorensen, and Stromberg (2011)). In contrast, we focus in this study on the direct micro-level connections between private equity financing and real investment at the firm level. Specifically, we examine the association between private equity inflows and new corporate investment by publicly traded firms that raise external equity via private placements, commonly referred to as private investments in public equity (PIPEs). This is an ideal setting to evaluate the real impact of access to private equity funding because detailed financing and investment data is available for public firms in the years leading up to and following the private equity inflows. Since a large (and increasing) number of firms *repeatedly* tap private equity markets, we can build a panel of firm-year observations on PIPE inflows and investment spending that allows us to both: i) isolate the impact of PIPE funding after controlling for firm-specific fixed effects, and ii) instrument for the PIPE inflows, as the decision to raise funds via a private placement is clearly endogenous.

We study a broad sample of Compustat firms that conduct at least one private placement between 1995 and 2008. PIPE transactions are almost always equity or equity-linked investments, and the typical firm that raises private equity with a PIPE is small (less than $1 million in sales) and generates no internal cash flow, but has a very high market-to-book ratio (the median value is 7.09), is highly R&D intensive (the median R&D-to-total assets ratio is 0.13), and maintains a large stock of cash reserves (the median cash-to-assets ratio is 0.25). These characteristics highlight the potential for financing constraints to have an economically significant impact on financing and investment behavior in the firms that rely on PIPE financing. In particular, these firms have substantial (intangible) investment opportunities relative to internal cash flows, and likely face a high cost of external finance given information asymmetries associated with their investment projects and lack of collateral value in their assets. For such firms, fluctuations in the availability of PIPE funding can have an important impact on both contemporaneous investment spending and the firm's ability to accumulate reserve stocks of cash for investment in future periods.[1]

Although PIPEs are sometimes viewed as "last resort" financing for firms that face severe financing constraints (e.g., Brophy, Ouimet and Sialm (2009)), they are typically not viewed as a regular and quantitatively important *source* of funds, perhaps because aggregate proceeds from PIPE transactions pale in comparison to aggregate public stock and debt issues.[2] However, for the firms that turn to private placements, cash inflows from PIPEs are substantial, and are typically a much more important source of funds than secondary public equity issues and new debt issues. In addition, firms that conduct PIPE transactions tend to repeatedly raise funds via private placements: over 70% of the firms in our sample have more than one private placement. Amarin Corporation offers a nice illustration of how important PIPEs can be in some firms. Between 2000 and 2008, Amarin undertook 12 private placements that netted the firm over $150 million, more than offsetting the *negative* $82.656 million in internal cash flow it generated over the same period. Furthermore, during this nine

[1] Several studies document a strong connection between cash holdings and financing constraints. See, for example, Faulkender and Wang (2006), Bates, Kahle, and Stulz (2009), and Denis and Sibilkov (2010).

[2] Floros and Sapp (2011) show that annual PIPE gross proceeds amount only to 34.23% of the annual SEO gross proceeds up to 2006. They also show that the economic significance of PIPE funds increases sharply over time and is especially pronounced in 2007 and 2008.

year period that Amarin had large, persistent negative cash flows, it maintained (on average) an R&D-to-assets ratio of 17.48% and had $14.24 million in cash reserves at the end of 2008.

Our primary interest is in exploring how access to private equity impacts real firm activities. We begin by examining how firms use the proceeds from PIPE transactions using pooled OLS regressions with controls for investment opportunities and other sources of finance, similar to the approach Kim and Weisbach (2008) use to study public equity issues. On average, firms initially invest over half of every dollar of PIPE financing in cash reserves. The remainder is used primarily for R&D and non-cash working capital, with very little of the PIPE proceeds going into capital spending, acquisitions, or long-term debt reduction. In the years following the infusion of PIPE funding, firms draw down the dollars initially going into cash reserves, using the funds almost exclusively for R&D investment. Thus, the vast majority of PIPE financing ultimately goes into R&D.

Of course, the decision to raise PIPE financing is endogenous and jointly determined with the decision on how to spend the funds. To deal with this endogeneity we estimate dynamic models using a "system" GMM estimator that uses lagged values of all regression variables as instruments (see Arrelano and Bover (1995) and Blundell and Bond (1998)). This approach is used in a number of recent studies (e.g., Levine, Loayza, and Beck (2000); Beck and Levine (2004); Detragiache, Tressel, and Gupta (2008); Quinn and Toyoda (2008); Faulkender, Flannery, Hankins, and Smith (2011)) and is an attractive way to deal with endogeneity when no obvious external instruments are available.[3] In addition, Almeida, Campello, and Galvao (2010) show that an approach like we employ is a tractable way to deal with measurement error in the explanatory variables (namely, the market-to-book ratio)

[3] Of course, this approach has limitations: namely, it returns unbiased estimates only if a number of somewhat restrictive conditions hold in the data. We supply standard tests for these conditions with the regression output.

that can bias inference in investment regressions (e.g., Erickson and Whited (2000)). Thus, the results using this approach allow us to make stronger inference about the causal connections between private equity financing and firm-level investment.

The GMM estimates show a quantitatively important link between PIPE financing and firm investment in both cash reserves and R&D. Across all firms, the GMM estimates indicate that for every $1 shock to PIPE financing, firm investment in cash reserves changes by approximately $0.60 and investment in R&D changes by approximately $0.26. Investment in non-cash working capital is also somewhat sensitive to PIPE funding (changes by approximately $0.13), but variation in access to PIPE financing has a much smaller impact on investment in fixed capital and spending on acquisitions ($0.05 and $0.04, respectively). As expected, R&D investment is most sensitive to PIPE funding in the firms that frequently raise funds via private placements and appear the most dependent on private equity.

These findings indicate a strong connection between private equity financing and innovative activity at the firm-level. While prior studies focus on private equity and innovative *outputs* (such as patents) after *controlling* for R&D investment (e.g., Kortum and Lerner (2000)), our results highlight the importance of private equity for directly funding R&D, the key *input* for innovation at the firm level. In particular, our findings show that funds raised in private placements support R&D investment in firms with limited internal funds and little or no access to public debt and equity markets. Furthermore, the importance of PIPEs for innovative activity also works through cash reserves: innovative firms save a significant fraction of PIPE inflows as cash reserves that are used to fund R&D in future periods. When we include the *change* in cash reserves as a source of R&D finance, we find a significant negative coefficient, suggesting that firms draw down cash reserves to support

R&D investment. Thus, our findings show that access to PIPE financing not only affects current period R&D spending, but also influences the ability firms have for maintaining R&D in future periods.

Our findings also offer new evidence on the increasingly relevant connections between R&D investment, external equity issues, and cash holdings in financially constrained firms. R&D is by far the most important investment for firms that raise PIPE funds – e.g., R&D ratios are over five times larger than capital spending ratios among the firms in our sample.[4] Recent studies show that R&D is financed extensively with external stock issues, particularly in younger firms (Brown, Fazzari, and Petersen (2009)). In addition, the rise in R&D investment has been accompanied by an increase in corporate cash holdings (Bates, Kahle, and Stulz (2009)) and an increasing propensity for firms to invest the proceeds from share issues in cash reserves (McLean (2011)). Consistent with these studies, our findings show that PIPE inflows have a significant impact on R&D investment in firms that appear "constrained" at the margin. Furthermore, we show that the firms dependent on PIPE funding at the margin invest the majority of all new equity financing in substantial stocks of cash reserves that they use, in turn, to finance R&D spending. These results suggest that: i) financing constraints have a quantitatively important impact on R&D, ii) the financing of R&D is an important reason for the large "precautionary" cash holdings in the firms we study, and iii) PIPE inflows are an important source of funding for these precautionary cash reserves.

[4] Our sample consists only of PIPE issuing firms and is skewed toward R&D intensive firms, but the trend toward increased R&D investment is broad. For example, Brown and Petersen (2009) document a decline in fixed investment and substantial increase in R&D spending in a broad sample manufacturing firms over 1970-2006.

Our study also contributes to the emerging literature focused specifically on PIPEs. Public firms' increasing use of PIPEs has attracted substantial interest in recent years.[5] Several studies emphasize that private placements are concentrated in the kinds of firms especially likely to face high costs of raising external funds: smaller, younger firms with little or no internally generated cash flow and potentially severe information problems (e.g., Wu (2004); Gomes and Phillips (2007); and Brophy, Ouimet and Sialm (2009)). However, although a number of studies following Wruck (1989) examine the stock price performance of firms issuing private placements (e.g., Hertzel, Lemmon, Linck and Rees (2002); Krishnamurthy, Spindt, Subramaniam, and Woidtke (2005); Dai (2007); Brophy, Ouimet, and Sialm (2009); and Chaplinsky and Haushalter (2010)), this literature has generally not focused on the real effects of PIPEs.[6] Furthermore, following an early precedent, almost all studies of PIPEs ignore offerings after the first transaction by a PIPE issuer (e.g., Freund, John and Vasudevan (2006) and Huson, Malatesta and Parrino (2010)). Our findings show that firms regularly and repeatedly use PIPE financing and that access to this financing has a substantial impact on their real investment behavior.

