Value Creation in New Firms: Evidence from the Biotechnology Industry[1]

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The purpose of this study is to empirically examine those factors that enhance the value of newly public firms. The article presents a model for the market value of a newly public biotechnology firm. Explanatory variables include several intangible indicators of the scientific capabilities of the firm including firm citations, licenses, patents, products in the pipeline, and R&D intensity. Top management team variables are also examined. The results support the conclusion that scientific capabilities significantly impact the value of the firm as viewed by public equity markets.

Recent research has examined both initial public offerings (IPOs) of stock[2] as well as post-IPO performance.[3] One specific characteristic of IPOs, namely underpricing, has been extensively examined[4] yet still offers researchers conflicting results. Underpricing simply refers to the price a firm goes public with and the prevailing market price in the immediate after market.[5] One topic which is lacking in the literature on IPOs is what specific factors are valued by public equity markets. To help answer this question, this article offers a model of new-firm valuation based on firm intangible assets, in particular scientific capabilities, and top management team factors.

The research of intangible resources has generally focused either on the perceived value of intangible resources by company CEOs,[6] their value in building competitive advantage,[7] or their role in the internationalization process.[8] In measuring intangible resources, researchers have tended to use proxies for each intangible asset such as advertising intensity, R&D intensity,[9] and legal intensity[10] without considering how these assets may directly impact the market value of the firm.

This article seeks to expand the literature stream in two ways. First, the market value of newly public biotechnology firms is used as a proxy for the value of the firm's intangible resources. These newly public firms have few, if any, products and little or no income to help the market in firm valuation, thus the firm's value is held almost totally in the form of intangible resources. Second, this article empirically shows how the market values an initial stock of intangible resources.

Small, high-technology companies face, as a major hurdle to their growth and development, the acquisition of capital. Organizations dependent on long, expensive, and risky development projects find the acquisition of capital to be particularly difficult. This may be due to the fact that information asymmetries between investors and entrepreneurs are extremely pronounced when the entrepreneurial endeavor is highly technical and depends on cutting-edge scientific research for its success.

Firms that base their growth and development on cutting-edge scientific research pose significant problems for the market because investors largely do not have the specific knowledge necessary to evaluate the scientific capabilities of the organization and the probability of the organization successfully commercializing their basic research.[11] These organizations depend almost totally on their proprietary knowledge and are therefore unlikely to provide information detailed enough about their research to allow investors to accurately evaluate the organization's chances for success. These firms are trapped in Arrow's paradox.[12] To properly evaluate an organization's initial public offering, investors require detailed information about the company's proprietary research, but if the firm discloses this information they increase the risk of their proprietary knowledge being transferred to competitors. Without this disclosure, however, investors are unable to accurately assess the organization's market potential.

To overcome these information asymmetries, entrepreneurs may send signals to potential investors which are meant to accurately represent the quality of the organization. Investors may use a number of observable characteristics (earnings, size, market share, total assets, etc.) as well as entrepreneurs' signals to evaluate organizations entering the equity market. However, since it is in the best interest of the entrepreneur to highlight the strengths and obscure the organization's weaknesses, the entrepreneur must send signals which investors can observe and believe to be credible. Spence argued that such credibility arises when the signal imposes nontrivial costs on the entrepreneur sending the signal.[13] These costs indicate that the entrepreneur expects future benefits from the signal to exceed the signal's current costs.

During the previous decade entrepreneurs in biotechnology firms have confronted the problem of asymmetrical information. Burrill and Lee report that 225 new biotechnology firms have raised capital using IPOs.[14] In most cases, these biotechnology firms have been young, small organizations which are undertaking highly uncertain projects dependent on the commercialization of recent scientific discoveries.[15] Most of the organizations are years away from any significant revenue stream and have no assets other than their scientific capabilities.[16]

To succeed, these organizations must accurately evaluate the commercial potential of a recent scientific discovery and possess the skills and knowledge necessary to move this discovery through the development process. The organization's ability to complete this task depends on its scientific knowledge, its access to additional relevant knowledge, and the skills of its top management team, in other words its intangible resources.

