THE VALUATION OF BIOTECH IPOS

By

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ABSTRACT

The valuation of initial public offerings (IPOs) is of considerable interest, given the important role these enterprises play in economic growth and investors' decisions. IPO valuation is particularly challenging due to the meager information available about new enterprises at offering dates. We extend the research on IPO valuation in various directions: First, we penetrate deep beyond the traditional proxies for value drivers, like R&D expenditures and cash flows, by defining and testing a host of specific product-related and competitive environment value drivers; second, we examine IPO valuations at three distinct phases of the going-public process; third, we employ both the direct valuation and relative valuation approaches; and fourth, we round up the analysis by examining the long-term performance of IPOs. Based on a sample of biotech IPOs that went public in the 1990s, we document the overwhelming importance of product-related and intellectual property fundamentals, as well as the irrelevance of several key signals, such as venture capital backing and the quality of underwriters, which played prominent roles in previous research.

Keywords: Valuation, Biotech IPOs, Non-Financial information

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1. Introduction

The valuation of initial public offerings (IPOs) is among the most intriguing finance and accounting phenomena, befuddling both investors and academics. Despite considerable research efforts over the past quarter century, IPO valuations are still largely mysterious: What, for example, accounts for the persistent IPO underpricing—the positive difference of close to 20%, on average, between the price at the end of the first day of IPO and the beginning-of-day offer price (Ritter and Welch, 2002)? And what about the long-term underpricing of IPOs (the three-to-five-year inferior performance of IPOs relative to similar seasoned issues), which characterizes certain types of IPOs (in particular, small issues and those without backing of venture capitalists)? Is such underperformance an indication of an overvaluation of IPOs at the end of the first day? While the extensive research on these and related issues provided useful insights, it is fair to say that several important questions remain unanswered. Underlying most of the IPO pricing and performance questions is the *valuation* of IPOs by the various parties involved—venture capitalists, underwriters, and, most importantly, investors. We address this matter of valuation in the current study.

The unique challenge to the valuation of IPOs lies in the meager information about the firm and its prospects that is publicly available at the IPO date: There are generally no established histories of sales, earnings, or cash flows for the firms going public; the issuers' assets-in-place are in most cases negligible; and for high tech and biotech IPOs—the majority of offerings in the past 20 years—the primary assets are

intangibles (patents, trademarks, and alliances), which are notoriously difficult to value. Nevertheless, the valuation of IPOs is of considerable practical and theoretical importance, particularly in dynamic economies where IPOs flourish, and represent the main driver of economic growth. It is important, therefore, to gain a thorough understanding of the valuation of enterprises that are newly introduced to capital markets.[1]

Prior IPO valuation studies examined three sets of potential value drivers: (a) financial fundamentals, such as sales, earnings, and research and development (R&D) expenditures, as well as market multiples like the book-to-market ratio or price-to-EBITDA (earnings before interest, taxes, depreciation, and amortization) ratio (e.g., Kim and Ritter, 1999; Purnanandam and Swaminathan, 2004); (b) non-financial information on managerial actions taken by e-commerce Internet firms, such as acquisitions, new products, and alliances (e.g., Rajgopal, Venkatachalam, and Kotha, 2002; Bartov, Mohanram, and Seethamraju, 2002); and (c) various firm and issue attributes, such as the stake retained by pre-IPO owners, presumably signaling firm value to investors (e.g., Leland and Pyle, 1977). However, the IPO valuation research is particularly thin regarding the second category of value drivers—non-financial fundamentals—with the exception of studies on the pre-bubble dotcom IPOs (see Bhagat and Rangan (2003) for a comparison of pre- and post-bubble valuation of IPOs). And yet, given the frequently negligible earnings, cash flows, and tangible assets of most IPOs, it is highly likely that the key to understanding the valuation of IPOs lies with the non-financial fundamentals.

[1] Hand (2004) examines a related issue—the value relevance of financial and non-financial variables in the venture capital market and post-IPO public equity market, excluding the IPO stages which we analyze.

Our study aims at filling the void in IPO valuation research. To provide specificity and depth, we focus on an important segment of IPOs during the past two decades and likely in the foreseeable future—biotech companies. For these firms, the non-financial fundamentals represent primarily the intangible assets of the enterprises (patents, development programs, alliances) and *a priori* are the primary value drivers. We reach far beyond previous valuation studies, which generally attempted to capture the value of intangibles by a single *input* measure—R&D expenditures—by focusing on the intermediate and final *outputs* of the development activities of the enterprise, such as patents, the stage of product development, and the diversity of the portfolio of products developed, as well as on other intangibles, such as alliances and joint ventures. In the analysis, we of course include financial variables and IPO attributes (e.g., retained ownership) that were substantiated as value drivers by our predecessors.

There are two broad approaches in the valuation literature. According to Bhojraj and Lee (2002), the first is a direct valuation approach, in which firm value is estimated directly from its fundamentals without considering the current price of other firms. The second approach is relative valuation, in which firm value is estimated indirectly by reference to the prices of comparable firms. While previous studies focus on either direct valuation or relative valuation, our study employs both valuation methods. In our direct valuation analyses, similar to Bartov, Mohanram, and Seethamraju (2002), we focus on three IPO pricing stages—the initial (expected) offer price, the final offer price, and the aftermarket price (the price at end of first trading day). This enables us to examine the pricing impact of information available at each pricing stage, as well as the effect of information revelation across stages. We find that our product-level, non-financial

variables (number of total products, product development stage, patent and alliances) are consistent and important value drivers in all three pricing stages. In our relative valuation analyses, we calculate an IPO firm's relative valuation as the firm's value-to-asset ratio over the corresponding ratio of a comparable publicly traded biotech firm, and find that product development stage and alliance are again significant factors in determining firm's valuation across three different IPO stages. We thus extend the current research in various directions by establishing the importance of non-financial fundamentals in valuing biotech IPOs under both the direct valuation and relative valuation approaches.

Our major findings are as follows:

1. Direct Valuation

   a. Of the various financial measures we examine, such as cash flows, sales, and assets, only R&D expenditures turns out to be a consistent value driver of IPOs.

   b. Our product-level non-financial variables are consistent and important value drivers in all three pricing stages. For biotech IPOs, major drivers are the stage of product development, the number of products under development along the path from research initiation to FDA approval, and the legal protection of intellectual property by patents.

   c. Surprisingly, we find a negative association between IPO prices and the issuer's number of alliances/joint ventures. Alliances, representing the firm's network of research and marketing, are prevalent in the examined sector and are often regarded as an important value driver

in the modern economy. However, most biotech IPO alliances are made with large pharmaceutical companies. In the process, the IPO firm relinquishes equity in exchange for research and marketing support, and the estimated negative coefficient of alliances apparently reflects investors' assessment that issuers transfer too much value to alliance partners.

2. Relative Valuation

   We calculate the firm's relative valuation as the IPO firm's value-to-asset ratio over the corresponding ratio of a comparable publicly traded biotech firm. Similar to the direct valuation results, we find that the stage of product development is a significantly positive factor and alliance is a significantly negative factor in determining firms' relative valuation.

3. Price Revisions

   We also perform cross-sectional regressions on initial price adjustment and underpricing in examining how the information of non-financial fundamentals is incorporated into valuation at different IPO stages. We hypothesize that if these fundamentals are fully utilized by underwriter when setting the expected offer price, then these variables would not be predictive of subsequent price revisions. The results are supportive of our hypothesis, since the non-financial variables are not significant in general. Instead, the initial price revision is significantly affected by ownership retention, offer range width, expected offer amount, venture capital backing and market condition, while the underpricing is significantly

affected by initial price adjustment, Nasdaq market return on IPO date, and the relative valuation measure. This indicates that signaling and market condition variables are the main drivers for price revisions, as the fundamental variables are fully valued in the initial expected offer price.

4. Long-Term Performance

   Finally, our long-term (three-year) examination of IPO performance reveals the reversal of several determinants of IPO values: Patent protection lead to excessive optimism of investors, indicated by negative long-term returns, whereas alliances, which are negatively perceived by investors at the IPO stage, in fact turn out to be value creators in the long-term.

Overall, our focus on the fundamental value drivers of biotech enterprises—the pace of product development, intellectual property protection, and collaborative activities—pays off by providing a consistent and rich set of determinants of IPO values.

The organization of the paper is as follows. Section 2 describes the sample selection procedure, and Section 3 reports the summary statistics of both financial and non-financial information for our sample. Section 4 discusses the direct valuation findings, Section 5 studies relative valuation findings, Section 6 analyzes price revisions, and Section 7 presents results of the post-IPO analysis. Section 8 concludes the paper.

2. Sample Selection

The data used in this study are derived from the following sources. First, we

obtained a list of IPOs underwritten by firm-commitment contracts from the Global New Issue database (available from Thomson Financial Data Corporation) for the period 1991–2000, and we identified offerings by pharmaceutical and biotech companies (with the three-digit SIC code of 283, or the four-digit SIC code of 8731). This yields an initial sample of 343 biotech IPOs from 1991 through 2000. We exclude from the sample 63 unit offerings, American Deposit Receipts (ADRs), offerings of foreign corporations (F-1 filings), and 37 firms for which we could not locate the prospectuses. The sample is further restricted to development-stage companies for which the products under development can be classified by the various stages specified in the FDA approval process (e.g., pre-clinical tests, clinical tests, etc.). Table 1 presents the sample selection stages, yielding a final sample of 122 IPOs, and Figure 1 presents the distribution of firms over the sample period.

[Table 1 and Figure 1 about here]

Financial information on the offerings (filing price ranges, offer prices, and shares filed and sold to the public), first-day returns, venture capital backing, as well as underwriters (number and identity of book managers/co-managers) is obtained from Thomson Financial's Global New Issue database. The data are supplemented by the updated Carter and Manaster's ranking of underwriters (Carter, Dark, and Singh, 1998). These rankings are frequently unavailable for small regional bankers with limited underwriting experience; we assign a rank of zero when no underwriting ranking is available. Financial statement information (assets, revenue, EBITDA, earnings,

shareholder's equity, R&D expense, and cash flows from operation) is obtained from COMPUSTAT.[2] Finally, we rely on the IPO prospectus filed with the Securities and Exchange Commission (SEC) for non-financial data on the number of employees, the number of PhDs or MDs, the number of patents owned, the number of products under development, the development stages of each product, and information on alliance agreements.

