R&D Spending And Sources Of Funding Of Private US Biopharmaceutical Firms Seeking To Go Public

By: **David R. Williams** and **Richard W. Pouder**

Abstract

This study analyzes the relationship between the amount of research and development (R&D) spending in private US biopharmaceutical firms before they go public and whether or not these firms tap into external sources of funding for investment before an initial public offering. We focus our study on three specific sources of funding (venture capital investors, biopharmaceutical firm investors and strategic alliance partners) for two different time periods (one year prior to firms going public and cumulative years prior to going public). We found an increase in R&D spending over the course of the study and a positive relationship between R&D spending in the year prior to its going public and venture capital involvement. We also found a positive relationship between the cumulative amount spent on R&D and venture capital involvement and ownership by other biopharmaceutical firms. We use the literature on tradable assets and signaling theory to interpret the implications of our findings. For managers, the results suggest that if their goal is to send signals to future investors by way of spending greater amounts on R&D in the year prior to going public, then venture capital investors are more likely to be associated with this type of activity.

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R&D spending and sources of funding of private US biopharmaceutical firms seeking to go public

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ABSTRACT **This study analyzes the relationship between the amount of research and development (R&D) spending in private US biopharmaceutical firms before they go public and whether or not these firms tap into external sources of funding for investment before an initial public offering. We focus our study on three specific sources of funding (venture capital investors, biopharmaceutical firm investors and strategic alliance partners) for two different time periods (one year prior to firms going public and cumulative years prior to going public). We found an increase in R&D spending over the course of the study and a positive relationship between R&D spending in the year prior to its going public and venture capital involvement. We also found a positive relationship between the cumulative amount spent on R&D and venture capital involvement and ownership by other biopharmaceutical firms. We use the literature on tradable assets and signaling theory to interpret the implications of our findings. For managers, the results suggest that if their goal is to send signals to future investors by way of spending greater amounts on R&D in the year prior to going public, then venture capital investors are more likely to be associated with this type of activity.**

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INTRODUCTION

Increasingly, medical innovation is having a profound effect on Americans' lives. Perhaps, nowhere is this more apparent than in the

biopharmaceutical industry (that is, biotechnology and pharmaceutical firms) where new disruptive technologies and drugs are creating a paradigm shift for both developers of drugs and providers of patient care.[1] With this shift has come new private-public relationships that are transforming communities as states, academia, corporations and financiers have sought to create geographic clusters for this industry.[2–4] These shifts have also fueled rising biopharmaceutical costs as Americans in 2006 spent five times more on drugs and therapies than they did in 1990.[5] US biopharmaceutical firms also spent approximately five times more on research and development (R&D) in 2003 compared with 1990[6] and more than US$65 billion on R&D in 2008 alone.[7] The majority of these R&D efforts, however, never make it to market[8] and for those few that do make it to market, most are not profitable.[9] Yet despite these increased efforts, we know very little about these phenomena.[10]

Seeking to expand our knowledge, this article examines two critical functions of new biopharmaceutical firms: R&D spending and the financing of this R&D spending. Our central premise is that given the cost requirements of new drug development, it is logical to suppose that those firms engaging in drug discovery and development with greater access to suppliers of resources (for example, venture capitalists, biopharmaceutical firm investors and strategic alliance partners) would also spend greater amounts on R&D before going public.

We choose new private biopharmaceutical firms to study because early in the life cycle of these firms the majority of funds available are dedicated to R&D activities.[11] We investigate these firms at the time that they are seeking to go public, as research suggests that this is the time when firms are most in need of funding and represents a milestone event for many firms in this industry.[12] In particular, we are interested in discerning the amount of funds spent on R&D by these new firms in the year prior to their going public, the cumulative amount spent on R&D prior to their going public, and which investors affect these amounts spent on R&D.

We incorporate work on tradable assets[13] and signaling theory[14,15] in discussing our results to help explain differences in the relationships between investors and the amount spent on R&D for each of the two periods preceding the initial public offering (IPO). Specifically, we suggest that firms engaged in R&D that is supported by pre-IPO investors may send positive signals to post-IPO investors because of their higher levels of R&D spending. Our work should be of interest to researchers and practitioners trying to understand the amount spent on R&D of private firms seeking to go public and their sources of capital.