The paper proceeds as follows. In the next section we provide additional background on the potential connection between private equity financing and innovative activity. We discuss our sample in section three and present the main results in section four. In the final section we summarize and discuss our main findings.

[5] The Wall Street Journal now regularly publishes statistics on aggregate PIPE investment activity (see, for example, "PIPE Rebound? Wait Til Next Quarter", October 21, 2010, "Market Woes Stall 2Q PIPE Activity But Could Lead To More Later", July 21, 2010 or "Risk Mitigation Could Lead To a Better PIPEline In 2010", January 21, 2010).

[6] One recent exception is Dai (2011), who examines firm operating performance in the years surrounding PIPE transactions.

II. Private Equity and R&D Investment

A. Private equity and real activity

There are several theoretical reasons that private equity financing may be important for R&D investment in firms with substantial intangible investment opportunities but limited internal funds. Notably, such firms likely have limited access to new debt for financing R&D because: i) debt contracts are poorly suited for financing risky investments with highly volatile returns (e.g., Stiglitz (1985)), ii) R&D investment is largely intangible and lacks collateral value, and iii) the costs of financial distress can be particularly severe for R&D intensive firms that take on additional debt (e.g., Opler and Titman (1994)). Consistent with these ideas, Brown, Fazzari, and Petersen (2009) find that internal and external equity finance are the primary marginal sources of finance for R&D investment in young firms, and a large number of studies document a negative link between leverage and R&D spending across firms (e.g., Bradley, Jarrell, and Kim (1984), Titman and Wessels (1988), Fama and French (2002), Hall (2002), Kayhan and Titman (2007), Hall and Lerner (2010)).

Though R&D is an "equity-dependent" investment, external issues of public equity can be costly for R&D-intensive firms. Information asymmetries between firms and potential investors can be severe, both because of the nature of the high-tech investment and because firms may be reluctant to reveal information about their activities (Kamien and Schwartz (1978)), which can increase the cost of public stock issues (Myers and Majluf (1984)). In addition, the transaction costs associated with public stock issues can be large, particularly in smaller firms (Lee, Lochhead, Ritter, and Zhao (1996)).

Private equity has several advantages over both debt and public equity issues for financing R&D. Relative to debt, private equity investors share in upside returns and should be less concerned with limited collateral value. Relative to public stock issues, private equity investors can have information advantages because of industry expertise and because of repeated or staged financing. For example, Billett and Floros (2011) show that corporate private investors are operational in the same industries as PIPE issuers and have more information about the issuing company's projects than public investors. In addition, for some firms, the overall costs associated with private placements can be significantly lower when compared to public issues. Huson, Malatesta, and Parrino (2010) document an economically significant decrease in PIPE price discounts in the later years of the 1995-2007 time period, which they attribute to the improving financials of PIPE issuers as well as the changes in the contracting process. Further, Dai (2011) shows that firms with greater agency costs are typically charged higher discounts, but staging helps mitigate the agency and information problems and thus lowers PIPE discounts and reduces the cost of financing for these firms. Thus, the cash inflows from private placements can potentially allow firms to undertake (or maintain) investment projects that would otherwise be bypassed due to high financing costs.

B. Private placements

Beginning in the mid-1990s, there is a sharp increase in private placements as a source of external capital for publicly traded U.S. firms. Between 1995 and 2008 aggregate gross proceeds from private investments in public equity (PIPEs) increased from $1.33 billion to $117.15 billion (Floros and Sapp (2011)). At the firm-level, PIPEs emerged as an important and frequently used source of external equity finance, particularly among smaller public firms with limited (and often negative) internal cash flows. For example, our analysis shows that over 70% of PIPE transactions between 1995 and 2008 were undertaken by firms with more than one private placement. Nonetheless, almost all studies of PIPEs either exclude or ignore offerings after the first PIPE transaction (e.g., Freund, John, and

Vasudevan (2006); and Huson, Malatesta, and Parrino (2010)). One exception is Floros and Sapp (2011), who show that the majority of PIPE transactions involve firms that self-select into repeated PIPE transactions. Another exception is Dai (2011), who studies the causes and consequences of staging in the setting of repeated PIPE offerings. She finds similarities to venture capital staging, since staging is used by investors as a monitoring mechanism to mitigate information asymmetry problems and agency costs. She finds that firms with staged financing have significantly better long run stock performance than their single round peers.

The findings in several studies suggest that access to PIPE financing may be an important marginal source of external finance for issuing firms. For example, Ellis and Twite (2008) argue that high levels of information asymmetry and significant future growth options cause equity issuers to choose PIPEs rather than SEOs. Chen, Dai, and Schatzberg (2010) argue that firms choosing PIPEs instead of SEOs lack access to the SEO market due to information asymmetry and weak operating performance. Martos-Vila (2011) shows theoretically that private equity financing can be optimal for companies plagued by information asymmetries. Chaplinsky and Haushalter (2010) find that PIPE issuers perform poorly before and after the PIPE offering, suggesting that PIPEs enable these firms to obtain financing that would otherwise be unavailable to them. Similarly, Brophy, Ouimet, and Sialm (2009) examine the performance of PIPEs invested by hedge funds versus all other investor types over 1995-2002 and argue that hedge funds provide funding for companies that are otherwise constrained from raising equity capital. We complement and extend this literature by directly exploring how the financing provided by PIPE issues affects real investment decisions in firms that appear to face severe financing constraints.

III. Data and Sample Statistics

A. Sample construction

We use Sagient Research's Placement Tracker as our data source for information on PIPE issues. We start with 14,258 PIPE offerings conducted between 1995 and 2008, which is essentially the entire universe of PIPE issues during this period. The universe of PIPE transactions amounts to 6,827 distinct PIPE issuers that tap private markets either once or multiple times. We then match the data on PIPE issuers with firm-year financing and investment data from Compustat. A significant fraction of PIPE issuers are very small firms that trade over-the-counter and thus are not covered in Compustat.[7] After excluding the firms without Compustat coverage and dropping firms from financial (SIC 6000-6999) and regulated industries (SIC 4900-4999), we are left with 1,532 firms that conduct either one or repeated PIPEs during the 1995-2008 period. Starting with the year of the first PIPE, we add firm-year financing and investment data from Compustat, giving us a panel of approximately 7,636 firm-year observations, with PIPE offerings occurring in 3,252 of those firm-years.[8] Finally, we include information on common stock public offerings from the Securities Data Corporation (SDC) database. All variables are winsorized at the 1% level.

B. PIPEs as a source of funds

To illustrate the importance of PIPE financing for our sampled firms, we begin in Figure 1 by comparing the frequency and magnitude of PIPE and SEO issuances across all sample years 1995-2008. Panel A of Figure 1 shows that for the firms we study, PIPEs are much more frequent than SEOs in each of the sample years. In particular, between 2000 and

[7] In accordance with Floros and Sapp (2011), we find that 21% of the entire universe of PIPEs spanning the period of 1995-2010 are traded on the Pink/OTC markets. For all these companies Compustat information is not available.

[8] Firms often conduct multiple PIPE transactions in the same fiscal year. In those cases, we aggregate the PIPE financings into a single fiscal year total that matches the fiscal year data from Compustat. The number of distinct PIPE transactions among our sampled firms is 4,069 (as shown in Figure 1).

2008, firms in our sample averaged approximately 291 PIPE issues but only 34 SEOs per year. In Panel B of Figure 1 we plot the yearly average gross proceeds from PIPE and SEO issues across our sampled firms. The figure shows that, after incorporating all firm-years of our sample, PIPE proceeds are larger (on average) than SEO proceeds in each year between 1995 and 2008.[9]

In Figure 2 we track the cumulative amount of financing the firms in our sample raise from key sources in the years following the first PIPE transaction (t=0). For each financing source, we sum values over the years since the initial PIPE and scale the total by the book value of assets at t=0. We then find and plot an average value at each subsequent year across the firms in our sample. The figure shows that, on average, PIPE financing dominates other financing sources in the years following the first private placement. The increase in the average amount of (cumulative) PIPE financing in the years after t=0 reflects the significant fraction of firms that have multiple private placements. On average, SEOs and new debt issues are both positive but very small sources of finance. Cumulative cash flows, on the other hand, are substantially negative; however, cash inflows from PIPEs are more than sufficient to offset these negative values. For example, the average cumulative PIPE to initial assets ratio over the five years following the first PIPE is 2.152 and the corresponding cash flow ratio is -1.369.

