Received April 2007
Revised September 2007
Accepted October 2007

Leverage and IPO under-pricing: high-tech versus low-tech IPOs

Jaemin Kim and Kuntara Pukthuanthong-Le
San Diego State University, San Diego, California, USA, and
Thomas Walker
Concordia University, Montreal, Canada

Abstract

Purpose – The extant literature on initial public offerings (IPOs) generally assumes that a high degree of pre-IPO leverage serves as a positive signal of firm quality as it forces a firm's managers to adhere to tough budget constraints. The purpose of this paper is to question the validity of this assumption when it is indiscriminately applied to all firms, while other potentially important determinants of a firm's optimal capital structure are ignored. High-tech versus low-tech firms are specifically focused on.

Design/methodology/approach – Multivariate regression controlling is used for various firm and offer characteristics, market and industry returns, and potential endogeneity between investment bank rankings, price revisions, and under-pricing.

Findings – It is found that debt only serves as a signal of better firm quality for low-tech IPOs, as reflected in smaller price revisions and lower under-pricing. For high-tech IPOs, the effect of leverage is reversed: for these firms, higher leverage is associated with increased risk and uncertainty as reflected by higher price revisions and greater under-pricing. The results remain significant after controlling for various firm variables as mentioned above.

Practical implications – The research results allow managers of high-tech firms that contemplate going public to better understand the effect their company's capital structure will have on the pricing of their IPO. Prior research generally suggests that – irrespective of a firm's underlying characteristics – higher financial leverage results in lower under-pricing. The findings highlight the falsity of this generalization and point out that it only holds for low-tech firms. Firms that operate in a high-tech sector, on the other hand, will leave less money on the table if they use equity rather than debt financing.

Originality/value – It is shown that leverage only serves as a positive signal for low-tech firms. The IPOs of these firms generally undergo smaller price revisions and are less under-priced than the IPOs of low-tech firms that use little debt in their capital structure. While this result is consistent with earlier studies, it is show that the relationship between these variables reverses for high-tech IPOs. Specifically, it is found that high-tech IPOs with high leverage undergo larger price revisions and are more under-priced than high-tech firms with low leverage. In contrast to earlier findings, this suggests that for high-tech IPOs, higher leverage implies increased ex-ante uncertainty and risks.

Keywords Pricing, Investments, Capital, Stock markets

Paper type Research paper

1. Introduction

During the late 1990s, the characteristics of high-tech and low-tech initial public offerings (IPOs) diverged to an extent that has not been seen in prior IPO markets. One aspect of the hot IPO market of 1999-2000 that has been highlighted by the press and the investment community is the large under-pricing (i.e. the difference between the offer price and the first day closing price) of high-tech IPOs. Most of these companies

Management Decision
Vol. 46 No. 1, 2008
pp. 106-130

0025-1747
DOI 10.1108/00251740810846770

had little revenues, and less than 10 percent of them were profitable. Moreover, many had been in business for only a few years or even a few months.

Researchers commonly perceive IPO under-pricing, a topic of numerous studies in the literature, as a contradiction to capital market efficiency. Yet, Loughran *et al.* (1994) document under-pricing in a number of countries. Explanations for this widely observed financial market anomaly are abundant. A vast body of the finance literature suggests that IPO under-pricing stems from asymmetric information about the issuing firm's value.

Rock (1986) and Beatty and Ritter (1986) offer one of the best known theories to explain the price behavior, the "winner's curse" theory. According to this hypothesis, informed investors will only bid for under-priced securities while less-informed investors end up bidding for overpriced securities. Thus, IPOs must be sufficiently under-priced in order to allow even uninformed investors to earn a risk-adjusted return. Another implication of the theory is that IPOs that have a higher level of asymmetric information and valuation uncertainty should be more under-priced. Evidence for the winner's curse explanation has been documented in many studies including Koh and Walter (1989), Muscarella and Vetsuypens (1989), Keloharju (1993), Michaely and Shaw (1994), Amihud *et al.* (2003), and Jaganathan and Sherman (2006)[1].

Closely related to under-pricing is the question of what drives a firm to revise its offer price. Benveniste and Spindt (1989) and Hanley (1993) argue that price revisions are the result of underwriters acquiring additional information about the firm's value from informed investors. When the information that investors reveal is positive, underwriters revise the offer price upward from the indicative prices listed in the preliminary prospectus. Demand for IPO shares is often intense, and more so for high-tech IPOs. Cornelli and Goldreich (2001, 2003) and Aggarwal *et al.* (2002) suggest that underwriters compensate investors who provide them with price indications with preferential allocations of under-priced shares. This implies a positive relation between upward price revisions and under-pricing.

Other things equal, an equity issue reduces a firm's debt to equity ratio. Since Modigliani and Miller (1958), capital structure theories have evolved to acknowledge the impact of taxes, costs of financial distress, asymmetric information, and agency costs. Modern theories of capital structure fall into two categories: the trade-off theory and the pecking-order hypothesis. Ross (1977) envisions a trade-off model in which an optimal debt/equity mix results from trading off the benefits of debt with its costs. Thus, a firm determines its optimal capital structure by balancing the tax advantages and signaling benefits of debt against the costs of financial distress (see Su, 2004). Myers and Majluf (1984) provide a different view and offer a pecking-order hypothesis to predict a hierarchy in raising funds. Under this theory, a firm prefers internal to external financing and, if the firm obtains external funds, it prefers debt to equity.

One of the fundamental premises of prior research on capital structure is the information asymmetry that exists between insiders (i.e. controlling owners or executives) and outside investors. Insider-managers hold private information about the expected return and variance of returns on their firm's assets, while outside investors are less informed about the firm's value. Ross (1977), John (1987), Noe (1988), Heinkel and Zechner (1990), Harris and Raviv (1990), and Nachman and Noe (1994) develop signaling models of capital structure in which leverage conveys information to the market: when insiders are optimistic about the firm and its investment opportunities

but perceive that outside investors don't share their optimism, they will use a great deal of debt to send a signal to the market that their firm is of superior quality.

Relating capital structure signaling models to IPO under-pricing, James and Wier (1990), Habib and Ljungqvist (2001), and Schenone (2004) point out that issuing private debt claims before issuing stock signals to the market that the firm is of high value since only high-value firms apply for, and are granted, inside debt. These authors hypothesize that such a signal reduces asymmetric information, thus lowering IPO under-pricing. In addition, managers of highly leveraged firms face tougher budget constraints and have less control over the firm's cash flows. This increases transparency and reduces the severity of agency conflicts between managers and outside investors. In sum, the use of debt financing by IPO firms is frequently seen as a signal of high firm quality.

Given the fact that the optimal debt/equity mix can vary widely from one firm to the next, we argue that higher leverage is not necessarily always a good thing. In other words, we hypothesize that higher debt financing will only serve as a signal of superior firm quality if its benefits indeed outweigh its costs. To examine whether the use of leverage can send different signals to investors, we focus specifically on two types of firms: those in the high-tech sector and those in the non-high-tech (or low-tech) sector.

High-tech firms differ from low-tech firms along several lines that make debt financing less attractive for them. First, operating cash flows of high-tech firms tend to be more volatile, which makes it difficult to meet interest and principal repayment obligations. Second, high-tech firms typically have few tangible assets but carry significant intangible assets in the form of patents and other intellectual property. As a result, the costs of financial distress tend to be significantly higher for high-tech firms. For example, one can compare Amgen, a bio-tech firm, with General Motors, an auto-manufacturer. Third, with typically little or no profitability in early years, high-tech firms tend to benefit little from the debt tax-shield, i.e. from tax savings associated with the tax deductibility of interest payments[2, 3].

Thus, we argue that a high degree of financial leverage will only serve as a positive signal for firms that are not in the high-tech sector. In line with the winner's curse model of under-pricing and a number of studies on price revisions, we predict that a higher degree of financial leverage will reduce the level of asymmetric information and investor uncertainty for these low-tech firms. Therefore, we expect a negative relationship between leverage and the size of the firms' offer price revisions, and the degree to which their shares are under-priced.