METHODOLOGY

Data collection method

Our sample represents US biopharmaceutical firms that went public for the first time between 1 January 1996 and 31 December 2007. Beginning in 1996, the Security & Exchange Commission's (SEC) internet site made publicly available the filings of all firms that were either publicly traded (for example, New York Stock Exchange; NASDAQ) or were filing to become publicly traded firms. We found most of the biopharmaceutical IPOs on the SEC's internet site; other sources accessed on the internet were Bio.org, Biospace, BioWorld, Edgar-Online, Ernst & Young, Hoover's and IPO Resources. We also read all news articles during this period related to public offerings from Biospace.com to ensure that all biopharmaceutical firms going public were captured. Plant and animal firms and foreign firms filing an F-1 foreign firm's registration statement were excluded. We included a small number of firms in our sample that appear to be foreign firms, but are incorporated in the United States and filed an S-1 general registration statement for US firms. In addition, we excluded firms that did not receive any direct proceeds from the sale

of their stock, but rather had the capital raised going solely to individual investors. As the SEC filings do not readily convey the date a firm goes public, we checked finance.yahoo.com and the appropriate stock exchanges' (for example, NASDAQ) websites to find and verify the date the firm's stock traded for the first time.

Sample

Similar to Golec and Vernon,[6] we use US biopharmaceutical drug firms as they represent the firms creating new end-products for human consumption ($N=158$). These are firms with standard industrial classification (SIC) codes 2834 (Pharmaceutical Preparations) and 2836 (Biological Products). For informational purposes, we provide data related to two different time-frames (for example, 1996–2001 and 2002–2007) to explore the effects, if any, of the increase in venture capital investment in this industry. We also provide initial data on biopharmaceutical drug firms that are complements which include SIC codes: 2833 (Medicinal Chemicals & Botanical Products), 2835 (In Vitro & In Vivo Diagnostic Substances), 3826 (Laboratory Analytical Instruments), 3829 (Measuring & Controlling Devices), 3841 (Surgical & Medical Instruments & Apparatus), 5122 (Wholesale-Drugs), 7371 (Services-Computer Programming Services), 7372 (Services-Prepackaged Software), 7389 (Services-Business Services), 8071 (Services-Medical Laboratories) and 8731 (Services-Commercial Physical & Biological Research). Our total sample of biopharmaceutical IPOs represented 215 firms of which 158 were classified as 'Drugs' and 57 as 'Complements'.

Measures and statistical method

Our data come from the firm's prospectus as filed with the SEC. The dependent variables are R&D expense by the firm in the year prior to its going public and the cumulative R&D expense of the firm prior to its IPO. We control for the firm's size (measured as total assets), age, stage of clinical trial of the most developed or lead product, and number of US patents under the control of the firm. Our independent variables are venture capital investment, pharmaceutical ownership interest and strategic alliances that pay or promise to pay the biopharmaceutical firm a fee (that is, an initial, milestone or royalty fee). To determine venture capital investment, we cross-matched firms with individuals listed in the Principal Stockholders section of Pratt's Guide to Venture Capital Sources.[16] Multiple linear regressions were used to analyze these relationships for Drug firms.

RESULTS

Figure 1 illustrates the average firm's R&D spending by year. Consistent with Golec and Vernon's[6] study of all publicly traded drug firms, we found a steep increase in spending by the average firm over the course of the study. Of the 215 Drug and Complement firms, the average firm spent almost $12 million on R&D in the year prior to its going public. The average Drug firm ($N=158$) spent $13.5 million on R&D compared to the average Complement firm ($N=57$) which spent $7.2 million on R&D. Between the years 1996 and 2001, the average Drug company ($N=75$) spent $8.5 million on R&D; whereas between the years 2002 and 2007 the average Drug company ($N=83$) spent $18.4 million on R&D. Given the age (7.4) and stage of clinical trials (2.2) for the typical Drug firm, this R&D finding did not appear to us to be an extraordinary amount in light of the findings related to costs and spending overall.

For informational purposes, we provide the total or cumulative amount of funds the Drug firms spent on R&D - from their conception to the end of the fiscal year just before their IPO. Figure 2 illustrates by year the average cumulative amount of R&D each of the Drug firms spent. Many of the firms ($N=38$), however, provided only partial data. Thus, within Figure 2 we see only the Drug firms that provided data for all years ($N=120$).

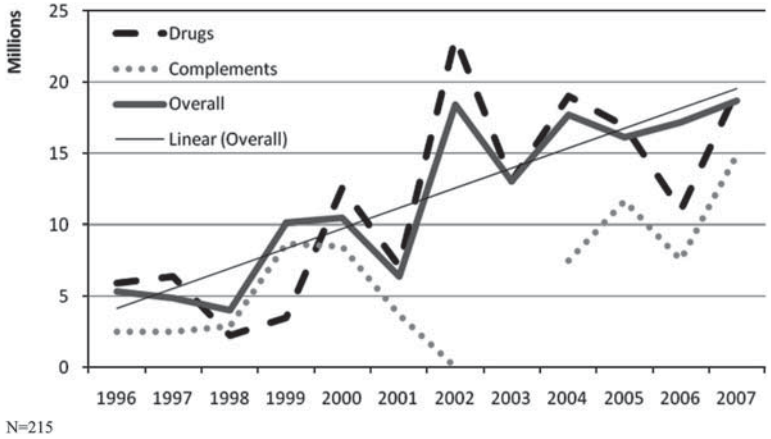

Figure 1: Average R&D spending per year.
Note: $N = 215$.