3. Summary Statistics

3.1 Share Price and Firm Value

The pricing of IPOs is set in stages. First, underwriters establish an expected offer price range in the preliminary prospectus filed with the SEC, which we will identify as the initial price. Second, underwriters determine the actual offer price based on "book building" by soliciting feedback from investors during road shows (Benveniste and Spindt, 1989; Spatt and Srivastava, 1991). This will be termed the offer price. Finally, actual market prices are determined when IPOs start trading, culminating with the end-of-first-day (aftermarket) price.

Our examination of IPO values, accordingly, consists of values of equities at three stages: the initial offer value, calculated as the product of the initial offer price (the midpoint of the preliminary offer price range) and the expected number of shares outstanding after the IPO; the final offer value, calculated as the product of the actual offer price and the expected number of shares outstanding at the end of the first day of trading; and the aftermarket value, calculated as the product of the closing price and

[2] Missing financial information in COMPUSTAT is supplemented with data extracted directly from the prospectuses and 10K.

number of shares outstanding at the end of first day trading of the IPO.[3] We also investigate the price adjustments across stages, namely the percentage change from the initial offer price to final offer price, as well as the percentage change from final offer price to the aftermarket price. Our analysis thus focuses on the information available to the various parties involved in the IPO: initial owner and venture capitalists, underwriters, and investors.

As presented in Table 2 Panel A, the mean (median) prices per share of our sample firms were, respectively, $12.09 ($12.00) for initial offer price, $10.67 ($10.00) for the actual offer price, and $12.45 ($11.00) for the aftermarket price. The corresponding firm values for each price stage exhibited wider variation, with a mean (median) firm value of $169 ($126) million for the initial market value, $155 ($101) million for the final offer market value, and $193 ($107) million for the aftermarket value, respectively.

The share prices of biotech IPOs are, on average, adjusted downward by underwriters after the process of book building. The mean (median) price adjustment is –11% (–8%). In the aftermarket, share prices of our sample firms increased by a mean value of 13% (with a median of 4%) in the first day of trading. The first-day underpricing of our sample—mean value of 13%—is lower than that of all IPOs, which is close to 20% (Ritter and Welch, 2002). This seems surprising, since underpricing is generally attributed to information asymmetry, and such asymmetry is believed to be high for biotech companies whose major assets are intangibles. However, as is made

[3] The number of shares outstanding at the end of the IPO day is obtained from Thomson Financial's Global New Issue (GNI) database, and supplemented with information from CRSP when the entry in the GNI database is either missing or erroneous. Note that Alexander Ljungqvist and Jay Ritter have reported that Thomson Financial Securities Data has a very high error rate on the post-issue shares outstanding (see http://www.stern.nyu.edu/~aljungqv/research.htm).

clear by our analysis, biotech companies disclose extensive product-related and intellectual property information in the IPO prospectus (and during road shows), and these data apparently substantially reduce information asymmetry, as evidenced by the below-average first day underpricing.

3.2 Financial Information

Our set of financial variables includes asset (COMPUSTAT item 6), revenues (item 12), EBITDA (item 13), earnings (item 18), shareholder's equity (item 216), research and development expense (item 46), cash flows from operation (item 308), as well as sales change (calculated as the change in revenue from the prior year to the year of the IPO offering). Table 2 Panel B indicates that the mean (median) size of our sample firms is $15.55 ($11.21) million in assets, indicating the negligible physical assets of new biotech companies, and $3.33 ($1.19) million in revenues. In our sample of 122 firms, 31 firms (25%) did not record any revenue, and 26 firms (21%) reported revenue less than $1 million in the year prior to IPO. The percentage of firms generating positive earnings is a meager 5% (6 out of 122 firms), with mean (median) earnings of –$7.34 (–$5.93) million. Similarly, only 3% (4 out of 122 firms) of firms have positive EBITDA, with mean (median) EBITDA of –$6.82 (–$5.45) million. In addition, 89% (108 out of 122 firms) of our sample firms have negative cash flows, with a mean (median) of –$5.12 (–$4.20) million. Research and development expense constitutes the major use of cash for our sample firms, as well as the major reason for the negative earnings, with a mean (median) annual R&D expenditure of $7.5 ($5.84) million. The mean (median) equity

value, is $10.06 ($6.97) million, and the mean (median) sales change is $1.56 ($0.18) million.

As most biotech firms have no positive earnings and negligible revenues at the time of IPO, accounting data might not be particularly informative. This lack of information is exacerbated by the fact the current accounting reports are poorly equipped to recognize and measure intangible assets, except for the reporting of total R&D expenditures.

[Table 2 about here]

3.3 Non-Financial Information

Previous studies have documented the utility of industry-specific non-financial measures in the valuation of emerging companies. Amir and Lev (1996) report that non-financial indicators, such as population size and market penetration, are highly value relevant for cellular phone companies. Similarly, Trueman, Wong, and Zhang (2000) and Demers and Lev (2001) report that Web traffic measures are value-relevant in determining the share prices of Internet companies. Bartov, Mohanram, and Seethamraju (2002) document that IPO valuations are significantly different between Internet and non-Internet companies, as well as across the IPO stages. Rajgopal, Venkatachalam, and Kotha (2002) find that investors appear to supplement the relatively meager accounting information with data on post-IPO managerial actions in setting stock prices of business-to-business (B2B) Internet firms. While most recent valuation studies focus on internet

or software companies, we extend the analysis to the large and fast growing biotech sector. Our set of non-financial value drivers consists of the following:

3.3.1 Pipeline of products under development: We use the following variables to capture various dimensions of the all-important product pipeline of the firm (see Table 2 Panel C):

1. Number of products: We identify all the products disclosed in the prospectus for each of our sample firms. The sample firms have mean and median of eight products in various stage of developments. Other things equal, the larger the number of products under development, the more diversified and less risky is the firm.
2. Number of patents owned: Patents provide the major protection for ownership of intellectual property. We identify all the patents owned by each sample firm from the prospectuses. The sample firms were granted a mean (median) of 7.46 (5.0) patents prior to their IPO offerings. Relative to products, our firms have a mean of 4.48 patented products under development, amounting to 60% of total products under development.
3. Product development stage: The development and approval process of a new pharmaceutical product can take more than a decade (Lerner, 2000). Once a chemical compound is identified as a potential candidate for treating a certain medical condition, preclinical testing begins, comprising chemical and animal studies, to assess safety and possible biological effects. Compounds with positive results from the preclinical trials that are accepted by the FDA are designated as "investigational new drugs" (INDs) for clinical testing in

humans. There are three phases in the clinical testing process. In Phase-I (safety) trials are primarily designed to determine the safety and pharmacological properties of the compound. Phase-II (efficacy) trials are designed to evaluate the effectiveness of the drug and to identify side effects. Phase-III trials are conducted on a large number of patients (sometimes in thousands) over several years in order to assess the long-term side effects of the drug and provide additional information on the effectiveness of the treatment. Upon the completion of Phase-III trials, firms are required to file a "new drug application" (NDA) for final review by the FDA. For each NDA, a special advisory committee is created that makes the final recommendation on whether the drug should be released for commercial sale or rejected.

We construct our development-stage indicator by adopting a procedure used in Guo, Lev, and Zhou (2004). The stage score for a given product is set equal to the total (expected) number of years spent, on average, to reach each development stage. Accordingly, a numerical variable with a value of 1, 2, 3, 4, 5, 7, 10, and 12 is assigned for products in the stage of screening, development, preclinical testing, IND application, Phase-I clinical trials, Phase-II clinical trials, Phase-III clinical trials, and NDA application, respectively. When a product has received FDA approval, it is also given a score of 12. For each firm with multiple products, we compute the "average development stage" as the mean development stage of all of its products (pipeline). As seen in Table 2 Panel C, the mean development stage of the sample firms' product is 3.87 years (median 3.58), which is close to Phase-I

clinical trials. Thus, most of the products under development of the sample firms are in a relatively early stage of development.

4. Number of alliance agreements: We record the number of alliance agreements, including strategic alliances, joint ventures, licensing agreements, R&D collaborations, as well as marketing/distribution, manufacturing, and supply alliance agreements. Alliance agreements might be value-relevant because they generally contribute research capabilities or capital from partners; furthermore, they often carry a positive signal about the future market potential of the product under development. In our sample, firms report a mean value of 2.22 alliance agreements. However, substantial equity is often relinquished to partners when biotech alliances are made with big pharmaceutical companies. This might have a negative effect on IPO valuation. In our sample, a mean of 2.77 products per firm are covered by the alliance agreements, and 1.84 products per firm are reported with commercial rights assigned to alliance partners, amounting to 22% of total products under development.

3.3.2 Financial Intermediaries: Previous research documents that participation by venture capitalists (Barry, Muscarella, Peavy, and Vetsuypens, 1990; Megginson and Weiss, 1991), as well as offerings underwritten by a highly ranked bankers (Beatty and Ritter, 1986; Carter and Manaster, 1990; Carter, Dark, and Singh, 1998), signal issue quality and therefore lead to favorable valuation by the capital market (reducing the perceived uncertainty about firm value). Our variable Venture Capital Backing is an

indicator with the value of 1 for an issue backed by venture capitalists, and 0 otherwise. Underwriter ranking is a discrete reputation measure ranging from 0 to 9, which was proposed by Carter and Manaster (1990), where a 9 (0) represents the most (least) prestigious underwriter. On average, 91% of the sample firms are backed by venture capitalists and the mean underwriter ranking is 8.75.

3.3.3 Ownership Retention: Grinblatt and Hwang (1989) report that high-quality IPOs differentiate themselves from those with low quality by retaining a higher portion of the firms' shares after IPO. The percentage of shares retained by firm insiders can serve as a signal for firm quality and thereby affect firm value. The variable Ownership Retention is the percentage of ownership retained by the pre-IPO shareholders after offerings. On average, pre-IPO owners retain 74% of ownership.

3.3.4 Market Condition: Kim and Ritter (1999) report that comparable firm multiples (e.g., book-to-market) are related to IPO valuation. Thus, valuation of IPOs could be more favorable when firms within the same industry are traded at high price levels. To capture market conditions, we construct the variable Market Condition by calculating the cumulative return of the value-weighted index of seasoned firms in the pharmaceutical and biotech industry in the six-month period prior to the IPO.[4] The mean six-month cumulative return is 15% (Table 2 Panel C), indicating that the sample IPOs chose to go public when market conditions were favorable. This is consistent with

[4] This value-weighted index includes firms in the three-digit SIC code 283, and the four-digit SIC code 8731, calculated using CRSP monthly returns. Results remain unchanged when Market Condition is measured over a 3- or 12-month period prior to the IPO.