For high-tech firms we expect to find the opposite effect: higher leverage provides fewer benefits and increases the firm's bankruptcy risk to a significantly larger extent than for low-tech firms. As a result, we expect a higher degree of information asymmetry and increased investor uncertainty for highly leveraged high-tech firms. This, in turn, should cause the relationship between leverage and both the firm's offer price revisions and its IPO under-pricing to be positive. More formally, we propose that:

H1. For low-tech IPOs, pre-IPO leverage is negatively associated with a firm's offer price revisions and under-pricing; for high-tech IPOs, pre-IPO leverage is positively associated with price revisions and under-pricing.

Our results support this hypothesis: both under-pricing and price revisions are negatively related to leverage for low-tech firms, whereas the relation is positive for high-tech firms. Consistent with the extant literature, we employ both ordinary least squares and two-stage least squares regressions to control for potential endogeneity among price revisions, under-pricing, and investment bank rankings. Our results remain robust after controlling for a variety of firm and offer characteristics as well as other factors that are related to a firm's price revisions and under-pricing. In addition, they are unaffected if we employ different variable definitions and model specifications.

To the best of our knowledge, this study fills a gap in the literature as it is the first to connect the findings of the capital structure literature to IPO under-pricing and price revisions in the context of high-tech versus low-tech IPOs. Our main conclusion is that pre-IPO leverage is a signal of better firm quality only for low-tech IPOs, as reflected in lower price revisions and under-pricing, but a sign of increased risk and uncertainty for high-tech IPOs.

The paper is organized as follows. Section 2 describes our sample, defines the variables used in this study, and provides descriptive statistics. Section 3 provides the results of our analyses. In section 4, we offer robustness tests. We discuss our results and provide concluding remarks in section 5.

2. Data

2.1. Sample selection

Our sample is based on IPO data from the Thomson Financial SDC database. We exclude unit offers, closed-end funds, REITs, financial institutions (firms with two-digit SIC codes ranging from 60 to 63 and 67), ADRs of companies already listed in their home countries, limited partnerships, and leveraged buyouts. Moreover, we exclude seasoned equity offerings and IPOs with an offering price below \$5[4] because firm valuations in such cases are problematic[5]. Our final sample consists of 2,391 firms completing an initial public offering between January 1996 and December 2002.

High-tech firms are identified following the classification methods in Loughran and Ritter (2004) and Cliff *et al.* (2004)[6]. For each IPO, we calculate post-offer institutional holdings as the number of shares owned by institutions divided by the estimated public float. The data is taken from institutional 13F filings with the SEC which are available on the SEC's Electronic Data Gathering, Analysis, and Retrieval (EDGAR) database and from Thomson Financial. We collect this data at the end of the first quarter that is at least one month after the issue and exclude institutions that owned shares prior to the IPO. We omit any institutions that are listed as a venture capitalist on SDC or whose name suggests that it is a venture capitalist (Dor, 2004)[7].

The public float should be approximately equal to the total number of shares offered in the IPO, which is equal to shares offered as listed in the prospectus plus the over-allotment option[8]. For some issues, we estimate shares sold through the over allotment option exercise by following the procedure used in Aggarwal (2000). The mean (median) post-offer institutional holdings as a percentage of the public float are 24.77 percent (29.36 percent) for high-tech firms and 31.98 percent (34.11 percent) for low-tech firms.

Forecasted earnings data are obtained from the I/B/E/S database. Underwriter quality is based on Loughran and Ritter (2004): the rankings are between 1.1 (low) and

9.1 (high) with integer increments. In addition, we calculate a company's age as the difference in years between its founding date and its IPO date[9].

First-day trading prices are from the Center for Research in Securities Prices (CRSP)[10]. Financials are collected from Compustat and are based on fiscal year data before the issue. We use that information to compute sales/gross costs, accruals/total assets, and the firm's book to market ratio. Gross costs are defined as sales minus EBITDA where EBITDA is the sum of earnings before interest and taxes (EBIT) and depreciation and amortization (DA) and represents operating cash flows. Accruals/total assets is the ratio of accruals to total assets based on the first annual statement after the firm goes public, in which accruals are computed as income before extraordinary items minus cash flows from operations. The book-to-market ratio is the ratio of the firm's book value of equity during the first fiscal year after the IPO date over the market value of equity measured at the end of the first trading day.

For each IPO, we manually identify its main intended use of proceeds using the numerical breakdown of intended uses if provided in a prospectus, or else based on a reading of the "Use of Proceeds" section. We treat the company as not having an identifiable main use of proceeds if the wording does not allow us to rank intended uses. All IPO information including the number of shares offered, the offer price, the initial pricing range, and the syndicate size (the number of banks making up the syndicate) are collected from SEC filings made available through the EDGAR database and from the SDC. Since Ljungqvist and Wilhelm (2003) document that there are significant errors in SDC's variables for venture-backing and shares outstanding pre- and post-IPO, we hand-collect these variables as well. Nevertheless, because EDGAR provides prospectuses only for IPOs issued after May 1996, we search for the prospectuses of IPOs issued between January and April 1996 by requesting them directly from the firms or by collecting them from the Disclosure Global Access database[11].

2.2. Firm characteristics

Table I, Panel A, provides descriptive statistics on the firm characteristics of all IPO firms in our sample. High-tech companies accounted for less than half of the total annual IPO volume during the years 1996 to 1998 and 2001/2002. During the hot IPO market in 1999 and 2000, however, high-tech firms made up around two-thirds of total IPO volume. In addition, firms that went public during the hot IPO market differed from prior and subsequent IPOs along various other dimensions: the median IPO firm during that period was less profitable, was more likely to have negative earnings per share, had lower revenues, had less leverage, and was younger than the median IPO firm in 1996-1998 or 2001-2001[12].

2.3. Transaction characteristics

Panel B of Table I provides IPO transaction details during our sample period. With respect to some characteristics the 1999/2000 IPO market clearly stands out again. For example, we find that both the frequency and magnitude of positive offer price revisions was considerably higher during that period than during any prior or subsequent year. This, in turn, also resulted in a higher fraction of IPOs being priced above the original filing price range as well as fewer IPOs that were priced below that range than during any other year. Moreover – and not surprisingly – we find that

Table I. Descriptive statistics

		1996 – 2002	1996	1997	1998	1999	2000	2001	2002
Panel A: firm characteristics:									
Number of IPOs in the sample		2,391	686	484	269	453	366	73	60
Percentage of high-tech IPOs		49.83	47.31	27.95	45.35	65.34	71.58	38.36	40.00
Net income after taxes ($m)	Mean	−6.31	−0.38	−3.48	0.04	−12.24	−19.87	−3.46	−1.23
	Median	−2.32	0.29	1.14	0.11	−10.38	−7.51	0.15	0.82
Fraction (%) with EPS < = 0		57.92	53.24	39.96	41.94	78.92	81.75	40.55	45.21
Revenue ($m)	Mean	174.94	133.41	154.74	159.19	261.43	181.59	203.68	154.81
	Median	22.36	25.53	36.08	20.95	12.74	11.61	24.97	26.12
Total debt/total assets	Mean	56.47	39.61	28.84	212.17	55.33	13.18	19.30	31.68
	Median	8.04	11.25	14.63	11.11	5.51	2.98	4.23	25.74
Age	Mean	12.27	14.61	16.08	17.52	8.89	9.66	13.01	14.25
	Median	6	8	8.50	9	4	6	7	9
Panel B: transaction characteristics:									
Expected gross proceeds ($m)	Mean	98.17	57.49	60.22	105	112.5	139.02	327.91	201.88
	Median	45.50	33.60	33.06	37.50	56.00	69.41	95.04	104.85
Midpoint of original filing price range ($)	Mean	12.86	12.29	12.64	12.61	12.74	13.62	15.18	15.82
	Median	12	12	12	12	12	13	14	16
Expected offer price ($)	Mean	13.01	12.17	12.36	12.31	13.72	14.30	14.82	15.67
	Median	13	12	12	12	13	13	14	16
Final offer price ($)	Mean	13.56	12.44	12.58	13.35	14.93	14.90	14.90	14.97
	Median	13	12	12	12	14	14	14	15
Price revision from midpoint of the original filing price range (%)	Mean	5.39	0.94	−0.77	2.68	18.26	11.29	−2.00	−5.26
	Median	0	0	0	0	11.11	6.67	0	0
Price revisions from expected offer price (%)	Mean	1.90	0.85	−1.59	0.06	7.70	3.80	0.40	−3.68
	Median	0	0	0	0	7.14	5.72	0	0

(*continued*)

Table I.

