ESSAYS IN PRE-IPO R&D AND GROWTH

by

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Essays in Pre-IPO R&D and Growth

Thesis directed by Professor of Finance Chris Yung

In the first essay, we examine the effect of pre-IPO growth rates on the valuation and long-run performance of new issues. IPOs with rapid pre-IPO revenue growth obtain significantly higher offer value and secondary market valuation but have relatively poor long-term stock returns. There is no evidence that performance differentials are due to risk premia. Indeed the high-growth firms are riskier according to traditional measures. Finally, we show that analysts' forecasts are upwardly biased for all firms, and the magnitude of these biases is greatest for firms with rapid pre-IPO growth. Overall these results are consistent with the behavioral model suggested by Lakonishok, Shleifer and Vishny (1994) and La Porta (1996).

In the second essay, we examine pre-IPO R&D investment as a signal for IPO issuer quality. We find that firms with high levels of pre-IPO R&D investment obtain significantly higher valuations at the IPO and experience superior post-issue operating performance. Pre-IPO R&D investment is positively related to the probability and size of subsequent seasoned offerings. Consistent with the usage of R&D as a signal – in particular, the overuse of it at the time of the IPO – there is a rapid reversal in the amount of post-IPO R&D. In general, these effects are pronounced for high-tech issuers.

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CONTENTS

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TABLES

Tables of Chapter I

`

Tables of Chapter II

`

FIGURES

Figures of Chapter 1

Figures of Chapter 2

`

CHAPTER 1 Extrapolation Errors in IPOs

1. Introduction

There is by now a long tradition of papers examining value trading strategies. The general pattern has been to document that stocks characterized as "value" according to some accounting ratio (e.g., P/E or B/M) outperform their growth stock counterparts.[1]

Two leading explanations have emerged. Fama and French (1992) emphasize that, in general, high returns are considered compensation for risk. But because value stocks do not seem riskier according to traditional measures, these stylized facts appear to expose limitations of existing asset pricing models such as the CAPM. In lieu of theory that more properly isolates the nature of the risk being priced, many researchers have settled for using Fama and French's value factor itself as a risk proxy.

Lakonishok, Shleifer and Vishny (1994) (henceforth LSV), instead favor a behavioral story in which investors incorrectly extrapolate past growth. If a stock does poorly and its price declines, naïve investors become overly pessimistic about future prospects, further (and artificially) depressing prices. On average, subsequent news then reveals that the level of pessimism was unwarranted. Eventually, the stock performs well as the effects of this incorrect extrapolation become undone. Clearly, LSV's story requires the absence of enough savvy investors aware of these biases – and attendant profit opportunities – to contemporaneously correct prices.

Though this debate is not settled, LaPorta (1996) offers a clever twist on LSV's argument. LaPorta argues that if extrapolation error is the underlying cause, then it is preferable

[1] See Basu (1977), Jaffe, Keim and Westerfield (1989), Chan, Hamao and Lakonishok (1991), Rosenberg, Reid and Lanstein (1985).

[2] Older IPO studies, before today's near-universal reliance on COMPUSTAT and/or Thompson SDC as

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to look directly at growth expectations rather than the financial ratios. (According to the Gordon growth model, valuation ratios merely serves as indirect proxies for expected growth anyway.)

Using analyst forecasts as a proxy for market expectations, he presents evidence consistent with LSV's story. In particular, he focuses on "long-run" growth forecasts (rather than the more commonly-employed quarterly estimates). LaPorta shows that these long-run growth forecasts are negatively correlated with future stock returns, in accord with LSV's story.

Initial public offerings serve as an excellent laboratory in which to further examine LSV and LaPorta's argument. Compared to seasoned issues, IPOs tend to have a greater proportion of their value justified by the net present value of expected growth. Thus, extrapolation errors have potentially severe consequences for valuation in this context. In addition, the barriers to arbitrage are simply higher: it is expensive to short-sell new issues, and there is no stock price history to serve as a frame of reference. Moreover, underwriters' practices such as price support and penalty bids have the de facto effect of delaying secondary market information aggregation.

Unfortunately, directly implementing LaPorta's test is problematic in an IPO setting. While analyst data availability is not a problem for seasoned issues, long-run growth forecasts are only available for a small fraction of our observations within one year after the offering. Yet forecasts issued after the first year (or even late in the first year) may bear little relation to expectations at the time of the IPO. In addition, initiation of analyst coverage is unlikely to be a random event, leading to questions of selection bias.

As an alternative metric, we focus on the pre-IPO growth rate in revenues – a variable which is known ex-ante from the prospectus, is uninfluenced by analyst reports, and seems likely to be a primary determinant of investors' growth expectations. If the effect described by LSV prevails then the following hypotheses should hold.

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H1: IPOs with rapid pre-IPO growth obtain high offer value.

H2: IPOs with rapid pre-IPO growth obtain high initial secondary market value.

H3: IPOs with rapid pre-IPO growth have poor long-run stock returns as extrapolation errors are gradually undone.

As a methodological aside, we note that the dominant source of accounting data for IPO research is COMPUSTAT. While this database permits useful examination of many questions, it is difficult to directly tackle questions about a firm's growth. COMPUSTAT typically reports exactly one pre-IPO years' worth of income statements. (Thompson SDC's pre-IPO coverage of accounting data is even worse.) It is thus impossible to compute a historical growth rate in the majority of cases. Instead we hand-collect revenue data from IPO prospectuses. Unlike COMPUSTAT, the prospectus typically covers at least three to five years of pre-IPO income statements. This data is readily available to investors, but has not been used in modern IPO studies, probably because it is not available in a convenient machine-readable format for quick import into statistical software packages.[2]

With a few caveats, our evidence is consistent with all three hypotheses above. Our first result is that pre-IPO revenue growth is an important determinant of valuation. The size of this effect is moderate: a one standard deviation increase in logged growth rate is associated with 0.08 (0.14) standard deviation increase in logged market value in the full sample (positive net income sample).

Our second result is that returns for the high-growth subsample have been quite low. As a simple cut, we partition firms into "high growth" and "low growth" classifications based on the annualized pre-IPO growth rate in the prospectus. For example, we consider three years growth

[2] Older IPO studies, before today's near-universal reliance on COMPUSTAT and/or Thompson SDC as data sources, did often pull selected accounting data directly from the prospectus.

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rate prior to the IPO, and then compare three-year buy-and-hold abnormal returns (BHARs). In the full sample, we find lower BHARs for high-growth firms than for low-growth firms: the difference is moderate when one considers equal-weighting (-9.5% vs. -17.2%) but dramatic when one considers value-weighting (+9.8% vs. -25.4%).[3] Nor do these differences seem to be driven by a single historical episode; similar inequalities hold in 12 of the 16 years in our sample.

Paralleling LSV's and LaPorta's interpretations, this result suggests either mispricing or that low growth stocks are riskier in some sense. We find little evidence in favor of the latter. Instead the low growth stocks have more stable returns, so that the median stock outperforms its high growth counterpart in 15 of 16 years in our sample. While it is possible that low growth stocks have disproportionate exposure to some events that (by chance) appeared infrequently in our sample period, the most natural explanation for our results seems to be that high growth firms are systematically overvalued during our sample period.

2. Literature review

A.1 Relationship to IPO Valuation

Our study is related to two distinct branches of IPO literature. In Panel A of Table 1, we summarize papers examining the determinants of IPO valuation. Perhaps because of differing time periods, sample sizes and/or different sample screens applied, there is not always agreement on the sign and magnitude of some of these variables' effects. For example, in OLS regressions examining the determinants of IPO offer value, Aggarwal, Bhagat and Rangan (2009) find that book value of pre-IPO equity doesn't load, in contrast to Beatty, Riffe and Thompson (2000) who find the coefficient on book value is positive with t-statistics in range of eighteen.

[3] This differential result according to weighting schemes suggests that there are some very small IPOs that do not conform to the overall trend. Their impact is minimal if one considers value-weighting.

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Similarly, for internet firms Bartov, Mohanram and Seethamraju (2002) find that earnings do not load whereas Hand (2000) reaches the opposite conclusion.

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Table 1: Related Literature

Panel A. Determinants of IPO Valuation

	Sample	Sample Restrictions	Growth Proxies	Main Results
Bartov, Mohanram and Seethamraju (2002)	98 Internet IPOs during 1996-1998 plus matches	Internet IPOs	Negative earnings, annual sales growth prior to IPO.	Sales growth is priced only for internet firms; earnings and cash flow are priced only for non-internet firms.
Beatty, Riffe and Thompson (2000)	2,577 IPOs from 1987-1998	Positive EPS and book value	N/A	Book value, earnings, revenue and other firm characteristics explain a large proportion of variation in offer prices. Earnings and book value are positively related to offer prices.
Bhagat and Rangan (2007)	1655 IPOs from 1986-1990 and 1997-2001	None	Negative earnings; R&D Expenditures; Price-to-sales ratio of comparable firms; dummies for tech and internet firms	Controlling for fundamentals, average valuations did not differ in boom and crash periods. Insider retention and earnings are valued even for tech firms.
Kim and Ritter (1999)	190 IPOs from 1992-1993	Positive EPS and book value	Firm age, dummy variable equalling one if sales growth rate over prior year is higher than that of comparable firm. (pre-IPO year to post-IPO year)	Examines the explanatory power of industry multiples as a determinant of offer prices. Power is low in general, but can be improved somewhat by using one-year-ahead earnings forecasts.
Klein (1996)	193 IPOs from 1980-1991	Positive income	N/A	Earnings and book value are positively related to offer prices
Hand (2000)	167 Internet IPOs from 1997-1999 plus matches	Internet IPOs	R&D; negative EPS	Market value is linear and increasing in book equity, but and concave and increasing (decreasing) in positive (negative) net income.

Panel B. IPO Returns and Growth Proxies

	Sample	Sample Restrictions	Growth Proxies Employed	Main Results
Purnanandam and Swaminathan (2004)	2288 IPOs from 1980-1997	Positive EBITDA	Ex-post consensus analyst long-run growth forecasts (used to select a matching firm with similar growth opportunities)	IPOs are overpriced relative to industry comparables on average. More overpriced IPOs have higher growth forecasts and poorer long-run performance.
Rajan and Servaes (1997)	2725 IPOs from 1975-1987	Most tests focus on 935 IPOs covered in IBES within one year	Long-run growth rate forecast issued by analysts	Higher underpricing leads to analyst coverage. Optimistic growth forecasts are associated with poor long-run performance. IPO cluster during periods when analysts are optimistic.

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Another possible explanation for these disparate findings is that each study uses a different set of proxies for growth. Lamenting the lack of a suitable direct proxy, Kim and Ritter (1999) state:

"There is a presumption that many firms going public have valuable growth options whose value is difficult to capture using one-year-ahead earnings forecasts, with this difficulty most severe for young growth firms. We test this idea by splitting the sample into young and old firms going public… Consistent with the presumption that the young firms are most difficult to value, we find that the valuation errors of the comparable firm multiples are noticeably smaller for the older firms than for the younger firms, especially when using earnings."

Our contribution is to augment these indirect proxies with a variety of direct measures of firm growth. As previously mentioned, we collect all annual revenue and income data listed on the prospectus. Consequently we have multiple measures of growth, corresponding to different horizons: i.e., annualized growth rate between years -t and -1 for various t.[4]

A.2 Relationship to IPO Returns

In Panel B of Table 1, we consider studies of long-run returns which are particularly closely related to ours.[5] In pioneering studies, Rajan and Servaes (1997) and Purnanandam and Swaminathan (2004) both view the well-documented long-run underperformance of IPOs through the lens of incorrect growth expectations, for which analysts long-run growth forecasts are taken as proxies. Useful as these results are, some limitations remain. As previously noted, the proportion of IPOs that are covered in I/B/E/S within a short window of time around the IPO

[4] The only study we are aware of that collects and uses this pre-IPO data is Bartov, Mohanram and Seethamraju (2002) study described above. This is a relatively small scale study (98 internet IPOs) examining a different set of questions than addressed here.

[5] See Ritter and Welch (2002) and Jenkinson and Ljungqvist (2001) for excellent and more general review of research on IPOs' long-run returns. We consider here only those studies that explicitly incorporate measures of historical or prospective growth.

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is modest. This leads to important questions of selection bias, particularly because analysts are more likely to initiate coverage when stock performance is strong. It is thus unclear how tightly connected are analysts' forecasts with ex-ante expectations. Finally, employing analysts forecasts leaves open the potential for causality to run in either direction. In particular, analysts' reports may simply reflect the prevailing sentiment, or alternatively they may actually *cause* inflated expectations. By considering only data available to investors at the time of the IPO (well before any analyst reports are issued) we circumvent all of the aforementioned limitations.

A.3 Relationship to IPO timing

Our study also relates to recent IPO studies that explore the timing of the IPO decision. Pastor et al (2009) model an environment with symmetric information where the benefit of going public is diversification, and the cost is loss of private benefits of control. They show that the entrepreneur optimally times the IPO when productivity is expected to peak. This finding is consistent with a large empirical literature which documents deterioration of operating performance after the IPO on average.[6] To our knowledge, there are no studies which examine whether such performance drop-offs are equally severe for low and high growth firms. Furthermore, if investors rationally anticipate this deterioration –as is the case for the rational investors in Pastor et al's model – then it should not affect returns.

A.4 Relationship to product market

Our study also relates to recent IPO studies that explore the relationship between real product market and IPO decisions. Pastor et al (2009) model predicts that entrepreneurs optimize the timing of IPO when the productivity reaches the peak and firm productivity should drop after

[6] See Chemmanur, He and Nandy (2010), Degeorge and Zeckhauser (1993), Jain and Kini (1994), Mikkelson, Partch, and Shah (1997), and Pagano, Panetta, and Zingales (1998).

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the IPO. Chemmanur et al (2010) use the Longitudinal Research Database of the U.S. Census Bureau and present an inverted U-shape of firm growth before and after IPO.

Our results of IPO growth are consistent with the theory developed in Pastor et al (2009). We show that the ex-post growth rate is much lower than the ex-ante growth rate. Pastor et al (2009) do not explicitly test this part of their theory as they only test the prediction that firm profitability drops starting from the IPO time up to three years following the IPO. While their paper examines IPO firms in general, we focus on IPOs based on their pre-IPO growth rate. We find that investor valuation at IPO is too high for firms with high pre-IPO growth, leading to poorer stock return of high growth IPOs afterwards since investors high expectation is not justified.

Our sample construction is different from Chemmanur et al (2010). While their sample consists both private and public manufacturing firms, we include both manufacturing and non-manufacturing IPO firms but not private firms. Their study the dynamics of a firm's product market before and after the IPO and document an inverted U-shape of growth before and after IPO. We also find similar results when comparing the pre- and post-IPO growth rate. Our focus is not on the product market. We examine whether past firm growth affects investor's valuation at the time of the IPO and subsequent stock performance after the IPO. We present evident consist with the behavior story that investors incorrectly extrapolate past growth.

3. Data and sample selection

The list of IPOs for this study was initially drawn from Thomson Financial's SDC database. After excluding unit offers, closed-end funds (including REITs), financial institutions (SIC codes 60 to 63 and 67), ADRs of companies already listed in their home countries, limited partnerships and penny stocks (IPOs with offer price below five dollars), we are left with 5,473

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IPOs between January 1988 and Dec 2003. Information was collected for each observation regarding the date of the offer, offer price, percentage insider retention, gross proceeds, the identity of the underwriter and venture capital backing.

We employ two sources of pre-IPO accounting information. After May 1996, prospectuses are provided by the Securities and Exchange Commission at www.edgarcompany.sec.gov/. For IPOs between 1988 and April 1996, we obtain them at our library via CD-ROMs produced by Compact Disclosure. We match IPO using issuer's name, but double-check these matches by comparing IPO dates listed in SDC and the release date of the prospectus. Of the IPOs in the initial list, we obtain valid matches with non-empty set of historical accounting statements in 4,730 observations. In each case we record all available pre-IPO observations of revenue, research and development, operating income, net income and book value of assets.

For the sake of comparison (and cross-referencing), we also attempt to pull off the same data items from COMPUSTAT. As shown in Table 2 Panel A, COMPUSTAT's coverage is quite spotty. For one year before IPO, COMPUSTAT has revenue coverage of 4,139 observations, 13% less than in our hand collected data (4,730 IPOs). However, the number of coverage drops to only 1,345 IPOs for year -2. For year -3 and earlier, only a few hundred firms are covered. Further, this coverage is highly non-random, with coverage highly biased toward large firms except for year -1. There appears to be no similar bias for our hand-collected data.

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Table 2 Data Coverage in the COMPUSTAT, IBES and the prospectus

Panel A. Revenue Coverage

	In Prospectus			In COMPUSTAT		
	Mean (mil $)	Median (mil $)	(No. of Obs)	Mean (mil $)	Median (mil $)	(No. of Obs)
1 yr pre-IPO	187.25	21.57	4,730	201.66	24.57	4,139
2 yrs pre-IPO	168.41	14.59	4,426	327.23	19.84	1,345
3 yrs pre-IPO	175.09	14.54	3,787	934.72	296.92	198
4 yrs pre-IPO	187.82	15.48	3,185	1278.12	513.69	127
5 yrs pre-IPO	188.01	13.66	2,424	1350.2	510.47	113

Panel B. Analyst Coverage in IBES

	Any I/B/E/S Forecast Available			LR Growth Forecast Available		
	Mean Revenue (mil$)	Median Revenue (mil$)	(No. of Obs)	Mean Revenue	Median Revenue	(No. of Obs)
By 1 month	773.85	43.44	248	1349.06	65.10	102
By 2 months	202.31	30.72	1,686	314.33	41.88	909
By 3 months	216.77	41.94	2,258	221.67	47.06	1,483
By 4 months	142.86	46.15	2,500	166.48	46.43	1,791
By 5 months	279.37	35.95	2,611	245.44	51.76	1,979
By 6 months	138.36	27.26	2,676	210.30	31.14	2,076
By 7 months	151.37	24.41	2,724	175.51	33.00	2,154
By 8 months	121.48	27.02	2,760	205.74	32.53	2,230
By 9 months	639.71	20.42	2,777	136.91	36.27	2,283
By 10 months	41.49	23.27	2,798	140.22	29.25	2,324
By 11 months	54.56	28.36	2,820	64.90	34.83	2,361
By 12 months	134.93	42.14	2,836	98.43	37.74	2,397
Total	249.45	35.25	2836	285.94	43.21	2397

	Any I/B/E/S Forecast Available		LR Growth Forecast Available	
	Yes	No	Yes	No
Mean Revenue(mil$)	249.45	95.01	285.94	90.76
No of Obs	2836	1869	2397	2371

In Table 2, Panel B, we summarize coverage in IBES. As the table makes clear, coverage is quite spotty in the early months following the IPO. Even by the end of the first year following the offer, only about half of new issues are covered. Table 2, Panel C demonstrates that the covered firms are quite different in nature from the uncovered firms. In particular, I/B/E/S coverage is biased toward large firms. For example, in our sample the revenue of year -1 for covered firms is twice as much as for uncovered firms (249 million for covered firms vs. 95 million for uncovered firms).

Finally, the database is matched with CRSP from which we obtain the post-IPO number of shares outstanding and stock return data. Because most IPO firms' first monthly return from CRSP are missing, (see footnote 2 in Loughran and Ritter 1997)[7], we therefore follow Ritter (1991) to calculate the aftermarket monthly returns. The aftermarket period includes the following 36 and 60 months after the IPO exclusive of the first-day return, where months are defined as successive 21-trading-day period relative to the IPO date. Thus, month 1 consists of event days 2-22, month 2 consists of event days 23-43, etc. Firms that drop out will have IPO returns and benchmark returns that are calculated over a shorter time periods. The benchmark-adjusted holding period return is defined as

$$\mathrm{BHAR}_{iT} = \prod_{t=1}^{T}(1 + r_{it}) - \prod_{t=1}^{T}(1 + r_{mt})$$

In our base-line model, we employ value-weighted market portfolios as the return benchmark.

As emphasized by Shumway (1997) it is important to correct for delisting bias, especially given the substantial proportion of IPOs which do so. We follow Shumway and Warther (1999)

[7] Because CRSP only assigns monthly returns to stocks that trade for an entire month, CRSP's monthly files are also missing returns for most stocks' first and last trading months.

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who recommend using a corrected return of -0.55 for missing performance-related delisting returns.

4. Main results

We first note a strong intertemporal trend in our data. As Figure 1 show, there has been an increasing incidence of firms going public with negative income – a trend which has only moderately reversed following the crash of 2000. A similar trend (which has not abated) occurs for firms going public with negative book values. In our sample period of 1988-2003, 44% of IPOs have negative net income at year -1 while 35% of IPOs have negative book value of equity at year -1. In fact, in recent years, new issues are nearly evenly split between negative and positive net income, and between negative and positive book value. Thus, sample screens requiring either value to be positive – which have been routinely imposed by earlier literature (see again Table 1) are increasingly restrictive.

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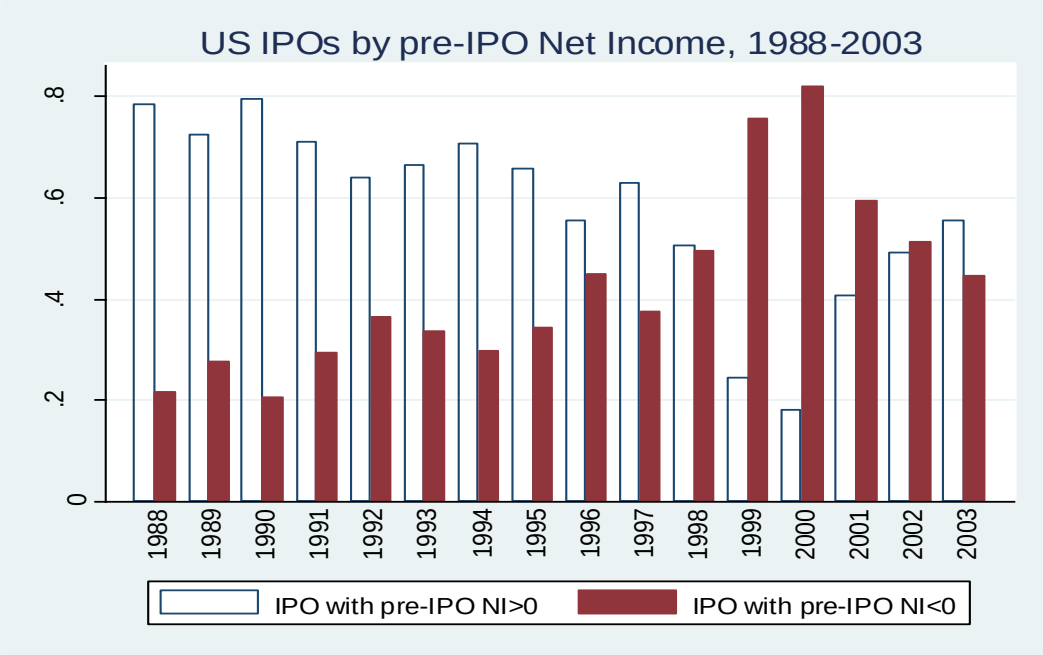
Figure 1

The figure depicts the proportion of IPOs based on whether net income at year -1 is positive or not. The sample consists of all U.S. IPOs excluding unit offers, closed-end funds (including REITs), financial institutions (SIC codes 60 to 63 and 67), ADRs of companies already listed in their home countries, limited partnerships and penny stocks (IPOs with offer price below five dollars).