C. Descriptive statistics for the PIPE sample

In Table I we report descriptive statistics on key firm financing and investment variables for the sample of PIPE issuers in the period 1995-2008. We report median values (mean values show a similar pattern) for all variables except PIPE gross proceeds and the

[9] This is driven by the fact that SEO proceeds are typically zero for the firms we sample. If we compare only positive SEO and PIPE values the average SEO is larger than the average PIPE. SEOs are positive in just 480 firm-years of our entire sample.

total gross proceeds from the sale of common and preferred stock. Stock issues are lumpy and the median value across firm-years is zero, which potentially understates the importance of stock issues to the firm. All firm-years are included in our sample regardless of the presence of a PIPE transaction. For comparison, we also report values for all non-PIPE-issuing Compustat firms over the same period and we test for differences across the PIPE and non-PIPE samples using the non-parametric Wilcoxon rank-sum test.[10]

The first two rows in Table I show that firms relying on private placements use more external equity than the typical publicly traded firm and that PIPE proceeds are the primary source of external equity for these firms. For the PIPE sample, the average PIPEs to assets ratio (0.2572) is 74% of the overall total stock issues ratio (0.3487). In addition, firms in our sample generate less internal cash flow, use less long-term debt, and maintain substantially larger stocks of cash reserves than other publicly traded firms. Perhaps most importantly, firms in the PIPE sample have a very high market-to-book ratio (7.09) and are extremely R&D intensive (0.1314).

Thus, PIPE issuers are unique from both financing as well as investments perspective as they utilize private markets as their main financing source and focus on R&D projects rather than fixed capital investments. Furthermore, the descriptive statistics indicate that PIPE-issuing firms are precisely the firms where finance can have an important impact on both real investment (R&D and capital spending) and financial-side adjustments (increases in cash reserves or reductions in long-term debt). Firms in the PIPEs sample appear to have a large number of intangible investment opportunities but limited internal funds, and they are clearly relying extensively on external (private) equity to finance these opportunities. In

[10] As with the sample of PIPE issuing firms, the Compustat sample excludes all utilities (SIC 4900-4900) and all financials (SIC 6000-6999). We allow only firms with no PIPE issues in the Compustat sample.

addition, the firms relying on PIPEs appear financially constrained based on a number of commonly used ex ante proxies for financial constraints: they are small and consistently unprofitable, and they pay no dividends.

In Table II we report separate descriptive statistics for firms sorted based on the number of PIPE transactions they undertake during the sample period. Columns (1)-(4) report statistics for firms with one, two, three, and more than three PIPE transactions, respectively. Table II shows that the firms least reliant on PIPE financing are larger, generate more internal cash flow, and have lower R&D to assets ratios than firms with more PIPE transactions. Among firms with more PIPE transactions, internal cash flow declines (and becomes negative in the category of PIPE issuers with more than three PIPE transactions) and the magnitude of PIPE financing, the level of precautionary cash reserves, and R&D intensity all increase sharply. In addition, firms with more frequent PIPE issuances have less tangibility in their assets, do not issue any new long-term debt, and have shorter debt maturities.[11] These statistics suggest that access to private equity financing is particularly important for real activity in the firms with multiple PIPE transactions.[12]

[11] In non-tabulated results, we analyze the debt maturity structure across firms according to the frequency of their PIPE transactions. Specifically, we analyze the percentage of firms in each of the three categories in Table II that issue short-term debt maturing within 1, 2, 3, 4 and 5 calendar years, respectively. We find that a significantly larger fraction of firms with at least three PIPE transactions have short-term debt maturing in one year than do firms with just one PIPE transaction (14.03% versus 10.21%). This evidence reinforces the argument that frequent PIPE issuers repeatedly tap private equity markets as they need to service their immediate operating needs.

[12] We also examine the financial characteristics of the PIPE issuers when splitting the sample into positive and negative net cash flow firms, according to their cash flow balances the year before each PIPE issuance. Negative net cash flow firms are smaller, have higher cash balances, higher valuation multiples, lower acquisitions and capital expenditures, lower maturity of short-term debt and higher R&D levels when compared to the positive net cash flow PIPE issuers.

IV. PIPE Funding and Real Investment

A. Empirical specification

We start the formal analysis by exploring the connection between PIPE funding and firm financing and investment activity. An extensive literature following Fazzari, Hubbard, and Petersen (1998) tests for the real influence of financing constraints by examining the sensitivity of fixed investment to fluctuations in internal cash flow. Our empirical approach generally follows this literature except we include other key sources of finance (besides cash flow), and we examine the link between finance and a number of alternative uses of funds (besides fixed investment). We estimate the following dynamic specification:

$$Y_{j,t} = \alpha_1 Y_{j,t-1} + \alpha_1 Q_{j,t-1} + \alpha_2 Ln(Assets)_{j,t-1} + \alpha_3 Sales_{j,t} + \alpha_4 CashFlow_{j,t} + \alpha_5 dCash_{j,t}$$
$$+ \alpha_6 PIPE_{j,t} + \alpha_7 NewLTDebt_{j,t} + \alpha_8 SEO_{j,t} + \alpha_9 OtherStk_{j,t} + FixedEffects + e_{jt}. \quad (1)$$

We are interested in the marginal effect that PIPE inflows in firm *j* in period *t* have on contemporaneous spending, where *Y* is either investment in R&D, spending on fixed investment (Capx), cash spending on acquisitions (Acquire), investment in cash reserves (dCash), investment in (non-cash) working capital (dWC), or reduction in long-term debt outstanding (LtDbtReduc). We control for investment opportunities with the beginning-of-period market-to-book ratio (Q) and the contemporaneous level of sales (the results are similar if we use sales growth instead of sales). We also control for firm size using the log of beginning-of-period firm assets (Ln(Assets)) and for other key sources of finance. The internal financing variables include current period cash flow (CashFlow) gross of both R&D and capital spending (income before extraordinary items plus depreciation plus R&D) and, in all regressions except for the investment in cash regressions, the period *change* in cash reserves (dCash). We thus look at both the propensity to invest PIPE proceeds in cash (dCash is the dependent variable), and we control for the potential for cash reserves to be a source of funds for other uses (dCash is an explanatory variable), in which case the coefficient on dCash should be negative since reductions in cash release funds for investment.[13] In addition to PIPE issues, the external financing variables include proceeds from new long-term debt issues (NewLTDebt), secondary stock offerings (SEO), and other (net) funds from stock issues (OtherStk), which would include things like employee exercises of stock options.[14] All variables except Ln(Assets) are scaled by the beginning of period book value of assets. We estimate both pooled OLS regressions with industry- and year-fixed effects, as well as GMM regressions with firm- and year-fixed effects. In all regressions the standard errors are clustered at the firm-level and are thus robust to any arbitrary form of within firm serial correlation (Petersen (2009)).

B. Baseline results

Baseline estimates are reported in Table III. We begin with pooled regressions that include all firm-years of data and industry and year fixed effects. The industry fixed effects control for all time invariant determinants of investment at the industry level, while the year fixed effects control for any aggregate shocks that impact firm-level investment spending, such as macro-economic fluctuations. While this approach exploits both between- and within-firm variation and imposes the least data restrictions, there are several reasons to expect the OLS estimates to be biased, and we address these concerns below. In particular, at this stage we do not deal with the endogeneity of the decision to raise PIPE financing; rather,

[13] We have also estimated the regressions without including "dCash" as an explanatory variable and all our main findings and conclusions are unaffected. As Brown and Petersen (2011) discuss, controlling for changes in cash can be particularly important when evaluating how access to finance affects investments (like R&D) with high adjustment costs. Firms have strong incentives to use cash reserves to buffer the flow of R&D spending from transitory finance shocks; since this smoothing activity will make R&D less volatile than key sources of finance, a regression with no controls for cash management can readily underestimate the true impact that finance has on R&D. Also see Brown, Martinsson, and Petersen (2011).

[14] We measure other stock issues as gross funds from stock issues minus proceeds from PIPEs minus proceeds from SEOs minus stock repurchases.

the estimates in Table III should be interpreted as showing the marginal relation between PIPE inflows and investment after controlling for the fixed effects, other financing sources, and firm growth opportunities.

In order, columns (1)-(6) report regression results for R&D, capital spending, acquisitions, change in cash holdings, change in non-cash working capital, and reduction in long-term debt outstanding. The first column shows a strong positive link between PIPE proceeds and R&D spending, while the next two columns show a positive but considerably smaller link between PIPE proceeds and spending on both fixed capital and acquisitions. The estimates suggest that, on average, each additional dollar of PIPE proceeds is associated with 18 cents of new R&D spending, five cents of spending on fixed investment, and seven cents on acquisitions. Column four shows that PIPE issues share a particularly strong association with corporate cash holdings. In particular, corporate cash reserves increase by approximately 56 cents for every additional dollar of PIPE financing. The final two columns show that PIPE issues are associated with a modest increase in non-cash working capital (13 cents) and a small reduction in long-term debt (four cents).

C. Cash reserves and the cumulative impact of PE financing

The strong connection between PIPE proceeds and changes in cash holdings suggests that the firms we study initially invest a substantial fraction of all new PIPE financing in cash. This cash saving behavior is consistent with cash reserves serving an important precautionary role in firms that face binding financing constraints (e.g., Almeida, Campello and Weisbach (2004)). Such precautionary cash reserves should be particularly important for the firms we study given their extensive reliance on external finance and very high R&D intensity. For these firms, we may observe a relatively small fraction of PIPE financing going immediately into new investment, but the remainder that is initially in cash can be used to fund investment in *future* periods. Thus, the cumulative impact that PIPE financing has on investment works directly through the initial PIPE inflow, and indirectly through PIPE-funded cash reserves.