		1996 – 2002	1996	1997	1998	1999	2000	2001	2002
Fraction (%) priced above range		24.17	19.68	17.15	17.84	36.64	34.70	10.96	18.33
Fraction (%) priced below range		12.88	12.54	18.18	14.50	6.84	11.75	12.33	20.00
Under-pricing (%)	Mean	34.49	16.81	13.33	23.67	72.46	58.95	20.47	7.76
	Median	13.20	10.00	7.50	9.14	37.50	28.67	11.03	8.45
Fraction (%) of firms with VC backing		42.99	37.9	26.86	29.37	57.62	65.30	47.95	40.00
Investment bank ranking	Mean	7.5	7.0	7.0	7.2	8.1	8.3	7.8	6.9
	Median	8.1	8.1	8.1	8.1	9.1	9.1	8.1	8.1

Notes: This table presents descriptive statistics for our sample firms. In Panel A, we characterize the firms in our sample with respect to industry, accounting performance and age. In Panel B, we provide information based on the IPO transaction details of each firm. High-tech companies are identified following Loughran and Ritter (2004) and Cliff *et al.* (2004) and include firms with the following SIC codes: 2833, 2834, 2835, 2836 (drugs), 3571, 3572, 3575, 3577, 3578 (computer hardware), 3661, 3663, 3669 (communications equipment), 3674 (electronics), 3812 (navigation equipment), 3823, 3825, 3826, 3827, 3829 (measuring and controlling devices), 4812, 4813, 4899 (communication services), and 7370, 7371, 7372, 7373, 7374, 7375, 7377, 7378, 7379 (software). Accounting data are from Compustat and prospectuses and based on fiscal year data prior to the IPO. Age is calculated as the number of years between the founding date and the IPO date. Expected gross proceeds are computed as the number of shares offered multiplied by the expected offer price. The midpoint of the original filing price range is defined as the midpoint of the indicative price range included in the issuer's original S-1 filing. The expected offer price is defined as the midpoint of the indicative price range included in the issuer's amended S-1 filing (or the original S-1 filing if no amendment was filed). The price revision from the midpoint of the original filing price range (the expected offer price) is calculated as the percentage change from the midpoint of the original filing price range (the expected offer price) to the final offer price. Under-pricing is calculated as the first-day closing price over the final offer price minus one. Investment bank rankings are based on the Carter and Manaster (1990) and Carter *et al.* (1998) reputation rankings as revised by Loughran and Ritter (2004) and range from 1.1 (worst) to 9.1 (best). VC backing information is from IPO prospectuses and includes backing by either venture capitalists or private equity (middle-market, buy-out, merchant banking) funds

hot-market IPOs were characterized by considerably higher under-pricing (mean under-pricing of 72.46 percent and 58.95 percent in 1999 and 2000, respectively) than IPOs during the remainder of our sample (sample average = 34.49 percent).

Most hot-market IPOs were backed by venture capitalists (approximately 60 percent, relative to a sample average of 43 percent) and were underwritten by a higher-ranked investment bank (median underwriter ranking of 9.1 in 1999/2000, compared to a median of 8.1 in all other years).

At the same time, we find a monotonic increase (rather than a mid-sample bulge) with respect to some other IPO characteristics. The mean and median value of expected gross proceeds, for example, rose fairly steadily during our sample period, with the mean nearly quadrupling from $57.49 million in 1996 to $201.88 million in 2002[13]. At the same time, we observe an almost monotonic increase in various IPO pricing measures. Specifically, we distinguish between three price measures that we will also use in our subsequent analysis:

(1) the midpoint of the original filing price range;

(2) the expected offer price; and

(3) the final offer price.

Whereas the midpoint of the original filing price range is defined as the mean of the indicative price range included in an issuer's original S-1 filing, the expected offer price is based on the filing price range in the firm's last amended prospectus (if the firm made any amendments)[14].

3. Methodology and results

3.1 Choosing comparable firms

In this section, we describe how we choose comparable firms to compute three control variables (the return of matched firms during the two weeks before the IPO, as well as matched firm under-pricing and an IPO's mis-pricing from its fundamental value) that will be used in the least squares regressions in Tables II to IV.

For each IPO firm in the sample, we select a matching firm that did not go public within three years prior to the IPO date, is in the same industry as the IPO firm, and is closest in terms of sales, and sales divided by gross costs in the most recent fiscal year[15].

We find comparable firms that are in the same industry as the IPOs because firms in the same industry are more likely to have similar operating risks, profitability, and growth prospects. Moreover, matching firms by industry should control for growth since firms in the same industry should have similar growth opportunities. We also match firms based on sales. Sales are frequently used as a proxy for size (see, for example, Kim and Ritter, 1999). Finally, matching firms based on sales per gross costs controls for profitability across firms. Since sales divided by gross costs measures operating profitability, it is a more stable measure of profitability than sales divided by net costs (sales minus earnings), because net costs are affected by interest expenses[16]. We make sure that each IPO gets a unique matching firm in a given cohort year. Sometimes the matching firms are repeated in subsequent years; nevertheless, dropping these cases does not appreciably affect our findings.

Independent variables	(1) Price revision OLS	(2) Investment bank ranking OLS	(3) Price revision 2SLS
Constant	−0.183***	0.986***	−0.129***
	(−6.33)	(4.01)	(−3.16)
Leverage	−0.192**	0.021**	−0.157**
	(−2.09)	(2.08)	(−2.01)
Leverage * High-tech dummy	0.339***	−0.044	0.284**
	(3.42)	(−1.18)	(2.03)
Comparable under-pricing	0.140***	0.024	0.180***
	(3.23)	(0.21)	(3.49)
Comparable return	0.314***	−0.125	0.328***
	(4.77)	(−0.62)	(5.45)
Mis-pricing	0.563***	0.317	0.455***
	(3.42)	(1.06)	(3.28)
Institutional holdings	0.284**	0.163	0.217**
	(2.65)	(1.32)	(2.49)
Firm age	−0.215**	0.078**	−0.182*
	(−2.34)	(2.32)	(−1.82)
High-tech dummy	0.034**	0.379***	0.025*
	(2.66)	(5.97)	(1.80)
Investment bank ranking	0.017***		0.011**
	(4.57)		(2.33)
Syndicate size	−0.002	0.009**	−0.001
	(−1.05)	(2.46)	(−1.01)
Venture capital backing dummy		0.794***	
		(5.43)	
ln(Expected gross proceeds)		1.442***	
		(4.12)	
Bubble period dummy	0.030	−0.078	0.016
	(1.05)	(−0.68)	(0.53)
Adjusted R^2 (%)	22.79	57.19	18.17