In essence, the value of the equity of these organizations depends on their intangible resources. The problem facing entrepreneurs in biotechnology has been how to overcome these information asymmetries and signal the strength of their intangible resources. This study focuses on two broad categories of intangible resources which can help investors overcome information asymmetries: top management team characteristics and scientific knowledge.

This article presents a literature review and hypotheses. It discusses the data and methodologies and analyzes the results. Finally, it offers a summary and concluding remarks.

Literature Review and Hypotheses

Intangible resources may be defined as "nonphysical assets whose values are difficult to define and measure, yet appear to play a major role in competitiveness."[17] Intangible assets include patents, trademarks, copyrights and registered designs, trade secrets, contracts and licenses, databases, information in the public domain, personal and organizational networks, employee know-how, reputation, organizational culture,[18] management,[19] R&D, and software.[20]

In general, an intangible asset is any attribute a firm's rivals cannot quickly or effectively imitate.[21] The research of intangible resources has generally focused either on the perceived value of intangible resources by company CEOs,[22] their value in building competitive advantage,[23] or their role in the internationalization process.[24] Accountants have difficulty among themselves when trying to determine the correct accounting technique for valuing intangible resources. In this study, the value of intangible assets manifests itself in the market value of the firm.

Citation Analysis

New product development in high-technology environments is increasingly being driven by basic scientific research.[25] This makes the quality of a biotechnology firm's scientific team critical to the product development process. One part of this scientific team is the Scientific Advisory Board. This group consists of a number of individuals with extensive backgrounds in fields such as immunology, virology, and microbiology. These individuals act as consultants to the firm's management. One signal a biotechnology firm can give to potential investors is the quality of its Scientific Advisory Board. One measure of this quality is citation analysis.

Citation analysis uses the number of times a paper or an author is cited as an indication of the importance of the work to the field. The more frequently the paper or an individual's body of work is cited the more important, and hence, the higher the quality of work. In recent years, citation analysis has been used to map the development of science,[26] to estimate the quality of the scientific capabilities of countries in specific fields,[27] the performance of academic departments,[28] and as the basis for the assessment of scientific and technical research programs. [29]

In addition, citation analysis has recently entered into the discussion of strategic planning. Ven Der Eerden and Saelens discussed the use of citations as indicators of research group performance and the quality of the scientific research being undertaken by the group, as well as a tool to guide competitive assessment, mergers and acquisitions, targeting, and research strategy.[30]

H1: The number of times Scientific Advisory Board members have been cited previous to the IPO will be positively related to firm market value.

Contracts and Licenses

According to Hall, contracts, which may be in any number of forms (agency agreements, license agreements, property leases), are considered one of the most important intangible resources for some businesses.[31] Contracts exist to regulate business and economic relationships.[32] Contracts then define the terms of agreement so that each party to the contract can protect and enforce their rights. Parties to a contract, however, cannot foresee all possible future contingencies which adds a dimension of risk to the contract.[33] In the case of biotechnology companies, contracts typically cover one of three areas: R&D alliances, marketing alliances, and, more rarely, production agreements. These external linkages provide an important source of new ideas to new firms.[34] Recent research has also documented a positive relationship between the number of firm alliances and the research productivity of the firm.[35] Assuming access to new ideas and increased research productivity is important to new firms.

H2: The number of contracts held by the firm at the time of the IPO will be positively associated with market value.

Patents

Patents have been associated with innovation and performance at many levels including company, region, and country. Patents are considered indicators of important technology positions and innovative activity[36] and can be considered inputs in the new product development process.[37] A positive relationship between patents and firm market value has been reported by a number of researchers.[38] Whether patents are a precursor to entering a product into trials, an important input into the development process, or an early stage in a process that leads to invention through development, testing, and engineering,[39] they will be positively related to the value of an entrepreneurial high-technology firm.

H3: The number of patents held by the firm at the time of the IPO will be positively related to firm market value.