One way to directly gauge the cumulative impact that PIPE inflows have on firm-level investment spending is to follow the approach Kim and Weisbach (2009) use to evaluate the motivations for public equity offerings. Kim and Weisbach (2009) study how firms use the capital raised in public equity offerings in subsequent years. Applying their approach to our setting, we estimate the following regression:

$$Y = \beta_1 ln[(PIPE\ proceeds/TA_0) + 1] + \beta_2 ln[(other\ sources/TA_0) + 1] + \beta_3 ln(TA_0) + Year + Industry + e.$$

Here, the dependent variable is the *cumulative* change in investment spending in the years following a PIPE issue (reported for one, two and three year intervals), and β_1 measures the cumulative impact that a PIPE inflow in a given period has in the years following the issue, after controlling for other financing inflows during the interval ("other sources"), the initial size of total assets, and industry and year fixed effects. We expect that an increasing share of every dollar of PIPE funding will go into R&D as firms spend down their cash reserves in the years following a PIPE issue.

The results are reported in Table IV. We only report estimates of β_1, the coefficient on PIPE raised in the current period (t=0). The results are generally consistent with Table III, but they show directly that PIPE dollars initially going into cash reserves ultimately fund R&D expenditures. In column one, the coefficient on PIPE proceeds increases sharply from 0.255 to 0.469 as we accumulate the change R&D over the t=1 to t=3 interval. At the same time, column four shows that the change in cash reserves *declines* as we examine longer intervals after each PIPE issue, indicating that firms spend down PIPE dollars initially invested in cash. In sharp contrast to R&D, the coefficient estimates in the capital spending (column two), acquisition spending (column three), and long-term debt reduction (column six) regressions are relatively modest and do not increase rapidly as we sum over longer intervals following the PIPE issue.

D. Dynamic GMM regressions

The findings presented thus far indicate that PIPE funds are the key marginal source of R&D finance for the firms we examine, and they highlight the potential for fluctuations in the availability of PIPE financing to limit R&D investment in these firms. One potential source of bias in the pooled OLS results (Table III) is omitted firm-specific factors that influence both the propensity to raise PIPE financing and to invest the funds in certain ways (e.g., increased R&D and cash holdings). We therefore move to regressions with firm fixed effects that control for all omitted, but time invariant, firm characteristics that can influence these decisions, such as geographic location (which might impact the access that firms have to PIPE finance or highly skilled labor) and managerial characteristics. However, including firm fixed effects in specifications with lagged dependent variables introduces the well-known dynamic panel bias (Nickell (1981)). We therefore proceed by estimating equation (1) with the "system" GMM estimator (Arellano and Bover (1995) and Blundell and Bond (1998)). This approach is appealing for our purposes for several reasons; most importantly, it allows us to simultaneously: i) control for firm fixed effects and address the resulting dynamic panel bias, ii) account for the endogeneity of the key financial variables, including PIPE issues, and iii) address the potential for measurement error in the market-to-book ratio to bias coefficient estimates on other regression variables.[15]

The systems approach jointly estimates the dynamic regression specification in both differences and levels. Blundell and Bond (1998) show that including the regression in levels can lead to marked improvement over the widely used "difference GMM" estimator (Arellano and Bond (1991)), particularly when there is substantial persistence in the explanatory variables.[16] Our primary results use lagged levels dated t-2 to t-4 to instrument the regression in differences and lagged differences dated t-1 to instrument the regression in levels. To assess instrument validity we report a Hansen J-test of the null that the over-identifying restrictions are valid, a difference-in-Hansen test that evaluates the validity of the additional instruments required for systems estimation (i.e., the validity of the instruments used in the levels equation), and an *m2* test for second-order autocorrelation in the first-differenced residuals. The results are similar if we use alternative instrument sets, including starting the instruments with lagged levels dated t-3 (which are valid even if the error term is MA(1)).

The estimates are reported in Table V with standard errors robust to heteroskedasticity and within-firm serial correlation in parenthesis. The firm and observation counts in Table V are smaller than in the preceding tables because the estimator relies on lagged values as instruments and thus firms with an insufficient number of observations are dropped. We continue to find: i) a strong positive link between PIPE issues and investment in both R&D and cash reserves, ii) a positive link between PIPE issues and investment in non-cash working capital, and iii) a positive but relatively weak link between PIPE issues and

[15] Hankins and Flannery (2011) highlight the benefits of the system estimator for dynamic panel analysis of corporate finance data. Almeida, Campello and Galvo (2010) provide evidence on the benefits of instrumental approaches like ours for dealing with measurement error in investment regressions.
[16] This approach is only valid if an additional moment restriction holds in the data: *differences* in the right-hand side variables in equation (1) must not be correlated with the firm-specific effect.

spending on fixed investment and acquisitions. The results also show a negative link between changes in cash reserves and R&D investment, indicating that the firms we study sometimes rely on their large stocks of cash reserves to finance R&D spending.

The results in Table V offer even stronger evidence that access to private equity financing (in the form of PIPEs) directly impacts R&D investment in the firms we study. Further, access to PIPE funds allows firms with little or no internally generated cash flow to increase cash reserves, which they subsequently use to finance ongoing operations, the most important of which is the flow of annual R&D expenditures. One way to interpret the GMM results is that, all else equal, firms will increase R&D spending by approximately 26 cents and cash reserves by 60 cents for each $1 exogenous increase in the supply of private equity financing, with the remaining funds going into working capital and other operational needs.

The results in Table V also show several differences in the marginal association between other sources of finance and firm investment. In particular, internal cash flow is only weakly related to R&D, fixed investment, and acquisition spending, likely because cash flow is low and often negative in our sample, which drives down the estimated investment-cash flow relation (e.g., Allayannis and Mozumdar (2004)).[17] In addition, PIPEs, SEOs, and other external equity issues share a similar positive relation with R&D spending (e.g., coefficient estimates between 0.25 and 0.27), indicating that the marginal propensity to invest external equity issues in R&D is similar for private or public issues. Although the *marginal* effects are similar, SEOs and other equity issues are a much less important source of funds for the firms we study (see Table II) and therefore have a much smaller impact than PIPEs on the *amount*

[17] If we drop years with negative cash flows (which account for a large share of our sample) we recover a positive, significant link between cash flow and R&D.

of R&D investment in our sampled firms.[18] Finally, both PIPE and SEO issues share a strong positive relation with changes in cash reserves, but firms initially store a much larger fraction of each SEO issue in cash (the coefficient on SEO proceeds is 0.848 in the cash regression).[19]

E. Frequent PIPE Issuers

As discussed above, some firms routinely raise external equity via PIPEs. The descriptive statistics show that frequent PIPE issuers are more R&D intensive, have lower cash flows, and maintain larger stocks of cash reserves. In Table VI we consider whether the impact of PIPE financing is different for the firms most reliant on PIPE financing. Panel A reports results for the frequent issuers only (at least three PIPE issues during the sample period), and panel B reports results for the remaining (infrequent issuers) firms. Comparing panels A and B reveals several interesting differences. Most importantly, R&D is much more sensitive to PIPE financing for the frequent issuers, while changes in non-cash working capital are less sensitive. These results further highlight the link between R&D and PIPE financing. For frequent issuers, PIPEs are by far the most important source of finance (see Table II). The vast majority of each dollar of PIPE financing goes into R&D and cash reserves, and cash reserves are then used to finance R&D. The importance of PIPEs as a source of funds, together with the estimates in Panel A suggest that R&D would fall substantially if the frequent issuers no longer had access to private equity.

F. Does Investor Type Matter?

In the final table (Table VII) we consider whether there are systematic differences in

[18] The results for public equity issues are consistent with other recent studies that emphasize a strong connection between public share issues and R&D investment (e.g., Brown, Fazzari, and Petersen (2009) and Kim and Weisbach (2009)). However, the limited use of SEOs, together with the strong sensitivity for R&D to PIPE funding, indicates that PIPEs and public share issues are not perfect substitutes for our sampled firms.

[19] One explanation for this finding is that SEOs are not a reliable source of funding for the firms we study, so a larger fraction is saved in precautionary cash reserves rather than used for immediate operational needs. Our estimates also indicate a stronger propensity to save than McLean (2011), who documents an increasing propensity for firms to invest stock issues in cash reserves in recent decades.

the impact PE inflows have depending on *source* of the PIPE funding. The regressions mirror those presented in the prior tables, but here we report only the coefficient estimate on PIPE funds for each of the dependent variables. In Panel A we look only at firms receiving PIPE funding primarily from hedge funds, and in Panel B we look at firms with PIPE funding provided by all other non-hedge fund suppliers (e.g., corporations, private equity firms, and venture capitalists).[20] We focus on hedge funds because the role of hedge funds in the private placement market has received considerable (and often negative) attention (e.g., Dai (2007); Brophy, Ouimet, and Sialm (2009)). The results indicate a slightly stronger link between PIPE funds and investment in R&D and non-cash working capital when hedge funds are the primary suppliers of capital. These results suggest that firms turning to hedge funds might be especially dependent on PIPE funding for immediate operational needs. However, the overall patterns are similar for all firms that rely extensively on PIPE financing, irrespective of the primary source for that finance.