Notes: This table presents least squares regression results for our sample of 2,391 IPOs between 1996 and 2002. The dependent variable in models (1) and (3) is the price revision, which is the final offer price divided by the midpoint of the original filing price range minus one. In model (2), the dependent variable is the rank of the firm's lead underwriter. Leverage is the ratio of total debt to total assets. Comparable under-pricing is the first-day return of the comparable firm. Comparable return is the return of the comparable firm during a 2-week period prior to the IPO. Comparable firms are selected based on industry, sales, and sales per gross costs. Mis-pricing is the ratio of the offer value to sales per gross costs of the IPO firm divided by the corresponding market value-to-sales divided by gross costs of the comparable firm (where gross costs are sales minus EBITDA; and the offer value is the final offer price multiplied by the number of shares outstanding at the end of the first trading day). Institutional holdings are the post-IPO number of shares owned by institutions divided by the estimated public float (where public float equals the total number of shares offered in the IPO plus the overallotment option). The high-tech dummy is a dummy variable that takes on a value of one if the firm belongs to a high-tech industry (based on the industry classification provided by Loughran and Ritter, 2004, and Cliff *et al.*, 2004) and zero otherwise. Syndicate size is the number of investment banks that comprise the underwriting syndicate. The bubble period dummy is equal to one if the IPO was issued in 1999 or 2000, and zero otherwise. Other firm and offer characteristics such as firm age, investment bank ranking, the venture capital backing dummy, and expected gross proceeds are as defined in Table I. Model (1) is estimated using OLS. Model (3) is estimated using 2SLS, with (2) being the first stage. Below each coefficient, we show *t*-statistics in parentheses. Standard errors are adjusted for time clustering of observations, based on the assumption that observations are independent for companies at different points in time, but not necessarily forcompanies that go public in the same month. The symbols *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent level (two-sided), respectively

Table II.
Regression: price revision and leverage

Independent variables	(4) Under-pricing OLS	(5) Under-pricing 2SLS
Constant	0.108**	0.202***
	(2.65)	(3.50)
Leverage	−0.152*	−0.190**
	(−1.98)	(−2.67)
Leverage * High-tech dummy	0.303**	0.427***
	(2.70)	(2.86)
Comparable under-pricing	0.121**	0.104*
	(2.08)	(1.95)
Comparable return	0.229**	0.172**
	(2.53)	(2.01)
Mis-pricing	0.628***	0.383***
	(3.29)	(2.79)
Institutional holdings	0.319**	0.234**
	(2.40)	(2.20)
Secondary shares sold	−0.063**	−0.051*
	(−2.09)	(−1.86)
Primary shares sold	−0.035	−0.028
	(−1.74)	(−1.22)
Proceeds-for-operating-expenses dummy	0.057*	0.102***
	(1.93)	(3.39)
Firm age	−0.230**	−0.316**
	(−2.18)	(−2.35)
High-tech dummy	0.053**	0.041**
	(2.12)	(2.02)
Investment bank ranking	0.008	−0.011
	(0.87)	(−1.01)
Price revision	0.417***	0.225**
	(3.16)	(2.54)
Price revision * Positive revision dummy	0.975***	
	(2.94)	
Bubble period dummy	0.154***	0.085
	(3.27)	(1.53)
Adjusted R^2 (%)	48.33	38.52

Notes: This table presents regression results for our sample of 2,391 IPOs between 1996 and 2002. The dependent variable is under-pricing, defined as the first-day closing price over the offer price minus one. Leverage is the ratio of total debt to total assets. Comparable under-pricing is the first-day return of the comparable firm. Comparable return is the return of the comparable firm during a two-week period prior to the IPO. Comparable firms are selected based on industry, sales, and sales per gross costs. Mis-pricing is the ratio of the offer value to sales per gross costs of the IPO firm divided by the corresponding market value-to-sales divided by gross costs of the comparable firm (where gross costs are sales minus EBITDA; and the offer value is the final offer price multiplied by the number of shares outstanding at the end of the first day of trading). Institutional holdings are the post-IPO number of shares owned by institutions divided by the estimated public float (where public float equals the total number of shares offered in the IPO plus the overallotment option). Secondary shares sold are the number of secondary shares sold at the IPO normalized by the number of pre-IPO shares outstanding. Primary shares sold is the number of primary shares issued normalized by the number of pre-IPO shares outstanding. The Proceeds-for-operating-expenses dummy takes on a value of one if the firm's prospectus indicates that proceeds will be primarily used to cover operating expenses. Price revision is the final offer price divided by the midpoint of the original filing price range minus one. The interactive variable "Price revision *Positive revision dummy" equals the percentage price revision if it is positive, and zero otherwise. The bubble period dummy is equal to one if the IPO was issued in 1999 or 2000, and zero otherwise. All other regressors are as defined in Table I. The 2SLS regression (5) uses regressions (2) and (3) in Table II as its first stage. Below each coefficient, we show *t*-statistics in parentheses. Standard errors are adjusted for time clustering of observations, based on the assumption that observations are independent for companies at different points in time, but not necessarily for companies that go public in the same month. The symbols *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent level (two-sided), respectively

Table III.
Regression: under-pricing and leverage

Independent variables	(6) Under-pricing OLS	(7) Under-pricing 2SLS
Intercept	0.937	1.235 *
	(1.69)	(1.76)
Leverage	− 0.161 **	− 0.176 **
	(− 2.21)	(− 2.36)
Leverage * High-tech dummy	0.296 **	0.336 ***
	(2.48)	(2.90)
Mis-pricing	0.701 ***	0.334 ***
	(3.61)	(2.81)
Institutional holdings	0.346 **	0.271 **
	(2.57)	(2.23)
Market return	0.262 *	0.276 **
	(1.88)	(2.17)
Accruals/total assets	− 0.252	− 0.211
	(− 1.30)	(− 1.17)
Sales/gross costs	0.165 **	0.188 **
	(2.02)	(2.34)
ln(Book-to-market ratio)	− 0.173 ***	− 0.156 **
	(− 2.80)	(− 2.25)
ln(1 + Analyst consensus growth)	0.144 **	0.101 *
	(2.19)	(1.78)
Investment bank ranking	0.120	0.116
	(0.99)	(0.45)
Firm age	− 0.207	− 0.186
	(− 1.68)	(− 1.32)
Price revision	0.324 ***	0.449 ***
	(2.77)	(2.94)
Price revision * Positive revision dummy	0.822 **	
	(2.68)	
Industry dummies	Included	Included
Year dummies	Included	Included
Adjusted R^2 (%)	41.54	52.82

Notes: This table presents regression results for our sample of 2,391 IPOs between 1996 and 2002. The dependent variable is under-pricing, defined as the first-day closing price over the offer price minus one. Leverage is the ratio of total debt to total assets. Mis-pricing is the ratio of the offer value to sales per gross costs of the IPO firm divided by the corresponding market value-to-sales divided by gross costs of the comparable firm (where gross costs are sales minus EBITDA; and the offer value is the final offer price multiplied by the number of shares outstanding at the end of the first day of trading). Institutional holdings are the post-IPO number of shares owned by institutions divided by the estimated public float (where public float equals the total number of shares offered in the IPO plus the overallotment option). Market return is the return on the CRSP NYSE/AMEX/NASDAQ value-weighted index during a 15-day period prior to the IPO. Accruals/total assets is the ratio of accruals to total assets based on the first annual statement after the firm goes public, in which accruals are computed as Income Before Extraordinary Items (Compustat annual data item 123) minus Cash Flows from Operations (item 308 minus item 124). Book-to-market ratio is the ratio of the firm's book value of equity during the first fiscal year after the IPO date over the market value of equity measured at the end of the first trading day. Sales/Gross costs is the ratio of sales over gross costs where gross costs are defined as sales (Compustat data item 12) minus costs of goods sold (Compustat data item 41). Analyst consensus growth is measured as the forecasted annual growth over the next five years or one year, whichever is available. Analyst growth rates are available only after the firm goes public. Price revision is the final offer price divided by the midpoint of the original filing price range minus one. The interactive variable "Price revision *Positive revision dummy" equals the percentage price revision if it is positive, and zero otherwise. Unless otherwise noted, accounting variables are based on fiscal year data prior to the IPO from Compustat and prospectuses. Growth rates are from I/B/E/S. Industry dummies are based on the full set of industry classifications provided by Fama and French (1997). Year dummies include yearly dummies for the years 1997 to 2002. All other regressors are as defined in Table I. The 2SLS regression (7) uses regressions (2) and (3) in Table II as its first stage. Below each coefficient, we show *t*-statistics in parentheses. Standard errors are adjusted for time clustering of observations, based on the assumption that observations are independent for companies at different points in time, but not necessarily for companies that go public in the same month. The symbols *, **, and *** indicate significance at the 10 percent, 5 percent, and 1 percent level (two-sided), respectively

Table IV.
Robustness tests of under-pricing and leverage

3.2. Price revisions and leverage

In this section, we examine the influence of changes in leverage on the price revision process. Since under-pricing reflects partial adjustment to the revelation of positive information, and price revisions and under-pricing are implicitly simultaneously determined (Benveniste and Spindt, 1989), we use ordinary least squares to estimate our price revision and under-pricing regressions and then two-stage least squares regressions to allow for potential endogeneity of several key explanatory variables (Ljungqvist and Wilhelm, 2003).