Perhaps surprisingly, IPOs with negative earnings or book value are not necessarily small issues. As Table 3 shows, the median offer value and market value of firms with negative net income/book value of equity is even higher than their positive counterparts. The median market value for IPOs with negative net income IPOs is 165 million versus 106 million for IPOs with positive net income IPOs. The median market value for IPOs with negative book value of equity is 153 million versus 118 million for IPOs with positive book value of equity.

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Table 3. IPO Valuation, Pre-IPO Accounting Variables, Insider Retention, Underwriter Rank, Pre- and Post-IPO Growth Rate Categorized by Pre-IPO Net Income, Pre-IPO Book Value of Equity, and Pre-IPO Growth

Unit offers, REITs, closed-end funds, banks and S&Ls, ADRs, IPOs with an offer price below $5.00 are excluded. Data are from Thomson Financial Securities Data and other sources. The sample size is xxx IPOs for 1988-2003. High-rank underwriters are those with a Ritter (2004) ranking of 8 or higher on a 9-point scale. Firms are classified on the baise of whether net income or book value of equity was postive or not at year -1. Firms are also classifed by growth rate on the basis of whether the three year pre-IPO growth rate is higher or lower than the median growth rate.

Panel A: variable	Total	NI<0	NI>0	BVE<0	BVE>0	High Growth	Low Growth
				Median			
Offer Value	114.46	145.99	96.58	131.49	104.87	118.36	108.98
Markt Value	129.89	165.09	106.58	153.12	117.94	137.44	119.55
Revenue (Year -1)	26.77	8.28	50.03	13.45	37.2	14.02	67.12
Net Income (Year -1)	0.49	-4.69	2.63	-2.85	1.43	-0.43	1.93
Book Value of Equity (Year -1)	2.52	-1.32	5.92	-8.49	8.34	1	7.07
R&D Expenses (Year -1)	0.09	1.24	0	1.2	0	0.51	0
Insider Retention	0.71	0.74	0.68	0.72	0.7	0.72	0.68
Underwriter Rank	8	8	8	8	8	8	8
Annualized Rev. Growth (Year -2 to Year -1)	0.36	0.66	0.31	0.51	0.32	0.8	0.16
Annualized Rev. Growth (Year -3 to Year -1)	0.34	0.55	0.29	0.47	0.3	0.81	0.14
Annualized Rev. Growth (Year -4 to Year -1)	0.3	0.4	0.27	0.36	0.28	0.64	0.15
Annualized Rev. Growth (Year -5 to Year -1)	0.27	0.35	0.26	0.33	0.26	0.57	0.15
Annualized Rev. Growth (Year 1 to Year 2)	0.33	0.47	0.28	0.41	0.3	0.47	0.22
Annualized Rev. Growth (Year 1 to Year 3)	0.27	0.34	0.24	0.32	0.25	0.36	0.2
Annualized Rev. Growth (Year 1 to Year 4)	0.23	0.28	0.21	0.25	0.22	0.29	0.17
Annualized Rev. Growth (Year 1 to Year 5)	0.2	0.26	0.18	0.23	0.2	0.26	0.15

Panel B: variable	Total	NI<0	NI>0	BVE<0	BVE>0	High Growth	Low Growth
				Mean			
Offer Value	275.12	294.76	259.89	246.4	289.71	246.71	318.06
Markt Value	386.14	469.29	321.69	384.9	386.77	397.78	368.54
Revenue (Year -1)	207.76	128.48	269.19	102.25	261.47	83.31	395.4
Net Income (Year -1)	1.18	-13.44	12.55	-7.32	5.5	-3.19	7.78
Book Value of Equity (Year -1)	35.32	7.13	57.6	-32.34	71.6	13.2	68.88
R&D Expenses (Year -1)	4.94	6.67	3.61	3.46	5.69	2.78	8.21
Insider Retention	0.68	0.7	0.65	0.69	0.67	0.7	0.64
Underwriter Rank	7.27	7.3	7.25	7.35	7.23	7.1	7.53
Annualized Rev. Growth (Year -2 to Year -1)	2.37	4.68	0.88	3.57	1.8	4.05	0.26
Annualized Rev. Growth (Year -3 to Year -1)	0.92	1.45	0.62	1.33	0.73	1.72	0.11
Annualized Rev. Growth (Year -4 to Year -1)	0.61	0.86	0.49	0.71	0.56	1.13	0.17
Annualized Rev. Growth (Year -5 to Year -1)	0.48	0.61	0.43	0.55	0.46	0.86	0.2
Annualized Rev. Growth (Year 1 to Year 2)	1.11	2.02	0.48	1.78	0.79	1.52	0.54
Annualized Rev. Growth (Year 1 to Year 3)	0.48	0.7	0.34	0.62	0.42	0.59	0.33
Annualized Rev. Growth (Year 1 to Year 4)	0.35	0.47	0.27	0.41	0.32	0.42	0.25
Annualized Rev. Growth (Year 1 to Year 5)	0.28	0.36	0.22	0.32	0.26	0.33	0.2

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We also divide our sample based on the rate of growth of pre-IPO revenue.[8] Table 3 indicates a clear difference in patterns across subsamples. In full sample, growth slows down dramatically after IPO. Yet for low growth firms there is no such slowdown. For example, high-growth firms grow at an annualized rate of 81% between t=-3 and t=-1, which declines to 36% from years t=1 to t=3. Low growth firms grow at 14% annualized between t=-3 and t=-1, which actually *increases* to 20% annualized from years t=1 to t=3.

A.1 Determinants of Value

Turning now to Hypothesis 1, we examine the role of firm characteristics in determining the firm's value at the time of the offering and at the close of the first trading day. The estimate from ordinary least squares regressions are summarized in Table 4.

[8] We divide our sample into high and low growth group based on whether the three year pre-IPO growth rate is greater than or less than the median three year pre-IPO growth rate.

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Table 4-Valuation model

The sample in row (1) includes 3,036 US operating firm IPOs over 1988-2003 where the offer price is at least $5.00 and completedata on all the variables is available. The subsamples have, respectively, 1,922, 1,114, 2,061, and 975 observations. The dependent variables in Panel A is ln(offer value) while in panel B is ln(market value). L(W) is defined as L(W)=ln(1+W) when W>=0; L(W)=-ln(1-W) when W<0. Offer value is the final offer price*number of shares outstanding immediately after the IPO(in $millions). Market value is the first-day clsoing price*number of shares outstanding immediately after the IPO (in $millions). Column (1) use all observations.Column(2) are for observations with positive net income at year -1; column (3) are for observations with negative net income at year -1. Column (4) are observations with positive book value at year -1; column (5) are for observations with negative book value at year -1.

Panel A	(1)	(2)	(3)	(4)	(5)
	All	Positive NI	Negative NI	Positive BVE	Negative BVE
VARIABLES	L(Offer Value)	L(Offer Value)	L(Offer Value)	L(Offer Value)	L(Offer Value)
Ln(Income)	-0.038***	0.288***	-0.229***	-0.021**	-0.010
	(0.008)	(0.022)	(0.017)	(0.010)	(0.012)
Ln(Book Value of Equity)	0.024***	0.011	0.030***	0.266***	-0.135***
	(0.006)	(0.007)	(0.007)	(0.016)	(0.017)
Ln(R&D)	0.117***	0.118***	-0.007	0.075***	0.058***
	(0.014)	(0.015)	(0.025)	(0.018)	(0.021)
Ln(Revenue)	0.259***	0.187***	0.167***	0.140***	0.166***
	(0.010)	(0.016)	(0.014)	(0.016)	(0.016)
Underwtiter Rank	0.228***	0.199***	0.198***	0.200***	0.195***
	(0.007)	(0.008)	(0.011)	(0.007)	(0.012)
Insider Retention	1.961***	1.834***	1.982***	1.963***	1.901***
	(0.083)	(0.085)	(0.152)	(0.081)	(0.146)
VC-backing	-0.106***	-0.060**	-0.088**	-0.074***	-0.156***
	(0.024)	(0.027)	(0.037)	(0.027)	(0.041)
Ln(Growth Rate)	0.131***	0.216***	0.021	0.193***	0.076***
	(0.023)	(0.033)	(0.027)	(0.030)	(0.029)
Constant	1.505***	1.032***	0.521**	0.974***	0.432**
	(0.118)	(0.147)	(0.238)	(0.144)	(0.218)
Year effects	Yes	Yes	Yes	Yes	Yes
Observations	3,036	1,922	1,114	2,061	975
R-squared	0.728	0.778	0.765	0.781	0.750

Table 4 (continued)

Panel B	(1)	(2)	(3)	(4)	(5)
	All	Positive NI	Negative NI	Positive BVE	Negative BVE
VARIABLES	L(Market Value)	L(Market Value)	L(Market Value)	L(Market Value)	L(Market Value)
Ln(Income)	-0.029***	0.290***	-0.200***	-0.011	-0.003
	(0.009)	(0.023)	(0.021)	(0.011)	(0.013)
Ln(Book Value of Equity)	0.023***	0.010	0.029***	0.253***	-0.120***
	(0.006)	(0.007)	(0.008)	(0.017)	(0.020)
Ln(R&D)	0.131***	0.127***	0.024	0.084***	0.092***
	(0.015)	(0.017)	(0.025)	(0.019)	(0.023)
Ln(Revenue)	0.247***	0.170***	0.169***	0.130***	0.168***
	(0.011)	(0.018)	(0.015)	(0.017)	(0.018)
Underwtiter Rank	0.239***	0.211***	0.210***	0.210***	0.215***
	(0.007)	(0.008)	(0.012)	(0.008)	(0.014)
Insider Retention	2.082***	1.925***	2.160***	2.076***	2.025***
	(0.088)	(0.091)	(0.168)	(0.087)	(0.165)
VC-backing	-0.088***	-0.047	-0.071	-0.059*	-0.127***
	(0.026)	(0.030)	(0.044)	(0.030)	(0.047)
Ln(Growth Rate)	0.183***	0.306***	0.050	0.235***	0.140***
	(0.027)	(0.040)	(0.033)	(0.036)	(0.037)
Constant	1.483***	1.060***	0.289	0.965***	0.158
	(0.122)	(0.162)	(0.250)	(0.167)	(0.230)
Year effects	Yes	Yes	Yes	Yes	Yes
Observations	3,036	1,922	1,114	2,061	975
R-squared	0.708	0.752	0.727	0.752	0.712

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The dependent variable is either logged offer value or logged market value at the first closing price. We also separate the sample by the sign of net income or book value of equity. We find that book value of equity is positively associated with IPO valuation; this is consistent with the prior findings for publicly traded firms (e.g., Collins, Maydew, and Weiss, 1997). Book value of equity is twice as much important in loss IPOs (coefficient of 0.03 and highly significant) than in profitable IPOs (coefficient of 0.01 and not significant); this is consistent with the notion that book value proxies for liquidation value in loss firms (e.g., Jan and Ou, 2008, Collins el al, 1999, Burgstahler and Dichev, 1997). Having a reputable underwriter or high insider retention is viewed positively by investors and leads to higher valuation in all specifications. The same is generally true for R&D expenses (with the exception of negative net income firms). The negative coefficient on VC-backing could be consistent with Brav and Gomper's (1997) that VC firms do not underperform on average, suggesting they are not overvalued at the time of the IPO.

Unsurprisingly, net income is valued positively for profitable firms. By contrast, for unprofitable firms the negative coefficient -0.229 is highly significant both economically and statistically. This finding leads to the seemingly counterintuitive result that income is not valued for this subsample of firms. On the other hand, note the regression's two scale variables, revenue and book value, take a high degree of significance in specification (3). Thus, for an unprofitable firm, size is the driver of firm value rather than the profitability: if the firm can be made profitable, then the scale of the existing firm provides a measure of how large those potential profits will be.

As an aside, we note that since a firm with a large loss tends to have a small ratio of revenue to book value of equity (BVE), scaling by BVE amplifies ROE and M/B while similarly scaling by revenue amplifies profit margin and price/sales ratio, both possibly inducing a

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negative relation between the measures of market value of equity and earnings. To confirm the scaling effect, we further scale the valuation equation with total assets at the end of year -1[9]. The coefficient on net income is reduced by half to -0.118 for loss firms (compared to -0.229 in Column (3)). For profitable firms, including total assets as a scale variable only slightly reduce the coefficient on net income to 0.24 (compared to 0.29 in Column (2)).

Figure 2 provides a sense of how scale affects valuation. The figure has near perfect symmetry. Panel A and B indicates that the relationship between logged market value and logged pre-IPO income (book value of equity) appears linear and homoscedastic, conditional on the sign of net income (book value of equity). Hand (2000) panel F illustrates a similar non-linear relationship between logged market value and net income for a small set of internet IPOs.

[9] Darrough and Ye (2007) point out that compared to book value of equity; total assets are less sensitive to current losses. The effect of scaling for loss firms is thus less severe.

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Figure 2 Panel A

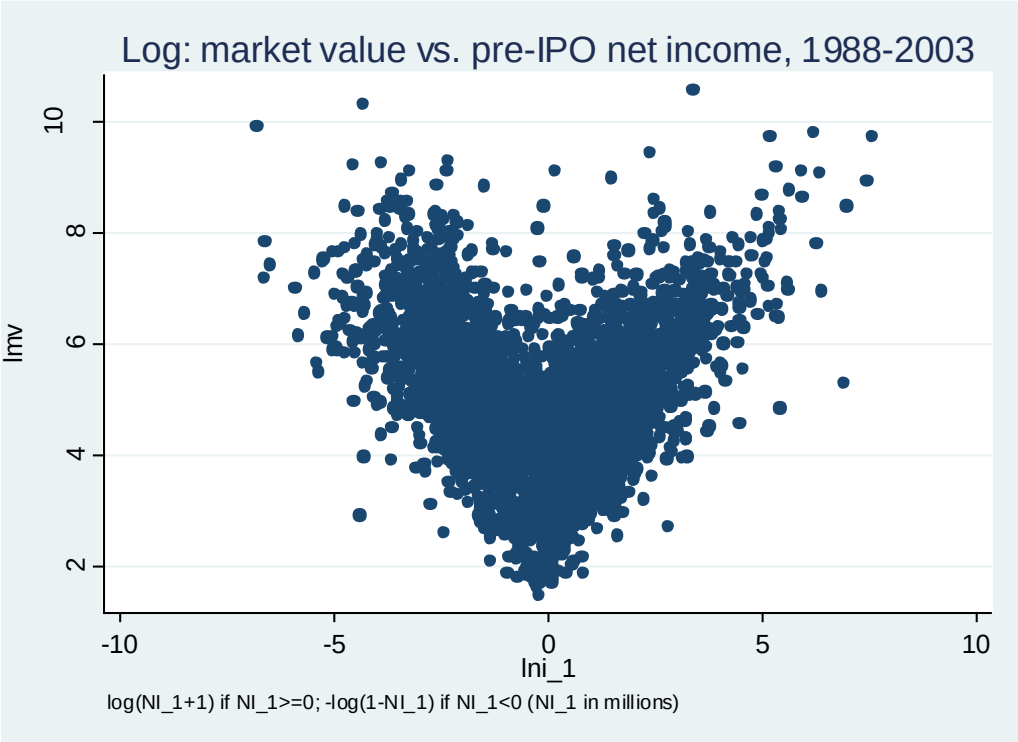
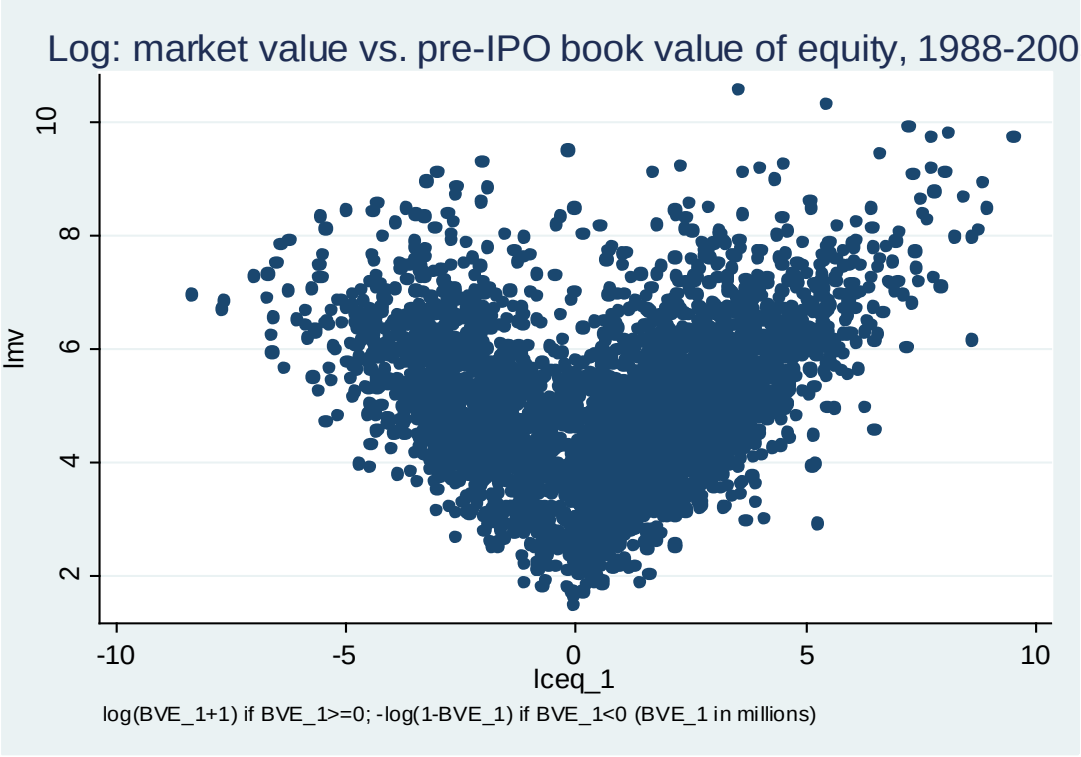


Figure 2 Panel B



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Turning to our growth measure, Table 4 indicates that pre-IPO revenue growth is valued both in the full sample and in most subsamples although the effects are modest. A one standard deviation increase in logged growth rate is associated with 0.08 (0.14) standard deviation increase in logged market value in the full sample (positive net income sample). By contrast the analogous coefficient does not load in specification (3) for negative net income IPO firms. Similar to the argument above, it seems that for unprofitable firms the relevant determinants are insider retention, underwriter rank and pure measures of scale.

A.2 Determinants of Aftermarket Performance

We report values for BHARs of new issues in each year in Table 5. As noted in panel A, these BHARs are generally worse for the high growth subsample, this relation holding in 12 of 16 years (whether one employs equally weighting or value-weighting) and in the full sample. The results for five-year holding periods are qualitatively similar. Exceptions to the general rule that low-growth stocks outperform appear to be randomly distributed throughout our sample period.

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Table 5: Mean and Median 3 and 5 Year Buy and Hold Abnormal Returns by Cohort Year

This table presents the median, equally-weighted and value-weighted mean of three and five year buy-and-hold abnormal return by issue year for IPOs between 1988 and 2003. The low and high growth group is defined based on whether the three year pre-IPO revenue growth rate is below or above their median. The buy-and-hold abnormal return is truncated at 99 percentile to avoid the outliers. The Z-statistics test the equality of distributions for unmatched pairs of observations using the Wilcoxon rank-sum test. The t-statistics test the equality of mean.