Total Products in the Pipeline

A common indicator of technological competence or expertise in the pharmaceutical industry is the number of drugs in development or in the "pipeline." Financial analysts and potential investors monitor the products being pursued[40] because in industries populated by high-technology firms success may be measured by the rate at which the firm develops new products.[41] Rapid development of new products and their marketing is important in gaining external visibility and legitimacy, gaining early market share and increasing the likelihood of survival.[42] The strength of a firm's pipeline is also considered an important indicator of a company's future cash flow although the exact value of any product in the pipeline is unknown.[43] The amount and type of new drugs in a company's research pipeline reveals to the financial markets the future potential value of the company's current scientific capabilities.

H4: The number of new drugs in a firm's pipeline will be positively related to the firm's market value.

R&D Expenditures

More important to this discussion, however, is the relationship between R&D expenditures and market value. This relationship has consistently been found to be significant and positive[44] especially so for high-technology firms.[45] Several studies have also investigated the relationship between R&D expenditures and productivity returns.[46] These results are to be expected given that management sets the R&D budget to maximize the discounted value of the firm's expected future cash flows and that the stock market measures the company's expectations subject to measurement error.

H5: The total R&D expenditures by firms in the last five years prior to their IPO will be positively related to their market value.

Top Management Teams

The study of top management teams are based largely on the works of Hambrick and his colleagues.[47] Top management team characteristics have been investigated as determinants of high-technology venture success,[48] innovation,[49] strategic change,[50] and corporate performance,[51] among others. This article seeks to link the firm's top management team with its market value. Three variables, in particular, should reflect the market value of management in newly public high-technology firms: education, the completeness of the top management team, and experience.

Education

An individual's education level reflects their cognitive ability and skills.[52] High education levels are associated with higher levels of information processing capacity and the ability to discriminate among a variety of stimuli.[53] Additionally, high levels of education have been associated with innovation receptivity.[54] These characteristics are especially important for the top management teams of biotechnology companies.

Top management team members may be among only a handful of people in the world with the necessary expertise to understand the scientific discoveries their firms are attempting to commercialize. Top management team members holding a Ph.D. in a technical area are recognized as likely having the expertise necessary to develop their firm's discoveries.

H6: There is a positive relationship between the percentage of the top management team holding a Ph.D. and firm market value.

Top Management Team Completeness

One under investigated feature of top management teams is the completeness of the team. A complete top management team includes a president and executives responsible for marketing, engineering, finance, and operations.[55] Due to the specialized nature of biotechnology firms, this list has been slightly amended to include an executive responsible for research and development in place of engineering. We also assume all firms have a president. Investigating technological start-ups, Roure and Maidique found that successful start-ups had teams either 100 or 80 percent complete teams while unsuccessful companies had teams ranging from 80 to 50 percent complete.[56] Given that companies with higher degrees of top management team completeness appear to be more successful and that the market rewards success:

H7: The degree of completeness of the top management team will be positively associated with the market value of newly public biotechnology firms.

Top Management Team Experience

A manager's previous experience in an industry has been argued to be a predictor of successful entrepreneurs.[57]Siegel, Siegel and MacMillan found industry experience to be positively related to the success of high-growth ventures,[58] while Roure and Maidique[59] found industry experience to be positively related to the success of high-technology ventures.

H8: The percentage of the top management team with experience in the biotechnology or pharmaceutical industry will be positively related to market value.

Data and Methodology

This section describes a study of intangible resources in biotechnology firms.

The Sample and Data

The biotechnology industry of 225 publicly held companies provides the population of firms for this investigation.[60] These firms were contacted by phone with a request for a copy of the prospectus from their IPO. A total of 106 companies provided a prospectus representing a response rate of 47 percent. However, 5 of these companies were excluded from the sample because of incomplete data. Thus, the final sample consisted of 101 companies.