3.2.1. Ordinary least squares (OLS) estimation. In model (1) of the regressions in Table II, price revision, which is the final offer price divided by the midpoint of the original filing price range minus one, is regressed on 11 independent variables including leverage and the interactive variable leverage*high-tech dummy. The interactive variable is introduced to allow for differences in the slope of the leverage coefficient between high-tech and low-tech firms. Leverage is defined as the ratio of total debt to total assets. As noted earlier, we predict a positive (negative) relation between price revision and leverage for high-tech (low-tech) IPOs.

Loughran and Ritter (2002) show that the compounded market returns for the 15 days prior to the IPO are significantly positively related to under-pricing and interpret their findings as indicating that underwriters do not entirely incorporate public information that becomes available during the registration period into the offer price. Lowry and Schwert (2004) examine this relation further, and find that the significance of market returns stems from private information that is acquired during the filing period, but is not incorporated into the offer price. To control for these relationships, we include the average under-pricing and the return of comparable firms during the two weeks before the IPO in the price revision and under-pricing regressions. Instead of computing market returns, we specifically compute the returns of comparable firms as comparable firm multiples are widely used by both practitioners and academics and are a standard practice in IPO valuation (Kim and Ritter, 1999).

In addition, we control for the mis-pricing of IPO firms from their fundamental value. Purnanandam and Swaminathan (2004) show that IPOs that are highly mis-priced from their fundamental value, that is, IPOs whose offer prices are too high relative to the offer prices of similar firms, are characterized by high under-pricing. Following Purnanandam and Swaminathan, we compute mis-pricing as the ratio of the offer value to sales per gross costs of an IPO firm divided by the corresponding market value-to-sales divided by gross costs of the comparable firm. We employ the same set of matching firms here that we used earlier to compute comparable under-pricing and comparable returns. Specifically, the offer value is the final offer price multiplied by the number of shares outstanding at the close of the first trading day, as reported by CRSP[17], and the market value of comparable firms is computed as the number of shares outstanding for the comparable firm multiplied by its stock price on the day prior to the offer date of the IPO firm.

Furthermore, underwriters are known to provide institutional investors with the ability to cherry-pick IPOs, in return for various benefits (information, brokerage business, future underwriting business, etc.) provided by these investors to underwriters and the firms that employ them (see, for example, Hanley and Wilhelm, 1995; Aggarwal *et al.*, 2002; Ljungqvist and Wilhelm, 2002). While allocations are difficult to observe in practice, Hanley and Wilhelm (1995) show a strong positive

correlation between institutional IPO allocations and post-DPO institutional holdings (information on which is publicly available). Therefore, we include post-offer institutional holdings as a control variable to test if underwriters allocate more under-priced IPOs to their favored customers.

Finally, we include a series of variables that control for firm and offer characteristics such as firm age, investment bank ranking, syndicate size, as well as an internet bubble period dummy, which takes on a value of one for the years 1999 and 2000. For all the least squares estimations in Tables II to IV, standard errors are adjusted for time clustering by assuming that observations are independent for companies at different points in time, but not necessarily for companies that go public in the same month. Thus, they are more conservative than White (1980) standard errors.

In model (1) of Table II, note first the significant coefficients for leverage and the leverage*high-tech dummy variable. Taken together, leverage for low-tech IPOs is significantly negatively associated with a firm's offer price revision, whereas leverage for high-tech IPOs is significantly positively associated with price revisions. Specifically, for low-tech IPOs, a one percent increase in leverage decreases the price revision by 19.2 percent with a *t*-statistic of -2.09. For high-tech IPOs, a 1 percent increase in leverage increases the price revision by 14.7 percent (where 0.147 is -0.192 plus 0.339, or the sum of the leverage and leverage*high-tech dummy coefficients). The *t*-statistic (unreported in the table) is equal to 2.48 for the summed coefficient. In addition, high-tech IPOs have significantly larger price revisions, as reflected by the coefficient of the high-tech dummy. Yet, even after controlling for the high price revisions of high-tech IPOs, leverage is still significantly positively related to the price revision variable, suggesting that an increase in leverage for high-tech IPOs does enhance ex-ante information asymmetry and risk, two factors that are frequently proxied for by price revisions.

The coefficients for comparable under-pricing and comparable return are positive and highly significant ($t = 3.23$ and ($t = 4.11$, respectively), suggesting that price developments in comparable firms exert a large influence on the pricing process of firms that subsequently go public. In unreported tests, we also included the return on a market-wide index (specifically, the value-weighted NYSE/AMEX/NASDAQ index from CRSP) during the book-building period, but observed that it had no additional explanatory power over the return and under-pricing of comparable firms in the models estimated[18].

IPOs that have high mis-pricing and post-offer institutional holdings have large price revisions. The results imply that IPOs that have large price discrepancies from their fundamental value also have large price revisions, at least partially reducing the amount of money that issuers "leave on the table" (Loughran and Ritter, 2002). In addition, a larger fraction of these IPOs tends to be allocated to underwriters' favorite clients, institutions. Price revisions are larger for high-tech IPOs, as previously mentioned, and are inversely related to firm age. In sum, we observe that firms that are difficult to value (such as high-tech firms), that are allocated to underwriters' favorite institutions, whose comparable firms have high under-pricing and returns, and that are relatively young, suffer greater information asymmetry and are thus most likely to benefit from information acquisition during the book-building period (Benveniste and Spindt, 1989).

In addition, price revisions increase with underwriter reputation ($t = 4.57$), indicating that more reputable banks extract more information from potential investors and incorporate it more aggressively in the offer price. Aggarwal *et al.* (2002) show that larger syndicates allocate significantly more stock to retail investors. In addition, Ljungqvist and Wilhelm (2002) argue that higher retail allocations may lead to less price discovery during the book-building process and thus to smaller price revisions. Taken together, syndicate size should have a negative effect on price revisions. Our findings, however, do not support this hypothesis[19].

Finally, the bubble period dummy is statistically insignificant indicating that our leverage, firm and offer characteristic variables fully explain the time-series patterns in price revisions. In other words, after controlling for other factors, we find no evidence that price revisions are different during the dot-com bubble period.

3.2.2. Two-stage least squares (2SLS) estimation. One fact that we ignored in model (1) was that not all of the variables in the price revision model are exogenously determined. Firms that are likely to undergo large price revisions might choose highly ranked underwriters. If so, the positive correlation between underwriter ranking and price revisions may not be causal but a consequence of the simultaneous selection behavior of such firms. Hence, we estimate a 2SLS (two-stage least squares) model that explicitly treats underwriter choice as a dependent variable (Habib and Ljungqvist, 2001). In the first stage, reported as model (2), we regress underwriter ranking on all independent variables in model (1) and two additional variables to ensure identification: a dummy variable for VC-backed IPOs and the natural log of expected gross proceeds.

Megginson and Weiss (1991) show that VC-backed IPOs are underwritten by higher ranked underwriters. Venture capitalists may develop long-term relationships with highly ranked underwriters, and thus such underwriters are more likely to manage a given IPO (Ljungqvist and Wilhelm, 2003). Moreover, high-ranked underwriters are more likely to be interested in larger offerings as a result of the greater wealth they can garnish from such deals. In the second stage, reported as model (3), we then re-estimate our price revision equation using the predicted value for the underwriter ranking variable from model (2) as a regressor.