We next sort firms based on whether they stay with the same supplier of PIPE funds (Panel C) or switch suppliers (Panel D) across financing transactions. For this analysis, we focus only on firms with information on the identity of the PIPE supplier and more than one PIPE transaction, which reduces the sample considerably. Relative to the firms switching suppliers, the firms that stay with the same supplier tend to invest a smaller fraction of PIPE financing in R&D. Though the limited sample size tempers the conclusions we can draw from these results, the weaker link between PIPE financing and R&D in the firms that do not switch potentially suggests that R&D in those firms is less sensitive to shocks in the availability of external finance, perhaps because of the relationship they have with key

[20] We sort firms into these categories based on the identity of the leading supplier type at the time of the firm's first PIPE transaction. The sample size declines in Table VII because we do not have information on the PE supplier for all firms.

suppliers of finance. Thus, the full set of results in Table VII suggests that the real impact of PIPE financing is not sensitive to investor identity, but it may differ according to the relationships PIPE issuers have with PIPE investors. We believe the potential for 'relationship PIPE financing' is an important topic for future research.

V. Conclusions

Our study offers new evidence on the real impact of firm access to private equity finance. Specifically, we study the affect cash inflows from private placements (PIPEs) have on firm-level investment decisions. We show that the firms most reliant on PIPE financing are extremely R&D intensive, generate little internal cash flow, and maintain sizable stocks of cash reserves. These firms likely have particular difficulty raising external debt or undertaking public stock offerings, in part because of the intangible and highly variable nature of R&D investment. As a result, PIPE financing is their primary source of external capital, and our findings show that access to this financing has an economically important and statistically significant impact on their R&D expenditures. Our results thus reveal a direct connection between PIPE *financing* and innovative activity at the firm-level.

Our study makes several contributions. Most importantly, we offer novel evidence on a largely unexplored mechanism – the funding of R&D – that connects private equity with innovation and, potentially, long-run economic performance. In so doing, our results show that financing frictions can exert a binding constraint on corporate investment in R&D, and that access to private equity financing can partially relax those constraints. In particular, our findings show that PIPEs have emerged as a key source of external finance for R&D-intensive public firms, and our estimates suggest that their R&D intensity would decline sharply if they did not have access to this financing.

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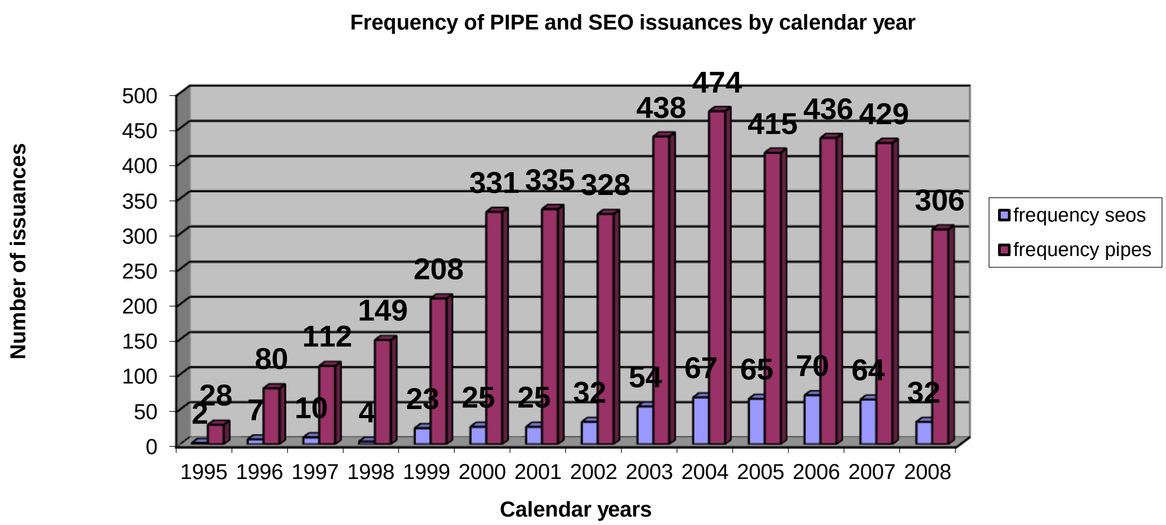
Figure 1
Distribution of PIPEs and Common Stock SEOs 1995-2008

In Panel A, the figure shows the number of PIPEs and common stock SEOs each year over the sample period 1995-2008. The sample is 4,069 PIPE transactions and 480 public equity SEOs conducted by the sample of PIPE issuers described in section III. The source of information for PIPEs is PlacementTracker provided by Sagient Research and for common stock SEOs is SDC Platinum provided by Thomson Reuters. In Panel B, the figure shows the annual mean gross proceeds for PIPEs and common stock SEOs for the same sample and time period. PIPE and SEO values are set to zero if the firm had no issues in that year. Figures are in millions of U.S. dollars.

Panel A:



Panel B:

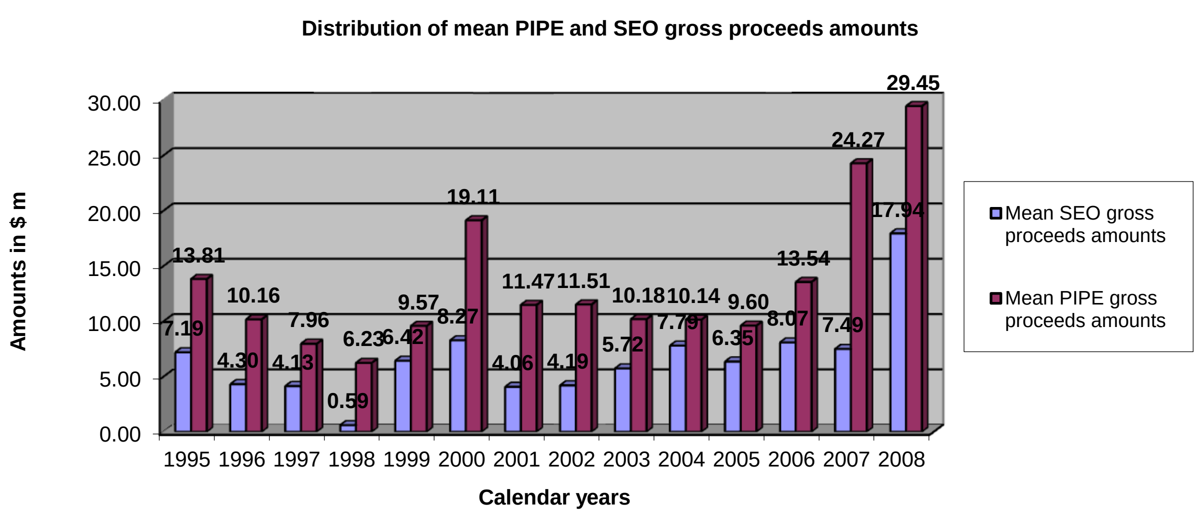


Figure 2
Sources of Finance for PIPE Sample

The figure shows the cumulative amount of internal and external capital raised by firms in the five years following their first PIPE transaction. The financial variables are accumulated across time and scaled by the book value of total assets in the year of the first PIPE transaction.