Panel A: 3 Year BHAR		Median			Equally-weighted			Value-weighted	
Year	Number of IPOs	Low Growth	High Growth	Z-Statistic	Low Growth	High Growth	t-Statistic	Low Growth	High Growth
1988	72	-0.308	-0.504	1.086	0.37	-0.148	1.454	0.233	-0.176
1989	72	-0.366	-0.518	0.856	-0.019	0.224	-0.582	-0.18	0.094
1990	89	-0.471	-0.824	0.961	-0.287	-0.599	1.605	0.182	-0.615
1991	210	-0.211	-0.547	2.454	0.109	-0.097	1.194	0.369	0.023
1992	287	-0.264	-0.415	0.961	-0.001	-0.026	0.175	0.107	-0.052
1993	350	-0.429	-0.489	1.335	-0.12	-0.125	0.039	-0.311	0.124
1994	278	-0.523	-0.717	0.781	-0.114	-0.033	-0.431	0.018	-0.248
1995	308	-0.925	-0.931	1.311	-0.429	-0.528	0.601	-0.398	-0.525
1996	437	-1.076	-1.132	1.146	-0.685	-0.7	0.130	1.428	-0.548
1997	287	-0.978	-1.054	1.148	-0.613	-0.509	-0.702	-0.598	0.48
1998	164	-0.476	-0.719	1.586	-0.054	-0.192	0.654	-0.084	-0.185
1999	264	-0.398	-0.644	3.933	-0.048	-0.326	1.906	-0.093	-0.458
2000	220	-0.236	-0.574	4.400	0.004	-0.409	4.263	-0.17	-0.525
2001	57	0.069	-0.424	2.355	0.263	-0.201	2.108	0.19	-0.364
2002	43	0.547	-0.006	0.828	0.452	0.375	0.196	0.35	0.254
2003	37	-0.731	0.362	-2.109	-0.406	0.315	-2.218	-0.503	0.25
Total	3175	-0.497	-0.636	3.897	-0.095	-0.172	1.8795	0.098	-0.254

Panel B: 5 Year BHAR		Median			Equally-weighted			Value-weighted	
Year	Number of IPOs	Low Growth	High Growth	Z-Statistic	Low Growth	High Growth	t-Statistic	Low Growth	High Growth
1988	71	-0.422	-0.631	1.208	0.155	-0.209	0.738	0.213	-0.338
1989	72	-0.466	-0.914	2.204	-0.085	-0.049	-0.074	-0.293	-0.201
1990	89	-1.139	-1.154	0.008	-0.375	-0.659	0.799	-0.06	-0.601
1991	208	-0.675	-1.055	1.888	-0.081	-0.418	1.339	0.175	-0.256
1992	285	-0.827	-0.961	0.508	-0.299	-0.324	0.111	-0.06	-0.26
1993	352	-0.959	-1.392	2.283	-0.458	-0.744	1.345	-0.445	-0.409
1994	277	-1.369	-1.398	0.957	-0.758	-0.8	0.169	-0.531	-1.037
1995	300	-1.409	-1.269	-0.529	-0.824	-0.493	-1.361	-0.678	-0.552
1996	435	-0.986	-1.16	1.190	-0.635	-0.666	0.233	-0.498	-0.543
1997	293	-0.592	-0.723	1.475	-0.358	-0.404	0.356	-0.288	-0.227
1998	168	-0.455	-0.564	1.071	-0.059	-0.07	0.049	-0.087	0.29
1999	265	-0.434	-0.705	3.807	-0.013	-0.313	1.700	0.156	-0.476
2000	220	-0.541	-0.67	3.016	-0.126	-0.416	1.832	-0.165	-0.708
2001	57	0.086	-0.353	2.195	0.684	-0.203	2.651	0.417	-0.455
2002	43	-0.066	-0.156	-0.097	0.371	0.21	0.305	0.358	0.348
2003	37	-0.796	-0.549	-1.298	-0.432	-0.098	-0.868	-0.665	-0.452
Total	3172	-0.708	-0.791	1.565	-0.122	-0.213	0.867	-0.096	-0.404

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A.2.a Aftermarket Performance in Subsamples by IPO Characteristics

To examine whether the observed relationship between pre-IPO growth and aftermarket performance is driven by one or two IPOs subsamples with specific firm characteristics, we compute the average BHAR in various subsamples. Table 6 Panels A through D summarize these averages in 2-by-2 splits, where we separate the sample based on the rate of pre-IPO growth and one additional firm characteristic. In Panel A, we split the sample according to underwriter rank. In either the high-rank or low-rank group, high-growth IPOs perform poorly both in relative and absolute terms. For example, for low-rank IPOs, the effect of high growth was to decrease the average 3-year BHAR by 4%; while for high-rank IPOs, the effect of high growth was to decrease 3-year BHAR by 11%. Similar qualitative findings hold for alternative definitions of "high-growth" or for alternative holding horizons.[10]

[10] We also classify IPOs into high-growth and low-growth based on their 4-year pre-IPO growth rates. Besides 3-year BHAR, we also examine 5-year BHAR. To check the robustness, we sort firms into terciles based on pre-IPO growth rate. The results are similar under these variants.

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Table 6: BHAR by Growth and IPO Characteristics

This table displays the long run abnormal returns for IPOs by 3-year pre-IPO growth rate. The results for 3-year and 5-year buy-and-hold abnormal returns (BHAR) are shown. The IPOs are sorted into 2 groups based on 3-year pre-IPO growth rate and each of the following variables: underwriter rank, VC-backing, size and insider retention. The separation of high and low underwriter rank is whether an underwriter's rank is greater than or equal to 8 from a 0-9 scale. The median of 3-year pre-IPO growth rate is used to separate high and low growth IPOs. The median of book value of equity at the first closing day is used to separate big and small IPOs. The t-statistic tests the hypothesis that the difference in returns between the low and high growth IPO portfolios is equal to zero.

Panel A: BHAR by Underwriter Rank and 3-Year Pre-IPO growth

		Equally-weighted				Value-weighted		
	Underwriter	Growth				Growth		
	Rank	Low	High	t-Statistic	Total	Low	High	Total
3-year	Low	-0.30	-0.34	0.44	-0.32	-0.29	-0.39	-0.34
BHAR		531	466		997	0.04	0.05	0.09
	High	0.01	-0.10	1.19	-0.05	0.13	-0.24	-0.05
		1071	1134		2205	0.47	0.45	0.91
	Total	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
		1602	1600		3202	0.51	0.50	1.00
5-year	Low	-0.32	-0.45	0.37	-0.38	-0.57	-0.51	-0.54
BHAR		531	466		997	0.04	0.05	0.09
	High	-0.02	-0.11	0.73	-0.07	-0.06	-0.39	-0.22
		1071	1134		2205	0.47	0.45	0.91
	Total	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
		1,602	1,600		3,202	0.51	0.50	1.00

Panel B: BHAR by VC-Backing and 3-Year Pre-IPO growth

		Equally-weighted				Value-weighted		
		Growth				Growth		
	VC-Backing	Low	High	t-Statistic	Total	Low	High	Total
3-year	No	-0.18	-0.26	1.02	-0.21	0.14	-0.25	0.00
BHAR		1077	755		1832	0.41	0.24	0.65
	Yes	0.07	-0.10	1.29	-0.03	-0.11	-0.26	-0.22
		526	848		1374	0.09	0.26	0.35
	Total	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
		1,603	1,603		3,206	0.51	0.50	1.00
5-year	No	-0.29	-0.32	0.24	-0.30	-0.09	-0.45	-0.22
BHAR		1077	755		1832	0.41	0.24	0.65
	Yes	0.22	-0.12	1.21	0.02	-0.11	-0.36	-0.30
		526	848		1374	0.09	0.26	0.35
	Total	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
		1,603	1,603		3,206	0.51	0.50	1.00

`

Table 6 (continued)

Panel C: BHAR by Size and 3-Year Pre-IPO growth

		Equally-weighted				Value-weighted		
	size	Growth				Growth		
		Low	High	t-Statistic	Total	Low	High	Total
3-year	Small	-0.11	-0.18	0.70	-0.14	-0.01	-0.21	-0.11
BHAR		846	717		1563	0.05	0.04	0.08
	Big	-0.08	-0.17	0.87	-0.13	0.11	-0.26	-0.07
		757	886		1643	0.46	0.46	0.92
	Total	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
		1603	1603		3206	0.51	0.50	1.00
5-year	Small	-0.12	-0.21	0.33	-0.16	-0.09	-0.23	-0.15
BHAR		846	717		1563	0.05	0.04	0.08
	Big	-0.12	-0.22	0.77	-0.18	-0.10	-0.42	-0.26
		757	886		1643	0.46	0.46	0.92
	Total	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
		1,603	1,603		3,206	0.51	0.50	1.00

Panel D: BHAR by Insider Retention and 3-Year Pre-IPO growth

		Equally-weighted				Value-weighted		
	Insider	Growth			Total	Growth		Total
	Retention	Low	High	t-Statistic		Low	High	
3-year	Low	-0.17	-0.24	0.85	-0.20	-0.04	-0.29	-0.13
BHAR		909	709		1618	0.15	0.08	0.23
	High	-0.04	-0.12	0.71	-0.09	-0.24	-0.25	-0.24
		633	882		1515	0.29	0.40	0.69
	Total	-0.11	-0.17	0.78	-0.14	-0.17	-0.25	-0.22
		1542	1591		3133	0.44	0.49	0.92
5-year	Low	-0.12	-0.26	0.64	-0.18	-0.01	-0.34	-0.13
BHAR		909	709		1618	0.15	0.08	0.23
	High	-0.12	-0.18	0.32	-0.16	-0.26	-0.43	-0.36
		633	882		1515	0.29	0.40	0.69
	Total	-0.12	-0.22	1.10	-0.17	-0.17	-0.41	-0.30
		1,542	1,591		3,133	0.44	0.49	0.92

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Turning to splits based on other characteristics, VC-backing, size and insider retention (Panels B through D), we see similar trends. In particular, in virtually all cases the high-growth IPOs perform poorly both in relative terms and absolute terms.

A.2.b Growth and Stock Performance: Univariate Tests

To further test the hypothesis that firms with high pre-IPO growth are overvalued, we more closely follow the methodology of LSV (1994) Table 1. We divide IPOs into two subgroups based on their pre-IPO growth rate and focus on the long-horizon (of up to 5 years) buy-and-hold raw and market-adjusted returns.

In Table 7, we present the long-horizon returns for IPOs based on the rate of pre-IPO growth. We include both the buy-and-hold raw returns (BHR1 through BHR5) and buy-and-hold abnormal returns (BHAR1 through BHAR5) for years 1 through year 5 following IPO (exclusive of the first-day return). We confirm the results established in LSV (1994) and extend to IPO firms. On average, over the 5 years following IPO, the portfolio of firms with the low past growth earns an average buy-and-hold return of 73% while the portfolio of firms with the high past growth earns an average buy-and-hold return of 43% percent. On a market-adjusted basis, the average buy-and-hold returns are -12% for the low growth firms and -21% percent for the high growth firms.

`

Table 7: Returns for IPOs Based on Pre-IPO Growth.

The IPOs are separated into high and low growth group based on 3-year pre-IPO growth rate. BHRt is the average buy-and-hold return for t years after IPO. BHARt is the average buy-and-hold abnormal return for t years after IPO.

Panel A: Equal-Weighted Buy-and-hold Raw Returns					
Growth	BHR1	BHR2	BHR3	BHR4	BHR5
Low	0.147	0.307	0.42	0.562	0.733
High	0.068	0.17	0.223	0.37	0.434

Panel B: Equal-weighted Buy-and-hold Abnormal Returns					
Growth	BHR1	BHR2	BHR3	BHR4	BHR5
Low	0.002	-0.024	-0.095	-0.159	-0.122
High	-0.059	-0.094	-0.172	-0.179	-0.213

Panel C: Value-weighted Buy-and-hold Raw Returns					
Growth	BHR1	BHR2	BHR3	BHR4	BHR5
Low	0.16	0.234	0.403	0.564	0.463
High	-0.154	-0.186	-0.167	-0.103	-0.141

Panel D: Value-weighted Buy-and-hold Abnormal Returns					
Growth	BHAR1	BHAR2	BHAR3	BHAR4	BHAR5
Low	0.069	0.023	0.098	0.096	-0.096
High	-0.19	-0.241	-0.254	-0.303	-0.404

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We further explore two dimensional versions of classifying firms based on pre-IPO growth rate and other IPO fundamentals. We first sort IPO stocks into high and low growth by pre-IPO growth rate, and then take intersections with underwriter rank and VC-backing.

These results are reported in Table 8. In Panel A we split the sample according to whether the firm was VC-backed or not, as well as by the pre-IPO growth rate. We first note that the results observed by Brav and Gompers (1997) hold in our sample as well. That is, VC-backed firms generally outperform non-VC firms, and this result continues to hold once we split firms according to growth rate. In addition, returns are generally lower for high-growth IPOs than for low-growth IPOs. This comparison holds for all relevant pairings in Panel A. Broadly similar results hold in Panels B through D.

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Table 8: IPO Returns Based on Pre-IPO Growth and VC-backing.
This table displays the long run returns for IPOs by 3-year pre-IPO growth rate and VC-backing. The results for 3-year and 5-year returns (BHAR) are shown. The IPOs are sorted into terciles based on 3-year pre-IPO growth rate. BHRt is the average buy-and-hold return for t years after IPO. BHARt is the average buy-and-hold abnormal return for t years after IPO.

Panel A: Buy-and-hold Raw Returns								
	Equal-weighted				Value-weighted			
VC	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
BHR1	0.13	0.05	0.18	0.08	0.15	-0.18	0.20	-0.13
BHR2	0.23	0.12	0.46	0.22	0.26	-0.19	0.14	-0.19
BHR3	0.35	0.18	0.56	0.27	0.45	-0.12	0.18	-0.21
BHR4	0.49	0.32	0.71	0.42	0.62	-0.05	0.31	-0.15
BHR5	0.55	0.34	1.10	0.52	0.46	-0.16	0.47	-0.12

Panel B: Buy-and-hold Abnormal Returns								
	Equal-weighted				Value-weighted			
VC	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
BHAR1	-0.02	-0.09	0.04	-0.03	0.06	-0.22	0.12	-0.16
BHAR2	-0.11	-0.18	0.16	-0.02	0.04	-0.28	-0.05	-0.20
BHAR3	-0.18	-0.26	0.07	-0.10	0.14	-0.25	-0.11	-0.26
BHAR4	-0.23	-0.26	-0.01	-0.11	0.16	-0.29	-0.17	-0.32
BHAR5	-0.29	-0.32	0.22	-0.12	-0.09	-0.45	-0.11	-0.36

Panel C: Buy-and-hold Raw Returns												
	Equal-weighted						Value-weighted					
VC	0	0	0	1	1	1	0	0	0	1	1	1
GS	1	2	3	1	2	3	1	2	3	1	2	3
BHR1	0.12	0.11	0.06	0.12	0.19	0.07	0.16	0.05	-0.23	-0.01	0.17	-0.13
BHR2	0.22	0.16	0.16	0.48	0.36	0.20	0.27	0.06	-0.21	0.07	0.08	-0.22
BHR3	0.34	0.25	0.23	0.55	0.42	0.26	0.50	0.13	-0.15	0.12	0.12	-0.26
BHR4	0.49	0.36	0.38	0.65	0.63	0.39	0.66	0.30	-0.10	0.23	0.24	-0.20
BHR5	0.57	0.35	0.45	1.19	0.79	0.48	0.42	0.36	-0.22	0.41	0.29	-0.17

Panel D: Buy-and-hold Abnormal Returns												
	Equal-weighted						Value-weighted					
VC	0	0	0	1	1	1	0	0	0	1	1	1
GS	1	2	3	1	2	3	1	2	3	1	2	3
BHAR1	-0.03	-0.05	-0.08	-0.01	0.05	-0.04	0.07	-0.06	-0.25	-0.09	0.11	-0.16
BHAR2	-0.12	-0.18	-0.13	0.18	0.05	-0.02	0.06	-0.18	-0.26	-0.11	-0.07	-0.21
BHAR3	-0.18	-0.27	-0.18	0.08	-0.06	-0.07	0.21	-0.23	-0.20	-0.16	-0.12	-0.27
BHAR4	-0.22	-0.32	-0.18	-0.07	-0.06	-0.08	0.21	-0.15	-0.29	-0.27	-0.16	-0.32
BHAR5	-0.27	-0.42	-0.19	0.32	-0.05	-0.10	-0.11	-0.18	-0.46	-0.19	-0.20	-0.36

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Table 8 (continued)

Panel E: Buy-and-hold Raw Returns

	Equal-weighted				Value-weighted			
Rank	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
BHR1	0.06	-0.03	0.19	0.11	-0.02	-0.29	0.18	-0.14
BHR2	0.24	0.05	0.34	0.22	0.11	-0.24	0.24	-0.18
BHR3	0.27	0.13	0.49	0.26	0.19	-0.18	0.42	-0.17
BHR4	0.36	0.26	0.67	0.42	0.16	-0.14	0.60	-0.10
BHR5	0.62	0.32	0.79	0.48	0.21	-0.11	0.48	-0.14

Panel F: Buy-and-hold Abnormal Returns

	Equal-weighted				Value-weighted			
Rank	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
BHAR1	-0.09	-0.17	0.05	-0.01	-0.13	-0.33	0.09	-0.18
BHAR2	-0.13	-0.26	0.03	-0.02	-0.20	-0.35	0.04	-0.23
BHAR3	-0.30	-0.34	0.01	-0.10	-0.29	-0.39	0.13	-0.24
BHAR4	-0.45	-0.39	-0.01	-0.09	-0.54	-0.46	0.15	-0.29
BHAR5	-0.32	-0.45	-0.02	-0.11	-0.57	-0.51	-0.06	-0.39

Panel G: Buy-and-hold Raw Returns

	Equal-weighted						Value-weighted					
	0	0	0	1	1	1	0	0	0	1	1	1
GS	1	2	3	1	2	3	1	2	3	1	2	3
BHR1	0.05	0.04	-0.05	0.15	0.20	0.11	-0.05	-0.02	-0.36	0.15	0.10	-0.15
BHR2	0.24	0.16	0.03	0.32	0.28	0.24	0.08	0.08	-0.31	0.25	0.07	-0.20
BHR3	0.25	0.20	0.17	0.47	0.39	0.27	0.18	0.08	-0.22	0.46	0.14	-0.21
BHR4	0.31	0.33	0.30	0.64	0.56	0.42	0.11	0.19	-0.21	0.63	0.29	-0.15
BHR5	0.67	0.38	0.38	0.80	0.61	0.50	0.15	0.28	-0.22	0.44	0.34	-0.19

Panel H: Buy-and-hold Abnormal Returns

	Equal-weighted						Value-weighted					
Rank	0	0	0	1	1	1	0	0	0	1	1	1
GS	1	2	3	1	2	3	1	2	3	1	2	3
BHAR1	-0.09	-0.11	-0.18	0.01	0.05	-0.01	-0.15	-0.15	-0.38	0.06	0.02	-0.18
BHAR2	-0.12	-0.19	-0.27	0.02	-0.03	0.01	-0.21	-0.24	-0.36	0.06	-0.13	-0.22
BHAR3	-0.30	-0.36	-0.30	-0.01	-0.09	-0.05	-0.25	-0.42	-0.36	0.19	-0.16	-0.23
BHAR4	-0.48	-0.44	-0.33	-0.04	-0.09	-0.04	-0.53	-0.51	-0.46	0.19	-0.11	-0.29
BHAR5	-0.24	-0.52	-0.36	-0.02	-0.13	-0.06	-0.58	-0.49	-0.54	-0.09	-0.15	-0.39

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Table 8, Panels E through H split the sample by underwriter rank rather than by VC with similar findings. The only subsamples of IPOs which appear to consistently have attractive returns are those that are low growth and either VC-backed or underwritten by reputable banks.

A.2.c Growth and Stock Performance: OLS Tests

Table 9, Panel A summarizes the results of an OLS regression estimating the determinants of aftermarket returns. The pre-IPO growth rate is used as an independent variable. Control variables include the post-IPO growth rate, Carter-Manaster rank of the underwriter, the level of insider retention, a dummy variable indicating whether or not the IPO was venture capital backed or not, book to market ratio and year fixed effects. As is common for these regressions, the R-squared measure is exceptionally low: returns are simply subject to a lot of noise.[11] Consistent with the results suggested by Table 6, higher pre-IPO growth is associated with poorer returns (though this result is not always significant and dependent on specification).

[11] Probably for this reason, this test has no counterpart in LSV (1994).

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Table 9: Determinants of Buy and Hold Returns

For each IPO firm in our sample, we compute its 3-year and 5-year buy-and-hold return (market-adjusted). The independent variables are (1) GS_3YearBefore, the rank of 3-year pre-IPO revenue growth; (2) GS_3YearAfter, the rank of 3-year post-IPO revenue growth; (3) underwriters' rank; (4) insider retention; (5) Venture capital backing dummy; (6) B/M(+), equal to B/M, the ratio of pre-IPO year(year -1) book value of equity to market value of equity at the first closing price. Panel A presents the OLS regression results. Panel B presents the results of rank regressions.

Panel A: OLS					Panel B: Rank Regression			
	(1) BHAR3	(2) BHAR3	(3) BHAR5	(4) BHAR5	(1) BHAR3	(2) BHAR3	(3) BHAR5	(4) BHAR5
Rev. Growth(Pre-IPO 3 Year)	-0.323**	-0.313*	-0.641**	-0.682*	-0.150***	-0.126***	-0.166***	-0.145***
	(0.155)	(0.180)	(0.311)	(0.372)	(0.020)	(0.020)	(0.021)	(0.022)
Rev. Growth(Post-IPO 3 Year)	2.091***	2.145***			0.441***	0.457***		
	(0.184)	(0.185)	4.958***	4.901***	(0.023)	(0.022)		
Rev. Growth(Post-IPO 5 Year)			(0.558)	(0.535)			0.661***	0.678***
							(0.030)	(0.030)
Underwriter Rank		0.075***		0.123***	0.152***		0.155***	
		(0.017)		(0.032)	(0.024)		(0.026)	
Insider Retention		-0.118		-0.243	0.001		0.008	
		(0.329)		(0.419)	(0.018)		(0.021)	
Venture Capital Backing		0.100		0.205	0.014		0.012	
		(0.091)		(0.256)	(0.020)		(0.022)	
Book/Market Ratio		0.119*		0.048	0.093***		0.092***	
		(0.063)		(0.082)	(0.016)		(0.018)	
N	2669	2537	2152	2038	2537	2537	2038	2038
r^2	0.088	0.097	0.060	0.061	0.142	0.168	0.206	0.231

Table 9, Panel B summarizes the rank-regression analog of this estimation. This non-parametric technique involves ranking the dependent and independent variables and then estimating an OLS regression using the rank-transformed data. It relaxes the assumption of linearity and assumes a monotonic relation. If the relation between the dependent variable and the independent variables in monotonic, a higher-ranked independent variable will correspond to a higher ranked dependent variable, regardless of the precise relation between the two variables. We first convert the ranks to percentiles: (rank-1)/(number of firms-1), so that the lowest-ranking firms receives a zero and the highest-ranking firms receives a one. We then estimate the OLS regression using the percentiles as independent and dependent variables. We find that pre-IPO growth is negatively related with post-IPO returns. Underwriter rank, book to market ratio and post-IPO growth is positively related with post-IPO returns.

A.3 Are Analysts Also Misled?

The evidence reviewed thus far suggests that, pre-IPO growth is negatively associated with long-run returns, and that this result is due to higher ex-ante valuation by the market. This misvaluation could be, in principle, due to a relatively small subset of irrational IPO investors. In this view, even if were widely known that a new issue was mispriced, the opportunity to take advantage of it is limited by post-IPO frictions (e.g., penalty bids and difficulty shorting stocks). Alternatively, it is possible the market's assessment is incorrect more generally.