To test for potential biases in this sample, the average total assets and average total liabilities of the firms in the sample in 1992 were compared to the average total assets and average total liabilities reported by Burrill and Lee[61] for all 225 public firms. The sample averaged $11,123,000 in total assets and $3,515,000 in total liabilities. Burrill and Lee reported the average total assets and total liabilities of the 225 public biotechnology firms in 1992 as $11,377,00 and $3,313,000 respectively. In addition, the percentage of nonpharmaceutical health care companies in the sample was 15 percent and the industry-wide percentage, as reported by Burrill and Lee was 17 percent.[62] Based on these comparisons and the size of the sample, we believe the sample is fairly representative of the publicly held biotechnology companies.

The data in the sample was gathered from (1) the prospectus from each of the IPOs by the firms in the sample, (2) the Science Citation Index and, (3) the Center for Research in Security Prices (CRSP) tapes.

Dependent Variables

The dependent variables in the study are the total market value of the offering firm's equity at the end of the first day (DAY), first week (WEEK), and first month (MONTH) of trading ($ 1990). The market value at the end of the first day and week of trading were used to present the market's initial reaction to the IPO. The market value of the firm at the end of the first month of operations was used to present how the market values an initial set of intangible assets after having had time to more closely examine the firm.

Independent Variables

This study used citation data as an indication of the quality of the scientific personnel of the biotechnology firm (CITATION). Names of the firm's top scientists listed in the prospectus were compiled. The Science Citation Index was used to gather the total number of citations for each scientist during his or her career. These citations were then totaled to create a measure of the quality of the scientific team employed by the biotechnology firm at the time of its IPO. Due to a skewed distribution, the total number of citations was transformed using a logarithmic transformation.

From the offering firm's prospectus, a count of the number of contracts and licenses (excluding sole licenses for patents) was obtained (CONTRAC). Licenses for the sole use of patents was included in the patent variable.

From the offering firm's prospectus, a count of the total number of patents held by that firm was obtained (PATENT). This includes both patents granted directly to the firm and patents in which the firm is the sole licensee. Patents which have been licensed are included here rather than under contracts/licenses because, as sole licensee, the firm has exclusive rights to the knowledge content of the patent as if the patent were directly granted.

In the business section of each prospectus, companies report the number of products under development or which have reached the market (PRODS). Only products that had reached the preclinical stage of development or beyond were included. Multiple applications of the same product were counted as a single product.

The measure of total research and development expenditures was defined as the total R&D spending divided by total expenditures in the year previous to the IPO (R&D). A logarithmic transformation was used to control for the skewness of the distribution.

The education level of the top management team was coded as a percentage of the members with a Ph.D. (EDUCAT).

The experience of the top management team was coded as the percentage of the members with experience in the biotechnology or pharmaceutical industries (EXP).

Finally, the completeness of the top management team was measured as the percentage of members of the top management team (as defined previously) each firm employed (TMTCOMP). All of the top management team data was collected from the prospectus for each firm's IPO.

Control Variables

The total assets of the offering firm prior to the IPO was used to control for the influence of size on market value (ASSET). A logarithmic transformation was used to control the skewness of the distribution.

It has been well documented[63] that the market for IPOs experiences periods in which the value of firms going public is substantially higher. The years 1983, 1986, 1991, and 1992 were hot markets for biotechnology IPOs. Therefore, to control for the effects of the hot market on firm value a dummy variable was included in the model (HOT). Those firms which made offerings during hot years were coded as "1" and all other firms were coded as "0."

Results

The data were analyzed using ordinary least squares regression. Descriptive statistics of the variables and the correlation matrices are presented in Exhibits 1, 2, and 3.

Exhibit 4 presents the regression analyses with the various market values of the firm as the dependent variables. Three different models were run corresponding to the firm's market value at the end of the first day, week, and month of trading. All three models are significant at the .001 level (model 1 F-statistic = 7.85, model 2 F-statistic = 7.61, model 3 F-statistic = 8.30).

These statistics indicate the model is explaining a significant amount of the variation in the market value of firms.

In each of the three models, the total number of products in the pipeline and the firm's R&D intensity were significant thus supporting hypotheses four and five. In model three, patents and the completeness of the top management team were significant, thus giving partial support for hypotheses three and seven. Hypotheses one, two, six, and eight were not supported.