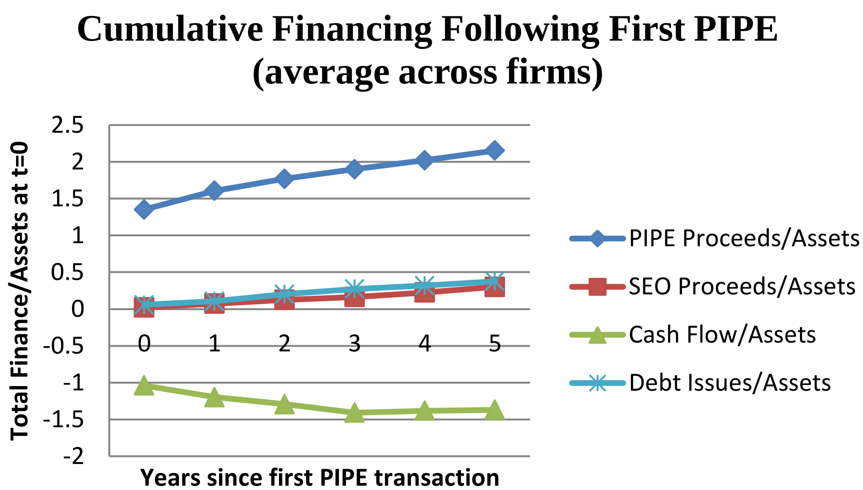


Table I
Sample Descriptive Statistics

Table I displays median values of key firm characteristics for the sample of firms with at least one PIPE transaction between 1995 and 2008 and a comparison sample of non-PIPE issuing firms in Compustat (for the PIPE proceeds ratio and the gross stock issues ratio we report the mean values). The PIPE proceeds ratio is total PIPE gross proceeds over total assets. Gross stock issues ratio is sales of common and preferred stock over total assets. Sales ratio is sales over total assets, cash ratio is cash and cash equivalents over total assets, repurchase ratio is the purchase of common and preferred stock over total assets, acquisitions ratio is the cash amount spent on acquisitions over total assets, tangibility ratio is Net PPE minus inventories over total assets, net assets is total assets minus cash, CAPEX ratio is capital expenditures over total assets, R&D ratio is research and development expenditures over total assets, leverage ratio is the sum of long-term and short-term debt over total assets issuance of new long-term debt ratio is the total issuance of new long-term debt over total assets, cash flow ratio is the sum of income before extraordinary items and any existing research and development expenses over total assets, dividends ratio is the ratio of total dividends over total assets. The last column reports Wilcoxon *z*-statistics with *p*-values in brackets (for the gross stock issues ratio we report the paired t-statistic with p-values in brackets).

Variables	PIPE Sample	Compustat Sample (Non-PIPE issuers)	Wilcoxon rank sums *z*-statistic
PIPE Proceeds ratio (%)	25.72		
Gross stock issues ratio (%)	34.87	21.98	7.31 (<.0001)
Cash flow ratio (%)	0.98	1.34	-11.08 (<.0001)
Issuance of new long-term debt ratio (%)	0	0.24	-65.73 (<.0001)
Cash ratio (%)	25	8.15	51.62 (<.0001)
Leverage ratio (%)	37.15	43.73	-14.09 (<.0001)
Market-to-book ratio	7.09	1.71	95.96 (<.0001)
R&D ratio (%)	13.14	3.66	44.52 (<.0001)
CAPEX ratio (%)	2.57	3.96	-20.77 (<.0001)
Sales ratio (%)	62.75	82.49	-18.73 (<.0001)
Repurchase ratio (%)	0	0	-24.49 (<.0001)
Acquisitions ratio (%)	0	0	-11.50 (<.0001)
Tangibility ratio (%)	20.98	37.59	-29.44 (<.0001)
Net assets ($m)	34.25	123.16	-32.78 (<.0001)
Dividends ratio (%)	0	0	-55.45 (<.0001)
Observations	7,636	125,706	

Table II
Firm Characteristics by Frequency of PIPE Transactions

Table II displays separate descriptive statistics for firms sorted based on the number of PIPE transactions during the sample period. The PIPE proceeds ratio is PIPE gross proceeds to total assets, other stock issuances ratio is net cash flow from non-PIPE and non-SEO proceeds (gross proceeds from stock issues minus proceeds from PIPE issues minus proceeds from SEOs minus stock repurchases), SEO proceeds ratio is total common stock gross public offerings' proceeds over total assets, sales ratio is sales over total assets, cash ratio is cash and cash equivalents over total assets, repurchase ratio is the purchase of common and preferred stock over total assets, acquisitions ratio is the cash amount spent on acquisitions over total assets, tangibility ratio is net PPE minus inventories over total assets, net assets is total assets minus cash, CAPEX ratio is capital expenditures over total assets, R&D ratio is research and development expenditures over total assets, leverage ratio is the sum of long-term and short-term debt over total assets, issuance of new long-term debt ratio is the total issuance of new long-term debt over total assets, cash flow ratio is the sum of income before extraordinary items, depreciation and R&D expenses over total assets. PIPE proceeds ratio and SEO proceeds ratio are average values across all firm-years, and all other values are medians across firm-years. All variables except the market-to-book ratio are scaled by lagged total assets.

Variables	Firms with 1 PIPE transaction	Firms with 2 PIPE transactions	Firms with 3 PIPE transactions	Firms with more than 3 PIPE transactions
PIPE proceeds ratio (%)	14.10	23.00	24.46	39.01
SEO proceeds ratio (%)	2.89	3.96	4.57	4.47
Other stock issues ratio (%)	0.09	0.19	0.37	0.45
Cash flow ratio (%)	7.72	2.02	1.45	-8.24
New long-term debt issuance ratio (%)	0	0	0	0
Cash ratio (%)	16.62	24.99	26.66	37.47
Market-to-book ratio	7.07	6.32	7.43	7.48
R&D ratio (%)	7.70	10.65	13.24	24.17
CAPEX ratio (%)	2.91	2.61	2.65	2.21
Sales ratio (%)	93.16	79.61	68.77	39.20
Repurchase ratio (%)	0	0	0	0
Acquisitions ratio (%)	0	0	0	0
Tangibility ratio (%)	26.31	21.39	20.49	16.61
Net assets ($ M)	85.27	37.43	31.49	18.13
Observations	2,566	1,435	1,000	2,634

Table III
Private Equity Inflows and Firm-level Investment: Pooled OLS Regressions

Table III presents pooled OLS estimates from regressing - in six separate estimation models -'R&D' R&D expenditures, 'Capx' capital expenditures, 'Acquire' cash acquisition expenditures, 'dCash' the change of the stock of cash holdings, 'dWC' the change in non-cash working capital (computed as the current assets minus current liabilities minus cash holdings) and 'LtDbtReduct' the reduction in long-term debt, on the following independent variables: 'PIPE' PIPE gross proceeds amounts, 'Q' the lagged market to book ratio, 'Ln(Assets)' the lagged book value of assets (logged), 'Sales' revenues, 'CashFlow' gross cash flow (income before extraordinary items plus depreciation plus R&D), 'dCash' the change in cash reserves, 'NewLTDebt' net new long-term debt issuances (computed as the difference between new long-term debt issuances and long-term debt reductions), 'SEO' common stock SEO gross proceeds amounts, 'OtherStk' net cash flow from non-PIPE and non-SEO proceeds (gross proceeds from stock issues minus proceeds from PIPE issues minus proceeds from SEOs minus stock repurchases). All variables are scaled by the lagged value of total assets except Ln(Assets) and Q. All ratios are winsorized at the 1% level. The regression controls for industry- and year-fixed effects, where industry effects are defined at the two-digit SIC level. Standard errors are robust to heteroskedasticity and within firm serial correlation. Statistical significance at the 1%, 5% and 10% levels are indicated by *, ** and *** respectively.

	Dependent variable:					
	R&D$_t$	Capx$_t$	Acquire$_t$	dCash$_t$	dWC$_t$	LtDbtReduct$_t$
	(1)	(2)	(3)	(4)	(5)	(6)
Variable						
DependentVar$_{t-1}$	0.394	0.343	0.100	-0.032	-0.095	0.399
	(0.024)***	(0.028)***	(0.017)***	(0.011)***	(0.029)***	(0.085)***
PIPE$_t$	0.180	0.051	0.070	0.557	0.130	0.040
	(0.019)***	(0.007)***	(0.009)***	(0.024)***	(0.019)***	(0.014)***
Q$_{t-1}$	0.004	0.001	-0.001	0.008	0.000	-0.003
	(0.002)**	(0.001)*	(0.001)*	(0.003)**	(0.002)	(0.001)***
Ln(Assets)$_{t-1}$	-0.016	0.002	0.006	0.016	0.002	0.004
	(0.003)***	(0.001)*	(0.001)***	(0.004)***	(0.002)	(0.003)
Sales$_t$	-0.007	0.010	0.022	0.049	0.004	0.028
	(0.005)	(0.002)***	(0.003)***	(0.008)***	(0.006)	(0.007)***
CashFlow$_t$	0.033	0.017	0.032	0.153	0.173	0.007
	(0.017)**	(0.007)**	(0.006)***	(0.027)***	(0.020)***	(0.009)
dCash$_t$	-0.023	-0.018	-0.084		-0.110	-0.022
	(0.018)	(0.007)**	(0.010)***		(0.018)***	(0.013)*
NewLTDebt$_t$	0.092	0.071	0.192	0.323	0.010	0.027
	(0.029)***	(0.014)***	(0.022)***	(0.051)***	(0.032)	(0.030)
SEO$_t$	0.141	0.061	0.116	0.843	0.101	0.046
	(0.025)***	(0.011)***	(0.017)***	(0.050)***	(0.022)***	(0.019)**
OtherStk$_t$	0.159	0.056	0.085	0.535	0.104	0.026
	(0.023)***	(0.010)***	(0.011)***	(0.039)***	(0.028)***	(0.024)
Constant	0.015	0.011	-0.145	-0.253	-0.023	-0.047
	(0.039)	(0.022)	(0.022)***	(0.087)***	(0.028)	(0.022)**
Industry fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Observations	4,535	5,979	5,830	6,017	5,974	4,737
R-squared	0.651	0.536	0.216	0.560	0.155	0.263