To help distinguish between these two scenarios, we obtain analysts' long-run growth estimates. We are interested in whether there are systematic biases in their expectations, and whether the direction and magnitude of these biases is dependent on the pre-IPO growth levels.

We create a measure of analyst bias which we call "optimism." The variable "optimism" is defined as the difference between the forecasted growth rate and the realized growth rate.

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From IBES, we extract the first long-run growth forecast of the sample firms within one year after the IPO and define it as forecasted growth rate. We then compute the realized arithmetic average of the growth rate of income before extraordinary items (Compustat Item epsfx) over the three (five) years after the IPO. Specifically, when the base year (IPO year) income is positive, the growth rate is defined as $((Income_t-Income_0)/Income_0)/t$; when the base year (IPO year) income is negative, the absolute value of $Income_0$ is used in the denominator and the growth rate is defined as $((Income_t-Income_0)/|Income_0|)/t$, where t is the number of years after IPO and 0 is the IPO year. The difference between the forecasted and realized growth rate is defined as the analyst's optimism. It measures by how much the analyst missed the mark. [12]

These results are presented in Table 10. The sample is separated into quintiles according the rate of pre-IPO growth. We present the realized 3 and 5 year revenue growth rates as well as analysts' over-optimism measures by pre-IPO growth. The first column reports the realized ex-post growth. Note that firms with rapid pre-IPO growth do not necessarily continue to grow faster than other firms except in the highest quintile of growth. In column B we report the optimism measure described above. Note that these measures are positive and large in all subsamples. More importantly in our context, the measures are nearly perfectly monotonic in pre-growth measure. For example, in the lowest quintile of growth, expected growth overshot realized 5-year growth by 19.9% whereas in this highest quintile these same estimates missed the mark by fully 29.2%.

[12] We report our results based on arithmetic average of growth rate because many firms have negative income at the base year (IPO year). Geometric mean growth rate is incomputable based on negative numbers. In unreported tables, we also compute realized growth rate using geometric average of growth rate. To accommodate negative base year income, we assign 1 as growth rate to firms whose income increases and -1 as growth rate to firms whose income decreases. And our results do not change quantitatively.

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Table 10: Realized vs. Predicted Growth Rates

This table presents the median of realized and predicted long term earnings growth rates. The realized earnings growth rate is computed using income before extraordinary items (item epsfx) from COMPUSTAT. Specifically, when the base year (IPO year) income is positive, the growth rate is defined as ((Incomet-Income0)/Income0)/t; when the base year (IPO year) income is negative, the absolute value of Income0 is used in the denominator and the growth rate is defined as ((Incomet-Income0)/|Income0|)/t, where t is the number of years after IPO and 0 is the IPO year. The difference between the forecasted and realized growth rate is defined as the analyst's optimism. The predicted growth rate is analysts forecasted long term growth rate from I/B/E/S. Realized5 is the realized 5 year earnings growth rate; Realized3 is the realized 3 year earnings growth rate. Optimism3 is defined as the analyst forecasted long term growth rate (Ltg) minus realized 3 year growth rate; Optimism5 is defined in the similar way. The sample IPOs are separated into quintiles according to the rate of pre-IPO growth. Panel A is based on 2 year pre-IPO growth; Panel B is based on 3 year pre-IPO growth;Panel C is based on 4 year pre-IPO growth; Panel D is based on 5 year pre-IPO growth.

Panel A: Based on 2-year pre-IPO growth rate.

		Realized3	Optimism3	Realized5	Optimism5	N.
"Low"	1	0.109	0.083	0.015	0.199	724
	2	0.132	0.087	0.049	0.178	724
	3	0.121	0.161	0.039	0.244	724
	4	0.083	0.293	0.092	0.323	724
"High"	5	0.159	0.249	0.164	0.292	724
Total		0.121	0.173	0.067	0.227	3620

Panel B: Based on 3-year pre-IPO growth rate.

		Realized3	Optimism3	Realized5	Optimism5	N.
"Low"	1	0.151	0.044	0.037	0.183	641
	2	0.123	0.109	0.060	0.151	641
	3	0.111	0.167	0.015	0.280	641
	4	0.058	0.261	0.046	0.292	642
"High"	5	0.187	0.247	0.147	0.300	641
Total		0.124	0.163	0.055	0.225	3206

Panel C: Based on 4-year pre-IPO growth rate.

		Realized3	Optimism3	Realized5	Optimism5	N.
"Low"	1	0.151	0.047	0.057	0.159	551
	2	0.103	0.113	0.022	0.199	552
	3	0.126	0.122	0.034	0.236	551
	4	0.040	0.265	0.060	0.234	553
"High"	5	0.145	0.270	0.115	0.319	551
Total		0.119	0.161	0.051	0.224	2758

Panel D: Based on 5-year pre-IPO growth rate.

		Realized3	Optimism3	Realized5	Optimism5	N.
"Low"	1	0.126	0.068	0.049	0.148	423
	2	0.050	0.154	0.006	0.212	423
	3	0.119	0.144	0.033	0.225	424
	4	0.095	0.247	0.063	0.267	424
"High"	5	0.083	0.344	0.130	0.314	423
Total		0.091	0.177	0.049	0.221	2117

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Overall, these results suggest that the incorrect extrapolation is not due to a narrow subset of irrational investors. Analysts too seem to systematic overestimate the future growth potential of IPOs with rapid historical growth.

A.4. Alternative Measures of Abnormal Return

The above results are based on market-adjusted return, that is, abnormal returns calculated as the IPO returns, R_{it}, relative to the market, R_{mt}. In order to check the robustness of our results, we consider other variant of abnormal return measurement.

Barber and Lyon (1997) document that matching sample firms to control firms of similar sizes and book-to-market ratios yields well-specified test statistics in virtually all sampling situations. We follow their study by measuring the abnormal return as the difference between the sample firm's return and that of a matching control firm.

Our control firms are chosen using three criteria: industry, market capitalization and market-to-book ratio. Specifically, we match an IPO firm with all existing firms in the same 2-digit SIC industry. Although Barber and Lyon (1997) do not use industry matching, we include SIC industry as one of the matching criteria because subsequent literature after Barber and Lyon (1997) has emphasized industry clustering.

To avoid matching with newly-listed firms, firms issued within three years preceding the initial public offerings of the firm under scrutiny are excluded from the candidate control firm pool. We first identify all firms with a market value of equity between 70% and 130% of the market value of equity of the sample firm. From the set of firms, we then choose the firm with the book-to-market ratio closest to that of the sample firm. Whenever a control firm return is not available, value-weighted market return is used instead.

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The results using control firm approach are in general consistent with our baseline model where market-adjusted returns are used. Again the data support the hypothesis that high growth firms underperform following the IPO compared to low growth firms. As indicated in Table 11, high growth firms experience lower aftermarket returns compared to low growth counterparts. This relationship holds for up to 5 years after IPO. Table 12 presents the regression analysis using control firm adjusted returns. The results are also similar to those using market adjusted returns.[13]

[13] We also compare the returns in subsamples of pre-IPO growth intersecting with one of the IPO characteristics: underwriter rank, VC-backing, size, retention. The results are similar to those using market-adjusted returns. Those tables are not presented in the paper.

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Table 11: Control Firm Adjusted Returns for IPOs Based on Pre-IPO Growth.

This table displays the long run buy-and-hold returns (adjusted by control-firm returns) for IPOs by pre-IPO growth rate. The IPO firms are separated into two subgroups based on the revenue growth rate from year -3 to year -1. The BHARs are calculated by measuring the difference between an IPO firm and a relevant control firm. Each IPO firm is matched to a control firm based on three criteria: 2-digit SIC industry, size and market-to-book ratios. The returns presented are averages over all IPOs. Panel A presents the long-run BHARs by growth rate. Panel B presents the long-run BHARs by growth rate and VC-backing. Panel C presents the long-run BHARs by growth and underwriter rank.

Panel A: Buy-and-hold Abnormal Returns up to 5 Years

	$BHAR_1$	$BHAR_2$	$BHAR_3$	$BHAR_4$	$BHAR_5$	$BHAR_1$	$BHAR_2$	$BHAR_3$	$BHAR_4$	$BHAR_5$
	Equally-weighted					Value-weighted				
Low GS	-0.001	-0.004	-0.086	-0.1	-0.039	0.026	-0.046	-0.29	-0.845	-0.444
High GS	-0.148	-0.132	-0.192	-0.239	-0.247	-0.341	-0.317	-0.329	-0.44	-0.515

Panel B: Buy-and-hold Abnormal Returns by VC-Backing and Growth

	Equally-weighted				Value-weighted			
VC	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
$BHAR_1$	0.008	-0.093	-0.019	-0.196	0.053	-0.284	-0.095	-0.394
$BHAR_2$	-0.062	-0.145	0.115	-0.12	-0.014	-0.335	-0.19	-0.3
$BHAR_3$	-0.16	-0.172	0.064	-0.209	-0.312	-0.296	-0.19	-0.36
$BHAR_4$	-0.174	-0.228	0.05	-0.248	-0.958	-0.469	-0.342	-0.413
$BHAR_5$	-0.172	-0.259	0.232	-0.237	-0.458	-0.559	-0.378	-0.474

Panel C: Buy-and-hold Abnormal Returns by Underwriter Rankd and Growth

	Equally-weighted				Value-weighted			
Rank	0	0	1	1	0	0	1	1
GS	1	2	1	2	1	2	1	2
$BHAR_1$	-0.058	-0.095	0.028	-0.17	0.036	-0.352	0.036	-0.352
$BHAR_2$	-0.047	-0.142	0.018	-0.129	-0.041	-0.326	-0.041	-0.326
$BHAR_3$	-0.221	-0.121	-0.018	-0.223	-0.284	-0.333	-0.284	-0.333
$BHAR_4$	-0.282	-0.133	-0.009	-0.284	-0.887	-0.448	-0.887	-0.448
$BHAR_5$	-0.068	-0.216	-0.023	-0.261	-0.45	-0.53	-0.45	-0.53

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Table 12: Determinants of Buy and Hold Returns (Control-firm Approach)

For each IPO firm in our sample, we compute its 3-year and 5-year buy-and-hold return measuring as the difference between the holding period raturn of an IPO firm and a control firm. Each IPO firm is matched to a control firm based on three criteria: 2-digit SIC industry, size and market-to-book ratios. The independent variables are (1) Rev. Growth (Pre-IPO 3 Year), the rank of 3-year pre-IPO revenue growth; (2)Rev. Growth (Post-IPO 3 Year), the rank of 3-year post-IPO revenue growth; (3) Rev. Growth (Post-IPO 5 YEar), the rank of 5-year post-IPO revenue growth; (4) underwriters' rank; (5) insider retention; (6) venture capital backing dummy; (7) B/M, the ratio of pre-IPO year(year -1) book value of equity to market value of equity at the first closing price. Panel A presents the OLS regression results. Panel B presents the results of rank regressions.

Panel A: OLS

	(1) BHAR3	(2) BHAR3	(3) BHAR5	(4) BHAR5
Rev. Growth(Pre-IPO 3 Year)	-0.431*	-0.498**	-0.741*	-0.801*
	(0.223)	(0.232)	(0.388)	(0.435)
Rev. Growth(Post-IPO 3 Year)	1.700***	1.781***		
	(0.237)	(0.241)		
Rev. Growth(Post-IPO 5 Year)			4.457***	4.534***
			(0.606)	(0.588)
Underwriter Rank		0.041*		0.096**
		(0.025)		(0.042)
Insider Retention		0.047		0.197
		(0.283)		(0.516)
Venture Capital Backing		0.023		-0.076
		(0.110)		(0.274)
Book/Market Ratio		0.135		0.057
		(0.094)		(0.123)
N	2669	2537	2152	2038
r^2	0.036	0.040	0.044	0.044

Panel B: Rank Regression

	(1) BHAR3	(2) BHAR3	(3) BHAR5	(4) BHAR5
Rev. Growth(Pre-IPO 3 Year)	-0.101***	-0.086***	-0.086***	-0.070***
	(0.020)	(0.021)	(0.023)	(0.023)
Rev. Growth(Post-IPO 3 Year)	0.313***	0.324***		
	(0.024)	(0.024)		
Rev. Growth(Post-IPO 5 Year)			0.466***	0.487***
			(0.032)	(0.032)
Underwriter Rank		0.063**		0.066**
		(0.025)		(0.027)
Insider Retention		0.009		0.049**
		(0.020)		(0.022)
VC Backing		-0.003		-0.036
		(0.022)		(0.025)
Book/Market Ratio		0.062***		0.076***
		(0.017)		(0.020)
N	2537	2537	2038	2038
r^2	0.068	0.076	0.098	0.113

A.5. The Quality and Timing of Accounting Information

The evidence in Sections 3 and 4 suggests that investors do not correctly extrapolate the growth rates implied by accounting data listed in the prospectus. This basic result is invariant to underwriter reputation, venture backing, size and insider retention. We now examine the nature of the accounting statements themselves in more detail.

A.5.1 Does Auditing Matter?

Financial accounting statements may or may not be audited, and there is variation in the quality of the auditors. Table 13, Panels A and B summarize the evidence for Hypothesis 3 when separating the sample according to these criteria. Our first observation is that almost all IPOs are audited, and almost all of these are audited by Big 6 auditors. Therefore, we have relatively little variation along this dimension. Nevertheless, it appears the basic result of Section 3 holds in all subsamples. Thus, investor extrapolation is neither mitigated nor caused by the scrutiny of top tier auditors.

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Table 14 -- BHAR Returns and the Nature of the Audit

For each IPO firm in our sample, we compute its 3-year and 5-year buy-and-hold abnormal returns measuring as the difference between the holding period return of an IPO firm and the value-weighted market index returns. Panel A presents the BHARs by whether or not an IPO is audited and by 3-year pre-IPO growth rate; panel B presents the BHARs by whether or not an IPO is audited by at least one of the big six auditors and by 3-year pre-IPO growth rate; panel C presents the BHARs in full sample and in the subsample (with 3-year pre-IPO data present in Compustat) by 3-year pre-IPO growth. T-statistics test the equality of means.

Panel A: BHAR by Presence of Auditor

		Equally-weighted				Value-weighted		
	Audited	Growth				Growth		
		Low	High	t-Statistic	Total	Low	High	Total
3-year	No	0.16	-0.43	1.05	-0.14	0.83	-0.48	0.18
BHAR		15	15		30	0.00	0.00	0.00
	Yes	-0.10	-0.17	1.02	-0.13	0.09	-0.25	-0.08
		1588	1588		3176	0.50	0.49	1.00
	Total	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
		1603	1603		3206	0.51	0.50	1.00
5-year	No	0.26	-1.20	2.90	-0.47	0.64	-1.30	-0.31
BHAR		15	15		30	0.00	0.00	0.00
	Yes	-0.13	-0.20	0.56	-0.17	-0.10	-0.40	-0.25
		1588	1588		3176	0.50	0.49	1.00
	Total	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
		1,603	1,603		3,206	0.51	0.50	1.00

Panel B: BHAR by Ranking of Auditor

		Equally-weighted				Value-weighted		
	Big Six Audited	Growth				Growth		
		Low	High	t-Statistic	Total	Low	High	Total
3-year	No	-0.41	-0.28	-0.63	-0.35	-0.12	-0.23	-0.17
BHAR		98	95		193	0.01	0.01	0.02
	Yes	-0.08	-0.17	1.24	-0.12	0.10	-0.25	-0.07
		1505	1508		3013	0.50	0.49	0.98
	Total	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
		1603	1603		3206	0.51	0.50	1.00
5-year	No	-0.68	-0.44	-0.78	-0.56	-0.39	-0.37	-0.38
BHAR		98	95		193	0.01	0.01	0.02
	Yes	-0.09	-0.20	0.78	-0.14	-0.09	-0.40	-0.25
		1505	1508		3013	0.50	0.49	0.98
	Total	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
		1,603	1,603		3,206	0.51	0.50	1.00

Panel C: BHAR by Presence of 3-years data in COMPUSTAT

		Equally-weighted				Value-weighted		
		Growth				Growth		
		Low	High	t-Statistic	Total	Low	High	Total
3-year	Full Sample	-0.10	-0.17	1.10	-0.13	0.10	-0.25	-0.08
BHAR		1603	1603		3206	0.51	0.50	1.00
	3 Years COMPUSTAT	0.11	0.19	-0.26	0.13	0.17	-0.18	0.10
		149	39		188	0.80	0.20	1.00
5-year	Full Sample	-0.12	-0.21	0.66	-0.17	-0.10	-0.40	-0.25
BHAR		1,603	1,603		3,206	0.51	0.50	1.00
	3 Years COMPUSTAT	0.08	0.16	-0.19	0.10	0.28	-0.31	0.17
		149	39		188	0.80	0.20	1.00

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A.5.2 Do Historical SEC Filings Matter?

We next note that there is not only variation in the quality of the accounting statements, but also variation in the *timing* of their release. Specifically, some private firms may have had prior corporate events which triggered the release of accounting information to the SEC. For example, some IPOs may be spinoffs of companies which are already public. Alternatively, some firms reverse the traditional life cycle pattern of young firms: they issue public debt before doing an IPO (Cai, Ramchand, and Warga 2004). These firms must file with the SEC when making such an offering.

As previously mentioned, one of the leading explanations for our results thus far is that firms artificially depress historical revenues in order to inflate growth rates. Doing so is impossible if the firm has historically filed accounting results with the SEC.

To proxy for events such as these, we separate the sample according to whether or not they list at least three years of data in COMPUSTAT. There are 188 such firms.[14] The results are summarized in Table 13, Panel C. As the table indicates, for these 188 IPOs, the basic result of Section 3 and 4 no longer holds. This finding suggests that what matters is not so much the presence of accounting statements, but rather the timing of them. That is, firms would (presumably) like to manipulate historical accounting statements in order to inflate growth rates but cannot do so because the historical accounting statements have already been publicly released.

Table 14 shows that the analogous result holds in an OLS setting rather than in a univariate sense. Since these 188 IPOs are disproportionally large, we match these firms with IPOs in similar size and compare their results accordingly. Specifically, we choose a control

[14] COMPUSTAT does not follow private issues.

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IPO firm (in the rest of the full sample excluding the 188 subsample) with the 1-year pre-IPO revenue closest to that of the sample firm. The result indicates that unlike the full sample or the control sample, pre-IPO growth does not negatively load in the BHAR regression. Firms with data in COMPUSTAT before the issue simply behave differently from the rest of the sample. Table 15 examines Hypothesis 1, and finds that growth loads positively in a valuation model. Thus, growth is valued by investors in this limited subset, but unlike in the full sample it is not overvalued.

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Table 15: Determinants of Buy and Hold Returns in Subsample and Control Firms

For each IPO firm in our sample, we compute its 3-year and 5-year buy-and-hold abnormal return measured as the difference between the holding period return of an IPO firm and a control firm. Each IPO firm is matched to a control firm with the 1-year pre-IPO revenue closest to that of the sample firm. The independent variables are (1) Rev. Growth (Pre-IPO 3 Year), the rank of 3-year pre-IPO revenue growth; (2)Rev. Growth (Post-IPO 3 Year), the rank of 3-year post-IPO revenue growth; (3) Rev. Growth (Post-IPO 5 Year), the rank of 5-year post-IPO revenue growth; (4) Underwriter Rank; (5) Insider Retention; (6) Venture Capital Backing ; (7) B/M, the ratio of pre-IPO year(year -1) book value of equity to market value of equity at the first closing price. Panel A presents the OLS regression results. Panel B presents the results of rank regressions.

	Subsample				Control Firms			
OLS	BHAR3	BHAR3	BHAR5	BHAR5	BHAR3	BHAR3	BHAR5	BHAR5
Rev. Growth(Pre-IPO 3 Year)	0.048	-0.039	0.083	0.298	-1.111**	-0.866	-2.259**	-2.184*
	(0.526)	(0.525)	(0.492)	(0.549)	(0.519)	(0.600)	(1.004)	(1.159)
Rev. Growth(Post-IPO 3 Year)	2.244***	2.579***			2.842***	2.679***		
	(0.518)	(0.555)			(0.623)	(0.591)		
Rev. Growth(Post-IPO 5 Year)			3.036***	2.796***			6.060***	5.680***
			(0.581)	(0.613)			(1.651)	(1.556)
Underwriter Rank		0.182*		0.137*	-0.042		-0.076	
		(0.094)		(0.070)	(0.114)		(0.140)	
Insider Retention		0.383		-0.469	-0.286		0.389	
		(0.808)		(0.655)	(0.967)		(1.825)	
Venture Capital Backing		0.091		0.193	0.817		1.519*	
		(0.359)		(0.437)	(0.532)		(0.833)	
Book/Market Ratio		0.451		0.403	1.329		1.933	
		(0.468)		(0.322)	(0.831)		(1.511)	
N	160	151	133	125	146	124	121	104
r2	0.192	0.243	0.323	0.361	0.244	0.337	0.303	0.358

Table 15-Valuation model in Subsample and Control Firms
The subsample in row includes 177 US operating firm IPOs over 1988-2003 that had at least three year pre-IPO Compustat accounting data coverage. The control firms include 149 IPOs that are closet in size to the subsample and did not have three year pre-IPO Compustat Coverage. The accounting information of control firms is collected from IPO prospectues. L(W) is defined as L(W)=ln(1+W) when W>=0; L(W)=-ln(1-W) when W<0. Offer value is the final offer price*number of shares outstanding immediately after the IPO(in $millions). Market value is the first-day clsoing price*number of shares outstanding immediately after the IPO (in $millions).