With respect to leverage variables, low-tech IPOs with high leverage should have no difficulty being certified by high-ranked underwriters as leverage tends to signal good firm quality. In contrast, high-tech IPOs with high leverage may find it difficult to be underwritten by highly ranked investment banks due to the increased risks and costs of financial distress (and the resulting reputational penalties and/or litigation risks that may affect investment banks if they take a firm public that fails soon after its IPO). In line with these conjectures, in model (2) we find that leverage for low-tech IPOs is positively associated with underwriter reputation, while leverage for high-tech IPOs is negatively associated with underwriter reputation. As before, we can determine the leverage coefficient for high tech IPOs (-0.023) as the sum of the coefficients on the leverage and leverage*high-tech dummy variables ($-0.044 + 0.021$). The t-statistic for the summed coefficient is -1.96 (not reported in the table).

Although Loughran and Ritter (2004) show that highly ranked underwriters tend to avoid risky deals, Ljungqvist and Wilhelm (2003) point out that risky firms (in our case high-tech firms) tend to benefit more from having highly ranked underwriters manage their IPOs and actively seek them out. Our findings provide mixed evidence with

respect to these studies. On one hand, highly ranked underwriters tend to be associated with deals by older and larger firms (firms with larger offerings), as well as firms that are backed by venture capitalists. Since these characteristics are usually associated with lower risk levels, our results are supportive of Loughran and Ritter's argument. On the other hand, we observe that prestigious underwriters are more frequently involved in IPOs of high-tech companies during our sample period, which lends support to Ljungqvist and Wilhelm's theory. However, because highly ranked underwriters syndicate more, it may help them spread at least some of the risks they incur by taking these high-tech firms public. The coefficient for the bubble period dummy is not significant, which stands in contrast with the univariate results in Table I that showed a larger proportion of highly ranked underwriters underwriting IPOs during the hot IPO market in 1999 and 2000.

When re-estimating the price revision model while at the same time controlling for endogeneity of investment bank ranking (see model 3), our findings remain consistent with the results of our OLS regression in model (1), i.e. IPOs underwritten by highly ranked investment bankers also have high price revisions. Nevertheless, the significance level of the underwriter ranking variable drops to 5 percent. With respect to our main hypothesis about leverage, in particular, the results in model (3) confirm the initial results in model (1): for low-tech IPOs, leverage is negatively associated with price revisions, whereas for high-tech IPOs, leverage is positively associated with price revisions ($t = 2.01$ for the summed coefficients, $0.127 = -0.157 + 0.284$; not reported in the table).

3.3. Under-pricing and leverage

Next, we focus our attention on the question whether leverage also affects a firm's IPO under-pricing and whether the relationship varies between high-tech and low-tech firms. Again, we estimate an ordinary least squares regression and a simultaneous equation model that controls for potential endogeneity among the independent variables.

3.3.1. Ordinary least squares (OLS) estimation. Table III reports the least-squares estimation results with under-pricing regressed on leverage, the leverage*high-tech dummy, the under-pricing and pre-IPO return of comparable firms, and a set of variables that describe the firm and its offering. In addition to the independent variables we used in our estimations in Table II, we include additional firm and offer characteristic variables in Table III that are uniquely related to IPO under-pricing.

Habib and Ljungqvist (2001) show that both the level of pre-IPO shareholder selling as well as the increase in shares outstanding from the issuance of primary stock are negatively related to under-pricing. The intuition is that under-pricing is less severe when current shareholders have more at stake and that they will set higher offer prices as a result. Similarly, an issuer selling more shares can lose more than an issuer selling fewer shares for a given level of under-pricing. Therefore, the former has a greater incentive to incur larger promotion costs in order to decrease under-pricing. Thus, we control for the number of primary and secondary shares sold relative to the number of pre-IPO shares outstanding.

Leone *et al.* (2007) find that the disclosure of proceeds intended for non-transitory uses is associated with a reduction in the ex-ante uncertainty surrounding the true value of the shares. Transitory uses include financing operating expenses or working

capital. Thus, we hypothesize that when issuers plan to use their offer proceeds to finance operating expenses or working capital, there is greater valuation uncertainty and thus higher under-pricing. Specifically, we define a dummy variable that takes on a value of one if the firm indicates that it intends to primarily use its offering proceeds to cover its operating expenses (see also Section 2.1). In addition, to allow for possible asymmetries in pricing, in addition to price revision itself, we include a variable which equals the price revision if it is positive and zero otherwise (Lowry and Schwert, 2002).

Our estimation results are provided in model (4) of Table III. We observe that under-pricing is significantly negatively related to leverage for low-tech IPOs, consistent with our hypothesis that leverage lowers ex-ante uncertainty, i.e. the level of information asymmetry, for low-tech firms, thus reducing under-pricing. In contrast, leverage is positively related to under-pricing for high-tech IPOs, that is, leverage increases uncertainty for high-tech firms, thus magnifying under-pricing. The sum of the coefficients for leverage and its interaction term with the high-tech dummy is 0.151 (= 0.303-0.152), and it is significantly different from zero ($t = 2.64$). Again, these results support our hypothesis, and the explanatory power of the regressions is high (the adjusted R^2 is 48.33 percent).

Price developments for comparable firms have an influence on under-pricing as well, although the influence is weaker than it was for price revisions. Specifically, we find that the under-pricing for a given firm is positively associated with the under-pricing and the two-week pre-IPO return of comparable firms (the *t*-stats are 2.08 and 2.53, respectively). Our results also support Purnanandam and Swaminathan's (2004) finding that IPOs that have high mispricing are also highly under-priced ($t = 3.29$). Moreover, a higher proportion of IPOs that have high under-pricing are allocated to institutions ($t = 2.40$). Under-pricing is inversely related to the proportion of secondary shares sold ($t = -2.09$) but is not significantly related to the proportion of primary shares sold. Additionally, offerings that are aimed at funding operating expenses are more severely under-priced (by about 5.7 percent with a *t*-statistic of 1.93), reflecting increased valuation uncertainty. Among the firm characteristic variables, firm age is negatively related to under-pricing ($t = -2.18$), similar to the result in Table II for price revisions.

In contrast to our previous analysis in which we investigated the relationship between price revisions and underwriter ranking, bank reputation does not have a significant effect on the degree of under-pricing in model (4). Underwriter reputation seems to affect under-pricing only indirectly by influencing price revisions first.

Finally, under-pricing is positively related to price revisions ($t = 3.16$) and the high-tech dummy *(1 = 2.12)*. The statistical significance of positive price revisions ($t = 2.94$) is consistent with the notion of asymmetric partial adjustment proposed by Benveniste and Spindt (1989), Hanley (1993), and Lowry and Schwert (2002). Not surprisingly, the bubble period dummy is positive and significant, indicating that there is higher under-pricing during the dot-com bubble period.

3.3.2. Two-stage least squares (2SLS) estimation. The under-pricing regression in model (4) of Table III treats both underwriter rankings and price revisions as exogenous variables. As we noted earlier, there is an endogenous relationship between the two variables. Moreover, Benveniste and Spindt (1989) argue that price revisions and under-pricing should be modeled simultaneously. In particular, they note that underwriters determine the offer price, and thus the price revision and under-pricing, simultaneously during the book building process. The positive relation between price

revisions and under-pricing is the result of compensating investors for revealing their information (Rock, 1986). To account for these endogenous relationships, we again estimate a two-stage least squares model (model 5). Here, we treat both underwriter ranking and price revisions as endogenous using their predicted values from models (2) and (3) in Table II as regressors. Inclusion of a number of instrument variables that are uniquely related to IPO under-pricing, such as the proportion of primary and secondary shares sold, and the dummy variable that identifies if the firm intends to use its offer proceeds for operating expenses, ensures that our model is properly identified.