Table IV
Private Equity Inflows and Cumulative Corporate Expenditures

Table IV presents estimates from regressions that measure the cumulative impact in the years that follow PIPE inflows. The dependent variable *Y* is the cumulative use of funds measured over one, two, and three year intervals following the PIPE issue. For R&D, fixed investment, acquisitions, and long-term debt reduction, *Y* is the sum of new spending over the relevant interval. For cash holdings and non-cash working capital, *Y* is the change in the level relative to t=0. Other sources include new cash inflows to the firm from internal cash flows and new stock and debt issues. All regressions are estimated with OLS and include year and industry fixed effects. Standard errors robust to heteroskedasticity and with-in firm serial correlation are reported in parenthesis. Statistical significance at the 1%, 5% and 10% levels are indicated by *, ** and ***. The number of observations and R-squared from the regression are in brackets.

$$Y = \beta_1 ln[(PIPE\ proceeds/TA_0) + 1] + \beta_2 ln[(other\ sources/TA_0) + 1] + \beta_3 ln(TA_0) + Year + Industry + e$$

Y =	sum_R&D	sum_Capx	sum_Acquire	dCash	dWC	sum_ LtDbtReduct$_t$
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS estimates of β_1					
Interval after IPO (t=0):						
t=1	0.255	0.065	0.043	0.740	0.068	0.024
	(0.015)***	(0.008)***	(0.008)***	(0.023)***	(0.028)**	(0.009)***
	[4431, 0.517]	[5818, 0.474]	[5728, 0.170]	[5834, 0.428]	[5782, 0.064]	[5835, 0.098]
t=1 to t=2	0.386	0.102	0.058	0.513	0.002	0.037
	(0.022)***	(0.016)***	(0.017)***	(0.034)***	(0.037)	(0.014)***
	[3331, 0.631]	[4362, 0.550]	[4260, 0.217]	[4379, 0.452]	[4326, 0.055]	[4379, 0.156]
t=1 to t=3	0.469	0.109	0.056	0.398	-0.039	0.040
	(0.034)***	(0.021)***	(0.025)***	(0.057)***	(0.041)	(0.022)*
	[2452, 0.673]	[3210, 0.595]	[3114, 0.233]	[3224, 0.501]	[3174, 0.064]	[3224, 0.207]

Table V
Private Equity Inflows and Firm-Level Investment: GMM Estimates

Table V reports GMM estimates from regressing - in six separate estimation models -'R&D' R&D expenditures, 'Capx' capital expenditures, 'Acquire' cash acquisition expenditures, 'dCash' the change of the stock of cash holdings, 'dWC' the change in non-cash working capital (computed as the current assets minus current liabilities minus cash holdings) and 'LtDbtReduct' the reduction in long-term debt, on the following independent variables: 'PIPE' PIPE gross proceeds amounts, 'Q' the lagged market to book ratio, 'Ln(Assets)' the lagged book value of assets (logged), 'Sales' revenues, 'CashFlow' gross cash flow (income before extraordinary items plus depreciation plus R&D), 'dCash' the change in cash reserves, 'NewLTDebt' net new long-term debt issuances (computed as the difference between new long-term debt issuances and long-term debt reductions), 'SEO' common stock SEO gross proceeds amounts, 'OtherStk' net cash flow from non-PIPE and non-SEO proceeds (gross proceeds from stock issues minus proceeds from PIPE issues minus proceeds from SEOs minus stock repurchases). All variables are scaled by the lagged value of total assets except Ln(Assets) and Q. All ratios are winsorized at the 1% level. The regression controls for firm- and year-fixed effects. Estimation is by systems GMM with lagged levels dated t-2 to t-4 used as instruments for the regression equation in first differences and lagged differences dated t-1 used to instrument the equation in levels. The *J*-test is a test of the null hypothesis that the over-identifying restrictions are valid, the diff-Hansen is a test of the null that the instruments used for the levels equation are valid, and *m2* is test for second-order autocorrelation in the first-differenced residuals. Standard errors are robust to heteroskedasticity and with-in firm serial correlation. Statistical significance at the 1%, 5% and 10% levels are indicated by *, ** and *** respectively.

	Dependent variable:					
	$R\&D_t$	$Capx_t$	$Acquire_t$	$dCash_t$	dWC_t	$LtDbtReduct_t$
	(1)	(2)	(3)	(4)	(5)	(6)
Variable						
$DependentVar_{t-1}$	0.233	0.310	0.047	-0.006	-0.021	0.176
	(0.032)***	(0.037)***	(0.023)**	(0.013)	(0.040)	(0.064)***
$PIPE_t$	0.263	0.051	0.042	0.604	0.134	-0.008
	(0.036)***	(0.015)***	(0.013)***	(0.041)***	(0.036)***	(0.018)
Q_{t-1}	0.002	-0.000	-0.002	0.004	-0.004	-0.004
	(0.004)	(0.001)	(0.002)	(0.007)	(0.003)	(0.002)*
$Ln(Assets)_{t-1}$	-0.044	0.016	0.010	0.033	0.000	-0.008
	(0.012)***	(0.005)***	(0.003)***	(0.015)**	(0.010)	(0.007)
$Sales_t$	-0.053	0.035	0.019	0.108	0.015	0.026
	(0.015)***	(0.006)***	(0.008)**	(0.022)***	(0.014)	(0.010)***
$CashFlow_t$	0.054	-0.013	0.014	0.086	0.185	0.006
	(0.028)*	(0.014)	(0.010)	(0.049)*	(0.040)***	(0.020)
$dCash_t$	-0.080	-0.022	-0.075		-0.086	0.014
	(0.036)**	(0.014)	(0.018)***		(0.036)**	(0.020)
$NewLTDebt_t$	0.203	0.021	0.138	0.543	-0.039	-0.046
	(0.053)***	(0.020)	(0.033)***	(0.116)***	(0.075)	(0.040)
SEO_t	0.251	0.052	0.160	1.001	0.081	0.052
	(0.066)***	(0.028)*	(0.042)***	(0.119)***	(0.071)	(0.052)
$OtherStk_t$	0.271	0.061	0.060	0.562	0.102	-0.025
	(0.043)***	(0.022)***	(0.017)***	(0.081)***	(0.059)*	(0.027)
Firm fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Observations	4,535	5,979	5,830	6,017	5,974	4,737
Number of firms	964	1,309	1,290	1,312	1,306	1,107
J-test	0.206	0.038	0.165	0.048	0.338	0.061
Diff-Hansen	0.556	0.000	0.148	0.292	0.519	0.006
m2	-1.23	1.13	1.34	-0.03	-1.31	0.54

Table VI
Private Equity Inflows and Firm-Level Investment for Frequent and Infrequent PIPE Issuers: Dynamic GMM Estimates

Table VI reports GMM estimates from regressing - in six separate estimation models -'R&D' R&D expenditures, 'Capx' capital expenditures, 'Acquire' cash acquisition expenditures, 'dCash' the change of the stock of cash holdings, 'dWC' the change in non-cash working capital (computed as the current assets minus current liabilities minus cash holdings) and 'LtDbtReduct' the reduction in long-term debt, on the following independent variables: 'PIPE' PIPE gross proceeds amounts, 'Q' the lagged market to book ratio, 'Ln(Assets)' the lagged book value of assets (logged), 'Sales' revenues, 'CashFlow' gross cash flow (income before extraordinary items plus depreciation plus R&D), 'dCash' the change in cash reserves, 'NewLTDebt' net new long-term debt issuances (computed as the difference between new long-term debt issuances and long-term debt reductions), 'SEO' common stock SEO gross proceeds amounts, 'OtherStk' net cash flow from non-PIPE and non-SEO proceeds (gross proceeds from stock issues minus proceeds from PIPE issues minus proceeds from SEOs minus stock repurchases). All variables are scaled by the lagged value of total assets except Ln(Assets) and Q. All ratios are winsorized at the 1% level. The regression controls for firm- and year-fixed effects. Estimation is by systems GMM with lagged levels dated t-2 to t-4 used as instruments for the regression equation in first differences and lagged differences dated t-1 used to instrument the equation in levels. The *J*-test is a test of the null hypothesis that the over-identifying restrictions are valid, the diff-Hansen is a test of the null that the instruments used for the levels equation are valid, and *m2* is test for second-order autocorrelation in the first-differenced residuals. Standard errors are robust to heteroskedasticity and with-in firm serial correlation. Statistical significance at the 1%, 5% and 10% levels are indicated by *, ** and *** respectively. Results in Panel A are for firms with at least three PIPE transactions during the sample period; results for firms with either one or two PIPE issues are in Panel B.