	Subsample		Control Firms	
VARIABLES	L(Offer Value)	L(Market Value)	L(Offer Value)	L(Market Value)
Ln(Income)	0.004	0.005	0.007	0.005
	(0.019)	(0.020)	(0.024)	(0.025)
Ln(Book Value of Equity)	0.001	0.003	0.016	0.016
	(0.012)	(0.013)	(0.017)	(0.017)
Ln(R&D)	0.091**	0.098**	0.272***	0.284***
	(0.039)	(0.042)	(0.053)	(0.058)
Ln(Revenue)	0.383***	0.367***	0.353***	0.329***
	(0.048)	(0.053)	(0.044)	(0.049)
Underwtiter Rank	0.186***	0.213***	0.297***	0.302***
	(0.036)	(0.040)	(0.035)	(0.036)
Insider Retention	1.539***	1.597***	2.444***	2.628***
	(0.273)	(0.287)	(0.369)	(0.381)
VC-backing	-0.045	0.016	-0.405***	-0.386**
	(0.103)	(0.115)	(0.133)	(0.149)
Ln(Growth Rate)	0.365**	0.597***	0.258**	0.271*
	(0.171)	(0.183)	(0.118)	(0.144)
Constant	0.777***	0.657**	-0.625	-0.546
	(0.294)	(0.307)	(0.403)	(0.417)
Year effects	No	No	No	No
Observations	177	177	149	149
R-squared	0.672	0.631	0.732	0.700

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5. Conclusions

In this article we examine the effect of pre-IPO growth rates on the valuation and long-run performance of new issues. Our results contribute to the literature by collecting multiple years of pre-IPO data. We are thus able to use a direct measure of growth, while most IPO valuation research has relied on either 1-year post-IPO growth or other indirect measures to proxy for growth.

The results establish three propositions. First, IPOs with rapid pre-IPO growth obtain higher offer value and market value. Second, IPOs with rapid pre-IPO growth have poor long-term stock returns. Third, there is a connection between pre-IPO growth, post-IPO returns and analysts' long-term growth forecasts. Specifically, analysts' growth forecasts are upward biased for all firms, but the magnitude of this bias is greatest – and the returns most disappointing – for the highest quintile of growth.

These results are unmitigated by any of the certification proxies used in the literature: VC backing, underwriter reputation and auditor reputation. The results hold independently of firm size or insider holdings. The one subset in which the basic result does not seem to hold is for firms with historical accounting already in COMPUSTAT before the issue. This finding is consistent with a world in which issuers are normally able to mislead investors by manipulating old accounting data, but are unable to do so when they have released accounting data in the past for other uses.

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CHAPTER 2 R&D as a Signal for IPO firms

1. Introduction

The process of going public is fraught with uncertainty. Lack of credible and verifiable information about these new issues provides strong incentives for issuing firms to signal their quality. Previous literature has focused on underpricing as a signal for IPO firms.[15] The evidence is, at best, mixed.[16] This empirical inconsistency is perhaps unsurprising, as Ljungqvist (2007) argues:

"Signaling models are open to the challenge that the proposed signaling device may be dominated by other signals. Would firms really choose the underpricing signal if they had a wider range of signals to choose from?.....Unless signaling via underpricing proves to be the most cost-effective way to persuade potential investors of the high quality of an IPO, which seems at least doubtful-the existence of alternatives dents the credibility of the signaling models."

This paper argues instead that pre-IPO research and development expenditures can serve a signaling role which is not subject to the aforementioned criticisms. The salient feature of R&D is that it is highly intangible, and the returns to it are likely to be long term in nature and highly dependent on the (uncertain) quality of the firm.

[15] See Allen and Faulhaber (1989), Grinblatt and Hwang (1989), Welch (1989,1996) for underpricing as a signal for IPO firms. Also other proposed signals include: underpricing to 'leave a good taste in investors' mouths' (Ibbotson 1975), particularly reputable underwriters (Booth and Smith 1986), auditors (Titman and Trueman 1986), ownership retention (Leland and Pyle, 1977) and the level of capital expenditure (McConnell and Muscarella, 1985; Trueman, 1986).

[16] Michaely and Shaw (1994), Spiess and Pettway (1997), Jain and Kini (1994) provide evidence inconsistent with underpricing as a signal. Jagadeesh et al (1993) find weak supporting evidence. For a full review, see "The Signalling Explanation of IPO Underpricing" in Handbooks in Finance: Empirical Corporate Finance Chapter III.4.

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The signaling argument works as follows. Suppose that firms are differentiated by their (privately-known) return to investments in intangible assets: high quality firms have positive NPV investments whereas low quality firms do not. Low quality firms then face a clear trade-off. Mimicking the R&D levels of high quality issuers improves investors' perceptions of their quality— which benefits old shareholders via improved IPO pricing – while also imposing a direct cost because of overinvestment in R&D. By contrast, high R&D expenditures are not as wasteful for high-quality firms, by definition. These differential returns to investment are what ensures the single-crossing property, and hence serve as a more effective signal than "underpricing" which is instead borne equally by all types.[17]

This signaling argument makes several empirical predictions. First, and most obviously, the IPO market will treat R&D favorably and apply higher valuation ratios to firms with high R&D levels. In addition, if high R&D firms have better investment opportunity sets, one would expect them to be more likely to reach the SEO stage, and when they do, their SEOs should be larger. They should also have superior operating performance.

Our econometric approach must account for the fact that high R&D expenditures proxy for growth opportunities. To address this correlation, it is important to control for expected growth. We do so by hand-collecting accounting data for up to 5 years prior to the IPO. We then create a measure of recent historical growth which we use a proxy for expected future growth. (This exercise is not feasible using Compustat data, which typically reports only one year of pre-IPO data, so that it is impossible to compute a growth rate.) In addition, having access to multiple years of pre-IPO R&D allow us to estimate the expected R&D at year -1 and

[17] For this reason, signaling stories of IPO pricing must generally invoke a second stage (SEO) which delivers differential payoffs. An early version of this paper contained a simple model showing that this second stage is not needed in the present setting.

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compute the discretionary R&D spending at year -1. This requires accounting information at year -2 due to the persistence of R&D activities. R&D at year -1 and year 0 from Compustat are not suitable for estimating pre-IPO R&D since R&D at year 0 (the fiscal year right after the IPO) mixes both pre- and post-IPO information.[18]

With some caveats, our analysis is consistent the above hypotheses. Pre-IPO R&D shows up as a strong determinant in OLS regression of IPO valuation. This result does not appear to be driven by the fact that R&D is correlated with growth opportunities, because in these regressions we control for directly observed growth itself. It is positively related to SEO likelihood and size (although the economic magnitudes of this result are generally small in most specifications). Our analysis also reveals fairly dramatic post-IPO differences in operating performance. Though low R&D firms have post-IPO declines in operating performance – mirroring the results of previous literature – high R&D firms actually have substantial *improvements* in operating performance. For example, low R&D firms show a 1.7% decline in operating return (scaled by assets) on average between the pre-IPO year and the first post-IPO year. High R&D firms show a 10.6% improvement over this same period. We are unaware of an IPO study which documents such post-IPO improvements in a relatively large subsample.

Unique to the R&D signaling explanation is the prediction that R&D reverses in the post-IPO period (i.e., if R&D is a signal it will be overused). Our data is strongly supportive of this prediction. For low R&D firms, R&D is virtually unchanged from year -1 to year 0. For high R&D firms it declines 17.1% in the first year. While it is possible that investment opportunities are time-varying (for example, they may be mean-reverting), we note that year 0 (the first year reported post-IPO) contains both pre-IPO and post-IPO financial results. It seems highly

[18] As an example, Starbucks Corp. went into public on June 26th, 1992. The year 0 is the fiscal year ending on September 30th ,1992, which includes 9 months pre-IPO and three months post-IPO information.

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unlikely that investment opportunities evaporate so rapidly – within a few months of going public. This reversal seems more consistent with the overuse of R&D as a signal of quality: when the need to signal decreases, so too does the usage of the signal. And this drop occurs at precisely the same time.[19]

Also in this spirit of changing investment opportunities, Carlson, Fisher and Giammarino (2005, 2006) emphasize that equity issuance events represent the conversion of growth options to assets-in-place. Most of Carlson et. al's predictions are framed in terms of SEOs and do not directly apply in our setting (e.g., there is no observable pre-IPO beta, no announcement effect, etc.). Nevertheless, we track beta in the early post-IPO period and find only a modest drift downward. There are only small changes in risk over the first two or so post-IPO years. Furthermore, their argument has the most bite for small firms with substantial growth options. We therefore partition the sample into high and low R&D firms. We find generally similar beta dynamics in both subsamples, which suggests that it is not the exercise of real options that is driving our R&D results.

In addition, we examine pre- and post-IPO R&D and compare it with pre- and post-IPO capital expenditure. Following Carlson et. al's logic, it is possible that growth options revealed through R&D are exercised and converted to assets-in-place. If so, one might expect to see the drop in R&D correspond to a spike in capital expenditure. This is not evident in our data. Capital expenditures are nearly flat (they actually decline slightly) after the IPO, leaving only R&D to experience a dramatic change.

[19] We examine periods further out than year 0. There are no further declines in R&D beyond year 0. Thus, the entire reversal happens within a few months of the IPO.

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Arguments about the signaling role of investment more generally can be found in prior literature. Perhaps the most closely related are Lichtenberg (1998) and Wang, Chua and Megginson (2001). Lichtenberg (1988) offers a signaling explanation for the observed increase in private R&D. His argument is that prior to contracting with private firms, the government induces them to incur their own R&D expense to demonstrate their capability. Lichtenberg's (1988) does not directly test R&D as a signal but only imply this possibility. Wang, Chua and Megginson (2001) compare signaling effects of traditional factors (underpricing and underwriter's reputation) vs. technology factors (pending patents, patents, R&D expenditure, R&D personnel and alliances). Their paper suggests the dominance of the traditional factors. Our paper differs from theirs in two ways. First, they focus on high-tech IPOs for a short period during Jan 1999 to May 2000; our paper includes all IPOs from 1980 to 2005 and thus examines a more comprehensive sample. Second, they focus on a short-term perspective of valuation following IPOs and do not relate signaling factors to issuers' long-term performance and future seasoned offerings.

1.1 R&D and information asymmetry

Several academic studies identify R&D as a source of private information leading to information asymmetry. Unlike physical capital investment (such as property, plant and equipment) whose resale value is comparable across firms, R&D has almost no resale value and its productivity is highly dependent on entrepreneurs' quality. The uniqueness of R&D gives insiders informational advantage to exploit benefits from outsiders. Aboody and Lev's (2000) argue that insiders know considerably more than do outsiders about the specification of products under development, results of product feasibility tests, and marketing prospects. Guo, Lev and

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Shi (2006) use R&D as a proxy of information asymmetry and argue that R&D contributes to information asymmetry leading to IPO underpricing.

In effect this story is the converse of ours, where information asymmetry causes R&D spending rather than vice versa. It is unclear how the converse story could explain rapid reversal in R&D spending in the post-IPO months, or why R&D would be positively associated with firm value after directly controlling for firm growth.

1.2 R&D and Firm Performance

Our paper is also related to several studies examining the connection between R&D spending and firm performance. Chan, Martin and Kensinger (1990) find positive announcement effects of increasing R&D spending. Sougiannis (1994) estimates that a one dollar increase in R&D expenditures leads to a five dollar increase in market value. Lev and Sougiannis (1996) demonstrates that R&D capital is significantly associated with subsequent stock returns, after controlling for other risk and fundamental factors. Eberhart et al. (2004) find a positive association between significant R&D increases and abnormal risk-adjusted returns for the five-year period following R&D increases. While prior literature focuses mainly on seasoned firms, our study contributes to the literature on R&D and firm performance from the perspective of IPO firms. We find that although IPO issuers on average underperform compared to seasoned firms, issuers with high pre-IPO R&D do not underperform.

In sum, this paper contributes to empirical R&D literature in three aspects. First, we investigate R&D from a different perspective: R&D decision can be a response to information asymmetry but not a cause of it. Second, by extending the IPO signaling literature, this paper suggests that issuers use R&D as a signal to reveal private information. Third, although IPO

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issuers underperform seasoned firms, issuers with high pre-IPO R&D experience superior post-issue operating performance.

This article is organized as follows. Section 2 develops the signaling hypotheses. Section 3 describes data sources, sampling procedures and summary statistics. Section 4 presents empirical results and discusses their implications. Section 5 examines some alternative explanations. Section 6 concludes.

2. Hypotheses development

The IPO market is subject to substantial information asymmetry. IPO firms are on average valued in discount by investors to compensate for paying too much for low quality issuers. Due to information asymmetry, good issuers have incentive to signal their quality to the market, so as to distinguish themselves from bad issuers and obtain a better pricing.

R&D is relatively costly for bad issuers for two reasons. First, since US GAAP generally requires R&D to be expensed as incurred, that is, R&D expenditures result in an expense in the income statement when the cash expenditure is made, leading to an immediate decrease in earnings (Darrough and Rangan (2005))[20]. A lower earning can potentially result in lower pricing. Second, bad issuers bear the consequence of low realized payoff (or zero payoff) of their R&D investment if they simply use R&D as a signal to pool with good issuers. This section describes testable hypotheses from signaling theory.

[20] The main exceptions from this general rule where R&D is permitted to be capitalized are for externally purchased R&D and internally developed software code after the point of technological feasibility.

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High quality issuers are more likely to obtain higher offer value and secondary market value at IPO. If R&D is a credible signal at IPO, firms with high pre-IPO R&D will be valued more.

H-1. There is a positive relationship between pre-IPO R&D and firm value at IPO.

High quality firms are less likely to be affected by unexpected economic shocks after IPO than low quality firms. Therefore, high quality firms are more likely to go back to issue seasoned equity.

H-2. Firms with high pre-IPO R&D are more likely to issue seasoned equity than firms with low pre-IPO R&D.

High quality firms are more likely to expand investment and need more capital than low quality ones. Therefore, firms with high pre-IPO R&D investment will raise a larger proportion of their capital requirements through seasoned offerings.

H-3. There is a positive relationship between pre-IPO R&D and the amount of subsequent seasoned equity issue.

If R&D investment serves as a credible signal for firm quality and subsequent operating performance proxies for unobservable firm quality, then firms with high pre-IPO R&D will experience better post-issue operating performance.

H-4. Firms with high pre-IPO R&D investment will have better post-issue operating performance compared to those with zero or low R&D.

If firms invest more in R&D than they otherwise would in order to convey a signal to the market, they will reduce their R&D investment following IPO.

H-5. Firms with high pre-IPO R&D will reduce their R&D expense in the subsequent years following IPO.

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If good issuers employ R&D as a signal and overinvest in R&D in order to distinguish themselves from bad issuers, then they will overinvest in R&D before they go public. The market will give favorable valuation for firms that overinvest in R&D prior to IPO.

H-6. The discretionary R&D is positively associated with IPO offer value and market value.

3. Sample Description and Data Sources

The sample consists of all firm-commitment U.S initial public offerings (IPOs) from 1980-2005, derived from the New Issues Database of Securities Data Co. (SDC). Following the conventions in the IPO literature, we exclude unit offerings, offerings of foreign corporations (F-1 filings), REITs and mutual fund filings. We also exclude IPOs issued after Dec 2005 because we require data on seasoned equity issues for a three-year period after the IPO. The seasoned-issue data ends in December 2008. We include only IPOs with an offer price of above $3 per share, and for which the required price and accounting data available from CRSP and COMPUSTAT. The R&D intensity (R&D deflated by either sales or assets) is winsorized at 1 percentile to eliminate the influence of outliers. The final sample includes 5,846 IPOs, and the sample selection process is summarized in Table 1.

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Table 1 : Sample Selection (IPOs)

Sample Selection Step		*No. Firms*
Total number of firms commitment domestic IPOs issued during 1980-2005		10954
Less: foreign issues and rights issues		(710)
	Subtotal:	10244
less: unit issues		(1207)
	Subtotal:	9037
less: close end fund/trust		(837)
	Subtotal:	8200
Less: REIT		(277)
	Subtotal:	7923
Less: IPOs with offer price less than $3 per share		(265)
	Subtotal:	7658
less: firms with no sales or assets information at the fiscal year prior to the IPO		(1812)
	Final Sample	5846

`

To compute the discretionary R&D one year prior to the IPO and the pre-IPO growth rate, we employ two sources of pre-IPO accounting information. After May 1996, prospectuses are provided by the Securities and Exchange Commission at www.edgarcompany.sec.gov/. For IPOs between 1988 and April 1996, we obtain them at our library via CD-ROMs produced by Compact Disclosure. We record all available pre-IPO observations of revenue, research and development, operating income, net income and book value of assets.

The main explanatory variable in the paper is pre-IPO R&D ratio measured as R&D expense deflated by sales (RDS) and by assets (RDA) at the end of the fiscal year before IPO. We employ R&D intensity both in raw form and in industry adjusted form. To measure the industry adjusted R&D intensity, we first match each IPO firm with contemporary firms in the same industry based on Fama-French 12 industry classification, then subtract the industry median R&D intensity from IPO R&D intensity.

The discretionary R&D at year -1 (relative to year 0) is measured as the difference between the actual R&D and the expected R&D spending. The expected R&D spending is obtained from a R&D forecast model.

To measure post-issue operating performance, we employ two cash flow variables. The first measure is operating return on assets, which is operating income (before depreciation and taxes) divided by total assets at the end of the fiscal year (COMPUSTAT data item 13 divided by data item 6). Operating income equals net sales less cost of goods sold and selling, general and administrative expenses before depreciation, depletion, and amortization. The second operating performance measure is operating cash flow deflated by total assets at the end of the fiscal year. This ratio equals operating income minus capital expenditures (COMPUSTAT data item 13 less data item 128), divided by total assets (COMPUSTAT data item 6). The operating return on

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assets measures the efficiency of asset utilization. Operating cash flows deflated by assets is a primary component in net-present-value (NPV) calculation used to value a firm. We measure the change in operating performance as the median change in levels, i.e., the median value of $Operating\ Return_i(t) - Operating\ Return_i(-1)$, where i represents the firm, -1 represents the fiscal year prior to the IPO, and *t* represents a post-IPO fiscal year end. Because operating performance measures may be skewed and the mean is particularly sensitive to outliers, we use the median as a measure of central tendency.

Since the importance of R&D varies for different industries, we further divide the sample into high-tech and low-tech industries. The classification of industries in defined using SIC industry codes in Appendix A. We further classify firms in pharmaceutical, medical equipment, telecom, and high-tech as "high-tech" issuers, and firms in healthcare service, durable goods, non-durable goods, energy, manufacturing, retail, and others as "low-tech" issuers.

The main variables used in this paper are listed as follows:

RDA= Research and development expense (#46) deflated by total assets (#6).

RDS= Research and development expense (#46) deflated by sales (#12).

Discretionary RDA=Actual RDA-Expected RDA.

IPO Offer Value = final offer price×number of shares outstanding immediately after the IPO (in $millions).

IPO Market Value = first-day closing price×number of shares outstanding immediately after the IPO (in $millions).

Pre-IPO growth = geometric growth of total revenue from year -3 to year -1 (relative to the IPO year defined as year 0).

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Underwriter Rank = Jay-Ritter (1994) rank for the leading investment bank for the IPO. The average of underwriters' ranks is taken if more than one lead investment banks underwrite the offering.

RESSIUE = dummy variable that assumes a value of one if the firm issues seasoned equity within three years of its IPO and zero otherwise.

CAR1=abnormal return over the period from trading day 1 to trading day 20 after the IPO date. The abnormal return is estimated as the raw return minus beta times the market return. The CRSP value-weighted NASDAQ index is used as the market proxy and beta is estimated from a market-model regression fitted over days 41 to 140 following the IPO date.

CAR2=same as CAR1, except that it covers the period from trading day 21 to trading day 40 after IPO.

LIPOSIZE=natural logarithm of the amount of capital raised in the IPO.

SEOSIZE=size of the first seasoned equity offering within three years of the IPO, expressed in millions of dollars. SEOSIZE is set to zero for firms not issuing seasoned equity within three years following the IPO.

SEO/IPO=the relative size of the capital raised in the seasoned offering versus the initial offering.

SIBRANK=Jay-Ritter (1994) rank for the leading investment bank for the SEO. The average of underwriters' ranks is taken if more than one lead investment banks underwrite the offering.

FFCAT12=set of 12 industry dummy variables based on the Fama-French 12 industry classification.

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IPOYEAR=set of 26 dummy variables that are equal to one for the year of issue and zero otherwise.

SEOYEAR=set of 29 dummy variables that are equal to one for the year of seasoned equity offerings and zero otherwise.

ROA (Operating return on assets) =Operating income (before depreciation and taxes) divided by total assets at the end of the fiscal year (COMPUSTAT data item 13 divided by data item 6).

OCF (Operating cash flow on assets) =cash flow from operation deflated by total assets at the end of the fiscal year. This ratio equals operating income minus capital expenditures (COMPUSTAT data item 13 less data item 128), divided by total assets (COMPUSTAT data item 6).

All dollar dominated variables are adjusted for inflation using the consumer price index and are expressed in 2000 dollars. Table 2 presents the distribution of new and seasoned equity offerings through time. Most IPOs and SEOs occur during the 90's. Issues from 1991-2000 account for 68% of the IPOs and 65% of the SEOs in the sample. Out of 5,846 IPOs, 1755 firms (about 30%) return to equity market to raise money within 3 years of their initial offerings.

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Table 2: IPOs and Subsequent SEOs by Year

Distribution of 5846 firm-commitment initial public offerings (IPOs) and 1755 first seasoned equity offerings (SEOs) by offering year, 1980-2008.

Initial public offerings by smaple firms are shown in column 2 and 3, seasoned equity offerings by these firms are shown in columns 4 and 5. For example, in 1981, we found 15 SEOs issued by some of the 181 (=46+135) IPO firms in 1980 and 1981. The IPOs are firm-commitment offerings excluding unit offerings, foreign issues and right issues, close end fund/trust, REIT and IPOs with offer price less than three dollars in the 1980-2005 period. The SEO sample consists of the first seasoned equity offering within three years following the IPO.