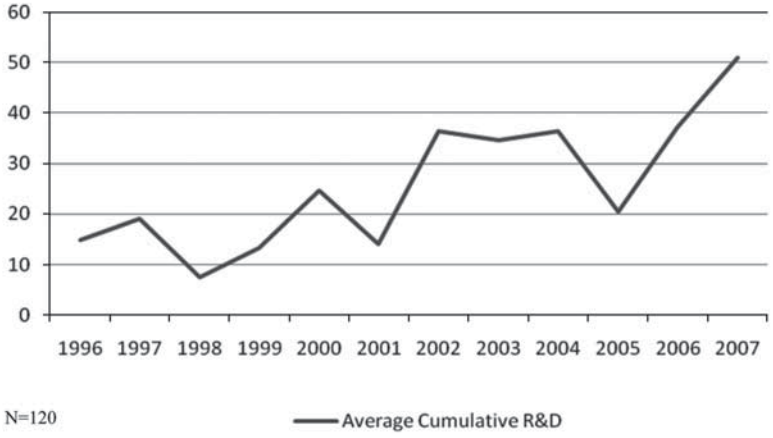

Figure 2: Cumulative R&D spending (in millions).
Note: $N = 120$.

Figure 2 does not show data for the Drug firms that provided only 5 years worth of Data ($N = 34$) (that is, only the last five fiscal years prior to their IPO) nor the four firms that provided either 1 ($N = 1$) or 3 ($N = 3$) years worth of R&D data. These four firms averaged about $31.1 million in R&D spending. For the Drug firms that provided only 5 years worth of R&D spending data, these firms spent on average $70.1 million in the 5 years prior to their IPO, with the average age of these firms being about 11 years old (thus, we do not have 5–6 years worth of data on average for these firms). Of note, in 2002, there was only one firm that provided 5 years worth of data and it spent $243.7 million over the course of these 5 years (and a firm in 2004 that spent $271.4 million). When we delete these two firms from the firms presenting 5 years worth of data, we have the typical firm ($N = 32$) spending $57.3 million on R&D over the last 5 fiscal years prior to their IPO. Although not depicted, the trend for firms with 5 years worth of data was that they were spending more on R&D cumulatively in recent periods.

For the Drug firms that provided complete R&D spending data beginning with the firm's

inception ($N=120$), the average firm spent approximately $25.8 million cumulatively on R&D prior to its going public, with the average age of the firm being about 6 years old. Of the Drug firms that went public between 1996 and 2001 ($N=61$), the typical firm cumulatively spent $18.1 million on R&D compared to the Drug firms that went public between 2002 and 2007 ($N=59$) that cumulatively spent $38.3 million on R&D. As we can see from Figure 2 (and similar to Figure 1), the trend has been for increased amounts of cumulative R&D spending.

We excluded eight outliers from our original sample of 158 Drug firms leaving us with 150 Drug firms. Table 1 presents the results from our multiple linear regressions for Drug firms. The first three columns present our findings related to R&D spending in the year prior to the IPO and the last three columns present our findings related to cumulative R&D spending. As presented in the first column, we find a positive statistically significant relationship between R&D spending in the year prior to the firm going public and the total assets of the firm, and venture capital investment ($N=150$). This finding supports the view that firms with access to venture capital investors spend more on R&D than firms without venture capital investors. Our regression model explains 46.7 per cent of the variance in R&D spending ($F=17.761$, $P=0.000$). Our findings do not show that investment by other biopharmaceutical firms or participation in strategic alliances was related to greater R&D investment. Interestingly, though not statistically significant, the variable for other biopharmaceutical investors had a negative relationship with R&D spending.[17,18]

As an additional step in the analysis we examined relationships between R&D spending and our independent variables over time. Specifically, we wanted to see what effect, if any, the increased venture capital interest in this industry would have. Beginning in the year 1999, venture capital moved from internet firms into biopharmaceuticals firms in large numbers. The second and third columns in Table 1 show drug firms divided by two 6-year time periods: 1996 through 2001 and 2002 through 2007. From this, we can see a statistically significant relationship between R&D spending and venture capital investment in the years 1996 through 2001, but do not see a statistically significant finding in the years 2002 through 2007.