Lerner (1994), who finds that the market condition is the primary factor in firms' decision to go public.

4. Direct Valuation of IPOs

4.1. Main Analyses

Considering that the variables for biotech IPO firms are highly skewed, we scale our variables by total assets when feasible and use the deflated data in our OLS regressions so as to control for heteroscedasticity.[5] We use total assets as the deflator because 25 percent (31 out of 122) of our sample firms have zero sales, 16 percent (19 out of 122) have negative book value of equity, and 95 percent (116 out of 122) have negative earnings. Table 3 presents the correlations among the variables (scaled by total assets) used in the study. Of the financial variables examined, cash flows, R&D expenditures and sales change are correlated with the IPO prices in each of the three stages (cash flow is negatively correlated, though). The product-level fundamentals—total number of products, stage of development, and patent protection—are all correlated with IPO prices. The number of products with assigned commercial rights is negatively correlated with prices, providing an initial indication that excessive rights are relinquished to alliance partners. Venture capital backing and underwriter quality are negatively related to prices, which runs counter to established results in the finance literature. These correlations, however, vanish in the regression analysis.

[5] We test heteroscedasticity for all models in Tables 4 through 9. Out of 19 models from these 6 tables, only two models have significant Chi-square statistics, one at the five-percent level and the other at the ten-percent level. We then calculate White (1980) heteroscedasticity consistent t-statistics for these two models, and find that the results remain unchanged.

[Table 3 about here]

Our main regressions results are presented in Tables 4, 5 and 6. To present our results in a clear manner, we classify our regression variables into the following three groups.

Group 1 – Financial variables: cash flow from operations, R&D expenses, sales change.

Group 2 – Signaling and market condition variables: ownership retention, venture capital backing, underwriter ranking, and market condition.

Group 3 – Fundamental non-financial variables: number of products, average development stage of pipeline, patent, and alliance.

Our valuation analyses are now conducted uniformly with the following three specifications: In Tables 4, 5 and 6, Model 1 reports results using Group 1 variables, Model 2 reports results using Groups 1 and 2 variables, and Model 3 reports results using Groups 1, 2 and 3 variables.

Table 4 presents various regression estimates of the first IPO price stage—the initial offer market value—regressed on combinations of financial and non-financial variables. Model 1 includes the main financial variables that were found significant in previous valuation studies. R&D expenditures—a major value driver of intangible assets—is highly significant. Cash flows is significant as well, but with a negative coefficient, reflecting the heavy investment in intangibles (R&D, customer relations)

made by biotech IPOs (note the negative correlation coefficient (–0.90) between R&D and cash flows in Table 3). Sales change is marginally positive.[6] Model 2 adds the variables of ownership retention ratio, venture capital backing, underwriter ranking, and market conditions to the regression. There is a slight decrease in adjusted R^2 which is negligible, seeming to suggest that ownership retention and market conditions are not significant value drives in the initial pricing stage. However, when the fundamentals are added to these variables in Model 3, ownership retention and market condition become significant. The added product-related fundamental variables—number of products, development stage, patents, and alliances—are highly statistically significant (at ≤5%), adding 16% to the R^2 value and yielding an adjusted-R^2 for Model 3 of 82.7%. This indicates the importance of non-financial variables in the valuation of IPOs at the initial offer stage. Notably, previous valuation studies using seasoned biotech firms (e.g., Hand, 2003) proxied for the intangible fundamentals by R&D expenditures. Our results indicate that R&D—an input measure—is only a partial indicator of value. An improved characterization of valuation can be achieved by measures that indicate the *output* of the R&D process: number of products under development, stage of product development, and patent protection (intellectual property).

[Table 4 about here]

[6] Out of 122 sample firms, the growth rate in sales is undefined for nine firms, which have positive sales in the IPO year, but zero sales in the year prior to the IPO. Because of this sample attrition issue, we use sales change deflated by total assets instead. Results are qualitatively similar to those reported in the paper for regression analysis based on growth rate in sales on a subsample of 113 firms.

Interestingly, ownership retention and market conditions at the time of IPO become significantly positive when combined with the non-financial variables, suggesting that IPO value increases when a firm retains more shares (as suggested by signaling theory), and when the IPO is conducted in a favorable market environment. Note that the cash flow variable becomes insignificant in the full models (Model 3). Thus, when both R&D and its consequences (products and patents) are fully accounted for, the counterintuitive negative coefficient of cash flows vanishes.

The variables representing venture capital backing and the Carter–Manaster underwriter ranking are both found to be insignificant. Other researches have previously found these variables to be positively and significantly associated with the quality of corporate governance, innovation activities, and operating efficiency of IPOs. Our findings indicate that at the initial stage of IPO pricing—where the value is set by owners and venture capitalists—the existence of venture capitalists, and the quality underwriters contribute little to valuation. Summarizing, estimates in Table 4 indicate that the initial pricing of biotech IPOs is almost fully determined (R^2 of 83%) by intangible assets: R&D expenditures and output indicators, which comprise the number of products under development, the stage of product development, and the legal protection (patents) of the products.

Tables 5 and 6 report the regressions of the market values at the final offer stage and the end-of-first-day IPO stage on financial and non-financial variables.[7] These prices reflect an increasing role of investors in setting prices: the reaction of prospective investors during road-shows affecting the final offer price, and the actual first day trading

[7] We remove one outlier for regressions in Tables 4 and 5, and two outliers for regressions in Table 6 based on standard SAS procedure.

affecting the aftermarket price. Note the decrease in adjusted R^2 as we move from explaining the initial price (Model 3, R^2 = 82.7%, Table 4), through the actual offer price (R^2 = 74.1%, Table 5), to the aftermarket price (R^2 = 59.7%, Table 6). Thus, the initial price for owners and VCs is primarily based on product development fundamentals, whereas subsequent prices, affected by investors, reflect various other factors and noise, which are unrelated to fundamentals. Nevertheless, in both Tables 5 and 6, the intangibles input (R&D) and output indicators are all highly significant and jointly explain more than half of the cross-sectional variability of IPO prices.

Investors appear to value patent protection more highly than do entrepreneurs/venture capitalists. The coefficient of this variable in Tables 5 and 6 is larger than that in Table 4. In the long-term analysis, (Section 7) we will see that those high valuations are excessive.

The consistent negative coefficients of alliances—both the percentage of products with alliances and the percentage of products with rights assigned to others—seem puzzling. The networking activities of firms, and in particular the development and marketing of products in alliance with other entities, were hailed in recent years as among the most important strategic developments of modern business. Our estimates, however, consistently indicate that alliances are considered by investors as value-reducing, other things being equal. A possible explanation is that investors perceive the ownership rights relinquished to alliance partners, mostly large pharmaceutical firms, as excessive relative to the benefits gained. Start-ups often negotiate alliance/joint venture terms with established companies from a position of weakness, and investors apparently assess that undue value and rights are given away. Since the coefficient on alliances are negative,

we believe that this suggest that the market views alliances as selling valuable equity in potential products, and thus reacts negatively.[8] To verify our explanation, we look into the contractual details of those alliance agreements, and find that there are a substantial number of firms who assign the commercial rights to their alliance partners. Thus, we create a new variable called Percentage of Products with Commercial Rights Assigned to Alliance Partners, and replace in the alliance variable in our regressions. As we predict, the coefficients on this variable are significantly negative (*t = –2.30* for the initial offer stage; *t = –2.01* for the final offer stage, *t = –2.25* for the aftermarket stage), indicating that the market indeed reacts negatively to the selling alliance agreements. In addition, we find that some firms reacquire the commercial rights of their products from their alliance partners several years after the IPO, further supporting our hypothesis. For example, AtheroGenics, which went public on August 9, 2000, disclosed the following in its 10K filing dated December 31, 2003.

> *In October 1999, we entered into a worldwide exclusive license agreement with Schering-Plough. Under the agreement we granted to Schering-Plough an exclusive license under our patents and know-how to make, use and sell AGI-1067 and other specified compounds for the treatment of restenosis, coronary artery disease and artherosclerosis. Schering-Plough paid us an initial nonrefundable licensing fee of $5,000,000 upon signing the agreement and, pursuant to the terms of the agreement, had assumed responsibility for all costs going forward associated with the development, manufacturing and commercialization of products containing AGI-1067 and any other licensed compound.*
>
> *In October 2001, we reacquired the rights to AGI-1067 and related technology and terminated the exclusive license agreement between us and Schering-Plough to permit us to expedite the development of the compound. With the termination of this license agreement, Schering-Plough has no further rights to the technology or financial obligations to us.*

[8] In the long-term analysis presented in Section 7, we will return to this issue with surprising results.

Finally, coefficients of venture capital backing and underwriters' quality remain insignificant in Tables 5 and 6.[9] It appears that in our sample where considerable information about the firms' intangible assets—and, most importantly, where their product development process is imparted to capital markets—noisy value proxies such as venture capital backing and underwriter quality become redundant. This is yet another indication of the importance to investors of information disclosure about the strategic fundamentals of the firm.

[Table 5 and Table 6 about here]

4.2 Additional Tests

4.2.1 Value-to-Sales Ratio

While value-to-sales, value-to-EBIDTA or value-to-earnings ratios are popular metrics in valuation studies (e.g. Purnanandam and Swaminathan, 2004), we use value-to-asset ratio as our main dependent variable because other metrics would cause severe attrition for our sample of biotech IPOs. Out of 122 firms in our sample, we find that 31 firms have zero sales, with another 26 firms have sales less than $1 million. In addition, 118 firms (97%) have negative EBITDA, and 116 firms (95%) have negative earnings.

The lack of direct application of conventional valuation metrics to our sample speaks to the challenge of valuing biotech/biotech IPOs. As the majority of our sample firms have no (positive) earnings and their business generates meager revenue at the time of the offering, most of our sample firms are therefore not included in previous valuation

[9] We scale the underwriter ranking variable by nine, the maximum underwriting ranking score. We also scale Underwriter Ranking by total assets, and find similar results to those reported in Tables 4, 5 and 6.

research on IPOs (Kim and Ritter, 1999; Purnanandam and Swaminathan, 2004). The results of our study present an alternative valuation approach to these IPOs.

For a subsample of 65 firms with at least $1 million in sales, we ran regressions using the value-to-sales ratio as the dependent variable, and scaled Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline by sales. Our results are similar to those reported in Tables 4, 5, and 6. The Average Development Stage of Pipeline is significantly positive (≤ 5% or better) at all three stages, and Percentage of Products with Alliances is significantly negative (*t = - 1.79*) at the final offer stage. However, due to severe attrition of sample size after excluding firms with zero/minimal sales, Number of Total Products and Percentage of Products with Patents are no longer significant.