When treated as endogenous, the price revision variable is still highly significant whereas the underwriter ranking remains statistically insignificant. Our finding differs from Loughran and Ritter (2004), who document a significant negative relation between underwriter prestige and initial returns between 1990 and 1998 and a significant positive relation in 1999 and 2000. Nevertheless, our results are consistent with the recent studies by Logue *et al.* (2002), who find no evidence of a significant relation between underwriter reputation and investor returns over different holding periods, and by Doukas and Gonenc (2005) who show that underwriter reputation is not linked to post-issue IPO performance after controlling for venture capital backing.

In addition, we observe that firms that are younger, whose comparable firms are highly under-priced and have a high return during the two weeks prior to the IPO, that are highly mis-priced from their fundamental value, that have high institutional holdings but a low proportion of secondary shares sold, and that use their offer proceeds to cover operating expenses have high under-pricing. On the other hand, firms that went public during the dot-com bubble do not have significantly different under-pricing relative to firms that went public in other periods. Compared to our OLS estimation in model (4), the coefficient for the bubble period dummy drops sharply in magnitude and becomes statistically insignificant.

Most importantly, with respect to our hypothesis, the significance of our leverage variables remains unchanged when we compare the OLS regression of model (4) with the 2SLS regression of model (5): leverage for low-tech IPOs is significantly negative, while leverage for high-tech IPOs is significantly positive, with a *t*-statistic of 2.79 for the combined coefficient of leverage and the interactive leverage*high-tech dummy variable.

Combined with the results in Table II, the evidence in Table III supports our hypothesis. In sum, low-tech IPOs with high leverage have lower under-pricing and price revisions, whereas high-tech IPOs with high leverage have higher under-pricing and price revisions, and vice versa. The significance of these results persists even after controlling for endogeneity as well as various firm and transaction characteristics and insider selling measures.

4. Robustness tests

4.1. Omitted variables

As in any study, it is always possible that we may have omitted certain variables that are related to both under-pricing and pre-IPO leverage. Although we employ the under-pricing and pre-IPO return of comparable firms in our estimation – which should arguably provide us with a better estimate of concurrent price trends in the EPO market than a general market index – it could still be possible that market returns are an important omitted variable that explains under-pricing. As part of a

robustness check, we substitute the two variables related to the under-pricing and pre-IPO return of comparable firms by market returns and re-perform our analysis[20].

In addition, based on previous studies that have investigated the relationship between IPO under-pricing, long-term performance, and earnings management through discretionary accruals, we hypothesize that under-pricing can be related to large accruals (Krigman *et al.*, 1999; Teoh *et al.*, 1998; Purnanandam and Swaminathan, 2004). To proxy for the degree of earnings management, we compute the ratio of accruals to total assets, where accruals are calculated as Income Before Extraordinary Items (Compustat annual data item 123) minus Cash Flows from Operations (item 308 minus item 124), based on the first annual cash flow statement after the firm goes public.

Furthermore, Purnanandam and Swaminathan (2004) include measures of a firm's profitability, book-to-market ratio, and analysts' earnings forecasts in their analyses of IPO valuation and under-pricing and show that overvalued IPOs with low profitability and strong analyst forecasts are characterized by high under-pricing. We measure profitability by sales per gross costs, wherein gross costs are sales minus EBITDA.

Finally, we include a full set of Fama and French (1997) industry dummy variables instead of the high-tech dummy, and year dummies instead of just a bubble period dummy. As before, we estimate both an OLS regression and a two-stage least squares model that treats both underwriter choice and price revisions as endogenous in the under-pricing regression. Our results are reported in models (6) and (7) in Table IV.

The results for our leverage variables remain significant in both the OLS and 2SLS estimations, providing additional support for our hypothesis. In particular, we find that the leverage for low-tech IPOs is negatively associated with under-pricing ($t = -2.21, -2.36$), while the leverage for high-tech IPOs is positively related to under-pricing ($t = 2.07, 2.65$, for the two coefficients combined). Most of the coefficients for our year and industry dummies are insignificant, and no clear pattern emerges. For brevity, we do not discuss the significance of other variables used in these regressions.

4.2. Different measures of leverage

In addition to measuring leverage by total debt over total assets, which is the book value of pre-IPO debt (short-term and long-term) divided by the book value of all assets, we also compute debt to net assets (i.e. the book value of pre-IPO debt divided by the book value of net assets), where net assets are total assets minus accounts payable and other current liabilities. Another leverage measure we use is debt to capital, defined as the book value of pre-IPO debt divided by the sum of the book value of debt and the market value of equity. The results remain qualitatively the same when we employ these alternative leverage measures in our estimation, and are not reported for brevity.

Also unreported are the correlation coefficients among the independent variables used in models (1) through (7). Most of the correlation coefficients are comparatively small in magnitude, alleviating any major concerns about multicollinearity. The only two variables that show a high degree of correlation are the price revision variable and the interactive variable that measures positive price revisions (correlation coefficient = 0.54). To account for this, we also performed all regressions with these two variables entering the respective equations separately. Again, the coefficients for leverage and the leverage*high-tech dummy variable remain qualitatively unchanged and significant.

5. Conclusions

The extant literature on initial public offerings widely views a high degree of pre-IPO leverage as a positive signal of firm quality. The notion behind this theory is that due to the risk of bankruptcy, firms that use a lot of debt in their capital structure mix are forced to adhere to tough budget constraints. As a consequence, a general assumption holds that leverage is negatively related to the level of offer price revisions a firm makes prior to its IPO as well as its degree of IPO under-pricing.

Yet, many assert wide variations in the optimal level of debt for seasoned firms. Because high-tech firms, for example, typically have fewer tangible assets and unstable cash flows, they are generally better off by employing comparatively little debt in their capital structure. Firms in more traditional (low-tech) industries, on the other hand, stand to benefit more from using debt. Because their assets tend to be more tangible, they are easier to liquidate in case the firm needs to raise cash. In addition, the cash flows of low-tech firms tend to be relatively stable, reducing the risk of temporary cash shortfalls (and the associated bankruptcy risk) that these firms incur. Finally, during their early stages, fewer high-tech firms generate profits which reduce the present value of their debt tax shield.

These differences – although well known in the capital structure literature – are usually ignored in the literature on IPOs where firms are usually "thrown into one basket", irrespective of their underlying characteristics. By distinguishing between high-tech and low-tech firms, we show that the stylized fact – that a high degree of pre-IPO leverage serves as positive signal about a firm's quality – is misleading as it ignores the underlying firm characteristics.

In particular, we show that leverage only serves as a positive signal for low-tech firms. The IPOs of these firms generally undergo smaller price revisions and are less under-priced than the IPOs of low-tech firms that use little debt in their capital structure. While this result is consistent with earlier studies, we show that the relationship between these variables reverses for high-tech IPOs. Specifically, we find that high-tech IPOs with high leverage undergo larger price revisions and are more under-priced than high-tech firms with low leverage. In contrast to earlier findings, this suggests that for high-tech IPOs, higher leverage implies increased ex-ante uncertainty and risks.

By employing two-stage least squares regressions, we control for potential endogeneity between price revisions, under-pricing, and investment bank rankings. Our results are robust when we employ different measures of leverage and when we consider different model specifications.

Aside from the theoretical contribution we hope to make in IPO research, our results should also be of interest from a practical standpoint because they allow managers of high-tech firms that contemplate going public to better understand the effect their company's capital structure will have on the pricing of their IPO. Prior research generally suggests that – irrespective of a firm's underlying characteristics – higher financial leverage results in lower under-pricing. Our findings highlight the falsity of this generalization and point out that it only holds for low-tech firms. Firms that operate in a high-tech sector, on the other hand, will leave less money on the table if they use equity rather than debt financing.