	Initial Public Offering		Seasoned Offerings	
year	Number	Percentage	Number	Percentage
1980	46	0.79%	2	0.11%
1981	135	2.31%	15	0.85%
1982	54	0.92%	30	1.71%
1983	323	5.53%	60	3.42%
1984	127	2.17%	18	1.03%
1985	113	1.93%	45	2.56%
1986	315	5.39%	57	3.25%
1987	234	4.00%	50	2.85%
1988	89	1.52%	22	1.25%
1989	86	1.47%	39	2.22%
1990	99	1.69%	16	0.91%
1991	259	4.43%	60	3.42%
1992	367	6.28%	81	4.62%
1993	447	7.65%	145	8.26%
1994	364	6.23%	95	5.41%
1995	404	6.91%	150	8.55%
1996	594	10.16%	171	9.74%
1997	395	6.76%	148	8.43%
1998	246	4.21%	99	5.64%
1999	409	7.00%	108	6.15%
2000	296	5.06%	96	5.47%
2001	65	1.11%	43	2.45%
2002	66	1.13%	23	1.31%
2003	48	0.82%	36	2.05%
2004	134	2.29%	36	2.05%
2005	131	2.24%	42	2.39%
2006			53	3.02%
2007			14	0.80%
2008			1	0.06%
Total	5,846	100%	1,755	100%

`

Table 3 presents descriptive statistics on variables used in the paper. The average pre-IPO R&D over assets ratio is 10.63% in the entire sample; 11.2% in the SEO subsample. The average pre-IPO R&D over sales is 45.84% in the entire sample; 57.71% in the SEO subsample. This suggests a higher pre-IPO R&D ratio for firms returning to equity market within three year following IPO. Finally, firms that issue seasoned equity on average raise 1.9 times as much capital through seasoned issues as they raise in their IPOs (both based on 2000 dollars).

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Table 3: Descriptive Statistics

Descriptive statistics on 5,846 firm-commitment IPOs in the 1980-2008 period and 1,755 seasoned equity offerings (SEOs) in the 1980-2008 period. To be included in the sample, an SEO had to occur within three years of the IPO and be the first SEO of the firm. The underwirtier rank is defined as Loughran and Ritter (2004).

5,846 Initial Public Offerings							
Variable	Description	N	Mean	Std. dev	Min	Med.	Max.
RDA	Pre-IPO R&D expense/Assets	5846	0.11	0.21	0.00	0.00	1.26
RDS	Pre-IPO R&D expense/Sales	5846	0.46	2.09	0.00	0.00	17.40
CAR1	First 20-day abnormal aftermarket return	5846	0.02	0.22	-1.15	0.01	4.75
CAR2	Second 20-day abnormal aftermarket return	5846	0.00	0.20	-1.09	0.00	3.88
IPOSIZE	IPO size (in 2000-million dollars)	5846	60.96	196.96	0.74	26.83	7122.30
REISSUES	Dummy for SEO issue	5846	0.30	0.46	0.00	0.00	1.00
1,755 First Seasoned Equity Offerings							
Variable	Description	N	Mean	Std. dev	Min	Med.	Max.
RDA	Pre-IPO R&D expense/Assets	1755	0.11	0.23	0.00	0.00	1.26
RDS	Pre-IPO R&D expense/Sales	1755	0.58	2.45	0.00	0.00	17.40
CAR1	First 20-day abnormal aftermarket return	1755	0.03	0.21	-0.82	0.02	1.46
CAR2	Second 20-day abnormal aftermarket return	1755	0.01	0.18	-0.81	0.00	1.27
IPOSIZE	IPO size (in 2000-million dollars)	1755	65.83	174.93	1.35	32.30	4222.84
SEOSIZE	SEO size (in 2000-million dollars)	1755	89.29	144.90	1.94	48.65	2174.74
SEOMKT	SEO size/outstanding market value of equtiy	1660	0.24	0.16	0.00	0.20	1.47
SEOIPO	SEOSIZE/IPOSIZE	1755	1.88	1.64	0.02	1.48	17.19

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4. Empirical Analysis

4.1 Pre-IPO R&D Intensity

4.1.1 IPO valuation

We test the hypothesis that higher pre-IPO R&D is positively related to offer value and market value at the time of IPO. Table 4 shows that firms with high pre-IPO R&D obtain higher offer value and secondary market valuation. A one standard deviation increase in R&D at year -1 is associated with 0.10 standard deviation increase in offer value (with similar magnitude for secondary market valuation). We include other variables that are correlated with IPO valuation: net income and revenue are proxies for cash flows, the book value of equity is proxy for the replacement cost of the firm's physical capital, and pre-IPO revenue growth is a direct measure of pre-IPO firm growth. Also included in the OLS regressions are fundamental IPO characteristics (underwriter rank, insider's retention and venture capital backing) that have been documented to be correlated with IPO pricing. Finally, we include year dummy variables to control for differences in IPO valuation over time.

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Table 4: Valuation Models

The sample in row (1) includes 3,036 US operating firm IPOs over 1988-2003 where the offer price is at least $3.00 and complete data on all the variables is available. The dependent variables in Panel A is ln(offer value) while in panel B is ln(market value). L(W) is defined as L(W)=ln(1+W) when W>=0; L(W)=-ln(1-W) when W<0. Offer value is the final offer price ×number of shares outstanding immediately after the IPO(in $millions). Market value is the first-day closing price ×number of shares outstanding immediately after the IPO (in $millions). All the independent variables are also in log forms defined as above excpet for underwriter rank, retention and VC-backing.

Panel A:						Panel B:				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
VARIABLES	lov	lov	lov	lov	lov	lmv	lmv	lmv	lmv	lmv
R&D(Yr -1)	0.117***					0.131***				
	(0.014)					(0.015)				
R&D(Yr -2)		0.121***					0.134***			
		(0.016)					(0.017)			
R&D(Yr -3)			0.107***					0.121***		
			(0.018)					(0.019)		
R&D(Yr -4)				0.105***					0.120***	
				(0.022)					(0.024)	
R&D(Yr -5)					0.066**					0.063**
					(0.027)					(0.030)
Net Income (Yr -1)	-0.038***	-0.041***	-0.041***	-0.043***	-0.042***	-0.029***	-0.031***	-0.032***	-0.034***	-0.032***
	(0.008)	(0.008)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Book Value of Equity (Yr -1)	0.024***	0.026***	0.026***	0.026***	0.025***	0.023***	0.025***	0.025***	0.025***	0.024***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Revenue (Yr -1)	0.259***	0.256***	0.256***	0.257***	0.256***	0.247***	0.243***	0.244***	0.245***	0.244***
	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Pre-IPO Growth	0.131***	0.138***	0.139***	0.139***	0.131***	0.183***	0.191***	0.192***	0.192***	0.181***
	(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.027)	(0.027)	(0.028)	(0.028)	(0.028)
Underwriter Rank	0.228***	0.231***	0.233***	0.236***	0.237***	0.239***	0.242***	0.245***	0.248***	0.250***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Retention	1.961***	1.971***	1.999***	2.035***	2.063***	2.082***	2.094***	2.123***	2.164***	2.199***
	(0.083)	(0.082)	(0.083)	(0.082)	(0.082)	(0.088)	(0.088)	(0.088)	(0.087)	(0.087)
VC-backing	-0.106***	-0.102***	-0.091***	-0.076***	-0.069***	-0.088***	-0.083***	-0.072***	-0.055**	-0.046*
	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.026)	(0.026)	(0.026)	(0.026)	(0.026)
Constant	1.505***	1.490***	1.464***	1.441***	1.445***	1.483***	1.465***	1.436***	1.410***	1.419***
	(0.118)	(0.119)	(0.120)	(0.121)	(0.123)	(0.122)	(0.122)	(0.123)	(0.125)	(0.126)
Observations	3036	3036	3036	3036	3036	3036	3036	3036	3036	3036
R-squared	0.728	0.727	0.724	0.721	0.719	0.708	0.707	0.704	0.702	0.699

4.1.2 Probability of SEO offerings

We test the hypothesis that the probability of a firm's issuing seasoned equity is positively related to pre-IPO R&D intensity and to aftermarket returns by estimating the following logit model:

$$P_i = e^{\alpha + x_i' \beta + u_i} / (1 + e^{\alpha + x_i' \beta + u_i})$$

where P_i is the probability that the i^{th} firm issues seasoned equity and x_i is the column vector of independent variables. The three independent variables of primary interest are the pre-IPO R&D intensity (RDA or RDS) and the cumulative abnormal returns in the two 20-day periods after the IPO (CAR1 and CAR2)[21]. Since firms that raise relatively small amounts of capital at the IPO may be more likely to return with a seasoned equity offering, we also include the natural logarithm of IPO size as an additional explanatory variable. Finally, we include industry and year dummy variables as independent variables in the logit regression to control for potential differences in SEO activity across industry and years.

Table 5 presents the logit regression estimates. Panel A in Table 5 shows that in the full sample, the slope coefficient (t-statistics) on the R&D intensity variable RDA is 0.306 (2.01) and RDS is 0.039 (2.84). The slope coefficient (t-statistics) on the aftermarket return variables CAR1 and CAR2 are 0.38 (2.63) and -0.004 (0.03). This is consistent with the market feedback hypothesis which posits that the high-quality firms issue seasoned equity if and when the market identifies them as such.

[21] We follow Jegadeesh et. al (1993) to measure the abnormal return over two 20-day horizons excluding the first trading day.

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Table 5: Logit Regression of Probability of SEO on Pre-IPO R&D

Logit regression estimate of the relation between R&D intensity before IPO and the probability of a subsequent seasoned equity offering (SEOs) for 5,846 firm commitment IPOs in the 1980-2005 period. To be included in the sample, an SEO had to occur within three years of the IPO and be the first SEO of the firm.

The dependent variable is the dummy that is assigned a value of one if a firm issues seasoned equity within three years of its IPO and zero otherwise. The independent variables are pre-IPO R&D relative to assets (RDA), pre-IPO R&D relative to sales (RDS), the abnormal aftermarket returns in the two 20-day period after the IPO (CAR1 and CAR2), the logarithm of IPO size (LOGIPOSIZE), and dummy variables for industry groups and the year of the IPO. The t-statistics are reported in parentheses below the corresponding estimates. Both RDA and RDS are winsorized at one percentile. Panel B uses industry adjusted R&D Expense/Assets and R&D Expense/Sales in place of the R&D Expense/Assets and R&D Expense/Sales as independent variables in the regression.

Panel A

	Full Sample		High-tech		Non-high-tech	
R&D Expense/Sales	0.039***		0.053***		-0.003	
	(2.84)		(3.50)		(-0.08)	
R&D Expense/Assets		0.306**		0.439**		0.001
		(2.01)		(2.53)		(0.00)
CAR1	0.381***	0.375***	0.463**	0.446**	0.192	0.191
	(2.63)	(2.57)	(2.47)	(2.39)	(0.79)	(0.79)
CAR2	-0.004	-0.000679	-0.182	-0.183	0.319	0.319
	(-0.03)	0.00	(-0.89)	(-0.89)	(1.28)	(1.28)
logiposize	0.313***	0.314***	0.337***	0.340***	0.300***	0.300***
	(10.17)	(10.17)	(6.51)	(6.54)	(7.71)	(7.70)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Uhler R square	0.081	8.04%	9.14%	8.87%	10.40%	10.40%
N	5846	5846	2770	2770	3076	3076

Panel B

	Full Sample		High-tech		Non-high-tech	
R&D Expense/Sales_Adj	0.034444**		0.048125***		-0.011546	
	(2.38)		(2.09)		(-0.27)	
R&D Expense/Assets_Adj		0.217591		0.384001**		-0.213517
		(1.36)		(2.09)		(-0.6)
CAR1	0.383188***	0.376643**	0.457966**	0.445135**	0.19353	0.197559
	(2.62)	(2.58)	(2.38)	(2.38)	(0.79)	(0.81)
CAR2	-0.001922	0.00035	-0.179474	-0.180616	0.324584	0.319959
	(-0.01)	0.00	(-0.88)	(-0.88)	(1.30)	(1.28)
logiposize	0.310738***	0.310975***	0.33568***	0.33866***	0.297578**	0.296422***
	(10.09)	(10.07)	(6.50)	(6.50)	(7.64)	(7.60)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Uhler R square	8.07%	7.98%	0.09	0.0878	0.105	0.1051
N	5843	5843	2770	2770	3073	3073

`

We further divide the sample into high-tech and low-tech industries. The estimated slope coefficient of RDA (RDS) is significantly positive for high-tech issuers and indifferent from zero for low-tech issuers. For example, the slope coefficient (t-statistics) on the variable RDA is 0.43 (2.53) for the high-tech vs. 0.001(0.00) for the low-tech firms. The slope coefficient (t-statistics) on the variable RDS is 0.05 (3.50) for the high-tech vs. -0.003 (0.08) for the low-tech firms. This suggests that R&D has predictive power for probability of seasoned equity offerings only for high-tech issuers.

Table 5, Panel B reports the same logit estimates using industry-adjusted R&D intensity as an independent variable in place of the raw R&D intensity. The results are quantitatively similar. The slope coefficients on the adjusted R&D measures are positive and significant only for the high-tech issuers.

While these coefficients are consistent with Hypothesis 2, the economic significance of these results is modest. When all other independent variables are valued at the mean, a change of R&D intensity deflated by assets (RDA) from 0 (1st quartile) to 12.76% (3rd quartile) increase the probably of reissue by 0.13%. Similarly, a change of R&D intensity deflated by sales (RDS) from 0 (1st quartile) to 11.49% (3rd quartile) increase the probably of reissue by 0.37% holding all other independent variables at the mean.

4.1.3 The Size of SEO Offering

We use a tobit model to estimate the hypothesis that sizes of firms' seasoned equity issues are positively related to pre-IPO R&D. The tobit regression specifies the relation between the size of seasoned offerings and the explanatory variables as follows:

$$\left(\frac{SEO}{IPO}\right)_i = \begin{cases} \alpha + x_i'\beta + u_i & if\ right - hand\ side > 0 \\ 0 & Otherwise \end{cases}$$

`

Where $(\frac{SEO}{IPO})_i$ is the real value of capital raised by the i^{th} firm in the seasoned offering as a fraction of the real value of capital raised in the IPO. The vector of independent variables x_i is the same as that used for the logit regression in the last subsection. This specification accounts for the fact that the recorded sizes of the seasoned offerings are bounded below by zero. The tobit specification explicitly accounts for the fact that the data are left-censored.

Table 6 reports the tobit regression estimates. The estimate (t-statistics) of the slope coefficient on the R&D intensity variable RDS is 0.04 (1.88) and on RDA is 0.51 (2.37), indicating that firms with higher pre-IPO R&D tend to raise more capital through subsequent seasoned equity issues. The estimated slope coefficients (t-statistics) on the aftermarket return variables CAR1 and CAR2 are 0.81 (3.43) and 0.79 (3.07), and both are significantly positive, meaning firms that experience larger price run-up after their IPOs are more likely to raise larger amount of capital through seasoned equity issues.

`

Table 6: Tobit Regression of SEO Size on Pre-IPO R&D

Tobit regression estimate of the relation between pre-IPO R&D and the size of subsequent seasoned equity offerings (SEOs) for 5,846 firm commitment IPOs in the 1980-2005 period. To be included in the sample, an SEO had to occur within three years of the IPO and be the first SEO of the firm.

The dependent variable is the size of the seasoned equity offering measured as a fraction of the IPO size(SEOSIZE/IPOSIZE). SEOSIZE is zero if a firm does not issue seasoned equity within three years of the IPO. The independent variables are pre-IPO R&D relative to assets (RDA), pre-IPO R&D relative to sales (RDS), the abnormal aftermarket returns in the two 20-day period after the IPO (CAR1 and CAR2), the logarithm of IPO size (LOGIPOSIZE), and dummy variables for industry groups and the year of the IPO. The t-statistics are reported in parentheses below the corresponding estimates. Both R&D Expense/Assets and R&D Expense/Sales are winsorized at one percentile. Panel B uses industry adjusted R&D Expense/Assets and R&D Expense/Sales in place of the R&D Expense/Assets and R&D Expense/Sales as independent variables in the regression.

Panel A

	Full Sample		High-tech		Non-high-tech	
R&D Expense/Sales	0.043885*		0.067478**		-0.002792	
	(1.88)		(2.37)		(-0.05)	
R&D Expense/Assets		0.514748**		0.712393**		0.234075
		(2.06)		(2.20)		(0.52)
CAR1	0.809684***	0.796063***	1.067477***	1.049105***	0.247824	0.23436
	(3.43)	(3.37)	(3.07)	(3.02)	(0.78)	(0.74)
CAR2	-0.008042	0.003178	-0.481872	-0.46967	0.665601**	0.676229**
	(-0.03)	(0.02)	(-1.25)	(-1.22)	(2.00)	(2.03)
logiposize	0.27244***	0.276727***	0.328345***	0.337179***	0.210401***	0.213265***
	(5.22)	(5.29)	(3.34)	(3.42)	(3.80)	(3.85)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Squared corr.	0.12%	0.00%	0.12%	0.00%	0.08%	0.08%
N	5846	5846	2770	2770	3076	3076

Panel B

	Full Sample		High-tech		Non-high-tech	
R&D Expense/Sales_Adj	0.035069		0.059128**		-0.013252	
	(1.44)		(1.99)		(-0.23)	
R&D Expense/Assets_Adj		0.379305		0.637464*		-0.081056
		(1.45)		(1.87)		(-0.18)
CAR1	0.805924***	0.797835***	1.059168***	1.04745***	0.24772	0.248215
	(3.41)	(3.38)	(3.04)	(3.02)	(0.78)	(0.78)
CAR2	-0.002869	0.006821	-0.475158	-0.4634	0.673706**	0.671085**
	(-0.01)	(0.03)	(-1.23)	(-1.2)	(2.02)	(2.01)
logiposize	0.268615***	0.271324***	0.326202***	0.334402***	0.205886***	0.205999***
	(5.15)	(5.19)	(3.32)	(3.40)	(3.72)	(3.72)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Squared corr.	0.15%	0.00%	0.09%	0.00%	0.08%	0.08%
N	5843	5843	2770	2770	3073	3073

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Table 6 also reports the tobit estimates for the subsample of high-tech and low-tech issuers. As with the logit regression, the slope coefficients of RDA and RDS are significantly positive only for high-tech issuers. For example, the slope coefficient (t statistics) on the variable RDS is 0.06 (2.37) in high-tech firms; on the variable RDA is 0.71 (2.20). For low-tech firms, the results indicate no significant relation between pre-IPO R&D and the amount of future equity offerings.

In panel B of table 6, we use the industry-adjusted R&D ratio in place of raw R&D ratio as an independent variable. The slope coefficients on the industry-adjusted RDA and RDS are both significantly positive in the high-tech firms. In the low-tech sample, the slope coefficients on R&D ratio are not significant.

These results are consistent with Hypothesis 3. A 10% increase in R&D intensity measured as R&D scaled by assets (sales) increases the relative size of capital raised in SEO over IPO by 5% (0.4%). While these effects seem strikingly different, this is mostly due to the different magnitude of sales versus assets. The R&D intensity is much lower when it is scaled by assets (the mean RDA and RDS are 0.11 and 0.46 respectively). Therefore, a 10% increase in the R&D intensity deflated by assets will be equivalent to almost a 40% increase in the R&D intensity deflated by sales when evaluated at the mean of both R&D intensity measures.

4.1.4 R&D Spending and Operating Performance

If R&D is a credible signal for IPO firms' quality, the separating equilibrium of signaling models then implies relatively superior operating performance for issuers with high pre-IPO R&D intensity in comparison to firms with low pre-IPO R&D intensity. To test this conjecture, we examine the relation between operating performance measures and pre-IPO R&D ratio. We separate the sample into three subgroups: zero, low and high R&D firms. First we

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separate out zero R&D firms, and then use the median R&D intensity ratio of the firms with positive R&D expense to separate low and high R&D firms. The results are similar when we split the sample using R&D scaled by either assets or sales.

The post-IPO operating performance of zero R&D sample is indistinguishable from the operating performance of low R&D sample, we only tabulate the comparison of the operating performance of low vs. high R&D firms.[22] The change in operating performance for the post-IPO period for the two subgroups, both before and after industry adjustment, is reported in table 7. Panel A of table 7 shows that compared to low R&D firms whose subsequent operating returns on assets decline following IPOs, the high R&D firms have superior operating performance for each of the four years relative to year -1, with the difference being significant for all time periods with or without industry adjustment.

[22] To save space, the comparison between no R&D with high R&D firms are not tabulated.

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Table 7: Post-issue Operating Performance by Pre-IPO R&D

Table values are for the median change/growth expressed as a percentage for 2,775 initial public offering (IPO) firms with positive R&D expense during the period 1980-2005. Unit offerings, foreign issues and right issues, closed end fund/trust, REIT and IPOs with offer price less than three dollars are excluded from the sample. Operating return on assets equals operating income before depreciation as a percentage of total assets measured at the end of the fiscal year. Operating cash flows are defined as operating income less capital expenditures. The industry-adjusted change/growth for a given firm is the deviation from the contemporaneous industry median. Year -1 is the fiscal year proceeding the year during which the firm goes public. The significance tests are based on the Wilcoxon signed rank test, which assumes that the observations are independent. Table 7-A presents the operating performance by pre-IPO R&D scaled by assets (RDA), and table 7-B presents the operating performance by pre-IPO R&D scaled by sales (RDS).

Panel-A

	Year Relative to Completion of IPO											
	-1 to 0			-1 to +1			-1 to +2			-1 to+3		
Measure of Operating Performance	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)
Panel A: Operating Return/Assets												
Median change(%)			-15.700			-12.687			-11.417			-10.070
	-0.017	0.106	(0.0001)	-0.054	0.070	(0.0001)	-0.073	0.035	(0.0001)	-0.074	0.038	(0.0001)
Median industry-adjusted change(%)	-0.014	0.114	-15.792 (0.0001)	-0.047	0.054	-13.168 (0.0001)	-0.071	0.041	-11.871 (0.0001)	-0.074	0.043	-10.303 (0.0001)
Number of observations	1325	1450		1254	1368		1128	1212		1014	1064	
Panel B: Operating Cash Flows/Total Assets												
Median change(%)			-17.695			-13.569			-11.994			-10.159
	-0.036	0.148	(0.0001)	-0.072	0.087	(0.0001)	-0.087	0.106	(0.0001)	-0.089	0.116	(0.0001)
Median industry-adjusted change(%)	-0.015	0.137	-17.755 (0.0001)	-0.049	0.068	-14.059 (0.0001)	-0.067	0.065	-12.494 (0.0001)	-0.059	0.062	-10.322 (0.0001)
Number of observations	1325	1450		1254	1358		1128	1211		1014	1064	

Panel B

	Year Relative to Completion of IPO											
	-1 to 0			-1 to +1			-1 to +2			-1 to+3		
Measure of Operating Perfor	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)
Panel A: Operating Return on Assets												
Median change(%)			21.219			13.827			12.631			13.118
	-0.009	0.171	(0.0001)	-0.037	0.067	(0.0001)	-0.058	0.054	(0.0001)	-0.073	0.063	(0.0001)
Median industry-adjusted change(%)	-0.008	0.175	21.805	-0.035	0.083	14.593	-0.053	0.055	12.840	-0.073	0.066	12.717
Number of observations	1329	1314	(0.0001)	1259	1229	(0.0001)	1136	1095	(0.0001)	1029	952	(0.0001)
Panel B: Operating Cash Flows/Total Assets												
Median change(%)			22.056			18.260			17.400			17.066
	-0.036	0.148	(0.0001)	-0.072	0.087	(0.0001)	-0.087	0.106	(0.0001)	-0.089	0.116	(0.0001)
Median industry-adjusted change(%)	-0.031	0.154	22.628	0.066	-0.099	18.621	-0.085	0.112	17.540	-0.086	0.119	16.990
Number of observations	1329	1314	(0.0001)	1259	1229	(0.0001)	1135	1096	(0.0001)	1030	951	(0.0001)

Table 7, Panel A (Panel B) uses median RDA (RDS) to separate the sample into low and high R&D firms. The results are similar in both panels. Take Panel A as an example, from year -1 to year 0, return on assets for high R&D firms increases by 10.63 percent while for low quality firms, this number decreases by 1.69 percent. For year +1, +2 and +3 relative to year -1, the changes in operating returns on assets for the high-R&D firms continue to be higher than that for the low-R&D firms, and the difference is significant at the 0.01 level.