4.2.2 Insider Presence

We also consider the insider presence at the time of IPO as an alternative to the signaling variable ownership retention ratio. We hand-collect this information on insider ownership (shares beneficially owned by all directors and executive officer as a group before the IPO and expected to be owned by these people after the IPO) from the prospectuses for all our sample firms. The mean (median) insider ownership is 50.5% (51.3%) before the IPO, and 37.6% (38.4%) after the IPO. We replace ownership retention with the insider ownership after the IPO in Model 3 of Tables 4, 5, and 6 and find our results are similar to those use ownership retention with one exception. The sign on the insider variable are now negative, insignificant for the initial offer stage (*t = -1.05*) and final offer stage (*t = -0.71*), and significant for the 1st day aftermarket stage (*t* = -

1.94). Findings are similar when we replace the ownership retention with the insider ownership prior to the IPO. The correlation between the insider presence prior to IPO and the ownership retention is significantly negative (ρ = -0.25, significant at the 1% level). This indicates that firms with a stronger insider presence are more likely to retain fewer shares. Our results suggest that the market considers a strong insider presence as being detrimental to shareholders' wealth.[10] When we run regressions with both ownership retention and insider ownership after the IPO (or prior to the IPO), our results are very similar to those reported in the tables. While the ownership retention variable is significantly positive at all three stages, the insider variable is negative but insignificant in all three stages.

5. Relative Valuation of IPOs

Since the IPO dates of our sample firms are spread from 1991 to 2000, the industry multiples may change considerably during this ten-year period. To remove this time effect, we choose a comparable biotech firm at the time of an IPO as a reference. We now use the ratio between the IPO firm's multiple and the comparable firm's multiple as a dependent variable to test the effect of non-financial fundamentals on this relative valuation measure.

Kim and Ritter (1999) and Purnanandam and Swaminathan (2004) report results on valuation of IPO firms using comparable firm multiples.[11] These two studies, however, differ slightly on the procedure of selecting a comparable firm. While Kim and

[10] Darrough and Rangan (2005) find when the insiders plan to sell their pre-offering shareholdings in an IPO, the firm tends to spend less in R&D to increase current earnings at the expense of future earnings.
[11] Liu, Nissim, and Thomas (2002) and Bhojraj and Lee (2002) study the relative valuations of mature firms.

Ritter use recent IPOs (those went public no more than 12 months prior to the offer date of the candidate IPO) in the same industry as comparable firms, Purnanandam and Swaminathan use selected publicly traded firms in the same industry as comparable firms. Procedure used by Kim and Ritter is not applicable in our study (we will be redrawing many of our sample IPOs as comparable firms). Therefore, we use a procedure similar to that used in Purnanandam and Swaminathan, as described in the following:

(1) For a given IPO year, we consider biotech firms (with SIC codes of 283x and 8731) which are covered in Compustat in the prior fiscal year. We exclude firms that went public during the past three years, and non-ordinary common shares, close-end funds, and ADRs.

(2) Remaining firms are sorted into three portfolios by total assets, and then each asset portfolio is sorted into three portfolios by EBITDA. As a result, we have 9 (3x3) portfolios of comparable firms in each year.

(3) Each sample IPO firm is matched with a portfolio of comparable firms based on total assets and EBITDA. In that portfolio, one firm with the closest total assets and the same (positive/negative) sign of EBITA is selected as the "comparable firm". In some cases, the matching firms are repeated as there are only a few firms that meet the criteria.

Table 2 Panel B provides summary statistics for our sample firms and matching firms. While the mean (median) total assets for sample firms is $15.55 million ($11.21 million), the mean (median) total assets for matching firms is $18.71 million ($10.98

million). While the mean (median) EBITDA for sample firms is $–6.82 million ($–5.45 million), the mean (median) EBITDA for matching firms is $–6.37 million ($–5.60 million). The sample firms and matching firms obviously share similar characteristics in term of total assets and EBITDA because our selecting procedure for matching firms is based on these two variables.

The relative valuation measure, P/V ratio, is calculated as the ratio between the IPO firm's value-to-asset ratio (P or price) and the corresponding value-to-asset ratio of the comparable firm (V or intrinsic value). Specifically, the Initial Offer P/V, Final Offer P/V, and Aftermarket P/V ratio are the firm's value-to-assets ratios at the initial offer, final offer and aftermarket stages divided by the corresponding value-to-asset ratio of the matching biotech firm. Table 2 Panel A presents summary statistics on P/V ratios at different stages. The median P/V ratios are 1.87, 1.59, and 1.92 at the initial offer, final offer and aftermarket stages. They are significantly different from 1 at the one-percent level, suggesting that biotech IPOs are consistently overvalued.

We use the P/V ratios at three different stages as dependent variables in Table 7 to examine their correlation with the non-financial variables. As our results in Table 7 indicate, our findings on relative valuation analyses are consistent with those on direct valuation analyses reported in Tables 4, 5 and 6.[12] Sales change, ownership retention, stage of product development and alliance are significant at all three stages, and market condition is significant at the final offer stage and aftermarket stage but marginal at the initial offer stage. Comparing with the direct valuation analyses in Tables 4, 5 and 6, we

[12] We exclude two outliers based on standard SAS procedure when run regressions for Table 7.

find that ownership retention, stage of product development, and alliance are important value drivers in determining the firm's absolute value and relative value.

[Table 7 about here]

6. Price Revisions

We now conduct the analysis on price revisions across three IPO stages (initial price adjustment and underpricing) to gauge whether there is any *differential* effect of non-financial variables on IPO valuation at the pre-offer, final offer, and aftermarket stages. If the results on price revisions indicate that non-financial variables are not significant in explaining the change in valuation, then it suggests that the underwriters and investors have fully priced these non-financial fundamentals in the pre-offer, final offer and aftermarket stages.

We first investigate the initial price adjustment, namely the difference between the final offer price and the initial price, divided by the initial offer price. From Table 2 Panel A, we learn that the mean (median) initial adjustment is –11% (–8%). Benveniste and Spindt (1989) argue that firms that have greater uncertainty surrounding the true value of the shares are more likely to revise their offer price. Consistent with Hanley (1993), we include the percentage width of offer range and the expected initial offer size as measures of ex ante risk in our initial price adjustment regressions. Following Purnanandam and Swaminathan (2004), we also control for size, and book-to-market

ratio. Size is measured as the log of total assets,[13] and book-to-market ratio is calculated as the book value of equity (data60) for the fiscal year after the IPO date over the market value of equity at the close of the first trading day.

Table 8 reports the regression estimates of the initial price adjustment on financial and non-financial variables, indicating that book-to-market, ownership retention, venture capital backing, offer range width, initial offer size, and market condition are significant. Book-to-market ratio is negatively significant because the first-day closing market capitalization will introduce a negative correlation between initial price revision and book-to-market ratio.[14] The significant negative coefficients on ownership retention and venture capital backing indicate that the firms tend to experience a small revision in offer prices between the initial offer and final offer stages when the firms' pre-IPO owners retain more shares or the firms have the guidance from the venture capitalists. The coefficients on offer range width and initial offer size are significantly positive. This is similar to Hanley (1993), who finds the coefficient on offer range width to be significantly positive and the coefficient on initial offer size to be marginally positive (t = 1.50). Underwriters are likely to set a wider offer range at the initial offer stage so as to provide flexibility in determining final offer price when they are not very certain of the true issue price. Thus, wider offer range width tends to lead to larger initial price revision. Since large initial offers are more likely to attract investors' attention, those firms with large initial offer sizes are also more likely to experience favorable initial price

[13] We also conduct analysis using log(1+Sales) as the size variable and find similar results. Note that log(1+Sales) is used because 31 firms have zero sales.

[14] Initial price revision and book-to-market ratio are indeed negatively correlated (p = - 0.18, significant at the 10% level). Purnanandam and Swaminathan (2004) argue that first-day return and book-to-market ratio are negatively correlated because closing price is used in calculating both variables. While closing price is not used in calculating initial price revision, initial price revision and book-to-market ratio are negatively correlated because initial price revision and first-day return are positively correlated (p = 0.40, significant at the 1% level).

revisions. Finally, our results suggest that underwriters often adjust the price between the initial and final offer primarily based on the prevailing market conditions.

[Table 8 about here]

The second price adjustment—from the final offer to the end-of-first-day price—which in fact is the widely studied IPO underpricing phenomenon, is examined in Table 9.[15] Table 2 Panel A indicates that the mean (median) underpricing is 13% (4%). To account for the "partial adjustment" phenomenon, [16] namely that underpricing is positively associated with prior revision in offer prices, (Ibbotson, Sindelar, and Ritter, 1988; Hanley, 1993) we include the initial price adjustment as an independent variable to our underpricing regressions. Purnanandam and Swaminathan (2004) document that "overvalued" (high P/V ratio) IPOs provide high first-day returns, and thus we add the final offer P/V ratio to our regression in Model 4. Because underpricing is the price revision on the IPO day, we use the Nasdaq market return on the IPO day to measure the market condition. We again control for offer size, size and book-to-market.

Table 9 estimates indicate that the book-to-market ratio, initial price adjustment, the Nasdaq market return on the IPO day, and the final offer P/V ratio are highly significant. Again, book-to-market ratio is negatively significant because underpricing and book-to-market ratio are negatively correlated as closing price is used to calculate

[15] We remove one outlier based on standard SAS procedure when running regressions for Table 9.
[16] Benveniste and Spindt (1989) provide a theoretical explanation for the "partial adjustment" phenomenon. They argue that strong demand for share (revealing good information) will lead to share rationing, and thus underwriters may not be able to fully reward investors for their truthful revelations. With shares rationing, the offer price will only partially adjust to good information, and underwriter will use underpricing, along with increased share allocation to compensate investors for revealing their information. Therefore, underpricing is positively related to prior revision in offer prices.

underpricing and book-to-market ratio.[17] Our sample of biotech IPOs also experience the "partial adjustment" phenomenon, as the underpricing is larger when the firm experiences a larger initial price adjustment. Not unexpectedly, the underpricing is positively related to the Nasdaq return during the IPO day. Since all our sample firms are traded on Nasdaq, the momentum on that market will cause the share prices of the IPO firm to rise as well, and thus lead to a larger underpricing. Consistent with Purnanandam and Swaminathan (2004), we also find that "overvalued" (high P/V ratio) IPOs tend to have high first-day returns. In addition, the underpricing is somewhat larger when pre-IPO owners retain a larger percentage of shares, probably because ownership retention signals the positive quality of the IPO, thereby creating a strong first-day demand by investors and in turn causing the share prices to rise. Finally, estimates in Table 9 imply that firms with venture capital backing and/or firms with more prestigious underwriters experience diminished underpricing. Since underpricing generally reflects the information asymmetry surrounding the IPO, these estimates suggest that venture capital and underwriters' quality reduce information asymmetry during the first trading day (Megginson and Weiss, 1991; Beatty and Ritter, 1986; Carter and Manaster, 1990).