Notes

1. There are various other explanations for IPO under-pricing that we do not discuss in this paper for the sake of brevity. For a thorough literature review see Ljungqvist (2006).
2. Consistent with these arguments, Audretsch and Lehman (2003) provide evidence that small and innovative firms are more likely to be financed by venture capitalists instead of banks. Similarly, Smith and Watts (1992), Barclay *et al.* (2001), and Frank and Goyal (2003) suggest that high-growth firms consistently use less debt in their capital structure. Tax shields can be carried forward to be realized in the future. However, uncertainty embedded in the future taxable income makes the present value of future tax savings smaller.
3. Of course, founders and/or professional managers who contemplate taking their firm public are not only concerned about how their firm's capital structure will affect the eventual under-pricing of their TPO shares. Rather, they are likely to be motivated by a variety of factors that will influence their choice of financing vehicles well before the IPO. Owners who anticipate high growth opportunities for their firm, for example, are likely motivated to retain more equity to benefit from any future appreciation of their shares. Similarly, if they believe that their firm is somewhat risky and that its cash flows may be unstable, they may wish to approach venture capitalists or private investors for additional equity financing. On the other hand, if managers believe that their firms' cash flows will be stable (and if they can convince their banks' loan officers or potential bondholders of their opinion), they are likely to issue debt. In addition, by issuing debt, managers can in many cases avoid giving up control of their firm whereas equity issues may result in a venture capitalist or private equity investor demanding an active participation in the firm's management. While these motivations are not the focus of our study, one should be aware that they are likely to differ between managers of high-tech and low-tech firms, and that they may well affect a manager's preference for debt or equity. In addition, one should be aware that what we describe as a "capital structure choice" may in fact not be a voluntary decision of a manager but the result of pure necessity. In other words, even if a manager would like to borrow, it is possible that his/her loan application gets rejected by a bank's loan officer because the firm's tangible assets are insufficient to serve as collateral or because the firm is viewed as too risky. Equity capital is in such cases the only alternative for many entrepreneurial firms.
4. The percentage of all IPOs that are included in the sample each year does not change much over the time period of this study even though the market has expanded during that timeframe. Hence, there is no indication that the cutoff size of $5 introduces a bias.
5. These sample selection criteria are consistent with previous studies by Ritter (1991) and Krigman *et al.* (1999).
6. Loughran and Ritter (2004) and Cliff *et al.* (2004) categorize firms with the following SIC codes as high-tech firms: 2833, 2834, 2835, 2836, 3571, 3572, 3575, 3577, 3578, 3661, 3663, 3669, 3674, 3812, 3823, 3825, 3826, 2827, 3829, 3841, 3845, 4812, 4813, 4899, 7370, 7371, 7372, 7373, 7374, 7375, 7377, 7378,7379.
7. Moreover, we ignore any institution that is listed as owning more than 15 percent of the shares offered in an IPO because it is extremely unlikely for any investor to receive such a large allocation in an IPO, implying that the institution probably owned these shares prior to the offering (Field and Lowry, 2004).
8. Field and Sheehan (2003) show that shares that are subject to lock-up provisions and Rule 144A restrictions are not part of the float.
9. We hand-fill gaps in SDC's coverage of company founding dates, and manually check all firms that according to SDC were zero to three years old at the time of their IPO, because Loughran and Ritter (2004) note that SDC frequently reports the most recent incorporation date rather than the founding date. A detailed discussion of some of the errors in the SDC

database can be found on Alexander Ljungqvist's web site at *http://pages.stern.nvu.edu/~aljungqvist.htm*. Furthermore, we check all remaining outliers for consistency.

10. Two hundred and twenty-six sample firms are not covered in CRSP, the we use the prices reported in SDC and verify them against news sources and the share price database on bigcharts.com.

11. Other variables that we considered for our analysis include (1) insider sales, i.e. shares sold by managers and founders as part of the IPO, (2) underwriter warrants, (3) a dummy variable that distinguishes between best efforts and firm commitment offerings, and (4) the presence of convertible debt in a firm's capital structure. High insider sales, for example, are often associated with lower firm quality and thus higher under-pricing as they suggest that managers lack confidence in the firm's future performance. Similarly, underwriter warrants may serve as an alternative measure of underwriter quality. In addition, prior research suggests that under-pricing tends to be higher for firms that use best efforts contracts because they are more speculative than firm commitment offerings. Finally, convertible debt should be differentiated from standard debt instruments because it allows creditors to acquire shares at an attractive cost basis if the offering is a success. Because none of these variables are available in SDC and because Chua (1995) notes that best effort contracts are comparatively rare in the USA, we refrained from pursuing these issues further. Future studies that employ data based on individual offering prospectuses (from which these variables could be manually collected) or a non-US dataset may likely yield additional insights in this area.

12. Many accounting figures in our dataset are right-skewed, thus we focus our discussion on medians. One of the reasons for the skewed distribution of these variables is that a number of well-established businesses went public during our sample period including, e.g. Lucent Technologies in 1996, Hertz in 1997, Fox Entertainment Group in 1998, United Parcel Service in 1999, AT&T Wireless in 2000, Kraft Foods in 2001, and Seagate Technology in 2002 (c.f., Ljungqvist and Wilhelm, 2003).

13. Expected gross proceeds are computed as the number of shares offered multiplied by the expected offer price, using the midpoint of the indicative price range in the issuer's amended or original S-1 filing if there is no amendment.

14. We use the term "expected offer price" rather than "midpoint of the amended filing price range" for brevity and to avoid a possible confusion with the midpoint of the original filing price range.

15. Specifically, when choosing an appropriate comparable firm, we first consider all firms in Compustat that are active during the fiscal year before the IPO year. From these firms, we delete firms that went public during the past three years, REITs, closed-end funds, ADRs, and firms with share prices below five dollars. To obtain a comparable firm, we first classify all remaining firms into industries based on their SIC codes obtained from CRSP as of the end of the prior calendar year. We group these firms into 48 industries using the updated industry specifications from Kenneth French's web site (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/), which are groupings of various 4-digit SIC codes, and then assign the IPO firm to its industry group. Potential matching firms in the same industry group as the TPO firm are expunged unless their revenue is between 70 percent and 130 percent of the IPO firm's revenue. From this final set, we select a match whose sales divided by gross cost is closest to that of the IPO firm (we employ sales divided by gross costs as a matching criterion to include observations with negative EBITDA). See Purnanandam and Swaminathan (2004) for similar matching routines.

16. To ensure the robustness of our results, we also performed our subsequent analysis by employing a firm's after-tax cash flow from operations instead of sales per gross costs as a matching variable and as a control variable in Table IV. Although the resulting sample size

is smaller because we can not identify a suitable match for some IPOs (particularly firms with negative after-tax cash flows from operations), our findings (not reported here for brevity and better comparability with prior IPO research) remain qualitatively and quantitatively unaffected. Using a firm's after-tax cash flow from operations is insofar interesting because (1) it represents the amount of money the firm actually has available to cover its debt obligations and (2) compared to high-tech firms, low-tech firms benefit from a greater depreciation tax shield due to their wider use of tangible assets; this shield may increase (on the firm's tax books) if certain asset revaluations take place that coincide with asset acquisitions. The authors thank an anonymous referee for pointing this issue out.

17. For firms with dual-class shares, we use their number of shares outstanding at the end of the first trading day from SDC. For instance, UPS went public on 9 November 1999, and CRSP reports it as having 109 million shares outstanding, whereas SDC reports 1,210 million shares outstanding.
18. Results are available upon request.
19. In unreported tests, we replaced the syndicate size variable with the natural log of expected gross proceeds, i.e. the number of shares offered multiplied by the expected offer price, to control for the issue size. Because larger issues are typically underwritten by larger syndicates, this also serves as an indirect measure of the syndicate size. The variable was insignificant and our other results were unaffected.
20. In particular, we use the return on the CRSP NYSE/AMEX/NASDAQ value-weighted market index during a 15-day period prior to the IPO as a proxy for market returns.

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Further reading

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Corresponding author
Kuntara Pukthuanthong-Le can be contacted at: kpukthua@mail.sdsu.edu