The last three columns in Table 1 present the results from our multiple linear regression related to cumulative R&D spending for drug firms ($N=120$). We found a positive

Table 1: Multiple regression results

Predictor variables	*1 year prior drug firms (1996–2007) Coefficient estimates*	*1 year prior drug firms (1996–2001) Coefficient estimates*	*1 year prior drug firms (2002–2007) Coefficient estimates*	*Cumulative drug firms (1996–2007) Coefficient estimates*	*Cumulative drug firms (1996–2001) Coefficient estimates*	*Cumulative drug firms (2002–2007) Coefficient estimates*
Age	0.041	0.239*	−0.030	0.263**	0.332**	0.219
Assets (log)	0.606**	0.646**	0.451**	0.097	0.029	0.375**
Clinical trials	0.015	0.140	−0.154	0.156	0.399**	−0.216
Patents (log)	0.093	−0.187*	0.177	0.146	−0.083	0.193
Venture Capital	0.131*	0.319**	−0.053	0.256**	0.395**	−0.020
Biopharmaceuticals	−0.049	−0.119	0.096	0.177*	0.218*	0.179
Alliances	0.026	0.163	0.054	0.022	0.324**	−0.217
N	150	70	80	120	61	59
R^2	0.467	0.629	0.271	0.260	0.482	0.253

Coefficient estimates are Standardized *Significant at the 0.05 level; **Significant at the 0.01 level.

statistically significant relationship between cumulative R&D spending and age of the firm, venture capital investment and biopharmaceutical investment. This finding supports the view related to firms with access to venture capital and biopharmaceutical investors spending more on R&D cumulatively than firms without these types of investors. Our regression model explains 26.0 per cent of the variance in cumulative R&D spending ($F=5.584$, $P=0.000$). Our findings do not show that firms with strategic alliance partners invest more in R&D.

DISCUSSION

The present study takes a first step toward understanding investments in R&D by private biopharmaceutical firms seeking to go public. We consider this an area of growing importance, as there are approximately 1100 private biopharmaceutical firms in the United States, many of which may go public in the near future or be acquired by other biopharmaceutical firms seeking to supplement their drug pipelines or add to their R&D capability.[12] As expected, we find that firms receiving funding from venture capital firms tend to spend more on R&D at this time than firms without venture capital funding. There were no statistically significant relationships found between R&D investment in the year preceding the IPO and biopharmaceutical firm investment or participation in strategic alliances. This is not exactly the case for cumulative amounts of R&D spending. Firms with venture capital and other biopharmaceutical firm investors spend greater amounts cumulatively on R&D than those that do not have these types of investors.

The implication for biopharmaceutical firms seeking to go public is that if they wish to spend more on R&D cumulatively, then they may need venture capital and/or other biopharmaceutical firm investors. However, if their primary goal is to spend greater amounts of funds on R&D just before going public, then it may be more advantageous to have venture capital investors than other biopharmaceutical firms, as either owners or strategic alliance partners. In other words, it appears that over time firms that wish to spend more on R&D need access to multiple sources of capital. Given the costs, venture capital alone may not be sufficient to capitalize ongoing R&D in the long term in this industry.

Dierickx and Cool[13] suggest that firms deploy both tradable and non-tradable assets. Venture capitalist may view their investment solely in terms of tradable assets (for example, a firm). Biopharmaceutical firms may view their investment needs in terms of both tradable and non-tradable assets. Strategic alliances may represent a mechanism for biopharmaceutical firms to invest in specific tradable assets (for example, technologies). When considering buying non-tradable assets such as R&D capability, they have to invest in a tradable asset such as the firm itself. Thus, biopharmaceutical firm investors may employ two different strategies for two distinct purposes: acquisition of specific technology by way of strategic alliances, and acquisition of R&D capability by way of acquisition of the firm's common stock.

Given this, our findings would suggest that biopharmaceutical firms follow the same type of process for both internal and external non-tradable resources. In other words, firms may follow a prescribed, time-phased flow process in which they develop, accumulate and deploy tradable and non-tradable assets. Thus, biopharmaceutical firms investing in other biopharmaceutical firms invest in order to acquire the non-tradable asset of R&D capability, and they follow similar investment logic externally as they do internally. Hence, these firms may view competitive advantage also being built through R&D capability, which is a cumulative (not single year) process.