Table 7, Panel A also compares the operating cash flows deflated by assets for high and low R&D firms. The median change in operating cash flows deflated by assets is higher for high R&D firms than low R&D firms for year 0 relative to year -1 as well as year +1, +2, +3 relative to year -1. For instance, from year -1 to year +2, the median operating cash flow deflated by assets increases by 10.58 percent (6.52 percent if industry adjusted) for high-R&D firms; decreases by 8.72 percent (6.69 percent if industry adjusted) for low R&D firms.

4.1.5 Pre- and Post-IPO R&D Spending

According to signaling theory, if firms over-invest in pre-IPO R&D to signal their quality, they will reduce R&D expense once the signaling is done. Therefore, we expect a negative change of R&D expense for high R&D firms following IPOs. Table 8 presents the percentage change in R&D expense for high R&D firms in each of the four years relative to year -1.

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Table 8: Post-Issue Changes of R&D by Pre-IPO R&D

Table values are for the median change/growth expressed as a percentage for 2,775 initial public offering (IPO) firms with positive R&D expense during the period 1980-2005. Unit offerings, foreign issues and right issues, closed end fund/trust, REIT and IPOs with offer price less than three dollars are excluded from the sample. The industry-adjusted change/growth for a given firm is the deviation from the contemporaneous industry median. Year -1 is the fiscal year proceeding the year during which the firm goes public. The significance tests are based on the Wilcoxon signed rank test, which assumes that the observations are independent. Table 8-A presents the R&D investment intensity by pre-IPO R&D scaled by assets (RDA), and table 8-B presents the R&D investment intensity by pre-IPO R&D scaled by sales (RDS).

Panel A

Year Relative to Completion of IPO												
Change of R&D	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)	rda <= 14.61%	rda >= 14.61%	Z-Statistic (p-value)
	-1 to 0			-1 to +1			-1 to +2			-1 to+3		
Panel A: R&D/Total Assets												
Median change(%)			37.225			29.185			24.261			22.968
	-0.004	-0.171	(0.0001)	-0.001	-0.135	(0.0001)	-0.002	-0.119	(0.0001)	-0.002	-0.118	(0.0001)
Median industry-adjusted change(%)	-0.005	-0.171	37.268	-0.003	-0.138	29.507	-0.003	-0.125	24.432	-0.003	-0.116	23.163
Number of observations	1325	1450	(0.0001)	1254	1358	(0.0001)	1128	1212	(0.0001)	1014	1065	(0.0001)
Panel B: R&D/Total Sales												
Median change(%)			12.203			8.674			-7.708			-7.682
	0.000	-0.025	(0.0001)	0.001	-0.024	(0.0001)	0.001	-0.028	(0.0001)	0.000	-0.029	(0.0001)
Median industry-adjusted change(%)	0.000	-0.028	12.341	0.000	-0.027	9.080	0.000	-0.031	-8.051	0.000	-0.032	-8.113
Number of observations	1306	1324	(0.0001)	1236	1238	(0.0001)	1112	1107	(0.0001)	998	963	(0.0001)

Panel B

	Year Relative to Completion of IPO											
	-1 to 0			-1 to +1			-1 to +2			-1 to+3		
Change of R&D	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)	rds <= 13.64%	rds >= 13.64%	Z-Statistic (p-value)
						Panel E: R&D/Total Assets						
Median change(%)	-0.008	-0.161	-27.691	-0.005	-0.122	-20.175	-0.005	-0.101	-16.373	-0.006	-0.105	-16.178
			(0.0001)			(0.0001)			(0.0001)			(0.0001)
Median industry-adjusted change(%)	-0.009	-0.160	-27.646	-0.007	-0.127	-20.676	-0.006	-0.105	-16.588	-0.007	-0.103	-16.102
Number of observations	1329	1314	(0.0001)	1259	1229	(0.0001)	1136	1096	(0.0001)	1030	952	(0.0001)
						Panel F: R&D/Total Sales						
Median change(%)	0.000	-0.046	-16.835	0.003	-0.051	-13.792	0.003	-0.064	-13.880	0.003	-0.082	-15.072
			(0.0001)			(0.0001)			(0.0001)			(0.0001)
Median industry-adjusted change(%)	0.000	-0.050	-17.064	0.002	-0.054	-13.985	0.002	-0.067	-14.110	0.003	-0.084	-15.043
Number of observations	1327	1303	(0.0001)	1258	1216	(0.0001)	1133	1086	(0.0001)	1026	935	(0.0001)

By separating sample firms into high and low R&D subsamples, Panel B of table 8 presents the changes of R&D ratio of high R&D firms to be -16.11, -12.15, -10.09, -10.54 percent for year 0, year +1, year +2, year+3 relative to year -1. The industry-adjusted numbers are similar to the raw numbers. The evidence suggests that firms with high pre-IPO R&D invest excessively in R&D prior to IPOs and subsequently reduce their R&D expense in the following years.

Although high level of R&D prior to IPO seems to be consistent with the signaling theory, we further examine whether issuers overinvest in R&D prior to IPOs by deviating from their expected R&D investment in order to signal their quality. The next section we examine the discretionary R&D spending prior to the IPO.

4.2. Discretionary R&D Spending

4.2.1 Discretionary R&D Model

The discretionary R&D spending is defined as the difference between the actual R&D spending and the expected R&D spending. To construct the expected R&D spending forecast model, we follow prior research on the determinants of R&D spending (Berger, 1993; Darrough and Rangan, 2005). The expected R&D is estimated using the following model:

$$\frac{R\&D_{i,j,t}}{ATA_{i,j,t}} = \alpha_{0,j,t} + \beta_{1,j,t}\frac{1}{ATA_{i,j,t}} + \beta_{2,j,t}\frac{R\&D_{i,j,t-1}}{ATA_{i,j,t}} + \beta_{3,j,t}\frac{\Delta Revenue_{i,j,t}}{ATA_{i,j,t}} + \beta_{4,j,t}Q_{i,j,t} + \varepsilon_{i,j,t}$$

Where the subscript i stands for an individual firm, j stands for the industry classification, and t stands for the year of the observation. The prior year's R&D(R&D) serves as a proxy for the firm's R&D opportunity set and captures the persistence of R&D activity. Changes in revenue ($\Delta Revenue$) is used to control for growth in R&D spending related to

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product life cycle. Tobin's Q(Q), which is measured by the sum of market value of equity and book value of debt divided by book value of total assets, proxies growth opportunities.

The model is estimated for each industry *j* and each year *t* from 1988 to 2003. This results in 176 (11 industries × 16 years) combinations. We include all firms in the Compustat database in each regression. Table 9 provides a summary of the mean estimates of the 176 regressions. Among the full sample and both high-tech and low-tech subsamples, the average coefficients of all explanatory variables are significant at 1% significance level with predicted sign. The average loading on $R\&D_{t-1}$ is 0.67 versus 0.72 on high-tech firms and low-tech firms, while the average loadings on other variables are larger for high-tech firms than low-tech firms. The mean and median adjusted R^2 are comparable for high-tech firms (0.54 and 0.61) and low-tech firms (0.58 and 0.63), indicating that the model explains a significant portion of the variation in R&D.

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Table 9 Estimation of Expected R&D Spending

We run regression for each industry, for each year from 1988 to 2003. This results in 176 (11 industries×16 years) combinations. We include all firms in Compustat in each regression. We report the mean, and P-value (in the parenthesis) of the coefficient estimates for 176 regressions for the whole sample, 64 regressions for the high-tech subsample, and 112 regressions for low-tech subsample. The dependent variable is the R&D expenditure scaled by the average of total assets at the year t and year t-1. The independent variables are listed as follows: the inverse of the average of total assets at year t and year t-1; lagged R&D spending scaled by the average of total assets at year t and year t-1; the changes in revenue scaled by the average of total assets at year t and year t-1; and Tobin's Q measured by the sum of market value of equity and book value of debt divided by book value of total assets.

	Predicted Sign	Whole Sample	High-tech	Low-tech
Intercept		0.012***	0.035***	-0.001
		(0.003)	(0.006)	(0.002)
1/(Average Assets)		0.012**	0.022*	0.006
		(0.006)	(0.012)	(0.005)
$R\&D_{t-1}$	(+)	0.702***	0.669***	0.720***
		(0.031)	(0.038)	(0.043)
Change in Revenue	(+)	0.013***	0.025***	0.006***
		(0.004)	(0.009)	(0.002)
Tobin's Q	(+)	0.004***	0.005***	0.003***
		(0.001)	(0.001)	(0.001)
Adj. R^2(mean)		0.566	0.545	0.578
Adj. R^2(median)		0.616	0.614	0.625
Number of Regresssions		176	64	112

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The Discretionary R&D for IPO issuers is constructed by subtracting the expected R&D from the actual R&D, i.e.,

$$Discretionary\ R\&D_{i,j,t} = Actual\ R\&D_{i,j,t} - Expected R\&D_{i,j,t}$$

where predicted $R\&D_{i,j,t}$ is calculated using IPO issuers' accounting variables and the estimated coefficients from its corresponding industry *j* and year *t*.

Table 10 tabulates the distribution of the discretionary R&D one year before firms go public. On average, IPO firms overinvest in R&D by 9.6% of total assets. The average discretionary R&D is 18.4% for high-tech issuers and 1.7% for low-tech issuers. Discretionary R&D also varies within high-tech issuers. Among the high-tech issuers, the 25 percentile of discretionary R&D is -2.4%, while the 75 percentile of discretionary R&D is 18.1%, suggesting that high-quality issuers can use discretionary R&D as a signal to distinguish themselves at IPO.

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Table 10 Discretionary R&D across Industries

Discretionary R&D is constructed by subtracting the predicted R&D from the actual R&D, expressed as a percentage of total assets. This table presents the discretionary R&D measured at the last fiscal year end before a firm goes public.

		N	Mean	Std Dev	Q1	Median	Q3
	Durables	85	0.225	1.351	-0.013	-0.004	0.031
	Non-durables	196	0.015	0.122	-0.004	-0.002	0
	Energy	83	0	0.022	-0.001	-0.001	0
	Manufacture	378	0.034	0.202	-0.012	-0.005	0.016
	Retail	482	0.011	0.144	-0.002	-0.001	0.001
	Health Service	129	0.015	0.11	-0.004	-0.001	0.001
	Others	657	-0.012	0.844	-0.004	-0.002	0
Low-tech		2010	0.017	0.571	-0.005	-0.001	0.001
	Pharmaceutical	230	0.53	1.921	0.055	0.237	0.51
	Medical Equipment	158	0.119	0.446	-0.037	0.028	0.167
	Telecom	161	0.026	0.256	-0.004	-0.002	0.001
	Hitech	1274	0.149	2.279	-0.035	0.044	0.16
High-tech		1823	0.184	2.034	-0.024	0.04	0.181
Full Sample		3833	0.096	1.464	-0.007	0	0.069

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4.2.2 The Impact of Discretionary R&D on IPO Valuation

If discretionary R&D is a signal of the IPO issuers' future growth opportunities, IPOs with higher discretionary R&D will be valued more at the IPO than those with lower discretionary R&D. We examine the impact of discretionary R&D on IPO offer value and market value. The OLS regression model is specified as follows:

$$IPO\ Value = \beta_0 + \beta_1 Discretionary\ R\&D + \beta_2 R\&DIntenisty + \beta_3 Revenue + \beta_4 ROA + \beta_5 Tobin's\ Q + \beta_6 UnderwriterRank + \beta_7 VC + \beta_8 InsiderRetention + Year\ Dummies + \varepsilon$$

where IPO value is measured as offer value and market value. We control for other factors that have been identified to be associated with IPO valuations. R&D intensity in the year prior to IPO serves as a proxy for growth opportunities. Revenue at year -1 captures cash flows. Tobi's Q captures future investment opportunities. Underwriters' rank, venture capital backing and insiders' retention captures fundamental IPO characteristics. Year dummies are included to control for any time-series variation.

The OLS regression results in table 11 indicate that discretionary R&D is positively related to IPO value. After controlling for other factors that are associated with IPO valuation, one percentage point increase in discretionary R&D scaled by assets is associated with 0.378 (0.469) percentage point increase in IPO offer value (market value) scaled by assets.

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Table 11 The impact of Discretionary R&D on IPO Offer Value and Market Value

Coefficient estimates and p-value (in the parenthesis) of OLS regressions of IPO offer value and market value at the time of IPO. The sample consists of IPOs from 1988-2003. The dependent variable is the IPO offer value and market value deflated by assets. The main independent variable is discretionary R&D, which is computed by subtracting actual R&D/Assets from predicted R&D/Assets. Control variables consists of R&D intensity, which is R&D deflated by assets, Revenue deflated by assets, Return on Assets which is the ratio of net income over total assets, Tobin's Q which is the sum of market value of equity and book value of debt divided by book value of total assets, Underwriter Rank which is investment bank's rank, VC-backing, and Insider's retention. Discretionary R&D intensity, Revenue and Return on Assets are from year -1. Tobin' Q is based on year 0 since it is not available at year -1. Year dummies are also included in the regression. Standard errors are heteroskedasticity-robust standard errors.

	Offer Value		Market Value	
	(1)	(2)	(3)	(4)
Discretionary R&D	0.343*	0.378**	0.341*	0.469***
	(0.205)	(0.164)	(0.202)	(0.147)
R&D Intensity		0.002		0.001
		(0.002)		(0.002)
Revenue		0.067**		0.052**
		(0.030)		(0.024)
Return on Assets		-0.002**		-0.001*
		(0.001)		(0.001)
Tobin's Q		0.000		0.014
		(0.004)		(0.010)
Underwriter Rank		0.018***		0.013**
		(0.007)		(0.006)
VC-backing		-0.023		0.020
		(0.028)		(0.034)
Insider's Retention		0.263***		0.451***
		(0.068)		(0.098)
Intercept	0.070**	-0.519***	0.084***	-0.616***
	(0.028)	(0.122)	(0.031)	(0.107)
N	3822	1934	3822	1934
R^2	0.252	0.812	0.238	0.671

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4.2.3 The Impact of Discretionary R&D in High-Tech vs. Low-Tech

R&D investment may be more effective in high-tech sectors. Prior literature suggests that the market react more favorably to R&D increase by high-tech firms (Chan, Martin, and Kensinger, 1990; Eberhart, Maxwell, and Siddique, 2004). As shown earlier in Table 10, the descriptive statistics indicates that high-tech IPO issuers overinvest in R&D while most low-tech issuers adhere to the predicted R&D spending. In this section, we examine whether the effect of discretionary R&D on IPO valuation differs between high-tech and low-tech issuers. We therefore add a high-tech dummy and an interaction term of high-tech and discretionary R&D to the regression equation in the previous subsection. The regression model is as follows:

$$\begin{aligned} IPO\ Value = {} & \beta_0 + \beta_1 Discretionary\ R\&D + \beta_2 HighTech + \beta_3 Discretionary\ R\&D \\ & \times HighTech + \beta_4 R\&DIntenisty + \beta_5 Revenue + \beta_6 ROA + \beta_7 Tobin's\ Q \\ & + \beta_8 UnderwriterRank + \beta_9 VC + \beta_{10} InsiderRetention + Year\ Dummies \\ & + \varepsilon \end{aligned}$$

Table 12 presents the OLS regression results. The coefficients on the interaction term are significant at 1% and 5% level after controlling for other non-R&D factors that are associated with IPO valuation. The results suggest that investors only favor high-tech issuers that have increased R&D spending over the expected level before the IPO. Low-tech issuers with unexpected R&D spending increase are not valued favorably by the market. The coefficients on discretionary R&D turn negative, but are not significant in all regressions.

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Table 12 Impact of discretionary R&D on IPO offer value and market value (with high tech dummy)

Coefficient estimates and p-value (in the parenthesis) of OLS regressions of IPO offer value and market value at the time of IPO. The sample consists of IPOs from 1988-2003. The dependent variable is the IPO offer value and market value deflated by assets. The main independent variables are discretionary R&D, which is computed by subtracting actual R&D/Assets at year -1 from predicted R&D/Assets at year -1, High tech dummy and the interaction term between the two variables. Control variables consists of R&D intensity, which is R&D deflated by assets, Revenue deflated by assets, Return on Assets which is the ratio of net income over total assets, Tobin's Q which is the sum of market value of equity and book value of debt divided by book value of total assets, Underwriter Rank which is investment bank's rank, VC-backing, and Insider's retention. Discretionary R&D intensity, Revenue and Return on Assets are from year -1. Tobin' Q is based on year 0 since it is not available at year -1. Year dummies are also included in the regression. Standard errors are heteroskedasticity-robust standard errors.

	Offer Value		Market Value	
	(1)	(2)	(3)	(4)
Discretionary R&D	-0.342	-0.197	-0.032	-0.048
	(0.323)	(0.225)	(0.237)	(0.230)
Discretionary R&D ×High Tech	0.481**	0.567***	0.308*	0.505**
	(0.210)	(0.183)	(0.180)	(0.208)
Hightech	-0.228***	-0.200***	-0.179**	-0.228***
	(0.077)	(0.063)	(0.070)	(0.078)
R&D Intensity	0.008**	0.002	0.005***	0.001
	(0.003)	(0.003)	(0.002)	(0.002)
Revenue		0.071**		0.055**
		(0.028)		(0.022)
Return on Assets		-0.002**		-0.001*
		(0.001)		(0.001)
Tobin's Q		0.003		0.017*
		(0.003)		(0.009)
Underwriter Rank		0.016**		0.011*
		(0.007)		(0.006)
VC-backing		0.015		0.064
		(0.031)		(0.039)
Insider's Retention		0.262***		0.464***
		(0.065)		(0.090)
Intercept	-0.055	-0.389***	-0.006	-0.479***
	(0.093)	(0.107)	(0.075)	(0.098)
N	1970	1934	1970	1934
R^2	0.784	0.820	0.650	0.678

`

Our results thus suggest that discretionary R&D can potentially act as a better proxy for high-tech issuers' investment opportunities. High-tech issuers can use discretionary R&D as a signal to improve their valuation. The overinvestment of low-tech issuers prior to IPOs, however, is not favored by the market[23].

5. Alternative Explanations

The evidence presented so far has supported that firms with high pre-IPO R&D are associated with better post-IPO performance. The presented results may also be driven by other alternative explanations.

5.1 Access to Debt

Firms with high pre-IPO R&D perform better could be the results that those firms are less cash constrained and have better access to debt market. Therefore, they can invest more in R&D. To examine this possibility, I sort IPOs into quintile based on pre-IPO R&D and examine their debt ratios.

Table 13 presents the mean and median long-term, short-term and total debt ratios by pre-IPO R&D. Firms in the highest pre-IPO R&D (measured by R&D scaled by Sales) quintile have a total debt ratio of 21% while firms with zero pre-IPO R&D have a total debt ratio of 39%. High R&D firms on average have lower debt ratio and therefore they do not appear to have better access to the debt market. In addition, we add the short-term and long-term debt ratios in previous regressions. The coefficient and significance of pre-IPO R&D, however, is quantitatively unchanged.

[23] For robustness check, we also categorize "hi-tech" vs. "non-high-tech" industries with software firms excluded. The results are quantitatively similar.

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Table 13: Pre-IPO Debt Ratio by Pre-IPO R&D.

This table displays the pre-IPO debt ratios by pre-IPO R&D Expense/Assets (RDA) or R&D Expense/Sales (RDS). The results for short-term debt, long-term debt and total debt ratios are shown. The IPOs are sorted into quintile based on pre-IPO R&D Expense/Assets (RDA) or R&D Expense/Sales (RDS). IPOs with zero R&D are separated out as group "0".

Panel A: Based on R&D over Sales Ratio at Yr -1.

		Mean			
		L-T Debt Ratio	S-T Debt Ratio	Debt Ratio	N
"Low"	0	0.276	0.121	0.390	3174
	1	0.265	0.103	0.366	535
	2	0.162	0.094	0.253	534
	3	0.105	0.078	0.183	535
	4	0.134	0.102	0.227	534
"High"	5	0.121	0.107	0.212	534

Panel B: Based on R&D over Sales Ratio at Yr -1.

		Median			
		L-T Debt Ratio	S-T Debt Ratio	Debt Ratio	N
"Low"	0	0.202	0.049	0.369	3174
	1	0.209	0.051	0.356	535
	2	0.068	0.037	0.177	534
	3	0.029	0.027	0.101	535
	4	0.036	0.034	0.097	534
"High"	5	0.040	0.024	0.090	534

Panel C: Based on R&D over Assets Ratio at Yr -1.

		Mean			
		L-T Debt Ratio	S-T Debt Ratio	Debt Ratio	N
"Low"	0	0.276	0.121	0.390	3174
	1	0.271	0.094	0.363	535
	2	0.150	0.083	0.230	534
	3	0.115	0.082	0.196	535
	4	0.102	0.071	0.170	534
"High"	5	0.150	0.155	0.283	534

Panel D: Based on R&D over Assets Ratio at Yr -1.