[Table 9 about here]

The results in Tables 4, 5 and 6 indicate that the non-financial fundamentals are important drivers in valuing biotech firms at various IPO stages, and now the results in Tables 8 and 9 further suggest these fundamentals are fully incorporated in the expected

[17] Underpricing and book-to-market ratio are negatively correlated (p = - 0.31, significant at the 1% level).

offer prices, since the non-financial variables, other than Alliance in Model 3 of Table 8 (*t=1.67*), are not significant in Tables 8 and 9 regressions. Instead, the initial price revision is significantly affected by ownership retention, offer range width, expected initial offer size, venture capital backing and market condition, and the underpricing is significantly affected by initial price adjustment, Nasdaq market return on IPO date, and the relative valuation measure final offer P/V ratio. This indicates that signaling and market condition variables are the main drivers for price revisions, as the fundamental variables are fully priced at various IPO pricing stages. Our results on these signaling and market condition variables are consistent with Hanley (1993), and that on the relative valuation measure is consistent Purnanandam and Swaminathan (2004). We believe that this strengthens our analyses, and provides extra support to our hypothesis that fundamentals are efficiently priced at the initial offer, final offer and 1st day aftermarket stages as shown in Tables 4, 5 and 6.

Loughran and Ritter (2004) find that the levels of underpricing are extremely different between the pre-internet bubble period (before 1998) and the internet bubble period (1999-2000). Following their paper, we divide our sample into two subsamples: the pre-bubble period (1991-1998) subsample with 96 firms, and the bubble period (1999-2000) subsample with 26 firms. We perform underpricing regressions for the pre-bubble period (1991-1998) sub-sample. The regression results are qualitatively similar to those for the full sample. Book-to-market ratio (t= −1.89), Nasdaq market return on IPO date (t = 2.39) and final offer P/V ratio (t = 1.82) are still significant, and the initial price adjustment is marginal (t = 1.53). Again, none of the non-financial variables is

significant. We are unable to perform similar analyses for the bubble period (1999-2000) subsample, as there are only 26 firms.

7. Post-Issuance IPO Performance

We have identified above the major determinants of IPO values. This leaves open the question whether the aftermarket prices are efficient, fully reflecting the information about the subsequent performance of IPOs available at the IPO date. This is an important question for resource allocation in capital markets, particularly given mixed evidence about the long-term performance of IPOs (e.g., Loughran and Ritter, 1995; Brav and Gompers, 1997; Brav, Geczy, and Gompers, 2000). Accordingly, we now examine the three-year performance of our sample IPOs.

Specifically, using the monthly data from CRSP, Nasdaq, and the Amex-NYSE, we record the returns of the sample IPO firms from the beginning of the second month dated from the month of the IPO until the earliest of its month of delisting, the 37th month after offering, or December 2002 (the end of our return data). A 36-month buy-and-hold abnormal return measure (BHAR) is calculated by compounding the monthly returns in excess of a matched portfolio returns:

$$\text{BHAR}_i = \left[\prod_{t=2}^{\min[37,\text{delist}]} (1 + r_{it}) - \prod_{t=2}^{\min[37,\text{delist}]} (1 + mr_{it}) \right],$$

where the index t takes on the value 1 at the month of IPO offering, and min[37,delist] is the earliest of the 37th month, the month of delisting, or December 2003. The variable r_{it} is the return for sample firm i in month t, and mr_{it} is the contemporaneous return

generated by the matched portfolio. We construct the matched size and book-to-market portfolio using the following procedure: Starting in January 1990, we form size quintile breakpoints using NYSE firms (Fama and French, 1992). Market value is obtained from CRSP as the number of shares outstanding multiplied by the stock price at the end of December of the preceding year, while book value is obtained from the annual COMPUSTAT file (data item 60). We create book-to-market quintiles using NYSE firms, and then form 25 size and book-to-market portfolios by intersecting the portfolios and allocating all NYSE, Amex, and Nasdaq firms (excluding our IPO firms) to be included in these portfolios. Such benchmark portfolios are reformed for each year. An equally weighted return of all firms in a given portfolio is calculated and used as the benchmark return. For the IPO firms, we calculate the market value of equity on the date of issuance. The book-to-market ratio of the IPO year is the value obtained by dividing per share book value of equity after the offering (available from the Global New Issue database) by the aftermarket closing price.

In Table 10 we present sample mean values of BHAR on our full sample of biotech IPOs, as well as subsamples of IPO firms with above- (high) and below- (low) median value in variables of market condition, development stage (scaled by total asset value), number of products (scaled by total asset value), percentage of products with patents, percentage of products with alliances, and underwriter ranking. Based on the buy-and-hold measure, the IPO sample underperformed the matched portfolio by 14.32%, but this excess return is not statistically different from zero. These results are consistent with Brav, Geczy, and Gompers (2000), who report that the documented IPO underperformance in the long-run vanishes when the returns are adjusted by size and

book-to-market ratio.

[Table 10 about here]

On a univariate basis, we next examine the differential performance of the sample IPOs grouped by the various value drivers established above: market conditions, development stage, number of products, percentage of products with patents, percentage of products with alliances, and VC backing. Sample IPOs with above- and below-median values of the variables examined are classified into corresponding high and low subsamples. Results presented in Table 10 indicate that IPOs issued when the market conditions were favorable perform poorly in the subsequent 36 months of trading according (with marginal significance). This implies a certain excessive optimism by investors. The results also show that IPOs rich in patents underperform in the long run (BHAR measure), as do IPOs with a below-median number of alliances. The latter two findings jointly suggest that investors' negative reaction to alliances during the IPO, apparently reflecting concerns with excessive rights relinquished to alliance partners, might have been exaggerated. As the benefits of alliances (higher revenues and earnings) become clear over time, investors revise the early valuations to reflect the contribution of alliances.

[Table 11 about here]

We examine the association between the long-term abnormal returns of IPOs in a

multivariate cross-sectional regression. First, we examine the distribution of the buy-and-hold abnormal returns (BHAR). We exclude one extreme outlier of the BHAR observation from our return analysis. Second, we perform the log BHAR regression (with detailed formulation as specified in Purnanandam and Swaminathan (2004)). The results are very similar to the BHAR regressions, as tabulated in Table 11. As the estimates of Table 11 indicate, the results suggest overreaction at IPO to patent information, a factor with positive coefficients in the models of Tables 4–6, but a negative coefficient in Table 11. Finally, note the positive and significant coefficient in Table 11 of "percentage of products with alliances." Recall the consistent negative coefficients of alliances in the pricing regressions (Tables 4–6). The positive alliances coefficients in Table 11 suggest that investors' concerns about relinquishing too much equity to alliance partners might be excessive. Developing products with alliance or joint venture partners appears to pay in the long-run after all.

[Table 12 about here]

In Table 12, we calculate the risk-adjusted returns --- these adjusted returns are the intercept terms by regressing each sample firm's monthly return in excess of one month T-bill rate on the Fama and French factors in the period of the 2nd to 37th months (or to the month of delisting) subsequent to the month of IPO issuance. We then perform the regression analysis with those risk-adjusted returns on our non-financial variables. As indicated in Table 12, the results are very similar to those with the BHAR analysis. The variable of Percentage of Products with Patents continues to be negatively correlated

with the subsequent returns, while the variable of the Percentage of Products with Alliances positively correlates with post-IPO risk-adjusted returns.

8. Conclusions

In this study, we use both the direct valuation and relative valuation approaches to examine the factors that determine the valuation of biotech IPOs at three pricing stages. We use a rich information set of value drivers that consist of both financial and non-financial variables. In direct valuation analyses, R&D expenditures are consistently relevant to the pricing of our sample IPOs, whereas operating cash flow and sales change are significant in some models.[18] The value-relevant non-financial variables are the output measures of the product development process, comprising the number of products under development, the stage of product development, and the legal protection of intellectual property by patents, as well as the alliance with other biotech companies. Of the traditional IPO signals, which were found to be relevant in previous studies—ownership retention, venture capital backing, and quality of underwriters—only the former (ownership retention) is consistently associated with IPO pricing. Apparently having the fundamental, product-related indicators in the valuation model obviates the utility of indirect value signals. The capital market climate prior at IPO is relevant in all three stages. In the relative valuation analysis, the stage of product development, alliances, and ownership retention continue to be significant factors in determining relative values of biotech IPOs.

In addition, we also consider the long-term post-IPO performance of these firms.

[18] This is consistent with Hand (2003) who notes that as firms mature, the value-relevance of financial variables increases.

The long-term (three-year) performance of IPOs suggests that investors' general optimism at time of IPO (positive capital market climate) can be somewhat excessive, along with the positive reaction to patent protection. Interestingly, investors concerns with alliances at the various IPO stages is also excessive, since the alliances variable has a positive and significant coefficient in the long-term regressions.

Overall our findings indicate the importance of the underlying, product-related and competitive environment fundamentals in the pricing of IPOs. With these variables we explain roughly 60–80% of the variability in prices. It is clear that proxies of these fundamentals, such as R&D expenditures, which are generally examined in the IPO valuation literature, provide an incomplete view of the economics and technology of biotech IPOs.

Finally, can our findings based on biotech firms be generalized to other sectors? We believe so. In the current, increasingly competitive global economic environment, new enterprises can succeed only by being innovative, namely developing unique products and services. Information about product development and competitive environment, be it the success of products in alpha and beta tests in software companies, market penetration and store performance of retailers, or load factors and route franchise for new airlines, are, we believe, the major value drivers of IPOs in any sector.