Signaling theory may also help to interpret our findings. Proponents of this tradition suggest that signals convey market value to IPO investors.[19,20] From this perspective, an

interpretation of our findings may be that the firms with venture capital investment are trying to raise the volume of the 'signals'. The means of raising this volume of the signal may be through the staging of investments.[21]

Pharmaceutical firms and venture capitalists 'stage' their investments. Pharmaceutical firms engaged in strategic alliances stage their investments primarily based on milestone payments related to a product moving through the clinical trial process. For example, as a product moves from stage I to stage II of clinical trials the pharmaceutical firm may pay the nascent biopharmaceutical firm a pre-arranged payment to further the development of this product. Announcements of these changes in the product development efforts of biopharmaceutical firms can bring about changes in their stock market value.[22,23] In addition to clinical advancements, venture capital firms also stage their investments based on other factors such as hiring management, establishing a board of directors and attracting additional investors.[24] A possible explanation of these results could suggest that venture capitalists may also stage their investments to coincide with an IPO, understanding that the potential payback period for such an investment is relatively short as venture capitalists typically divest themselves of their stock after the IPO and its 'lock-up' period.

These signals may be of less importance to biopharmaceutical firms that invest in other biopharmaceutical firms because of their different purposes for investment. As noted above, biopharmaceutical firms invest in other firms in order to acquire the firm's technology or the firm itself in order to supplement resources and capabilities. Venture capitalists act as financial intermediaries[25] until other private or public investors acquire their shares. Thus, the intention of investment by venture capitalists and biopharmaceutical firms might be different and may result in different levels of investment and at different times (for example, stages). This is to say that venture capitalists have an eye toward exit, whereas biopharmaceutical firms have an eye toward entry. The IPO provides an exit vehicle for the venture capitalists, but for the biopharmaceutical firm investor, the IPO merely may represent another means in which to raise capital until a firm's product(s) is further developed; at that point, the biopharmaceutical firm investor may make the decision to purchase the firm or make a milestone payment. Hence, biopharmaceutical firm investors may be less concerned about 'signals' (which may be what the negative direction of the biopharmaceutical firm's ownership interest variable is indicating in the one year prior to IPO model) and may represent a more focused approach to R&D spending on the part of other biopharmaceutical firms. This is congruent with our discussion above that noted that biopharmaceutical firms invest in different ways for tradable and non-tradable assets.

Furthermore, given the fact that fewer firms are going public of late, another implication for practitioners is that private biopharmaceutical firms may need to rely to a greater extent on their pre-IPO investors for a longer period of time. This may require an increase in the number and type of pre-IPO investors (for example, venture capitalists, other biopharmaceutical firms) and inevitably may increase the cumulative amount of R&D spent before the IPO. This increase in funds over time may mean firms are less able to raise the volume of the signal in the year prior to the IPO. These implications are dependent upon the duration of the slowdown in the IPO market.

There also may be an alternative (and opposite) explanation that is related to our findings and the IPO itself. Our findings from the two regression models may mean that the other biopharmaceutical firms are less likely to invest further in the company, which creates the need to go public. Our results taken together show that biopharmaceutical firms over time are significantly associated with R&D spending, but not in the year prior to the IPO. This may suggest that they have lost interest in the firm or are unwilling to invest

further. This may mean a negative signal to IPO investors; clearly, more research is needed in this area.

Limitations and conclusion

There are some limitations to our study. As we have studied only US biopharmaceutical firms, we do not know if our study's results are generalizable to other industries or firms in other countries. We study only firms going public as opposed to other private firms. The performance (that is, drugs developed or clinical libraries) related to these R&D expenditures is also unknown. Neither is the study very fine-grained, as we do not take into account the number of products pursued by the firms nor the amounts spent on each drug/therapy being pursued or the therapeutic class of the end-product. We did not examine the amounts invested by each type of investor. We also combine both pharmaceutical and biotechnology firms together, though the technology and knowledge related to both segments of this industry is different and at different stages of development. Thus, there are other factors worth understanding regarding these findings, firms and industry.

In summary, the present study has examined factors associated with R&D spending of private biopharmaceutical firms prior to their going public. Similar to other work on large biopharmaceutical firms, our results show that emerging biopharmaceutical firms are spending increasing amounts of funds on R&D. Additionally, firms with venture capitalists and other biopharmaceutical firms are associated with higher cumulative R&D spending prior to their going public, but only venture capitalists are associated with higher R&D spending in the year prior to the IPO. The study's results add to our knowledge concerning nascent biopharmaceutical firms' R&D expenditures and their relationship to their sources of capital. Based on these and other studies' findings related to biopharmaceutical spending, we can assume that the paradigm shift in new drug development and patient care attributable to biopharmaceutical products will continue into the future for some time to come.

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