		Median			
		L-T Debt Ratio	S-T Debt Ratio	Debt Ratio	N
"Low"	0	0.202	0.049	0.369	3174
	1	0.218	0.042	0.359	535
	2	0.060	0.031	0.165	534
	3	0.033	0.023	0.098	535
	4	0.034	0.027	0.086	534
"High"	5	0.047	0.045	0.136	534

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5.2 Survivorship Bias

The superior performance of high R&D firms could also be driven by survivorship bias. It is possible that firms with high R&D are more likely to fail and do not survive until SEO and those firm that remains perform better.

To check this possibility, we measure the incidence of delisting. We use the information from CRSP files to determine which of the IPOs were delisted within 3 years following IPO. Not all delistings represent failure. To define failure, we include delistings due to liquidation (CRSP codes between 400 and 499) and inability to meet listing exchange requirements (codes from 500 to 599, or code 700).

Table 14 shows the delisting rate of IPOs sorted by pre-IPO R&D. The failure rate of IPOs with zero pre-IPO R&D is 7.7%, and this number is 9.9% for IPOs in the highest pre-IPO R&D quintile. Although IPOs with the highest R&D have slightly higher rate of failure, it is unlikely that the 2% failure rate is large enough to drive survivorship bias, especially when the changes in post-IPO performance reported in Table 7 are median changes instead of mean changes.

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Table 14: IPO Failure Rate

This table displays the post-issue failure rate of IPOs within 3 years after going public by pre-IPO R&D intensity at year -1. Pre-IPO R&D intensity is defined as either R&D/Sales (RDS) or R&D/Assets (RDA).

IPO Failure Rate

		RDS	RDA	
		Mean		N
"Low"	0	0.077	0.077	3174
	1	0.058	0.064	535
	2	0.047	0.062	534
	3	0.032	0.052	535
	4	0.071	0.056	534
"High"	5	0.099	0.073	534

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5.3 The Exercise of Real Options

Carlson et al (2005) model relates stock offerings to an endogenous decrease in expected returns. The intuition in their model is that equity issuance is associated with firm expansion. As firms grow, real options are converted into assets in place. The new assets are less risky than the options they replace. As a results, firms' total (asset) risk decreases.

Growth options theories explain that equity issuance is associated with real investment, optimally timed to occur after growth options move into the money. Apply these theories in our setting, those firms that invest in R&D before the IPO may simply have more growth options but not necessarily signal their quality. The firms with better growth options will have better operating performance afterwards. After the IPO, growth options are converted into assets in place. The observed reduction in R&D after the IPO could also be substituted by capital expenditure as real options are converted into assets in place. The new assets are less risky than the options they replace. As a result, firms' total (asset) risk decreases.

Carlson et al (2006) propose real options theories in the context of a seasoned equity offering (SEO). Because growth opportunities are exercised only when they move into the money, above average returns naturally precede SEO announcement. This explains the price run-up before the SEO. Due to the asymmetric information about growth options, managers can optimally choose the SEO timing. This results in negative SEO announcement effects. Finally, the subsequent stock underperformance can be explained as that a decline of returns following investment is a natural consequence of growth option exercise. Although their model's predictions do not explicitly apply in an initial public offering context (price run-up and announcement effect are not observable in an IPO), intuition from their model can be applied.

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Their model suggests that the decline in risk following a stock issuance should be largest for small firms with substantial growth options.

If pre-IPO R&D proxies for growth options which lead to better operating performance, then the decline in risk following IPO should be largest for small IPOs with high pre-IPO R&D and smallest for large IPOs with low pre-IPO R&D. We examine this prediction by plotting the beta dynamics for up to five years after the IPO. Monthly beta is calculated from daily data. The post IPO month is defined as 21 trading days following the IPO excluding the first trading day. We divide our sample into four subsets based to the size (median value of revenue at year 1) and R&D (median value of R&D at year -1). Figure 1-3 show the beta dynamics for the full sample as well as for the small IPO with high R&D and the large IPO with low R&D. For the full sample, beta drops after the IPO. Although beta decreases for small and high R&D IPOs, we observe a similar pattern in the large and low R&D IPOs. The beta dynamics does not suggest that firms with high pre-IPO R&D bear better growth options.

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Figure 1: Beta dynamics of the full sample, 1988-2003

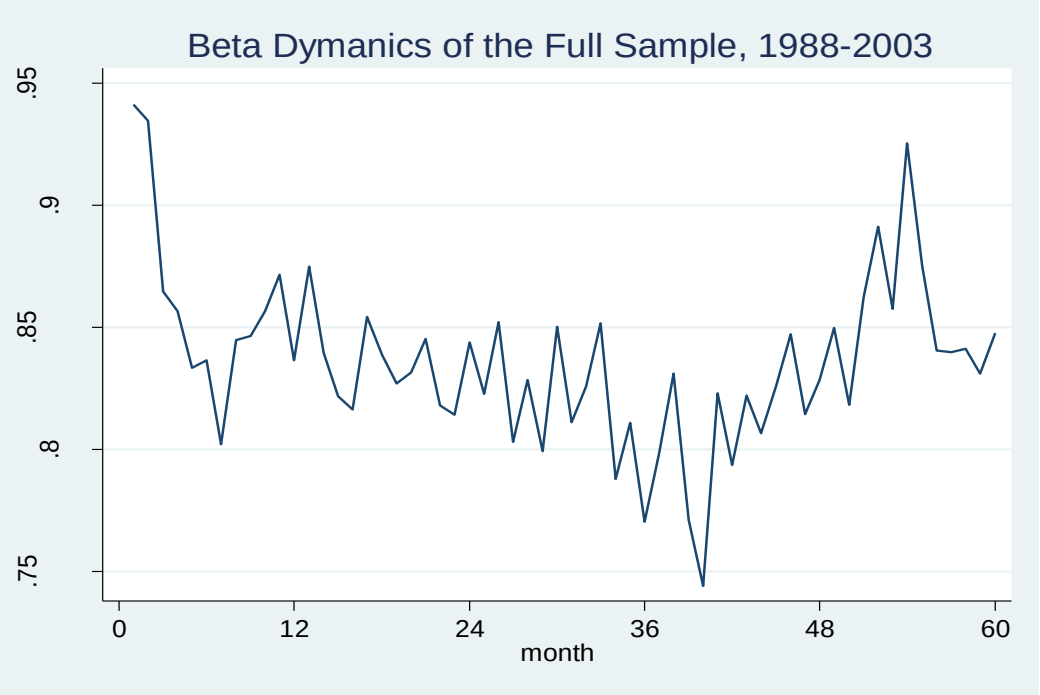

Figure 2: Beta dynamics of small and high R&D IPOs, 1988-2003

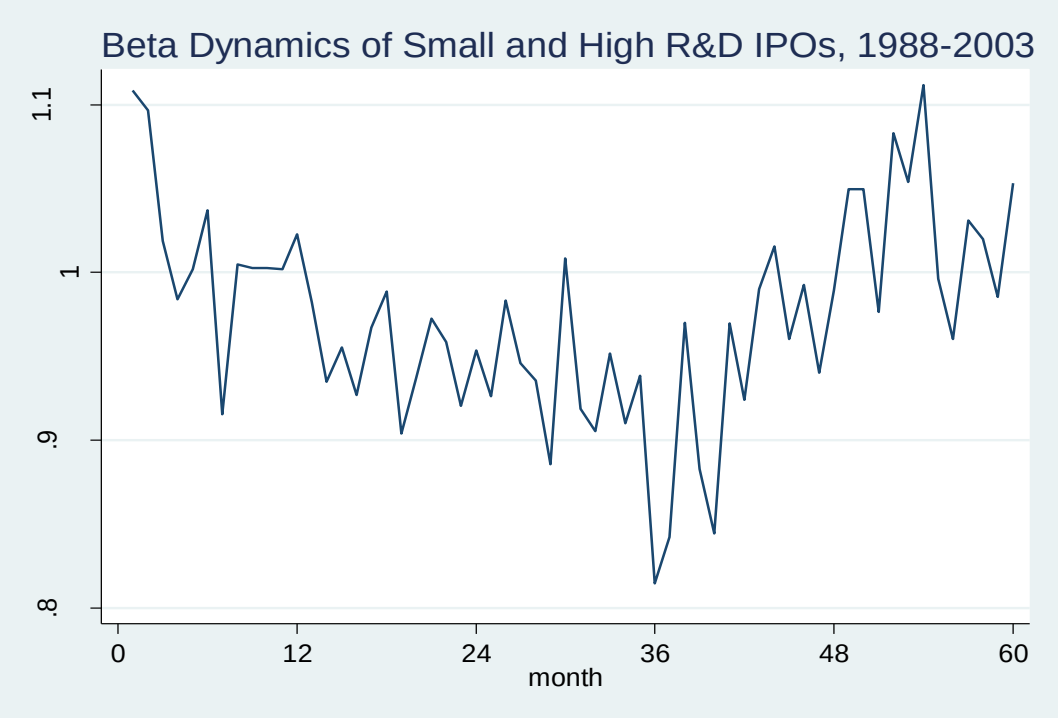

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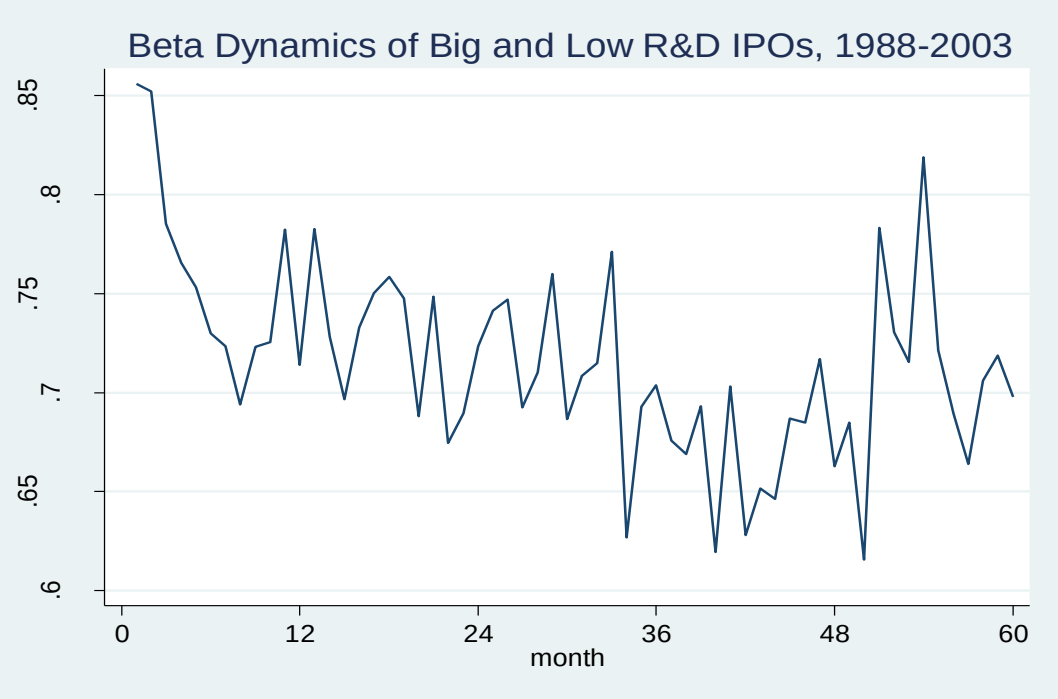
Figure 3: Beta dynamics of big and low R&D IPOs, 1988-2003



We next examine the R&D and capital expenditure evolution around the IPO. As seen in Figure 4, R&D intensity (measured at R&D deflated by assets) increases from 12.9% at year -2 to 15.4% at year -1, and then decreases to 12.4% at year 0 and 5.1% at year +1. (Note: the year 0 contains both pre- and post-IPO data). Compared with R&D, capital expenditure is more stable over time but also exhibits the pattern of an increase before the IPO and decrease after the IPO, but with smaller magnitude compared to R&D. In figure 4, capital expenditure (measured as capital expenditure deflated by assets) increase from 7.5% at year -2 to 9.2% at year -1 to 9.5% at year 0 and decreases to 8.6% at year +1. Figure 5 shows similar patterns when R&D is deflated by sales rather than assets. The evolution of capital expenditure does not seem to substitute the reduction of R&D after the IPO. The evidence so far does not suggest a real options phenomenon.

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Figure 4: Dynamic pattern of R&D and CAPEX around IPO (scaled by assets)

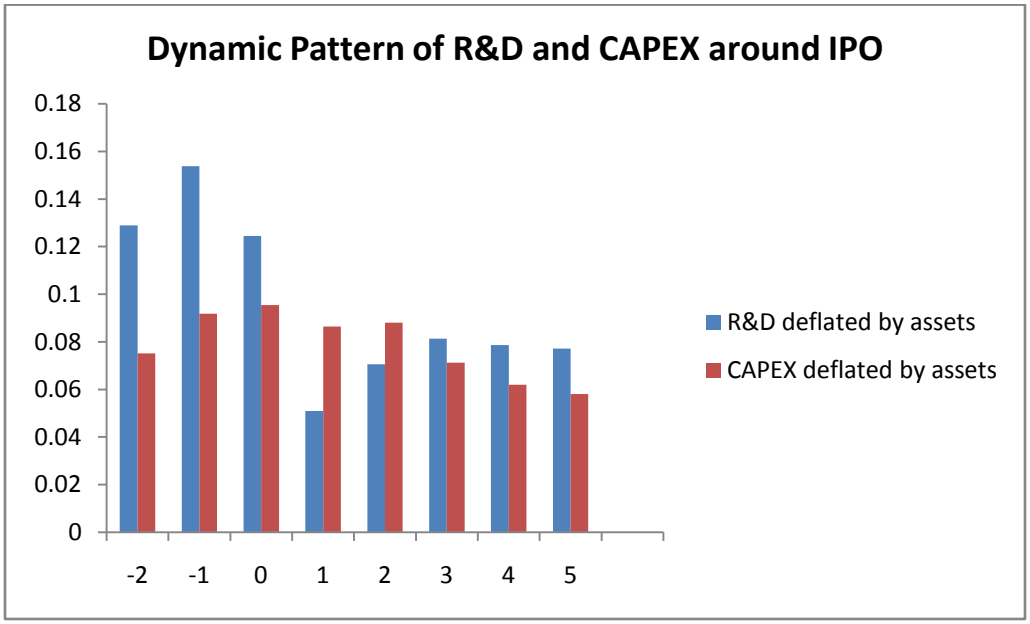
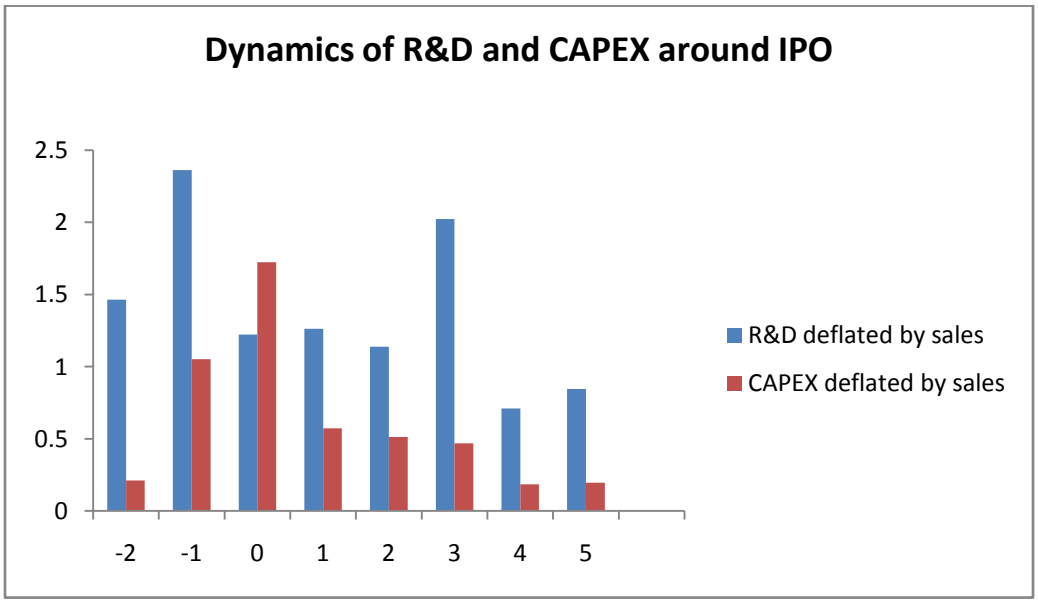


Figure 5: Dynamic pattern of R&D and CAPEX around IPO (scaled by sales)



5.4 Corporate Governance

Gunny (2005) suggests that public firms have the incentive to cut R&D as a form of real earnings management and it will result in lower subsequent operating performance. It is possible

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that the IPO firms with weak corporate governance engage in real earnings management by cutting R&D spending, resulting in a sharp decrease in R&D from pre-IPO era. We check this possibility by separating IPOs into strong and weak corporate governance groups. Earnings management hypothesis suggests that IPOs with weak corporate governance will cut R&D spending more than those with strong corporate governance. This may in turn result in a sharp decrease in R&D spending following the IPO as shown in Table 8.

To proxy for corporate governance, we employ G-index provided by GIM (2003). We match our IPO data with the G-index. We assume that firms which appear in the index three or more years after the IPO are seasoned firms. Therefore we only include firms listed in the G index within three years of their initial public offering. This reduces our sample into 245 IPOs.

The median G score for the entire sample created by GIM (2003) is 9. The distribution of G score is heavily centered between 7 (25 percentile) and 11(75 percentile). For the IPO sample of 245 firms used here, the mean G-index is 7.23 and the median G-index is 7. The distribution is centered between 6 (25 percentile) and 9 (75 percentile). In general, the distribution of IPO firms is skewed more toward lower value of G score than the sample containing all firms.

GIM (2003) classify the domestic firms as G<=5 and dictator firms as G>=14. This criterion does not apply to our IPO sample since the 245 IPOs are a small subset of about 1500 firms in the GIM dataset. There are no firms with G>=14 in our IPO sample. Instead, we classify firms into domestic (strong shareholder rights) IPOs as G<=7 and dictator (weak shareholder rights) IPOs as G>=9.

We then check whether R&D reduction is associated with shareholder rights. Table 15 tabulates the median change of R&D from year -1 to up to five years post the IPO. The results

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indicate no significance difference of R&D reduction between IPOs with high shareholder rights and those with low share holder rights. The Wilcoxon rank test statistics are not significance in all pairs. The results thus suggest that firms with high and low shareholder rights both reduce R&D after the IPO and the reduction of R&D is not significantly different across the two groups.

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Table 15 Median Change of R&D by Shareholder Rights

			R&D deflated by assets			
right	-1 to +1	-1 to +2	-1 to +3	-1 to +4	-1 to +5	Freq.
Strong		-0.048	-0.048	-0.025	-0.033	-0.033	134
Weak		-0.066	-0.039	-0.012	-0.015	-0.017	74
Z-stat		0.089	-0.236	-0.649	-0.915	-0.823	
(P-value)		0.9294	0.8138	0.5166	0.3601	0.4104	
			R&D deflated by sales			
right	-1 to +1	-1 to +2	-1 to +3	-1 to +4	-1 to +5	Freq.
Strong		-0.005	-0.004	0	0.001	-0.001	134
Weak		-0.015	-0.006	-0.006	-0.011	-0.006	74
Z-stat		0.903	0.229	1.022	1.539	0.954	
(P-value)		0.3666	0.8192	0.3068	0.1239	0.3403	

6. Conclusion

Previous literature has studied various signals that firms can use to reveal their quality to the outside investors at IPO. This paper provides evidence supporting pre-IPO R&D investment as one signal of firm quality. We find that firms with high pre-IPO R&D are valued more at IPO. They are more likely to issue seasoned equity within three years following IPOs and their amount of seasoned equity offerings tends to be larger. Firms that overinvest in Pre-IPO R&D are valued more by the market and this only apply to high-tech firms.

In contrast to the documented underperformance of IPO firms, over a four-year period extending from the year prior to the IPO until three years after the offering, firms with high pre-IPO R&D experience superior post-issue operating performance compared to firms with zero or low pre-IPO R&D. Firms with high pre-IPO R&D tend to reduce R&D expense following IPOs when signaling is done. This study suggests that as R&D becomes increasingly important for firms' long-term success, high quality firms may undertake R&D investment to differentiate themselves from low quality ones. The evidence supports pre-IPO R&D serving as a signal for IPO firm quality.

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Appendix A: breakdown of industries

We follow Fama-French's 10-industry specification with the exception of the "health" industry. We further divide the “health” industry into "pharmaceutical", "medical equipment", and "healthcare service" according to Fama-French's 49-industry specification to account for the distinctive R&D investments in these three industries. Four digit SIC codes are provided in the appendix. We further classifiy these industries into "high-tech" and "low-tech" groups.

High-tech			Low-tech		
Pharmaceutical	2830 - 2839		Health service	8000 - 8099	
Medical	3693 - 3693		Durables	2500 - 2519	3716 - 3716
Equipment	3840 - 3859			2590 - 2599	3750 - 3751
				3630 - 3659	3792 - 3792
Telecom	4800 - 4899			3710 - 3711	3900 - 3939
				3714 - 3714	3990 - 3999
High tech	3570 - 3579	7375 - 7375			
	3622 - 3622	7376 - 7376	Nondurables	100 - 999	2770 - 2799
	3660 - 3692	7377 - 7377		2000 - 2399	3100 - 3199
	3694 - 3699	7378 - 7378		2700 - 2749	3940 - 3989
	3810 - 3839	7379 - 7379			
	7370 - 7372	7391 - 7391	Energy	1200 - 1399	2900 - 2999
	7373 - 7373	8730 - 8734			
	7374 - 7374		Manufacture	2520 - 2589	3700 - 3709
				2600 - 2699	3712 - 3713
				2750 - 2769	3715 - 3715
				2800 - 2829	3717 - 3749
				2840 - 2899	3752 - 3791
				3000 - 3099	3793 - 3799
				3200 - 3569	3830 - 3839
				3580 - 3629	3860 - 3899
			Retail	5000 - 5999	7600 - 7699
				7200 - 7299	
			Others		

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