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Figure 1. Initial Public Offerings of Sample Firms
1991–2000

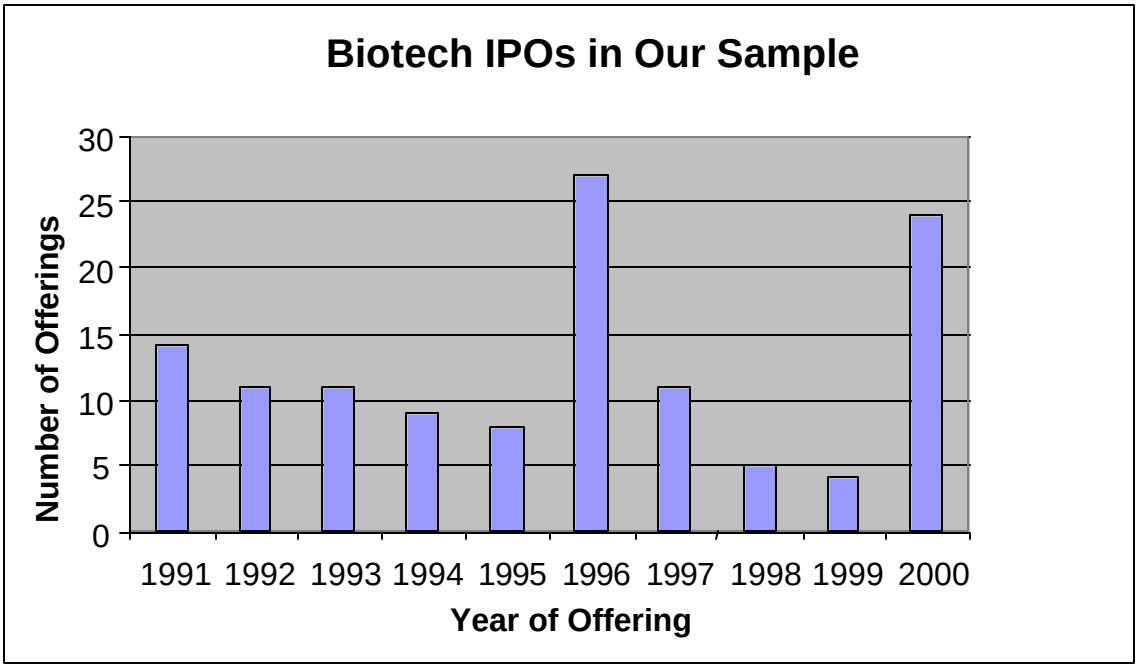

Table 1. Sample Selection Procedure

The sample consists of biotech companies issuing initial public offerings (IPO) in the ten-year period of 1991–2000. A list of IPO companies underwritten by firm-commitment contracts was obtained from the Global New Issue database (available from Thomson Financial Data Corporation), and offerings by pharmaceutical and biotech companies (with the three-digit SIC code of 283, or the four digit SIC code of 8731) were identified. Unit offerings, ADRs, and offerings by foreign corporations (F-1 filings) were excluded from the sample. The sample is further restricted to development-stage companies for which the products can be classified by the various development stages specified in the FDA approval process. Data in parentheses indicate number of firms removed from the full set of 343 firms to obtain the final sample of 122 companies.

Sample Characteristics	Number of Firms
IPO firms in the biotech industry (with 3-digit SIC code of 283 or 4-digit code of 8731) issued during 1991–2000	343
Excluding unit offerings, ADRs, and offerings by foreign companies	(63)
Excluding firms with no available prospectuses.	(37)
Excluding non-development-stage firms (e.g. generic drug producers) or firms with no stage information (e.g. medical device manufacturer or research service providers)	(121)
Final Firm Sample	122

Table 2. Descriptive Statistics.

Panel A. Dependent Variables

The final 122-firm sample is as identified in Table 1. Initial Offer Price is the midpoint of the offer price range indicated in the preliminary prospectus. Final Offer Price is the final offer price of the IPO offering. Aftermarket Price is the closing price of the IPO share in the first aftermarket day of trading. Initial Offer Market Value is the Initial Offer Price multiplied by the expected number of shares outstanding after IPO. Final Offer Market Value is the Final Offer Price multiplied by the expected number of shares outstanding after IPO. Aftermarket Market Value is the Aftermarket Price multiplied by the number of shares outstanding after IPO. Initial Offer, Final Offer, and Aftermarket Value-to-Asset Ratios are the Initial Offer, Final Offer, and Aftermarket Market Values divided by the book value of total assets of the fiscal year prior to the IPO. P/V Ratios are the Initial Offer, Final Offer, and Aftermarket Value-To-Asset ratios divided by the corresponding ratio of the peer biotech firm. The matching peer biotech firm is a publicly traded firm in the biotech industry, with the closest value of total assets and with EBITDA of the same sign in the most recent fiscal year. Initial Price Adjustment is the difference between the final offer price and expected offer price divided by the expected price. Underpricing is the difference between the aftermarket price and final offer price divided by the final offer price.

Variable	Number of Firms	Mean	25^{th} Percentile	50^{th} Percentile	75^{th} Percentile	Std Dev
A. Share Prices						
Initial Offer Price	115	12.09	11.00	12.00	13.00	2.77
Final Offer Price	115	10.67	8.00	10.00	12.50	3.50
Aftermarket Price	113	12.45	8.50	11.00	14.00	6.95
B. Market Values (in millions)						
Initial Offer Market Value	115	169.09	95.24	125.91	186.89	148.19
Final Offer Market Value	115	155.01	69.53	101.40	174.12	151.85
Aftermarket Market Value	112	193.31	71.88	106.91	212.55	224.53
C. Value-to-Asset Ratios						
Initial Offer Value-To-Asset Ratio	115	20.66	7.10	12.49	25.37	20.45
Final Offer Value-To-Asset Ratio	115	18.34	6.26	10.70	23.58	19.09
Aftermarket Value-To-Asset Ratio	112	21.49	7.03	12.68	27.09	23.94
Matching Firm Value-To-Asset Ratio	122	11.11	3.23	5.81	13.22	12.49
D. Relative Valuation: P/V Ratios						
Initial Offer P/V Ratio	115	3.79	1.18	1.87	4.18	5.19
Final Offer P/V Ratio	115	3.37	1.05	1.59	3.25	4.96
After Market P/V Ratio	112	3.91	1.09	1.92	3.79	6.21
C. Returns						
Initial Price Adjustment	115	–0.11	–0.29	–0.08	0.00	0.21
Underpricing	106	0.13	0.00	0.04	0.14	0.30

Panel B. Financial Variables

Total Asset (data 6), Sales (data 12), EBITDA (data13) Earnings (data18), Shareholder's Equity (data216), R&D Expense (data46), and Cash Flow from Operation (data308) of the fiscal year prior to the IPO offerings are collected from COMPUSTAT. Sales Change is the difference in revenue between the year of the IPO offering and the prior year. Book-to-market ratio is calculated as the book value of equity (data60) at the end of first post-IPO fiscal year over the market value of equity at the close of the first trading day. The aforementioned financial information, if missing in COMPUSTAT, is supplemented by information hand-collected from the prospectuses and 10Ks. All financial variables, except book-to-market, are in millions of dollars.

Variable	Number of Firms	Mean	25th Percentile	50th Percentile	75th Percentile	Std Dev
Sample Firms:						
Total Assets	122	15.55	4.78	11.21	18.25	20.96
Sales	122	3.33	0.00	1.19	4.42	6.89
EBITDA	122	–6.82	–9.75	–5.45	–3.31	5.95
Earnings	122	–7.34	–10.10	–5.93	–3.40	6.73
Shareholder's Equity	122	10.06	1.06	6.97	14.26	19.84
R&D Expense	122	7.50	3.43	5.84	9.38	6.79
Cash from Operation	122	–5.12	–7.83	–4.20	–2.45	5.67
Sales Change	122	1.56	–0.04	0.18	2.50	3.68
Book-To-Market	112	0.29	0.21	0.27	0.35	0.13
Matching Firms:						
Total Assets	122	18.71	5.40	10.98	18.74	46.14
Sales	122	4.32	0.08	2.12	5.12	6.97
EBITDA	122	–6.37	–9.84	–5.60	–2.61	5.50

Panel C. Non-Financial Variables

Sample Firms' non-financial information in the year prior to the IPO offerings is hand-collected from the prospectuses. Number of Employees and Number of PhDs/MDs are the firm's total number of employees and the number of employees with the indicated advanced degrees. Development Stage is a numerical variable, which is assigned a value of 1, 2, 3, 4, 5, 7, 10, and 12 for products in the stage of screening, development, preclinical testing, IND application, phase-I clinical trials, phase-II clinical trials, phase-III clinical trials, and NDA application or on the market, respectively. Number of Products is the total number of products in these development stages. Average Development Stage of Pipeline is the average development stage of all products (pipeline) for each firm. Number of Patents Owned is the number of U.S. patents owned by that company. Alliance Agreements include strategic alliance, joint venture/committee, licensing, R&D collaboration, marketing/distribution, manufacturing, and supply agreements. Number of Alliances is the number of these alliance agreements reported in the prospectus of each IPO firm. Number (Percentage) of Products with Patents is the number (percentage) of products with patent protection. Number (percentage) of Products with Alliances is the number (percentage) of products covered by the alliance agreements. Number (percentage) of Products with Commercial Rights Assigned to Alliance Partners is the number (percentage) of products whose commercial rights are thus assigned. Ownership Retention is the percentage of ownership retained by the pre-IPO shareholders. Market Condition is the cumulative return of the value-weighted biotech index for the six months prior to the IPO. Venture Capital Backing is a binary variable, with value of one for IPO firms backed by venture capitalist, and zero otherwise. Underwriter Ranking is the Carter–Manaster ranking.

Variable	Number of firms	Mean	25th Percentile	50th Percentile	75th Percentile	Std Dev
Fundamental Variables						
Number of Total Products	122	8.01	5.00	7.50	9.00	4.46
Average Development Stage of Pipeline	122	3.87	2.33	3.58	5.20	1.89
Number of Patents Owned	117	7.46	2.00	5.00	8.00	10.47
Number of Alliance Agreements	122	2.22	1.00	2.00	3.00	1.87
Number of Products with Patents	122	4.48	1.00	4.00	7.00	4.53
Number of Products with Alliances	122	2.77	1.00	2.00	4.00	2.68
Number of Products with Commercial Rights Assigned to Alliance Partners	122	1.84	0.00	1.00	3.00	2.51
Percentage of Products with Patents	122	0.58	0.11	0.75	1.00	0.41
Percentage of Products with Alliances	122	0.37	0.13	0.33	0.56	0.30
Percentage of Products with Commercial Rights Assigned to Alliance Partners	122	0.22	0.00	0.12	0.38	0.27
Signaling and Market Condition Variables						
Ownership Retention	122	0.74	0.71	0.74	0.78	0.07
Venture Capital Backing	122	0.91	1.00	1.00	1.00	0.29
Underwriter Ranking	122	5.96	0.00	8.75	8.88	3.82
Market Condition	122	0.15	0.09	0.15	0.25	0.13

Table 3. Pearson (Upper Right) / Spearman (Lower Left) Correlation Coefficients

The 122-firm sample is as identified in Table 1. Financial variables and non-financial variables are defined in Tables 2 and 3, respectively. The tabulated Initial Offer Market Value, Final Offer Market Value, Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, 1 percent levels, respectively.