Discussion

From the entrepreneur's perspective, the purpose of this article has been to present how the market value of biotechnology firms can be enhanced. Effective managers can use this study's results to gain insight into what resources are highly valued in equity markets and can then increase the value of their firm by accumulating these resources (when relevant to their specific firm, industry, etc.), especially when the firm is preparing its IPO of stock.

Ambiguity concerning the research potential and future profitability of biotechnology firms poses significant informational obstacle for financial markets. This forces biotechnology firms and investors to rely on credible signals to communicate the value of the firm.

The results of this study support the hypothesized relationship between firm market value and four of the hypotheses (patents, R&D intensity, total products in the pipeline, and completeness of the top management team). Although the results for the hypotheses are somewhat tenuous, this is not surprising given the general lack of explicit knowledge concerning individual biopharmaceutical products among investors. The most highly significant variables—firm assets and hot market—are very easy for investors to interpret. The remaining significant variables—patents, R&D intensity, products in the pipeline, and TMT completeness—are either minimally significant or appear as significant only after a month of trading. This suggests that investors are unclear as to what factors may lead to future success in this industry. Given some time, investors are more able to evaluate the newly public biotechnology firms and are able to be gin the process of determining what intangible factors may lead to future success. This clearly demonstrates that given time, investors in biotechnology firms come to believe that several indicators of firm scientific capabilities are signals of the future value of the firm.

A major implication of the results is the importance of the credibility of the signal being sent by the firm to investors. Each of the significant predictors can be verified by potential investors although some are more difficult to interpret than others. All of the variables related to the scientific capabilities of the firm, except firm citations, were significant in the third model. This suggests that the market needs some time to put a value on the firm's scientific capabilities. Firm citations may not reflect a true measure of

Exhibit 1
Correlation Matrix —Model 1

	mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1. DAY	95209	77189	1.00										
2. EDUCAT	.48	.20	.11	1.00									
3. TMTCOMP	.61	.23	.21[b]	-.08	1.00								
4. HOT	.79	.41	.32[d]	-.04	.08	1.00							
5. R&D	.60	.23	.40[d]	.41[d]	.04	.10	1.00						
6. CITATION	139.37	196.91	.21[b]	.19[b]	-.04	.09	.22[b]	1.00					
7. ASSET	10323397	10069583	.55[d]	.11	.28[c]	.03	.25[c]	.15[a]	1.00				
8. PRODS	3.30	4.26	.30[c]	.16[a]	.17[a]	.02	.35[d]	.11	.08	1.00			
9. EXP	.70	.22	-.01	-.14[a]	.16[a]	-.03	-.01	-.00	-.04	.05	1.00		
10. PATENT	3.30	4.85	.02	-.06	.15[a]	.06	.09	-.00	-.07	.41[d]	.05	1.00	
11. CONTRAC	4.97	4.15	.16[a]	.17[a]	.12	.02	.35[c]	.50[c]	.15[†]	.08	.03	-.04	1.00

a. p<.10. b. p<.05. c. p<.01. d. p<.001.

Exhibit 2
Correlation Matrix—Model 2

	mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1. WEEK	92888	76594	1.00										
2. EDUCAT	.48	.20	.12	1.00									
3. TMTCOMP	.61	.23	.22[b]	-.08	1.00								
4. HOT	.79	.41	.30[c]	-.04	.08	1.00							
5. R&D	.60	.23	.40[d]	.41[c]	.04	.10	1.00						
6. CITATION	139.37	196.91	.21[b]	.19[b]	-.04	.09	.22[b]	1.00					
7. ASSET	10323397	10069583	.55[d]	.11	.28[c]	.03	.25[c]	.15[a]	1.00				
8. PRODS	3.30	4.26	.29[c]	.16[a]	.17[a]	.02	.35[d]	.11	.08	1.00			
9. EXP	.70	.22	-.03	-.14[a]	.16[a]	-.03	-.01	-.00	-.04	.05	1.00		
10. PATENT	3.30	4.85	-.01	-.06	.15[a]	.06	.09	-.00	-.07	.41[d]	.05	1.00	
11. CONTRAC	4.97	4.15	.15[a]	.17[a]	.12	.02	.35[d]	.50[d]	.15[a]	.08	.03	-.04	1.00

a. p<.10. b. p<.05. c. p<.01. d. p<.001.