	Dependent variable:					
	$R\&D_t$	$Capx_t$	$Acquire_t$	$dCash_t$	dWC_t	$LtDbtReduct_t$
	(1)	(2)	(3)	(4)	(5)	(6)
Variable			Panel A: Frequent PIPE Issuers Only			
$DependentVar_{t-1}$	0.240	0.384	0.044	-0.014	-0.077	0.232
	(0.032)***	(0.049)***	(0.034)	(0.016)	(0.048)	(0.105)**
$PIPE_t$	0.224	0.042	0.048	0.607	0.095	-0.006
	(0.036)***	(0.017)**	(0.015)***	(0.047)***	(0.036)***	(0.019)
Q_{t-1}	-0.000	-0.001	-0.002	0.009	-0.002	-0.003
	(0.005)	(0.001)	(0.002)	(0.007)	(0.003)	(0.002)
$Ln(Assets)_{t-1}$	-0.060	0.011	0.015	0.038	0.006	-0.012
	(0.015)***	(0.005)**	(0.004)***	(0.018)**	(0.012)	(0.011)
$Sales_t$	-0.066	0.022	0.029	0.071	0.020	0.032
	(0.019)***	(0.006)***	(0.008)***	(0.027)***	(0.018)	(0.016)**
$CashFlow_t$	0.024	-0.008	0.013	0.178	0.140	0.013
	(0.027)	(0.018)	(0.011)	(0.055)***	(0.045)***	(0.016)
$dCash_t$	-0.053	-0.014	-0.068		-0.047	0.009
	(0.033)	(0.016)	(0.018)***		(0.039)	(0.020)
$NewLTDebt_t$	0.189	0.008	0.124	0.540	-0.100	-0.031
	(0.055)***	(0.023)	(0.033)***	(0.124)***	(0.077)	(0.040)
SEO_t	0.225	0.063	0.138	0.870	0.017	0.010
	(0.065)***	(0.023)***	(0.040)***	(0.125)***	(0.063)	(0.037)
$OtherStk_t$	0.273	0.054	0.070	0.569	0.044	-0.025
	(0.039)***	(0.023)**	(0.021)***	(0.081)***	(0.052)	(0.030)
Firm fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Observations	2,605	3,148	3,094	3,167	3,151	2,644
Number of firms	447	545	538	545	544	524
J-test	0.924	0.387	0.775	0.612	0.864	0.539
Diff-Hansen	0.834	0.882	0.942	1.000	0.998	1.000
m2	-1.60	-0.55	0.63	-1.01	-0.63	1.07

Table VI – continued

	Dependent variable:					
	$R\&D_t$	$Capx_t$	$Acquire_t$	$dCash_t$	dWC_t	$LtDbtReduct_t$
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Panel B: Infrequent PIPE Issuers Only					
$DependentVar_{t-1}$	0.232	0.270	0.049	-0.032	0.009	0.158
	(0.052)***	(0.045)***	(0.024)**	(0.021)	(0.053)	(0.090)*
$PIPE_t$	0.088	0.087	0.096	0.582	0.267	0.133
	(0.060)	(0.046)*	(0.036)***	(0.098)***	(0.125)**	(0.067)**
Q_{t-1}	0.009	-0.001	-0.001	0.019	-0.003	-0.009
	(0.004)***	(0.002)	(0.003)	(0.008)**	(0.006)	(0.003)***
$Ln(Assets)_{t-1}$	-0.013	0.008	0.007	0.022	0.006	0.008
	(0.009)	(0.004)**	(0.004)*	(0.012)*	(0.010)	(0.006)
$Sales_t$	-0.039	0.022	0.020	0.097	0.007	0.034
	(0.014)***	(0.009)**	(0.008)**	(0.021)***	(0.013)	(0.013)***
$CashFlow_t$	0.064	0.008	0.024	0.028	0.205	-0.029
	(0.028)**	(0.021)	(0.015)	(0.051)	(0.055)***	(0.018)
$dCash_t$	-0.004	-0.022	-0.123		-0.233	-0.074
	(0.029)	(0.020)	(0.039)***		(0.045)***	(0.048)
$NewLTDebt_t$	0.057	0.077	0.257	0.440	0.086	0.046
	(0.049)	(0.043)*	(0.058)***	(0.133)***	(0.092)	(0.063)
SEO_t	0.111	0.092	0.173	0.853	0.254	0.250
	(0.055)**	(0.038)**	(0.068)**	(0.170)***	(0.060)***	(0.134)*
$OtherStk_t$	0.081	0.068	0.086	0.472	0.310	0.101
	(0.046)*	(0.027)**	(0.031)***	(0.097)***	(0.099)***	(0.064)
Firm fixed effects	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes
Observations	1,930	2,831	2,736	2,850	2,823	2,093
Number of firms	517	764	752	767	762	583
J-test	1.000	0.979	0.973	0.999	0.909	0.985
Diff-Hansen	1.000	0.931	0.782	0.999	1.000	0.936
m2	1.50	1.33	0.96	1.38	-2.26	-0.20

Table VII
Private Equity Financing and Firm-Level Investment by Investor Type: Dynamic GMM Estimates

Table VII eports GMM estimates from regressing - in six separate estimation models -'R&D' R&D expenditures, 'Capx' capital expenditures, 'Acquire' cash acquisition expenditures, 'dCash' the change of the stock of cash holdings, 'dWC' the change in non-cash working capital (computed as the current assets minus current liabilities minus cash holdings) and 'LtDbtReduct' the reduction in long-term debt, on the following independent variables: 'PIPE' PIPE gross proceeds amounts, 'Q' the lagged market to book ratio, 'Ln(Assets)' the lagged book value of assets (logged), 'Sales' revenues, 'CashFlow' gross cash flow (income before extraordinary items plus depreciation plus R&D), 'dCash' the change in cash reserves, 'NewLTDebt' net new long-term debt issuances (computed as the difference between new long-term debt issuances and long-term debt reductions), 'SEO' common stock SEO gross proceeds amounts, 'OtherStk' net cash flow from non-PIPE and non-SEO proceeds (gross proceeds from stock issues minus proceeds from PIPE issues minus proceeds from SEOs minus stock repurchases). All variables are scaled by the lagged value of total assets except Ln(Assets) and Q. All ratios are winsorized at the 1% level. The regression controls for firm- and year-fixed effects. Estimation is by systems GMM with lagged levels dated t-2 to t-4 used as instruments for the regression equation in first differences and lagged differences dated t-1 used to instrument the equation in levels. The *J*-test is a test of the null hypothesis that the over-identifying restrictions are valid, the diff-Hansen is a test of the null that the instruments used for the levels equation are valid, and *m2* is test for second-order autocorrelation in the first-differenced residuals. Standard errors are robust to heteroskedasticity and with-in firm serial correlation. Statistical significance at the 1%, 5% and 10% levels are indicated by *, ** and *** respectively. In panels A and B the primary supplier of finance is based on the lead PIPE investor during the firm's first PIPE transaction. In panels C and D only firms with more than one PIPE transaction are included.

	Dependent variable:					
	R&D$_t$	Capx$_t$	Acquire$_t$	dCash$_t$	dWC$_t$	LtDbtReduct$_t$
	(1)	(2)	(3)	(4)	(5)	(6)
	Panel A: Firms that rely on primarily on PIPE funding supplied by hedge funds					
PIPE$_t$	0.258	0.054	0.061	0.645	0.164	0.031
	(0.034)***	(0.016)***	(0.016)***	(0.037)***	(0.037)***	(0.022)
	[0.998; 1.000]	[0.836; 1.000]	[0.794; 0.996]	[0.954; 1.000]	[0.989; 1.000]	[0.984; 1.000]
obs	*2069*	*2564*	*2500*	*2575*	*2565*	*2055*
	Panel B: Firms that rely on primarily on PIPE funding supplied by sources besides hedge funds					
PIPE$_t$	0.207	0.081	0.086	0.685	0.130	0.024
	(0.036)***	(0.022)***	(0.025)**	(0.053)***	(0.049)***	(0.028)
	[1.000; 1.000]	[0.999; 0.996]	[1.000; 1.000]	[1.000; 0.999]	[1.000; 0.992]	[0.993; 0.998]
obs	*1599*	*2063*	*2015*	*2079*	*2068*	*1662*
	Panel C: Firms that use the same supplier of PIPE funding across multiple rounds					
PIPE$_t$	0.130	0.070	0.073	0.720	0.147	0.030
	(0.081)	(0.024)***	(0.035)**	(0.076)***	(0.062)**	(0.035)
	[1.000; 1.000]	[1.000; 1.000]	[1.000; 1.000]	[1.000; 1.000]	[1.000; 1.000]	[1.000; 1.000]
obs	*187*	*296*	*288*	*296*	*296*	*225*
	Panel D: Firms that switch suppliers of PIPE funding across multiple rounds					
PIPE$_t$	0.247	0.052	0.031	0.583	0.113	-0.010
	(0.039)***	(0.012)***	(0.012)**	(0.044)***	(0.041)***	(0.016)
	[0.699; 0.993]	[0.408; 0.432]	[0.277; 0.852]	[0.176; 0.510]	[0.710; 0.502]	[0.185; 0.193]
obs	*3106*	*3930*	*3833*	*3953*	*3918*	*3192*