	Initial	Final	After	Cash	R&D	Sales Change	Own Retent	VC	Under writer	Mkt Cond	Total Product	Stage	Patent	Alliance	Comm. Rights
Initial Offer Market Value		0.96***	0.90***	–0.80***	0.80***	0.28***	–0.01	–0.12	–0.15	0.13	0.67***	0.76***	0.17*	–0.06	–0.27***
Final Offer Market Value	0.95***		0.96***	–0.78***	0.76***	0.24**	–0.05	–0.20**	–0.13	0.21**	0.61***	0.70***	0.18**	–0.04	–0.27***
Aftermarket Market Value	0.91***	0.97***		–0.75***	0.72***	0.26***	0.03	–0.28***	–0.16*	0.18*	0.48***	0.59***	0.22**	–0.11	–0.26***
Cash Flow from Operations	–0.66***	–0.63***	–0.58***		–0.90***	–0.25***	0.11	0.14	0.16**	–0.13	–0.58***	–0.60***	–0.16*	0.05	0.21**
R&D Expense	0.70***	0.67***	0.56***	–0.75***		–0.16*	–0.09	–0.11	–0.16*	0.13	0.54***	0.57***	0.11	0.06	–0.16*
Sales Change	0.10	0.14	0.21**	–0.12	0.06		0.04	0.00	–0.04	0.17*	0.27***	0.29**	–0.10	–0.01	0.03
Ownership Retention	–0.04	–0.08	0.03	0.23***	–0.21**	0.07		0.26***	0.01	–0.02	–0.30***	–0.27***	–0.04	0.09	0.00
Venture Capital Backing	–0.08	–0.14	–0.17*	0.07	–0.01	0.13	0.22**		0.08	–0.07	–0.16**	–0.20**	–0.15*	0.04	0.07
Underwriter Ranking	–0.28***	–0.27***	–0.31***	0.29***	–0.15*	0.04	0.03	0.12		0.05	–0.20**	–0.25***	–0.21**	0.08	0.11
Market Condition	0.04	0.12	0.11	–0.02	0.08	0.19**	–0.03	–0.04	0.12		–0.04	0.01	–0.15	–0.02	0.05
Number of Total Products	0.71***	0.68***	0.64***	–0.55***	0.64***	0.12	–0.32***	–0.13	–0.15*	0.04		0.68***	0.00	–0.09	–0.13
Average Development Stage of Pipeline	0.72***	0.68***	0.63***	–0.63***	0.58***	–0.03	–0.36***	–0.23**	–0.10	–0.06	0.74***		0.13	0.03	–0.20**
Percentage of Products with Patents	0.15	0.15	0.18*	–0.20**	0.07	–0.13	0.01	–0.15*	–0.23**	–0.17*	–0.02	0.20**		0.15	0.03
Percentage of Products with Alliances	–0.08	–0.08	–0.15	0.07	0.10	0.05	0.11	0.04	0.09	0.02	–0.16*	–0.07	0.14		0.63***
Percentage of Products with Commercial Rights Assigned to Partners	–0.27***	–0.28***	–0.27***	0.24***	–0.14	0.13	0.03	0.03	0.12	0.11	–0.11	–0.29***	0.00	0.57***	

Table 4. Regressions of Initial Offer Market Values on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variable is Initial Offer Market Value (calculated as product of the midpoint of the offer range indicated in the preliminary prospectuses, and expected shares outstanding after the offering) scaled by asset value. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Variable	Model 1	Model 2	Model 3
Intercept	5.66***	–9.18	–50.48***
	(3.62)	(–0.73)	(–5.00)
Cash Flow from Operations	–6.43**	–6.59***	–0.75
	(–2.62)	(–2.62)	(–0.39)
R&D Expense	10.47***	10.32***	9.57***
	(3.74)	(3.63)	(4.48)
Sales Change	3.35	3.12	2.10
	(1.65)	(1.48)	(1.37)
Ownership Retention	…	22.61	66.10***
		(1.31)	(5.02)
Venture Capital Backing	…	–1.86	0.94
		(–0.45)	(0.31)
Underwriter Ranking	…	–0.71	1.56
		(–0.27)	(0.78)
Market Condition	…	2.24	12.69*
		(0.25)	(1.93)
Number of Total Products	…	…	2.78***
			(3.51)
Average Development Stage of Pipeline	…	…	7.94***
			(6.67)
Percentage of Products with Patents	…	…	5.43**
			(2.60)
Percentage of Products with Alliances	…	…	–8.74***
			(–3.04)
Adjusted R^2	66.74%	66.08%	82.70%
No. Observations	114	114	114

Table 5. Regressions of Final Offer Market Values on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variable is Offer Market Value (calculated as product of the final offer price and expected shares outstanding after the offering) scaled by asset value. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Variable	Model 1	Model 2	Model 3
Intercept	5.05***	–2.32	–36.36***
	(3.20)	(–0.19)	(–3.12)
Cash Flow from Operations	–6.97***	–6.83***	–2.22
	(–2.80)	(–2.73)	(–0.99)
R&D Expense	8.07***	7.86***	7.05***
	(2.85)	(2.78)	(2.85)
Sales Change	4.04*	3.31	2.43
	(1.97)	(1.56)	(1.37)
Ownership Retention	…	16.06	50.81***
		(0.94)	(3.34)
Venture Capital Backing	…	–6.14	–3.72
		(–1.49)	(–1.07)
Underwriter Ranking	…	–0.84	0.99
		(–0.31)	(0.43)
Market Condition	…	13.85	22.71***
		(1.55)	(2.99)
Number of Total Products	…	…	2.22**
			(2.43)
Average Development Stage of Pipeline	…	…	6.49***
			(4.72)
Percentage of Products with Patents	…	…	5.02**
			(2.07)
Percentage of Products with Alliances	…	…	–5.83*
			(–1.75)
Adjusted R^2	61.94%	62.38%	74.13%
No. Observations	114	114	114

Table 6. Regressions of Aftermarket Market Values on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variable is the Aftermarket Market Value (calculated as product of the closing price and number of shares outstanding at the end of the first day trading after the IPO) scaled by asset value. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Variable	Model 1	Model 2	Model 5
Intercept	6.37***	–14.02	–41.95***
	(3.01)	(–0.85)	(–2.56)
Cash Flow from Operations	–6.89**	–6.73**	0.37
	(–2.06)	(–2.04)	(0.11)
R&D Expense	8.21**	8.28**	8.87**
	(2.16)	(2.22)	(2.50)
Sales Change	9.32***	8.92***	7.93***
	(3.64)	(3.45)	(3.32)
Ownership Retention	…	47.39**	72.62***
		(2.10)	(3.36)
Venture Capital Backing	…	–13.89**	–8.31*
		(–2.65)	(–1.67)
Underwriter Ranking	…	–4.55	–2.97
		(–1.32)	(–0.91)
Market Condition	…	8.49	19.06*
		(0.76)	(1.78)
Number of Total Products	…	…	0.77
			(0.57)
Average Development Stage of Pipeline	…	…	7.37***
			(3.45)
Percentage of Products with Patents	…	…	7.83**
			(2.30)
Percentage of Products with Alliances	…	…	–10.74**
			(–2.37)
Adjusted R^2	48.05%	51.82%	59.68%
No. Observations	110	110	110

Table 7. Regressions of P/V Ratios at Different IPO Stages on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variables of P/V Ratios are the Initial Offer, Final Offer, and Aftermarket Value-To-Asset ratios divided by the corresponding (value-to-asset) ratio of the peer biotech firm. The peer biotech firm is a publicly traded firm in the biotech industry, with the closest value of total assets and with EBITDA of the same sign in the most recent fiscal year. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Dependent Variable	Initial Offer P/V	Final Offer P/V	Aftermarket P/V
Intercept	–4.31	–3.34	–6.62
	(–1.11)	(–0.91)	(–1.45)
Cash Flow from Operations	0.88	0.81	0.85
	(1.16)	(1.12)	(0.92)
R&D Expense	0.27	0.16	–0.40
	(0.34)	(0.21)	(–0.41)
Sales Change	1.27***	1.04***	1.18***
	(3.71)	(3.22)	(3.05)
Ownership Retention	9.28*	8.31*	12.21**
	(1.85)	(1.74)	(2.04)
Venture Capital Backing	–0.81	–1.58	–1.64
	(–0.66)	(–1.37)	(–1.20)
Underwriter Ranking	1.10	1.14	1.23
	(1.45)	(1.59)	(1.40)
Market Condition	3.93	4.51*	7.46**
	(1.58)	(1.92)	(2.54)
Number of Total Products	–0.33	–0.36	–0.33
	(–1.09)	(–1.24)	(–0.88)
Average Development Stage of Pipeline	2.25***	2.16***	2.41***
	(4.71)	(4.75)	(4.08)
Percentage of Products with Patents	0.24	0.40	1.09
	(0.31)	(0.53)	(1.16)
Percentage of Products with Alliances	–2.46**	–2.33**	–2.17*
	(–2.24)	(–2.24)	(–1.73)
Adjusted R^2	32.87%	32.10%	29.84%
No. Observations	113	113	110

Table 8. Regressions of Initial Price Adjustments on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variable, Initial Price Adjustment, is the difference between the final offer price and expected offer price divided by the expected offer price. Offer Range Width is the percentage width of the preliminary offer price range, calculated as (High Offer Price – Low Offer Price)/Low Offer Price. Expected Initial Offer Size is the product of Initial Offer Price and number of shares offered. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Variable	Model 1	Model 2	Model 3
Intercept	–0.11	0.09	0.02
	(–1.16)	(0.37)	(0.06)
Cash Flow from Operations	–0.03	0.03	0.01
	(–0.60)	(0.58)	(0.24)
R&D Expense	–0.02	0.01	–0.02
	(–0.41)	(0.23)	(–0.32)
Sales Change	0.00	0.00	–0.01
	(0.01)	(0.08)	(–0.35)
Log (Total Asset)	0.03	–0.01	–0.01
	(1.27)	(–0.27)	(–0.35)
Book To Market	–0.29*	–0.35**	–0.30*
	(–1.66)	(–2.06)	(–1.69)
Ownership Retention		–1.02***	–1.13***
		(–2.99)	(–3.22)
Venture Capital Backing		–0.19***	–0.20***
		(–2.65)	(–2.78)
Underwriter Ranking		0.03	0.01
		(0.62)	(0.20)
Offer Range Width	-	1.06**	1.21**
		(2.38)	(2.54)
Log(Expected Initial Offer Size)	-	0.17***	0.21***
		(3.26)	(3.68)
Market Condition		0.29***	0.27**
		(2.84)	(2.49)
Number of Total Products			0.00
			(0.15)
Average Development Stage of Pipeline			0.01
			(0.37)
Percentage of Products with Patents			–0.04
			(–0.78)
Percentage of Products with Alliances			0.12*
			(1.67)
Adjusted R^2	0.36%	21.14%	21.65%
No. Observations	105	105	105