Exhibit 3
Correlation Matrix—Model 3

	mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1. MONTH	93458	70134	1.00										
2. EDUCAT	.48	.20	.17[a]	1.00									
3. TMTCOMP	.61	.23	.30[c]	-.08	1.00								
4. HOT	.79	.41	.33[d]	-.04	.08	1.00							
5. R&D	.60	.23	.40[d]	.41[d]	.04	.10	1.00						
6. CITATION	139.37	196.91	.18[b]	.19[b]	-.04	.09	.22[b]	1.00					
7. ASSET	10323397	10069583	.52[d]	.11	.28[c]	.03	.25[c]	.15[a]	1.00				
8. PRODS	3.30	4.26	.31[d]	.16[a]	.17[a]	.02	.35[d]	.11	.08	1.00			
9. EXP	.70	.22	-.04	-.14[a]	.16[a]	-.03	-.01	-.00	-.04	.05	1.00		
10. PATENT	3.30	4.85	-.03	-.06	.15[a]	.06	.09	-.00	-.07	.41[d]	.05	1.00	
11. CONTRAC	4.97	4.15	.13	.17[a]	.12	.02	.35[d]	.50[d]	.15[a]	.08	.03	-.04	1.00

a. $p<.10$. b. $p<.05$. c. $p<.01$. d. $p<.001$.

Exhibit 4
Regression Results

	Dependent Variables		
Independent Variables	Day	Week	Month
EDUCAT	-.06	-.05	.02
TMTCOMP	.03	.05	.17[a]
HOT	.27[c]	.26[c]	.29[d]
R&D	.21[b]	.22[b]	.20[b]
CITATION	.08	.09	.07
ASSET	.46[d]	.46[d]	.39[d]
PRODS	.23*	.21[b]	.24[b]
EXP	.01	-.02	-.04
PATENT	-.09	-.11	-.16[a]
CONTRAC	-.04	-.07	-.08
Adj. R^2	.43	.42	.45
F-statistic	7.85[d]	7.61[d]	8.30[d]
N	91	91	91

a. $p<.10$. b. $p<.05$. c. $p<.01$. d. $p<.001$.

the company's scientific capabilities because Scientific Advisory Board members are typically not full-time employees and largely act as consultants to the top management team. Scientific capabilities also appear more important to investors than top management team variables. Only the completeness of the top management team was significant in the third model. This is surprising given the wealth of evidence relating TMT variables with various outcomes.[64] One possibility is that the value of a biotechnology firm is carried almost totally in its scientific knowledge and commercialization capabilities rather than the demographics of its top management team.

While the results provide strong support for the conclusions, the focus on biotechnology firms raises questions about the generalizability of the findings. Despite the unique characteristics of the biotechnology industry, we believe the results are generalizable. Basic science appears to be playing a greater role in the success or failure of individual firms.[65] This increases the importance of scientific capabilities to investors in all types of high-technology firms, and the importance of effectively signaling these capabilities to investors by entrepreneurs interested in taking their companies public.

While we have found strong empirical support for the model, there is still a significant amount of variation in the market value of the firm that is unexplained. Obviously there remain other variables which demand further study. One particular avenue of investigation should include a much closer examination of the TMT. Factors such as industry experience and previous entrepreneurial activity may be valued by investors especially when investors have very little specific knowledge regarding the development and commercialization of a product. Additional research needs to expand this study by including firms from other industries. Finally, the value of the initial stock of resources needs to be measured at other points in time such as at the end of the first year of trading to determine if and when this initial stock of assets begins to lose its value.

Endnotes

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