Table 9. Regressions of Underpricing on Financial and Non-Financial Variables

The 122-firm sample is as identified in Table 1. The dependent variable, Underpricing, is the difference between the aftermarket price and final offer price divided by the final offer price. Initial Price Adjustment is the difference between the final offer price and expected offer price divided by the expected offer price. Nasdaq Market Return on IPO is the return of Nasdaq Composite Index during the first day of each sample firm. Offer Range Width is the percentage width of the preliminary offer price range, calculated as (High Offer Price – Low Offer Price)/Low Offer Price. Expected Final Offer Size is the product of Final Offer Price and number of shares offered. Other financial and non-financial variables are described in Table 2. Variables of Cash Flow from Operations, R&D Expense, Sales Change, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Underwriter Ranking is scaled by nine, the maximum scores possible. Entries are coefficients with *t*-statistics in parenthesis. One, two, and three asterisks indicate the two-tailed significance at the 10, 5, and 1 percent levels, respectively.

Variable	Model 1	Model 2	Model 3	Model 4
Intercept	0.10	0.01	0.10	0.20
	(1.10)	(0.05)	(0.39)	(0.84)
Cash Flow from Operations	–0.03	–0.02	–0.02	–0.02
	(–0.64)	(–0.53)	(–0.53)	(–0.40)
R&D Expense	–0.01	–0.01	0.01	0.01
	(–0.12)	(–0.13)	(0.13)	(0.26)
Sales Change	0.01	0.00	0.01	0.00
	(0.38)	(0.25)	(0.61)	(0.15)
Log (Total Asset)	0.05**	0.04	0.02	0.03
	(2.07)	(1.23)	(0.56)	(0.87)
Book To Market	–0.43***	–0.35**	–0.38**	–0.41**
	(–2.64)	(–2.25)	(–2.33)	(–2.56)
Ownership Retention	…	0.36	0.43	0.35
		(1.11)	(1.29)	(1.06)
Venture Capital Backing	…	–0.10	–0.10	–0.08
		(–1.50)	(–1.40)	(–1.09)
Underwriter Ranking	…	–0.03	–0.02	–0.05
		(–0.70)	(–0.54)	(–1.16)
Initial Price Adjustment	…	0.36***	0.40***	0.40***
		(3.08)	(3.17)	(3.32)
Log(Expected Final Offer Size)	…	–0.00	–0.02	–0.05
		(–0.08)	(–0.45)	(–1.00)
Nasdaq Market Return on IPO Date	…	4.83***	4.84***	5.38***
		(3.49)	(3.39)	(3.84)
Number of Total Products	…	…	–0.01	–0.01
			(–0.56)	(–0.43)
Average Development Stage of Pipeline	…	…	–0.02	–0.04
			(–0.74)	(–1.25)
Percentage of Products with Patents	…	…	0.01	0.00
			(0.24)	(0.02)
Percentage of Products with Alliances	…	…	–0.06	–0.04
			(–0.99)	(–0.67)
Final Offer P/V	…	…		0.01**
				(2.54)
Adjusted R^2	7.12%	29.66%	28.13%	32.32%
No. Observations	104	104	104	104

Table 10.
Post-Issuance Long-run Performance of IPO Firms

The initial sample of biotech IPOs is as identified in Table 1. The variable BHAR is the buy-and-hold abnormal return, calculated as equally weighted buy-and-hold returns of IPO firms in excess of the corresponding returns of a matching portfolio in 2nd to 37th months subsequent to the month of IPO issuance. If a firm is delisted before the 37th month, its return is compounded up to the delisting month. The matching portfolios are generated by first forming size quintile breakpoints using NYSE firms. The quintiles are split further into book-to-market quintiles on NYSE firms. The universe of non-IPO firms is allocated into the resulting 25 portfolios. Breakpoints are recalculated annually and equally weighted portfolio returns are computed. Return performance of full sample, as well as subsamples of IPO firms with above- (high) and below- (low) median value in variables of market condition, development stage (scaled by total asset value), number of products (scaled by total asset value), percentage of products with patents, percentage of products with alliances, and underwriter ranking are presented. Return performance of subsamples of IPO firms with/without venture capital backing are also tabulated. Entries are mean returns with *t*-statistics in parenthesis. One, two, and three asterisks indicate the significance at the 10, 5, and 1 percent levels, respectively.

	BHAR
Full Sample	-14.32%
	(-1.34)
Subsamples sorted by market condition:	
high	-22.81%
	(-1.57)
low	-4.17%
	(-0.26)
Subsamples sorted by development stage:	
high	-20.76%
	(-1.35)
low	-8.00%
	(-0.53)
Subsamples sorted by number of products:	
high	-3.95%
	(-0.24)
low	-25.78%*
	(-1.88)
Subsamples sorted by percentage of products with patents	
high	-30.40%**
	(-2.62)
low	3.43%
	(0.19)
Subsamples sorted by products with alliances:	
high	8.61%
	(0.58)
low	-36.81%**
	(-2.48)
Subsamples sorted by underwriter ranking:	
high	-13.23%
	(-0.92)
low	-15.31%
	(-0.97)
Subsamples sorted by VC backing:	
with VC	-18.64%*
	(-1.81)
without VC	17.72%
	(0.37)

Table 11. Cross-section Regression of Post-Issuance Long-Term Performance Buy-and-hold Abnormal Return

The sample of biotech IPOs is as identified in Table 1. The dependent variable BHAR is the buy-and-hold abnormal return, calculated as equally weighted buy-and-hold returns of IPO firms in excess of the corresponding returns of a matching portfolio in 2nd to 37th months subsequent to the month of IPO issuance. If a firm is delisted before the 37th month, its return is compounded up to the delisting month. LBHAR is calculated as the difference between the logarithm of (1+BHAR), and the logarithm of (1+the corresponding return of the matching portfolio). The matching portfolios are generated by first forming size quintile breakpoints using NYSE firms. The quintiles are split further into book-to-market quintiles on NYSE firms. The universe of non-IPO firms is allocated into the resulting 25 portfolios. Breakpoints are recalculated annually and equally weighted portfolio returns are computed. Other financial and non-financial variables are described in Table 2. Variables of Sales Change, R&D Expense, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. See Entries are coefficients with *t*-statistics in parenthesis. One, two and three asterisks indicate the significance at the 10, 5, and 1 percent levels, respectively.

Dependent Variable	BHAR		LBHAR	
	Model 1	Model 2	Model 1	Model 2
Intercept	1.10	0.22	0.60	-0.11
	(0.82)	(0.51)	(0.48)	(-0.26)
Sales Change	0.45**	0.36*	0.32	0.28
	(2.07)	(1.82)	(1.63)	(1.48)
Log (Total Asset)	0.09	-	-0.00	-
	(0.47)		(-0.03)	
R&D Expense	-0.03	-	0.06	-
	(-0.18)		(0.41)	
Ownership Retention	-1.30	-	-0.42	-
	(-0.67)		(-0.23)	
Market condition	-1.55	-1.38	-0.87	-0.82
	(-1.65)	(-1.59)	(-1.02)	(-1.01)
Number of Products	0.00	-	-0.00	-
	(-0.10)		(-0.08)	
Average Development Stage of Pipeline	-0.10	-	-0.25	-
	(-0.62)		(-1.58)	
Percentage of Products with Patents	-0.43	-0.48*	-0.59**	-0.54**
	(-1.50)	(-1.78)	(-2.29)	(-2.20)
Percentage of Products with Alliances	0.84**	0.83**	0.93**	0.83**
	(2.18)	(2.29)	(2.62)	(2.45)
Venture Capital Backing	-0.40	-0.33	-0.51	-0.44
	(-1.03)	(-0.91)	(-1.44)	(-1.30)
Underwriter Ranking	0.00	-	-0.03	-
	(0.01)		(-1.20)	
Adjusted R^2	4.29%	7.46%	7.27%	7.58%
No. Observations	101	101	102	102

Table 12. Cross-section Regression of Post-Issuance Long-Term Performance Risk-Adjusted Return

The sample of biotech IPOs is as identified in Table 1. The dependent variable is the risk-adjusted return, calculated by regressing each sample firm's monthly return in excess of one month T-bill rate on the Fama and French factors in the period of the 2nd to 37th months (or to the month of delisting) subsequent to the month of IPO issuance. . Other financial and non-financial variables are described in Table 2. Variables of Sales Change, R&D Expense, Number of Total Products, and the Average Development Stage of Pipeline are scaled by Total Assets. Entries are coefficients with *t*-statistics in parenthesis. One, two and three asterisks indicate the significance at the 10, 5, and 1 percent levels, respectively.

Dependent Variables	Risk-Adjusted Return	
	Model 1	Model 2
Intercept	0.100**	0.024**
	(2.30)	(1.67)
Sales Change	0.010	0.006
	(1.52)	(0.94)
Log(Total Asset)	-0.001	-
	(-0.21)	
R&D Expense	0.004	-
	(0.82)	
Ownership Retention	-0.091	-
	(-1.55)	
Market condition	-0.039	-0.029
	(-1.35)	(-1.05)
Number of Products	-0.002	-
	(-0.61)	
Average Development Stage of Pipeline	-0.007	-
	(-1.45)	
Percentage of Products with Patents	-0.020**	-0.021**
	(-2.34)	(-2.41)
Percentage of Products with Alliances	0.037***	0.035**
	(3.10)	(3.00)
Venture Capital Backing	-0.011	-0.011
	(-0.92)	(-1.02)
Underwriter Ranking	-0.002*	-0.002*
	(-1.77)	(-1.75)
Adjusted R^2	10.53%	9.62%
No. Observations	102	102