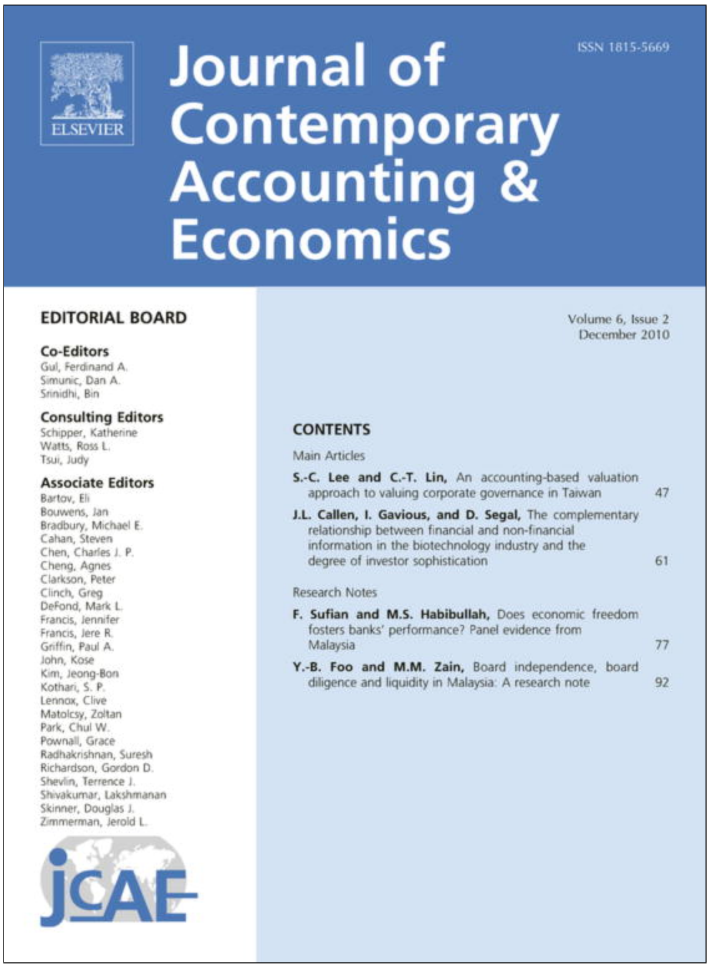
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The complementary relationship between financial and non-financial information in the biotechnology industry and the degree of investor sophistication

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ABSTRACT

We examine whether financial and non-financial variables, separately and in tandem, are value relevant in explaining market returns, equity values and the degree of investment by sophisticated investors for a sample of drug development companies. Patent counts, number of collaborations and probability-adjusted portfolios of drugs under development are the non-financial information metrics used in this study. Earnings are the main financial information variable. We show that news about these non-financial measures is significantly associated with abnormal returns. We also find that earnings are value relevant in explaining cumulative abnormal returns and equity prices around earnings announcement dates despite the fact that R&D expenditures are large and usually expensed as incurred. We further show that non-financial information is value relevant in explaining annual returns, equity prices and degree of investment by (long-horizon) sophisticated investors. Moreover, non-financial variables are value relevant after controlling for financial variables suggesting that the two types of variables are complements.

1. Introduction

Users of corporate financial reports (e.g., investors and creditors) require adequate information in order to properly judge the opportunities and risks of a company, and to form expectations about future cash flows for equity valuation and/or assessment of debt repayment prospects. Non-financial measures such as customer penetration rates for cellular companies and the number of patents granted to biotechnology companies are important sources of information for fast-changing technology-based industries. The AICPA Committee on Financial Reporting (the Jenkins Committee Report, 1994) has called for the inclusion of non-financial data in corporate financial reports. The AICPA believes that the inclusion of non-financial information enhances the utility of business reporting, particularly in the case of scientifically complex firms, leading to improved management performance, more innovation and improved capital allocation to innovative value-creating companies.[1] Another fundamental motivation for the inclusion of non-financial data in corporate reports is GAAP's traditional fixation on a functional classification that reports cost of sales and SG&A in the income statement, and residual net assets not yet consumed

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[1] A recent study by Matolcsy and Wyatt (2008) shows that technological conditions (proxied by the success rate of past technological investments, technology complexity, and the technology development period) of firms which actively produce new technologies and firms which adopt new technologies for their processes and products drive earnings growth and, hence, market value of equity.

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on the balance sheet. GAAP only makes a limited attempt to capture the processes by which businesses generate revenues. Accordingly, companies that undertake significant search and discovery activities to generate future revenues do not have these activities recognized in the financial statements in any systematic and transparent way. Instead, these companies tend to have low or negative earnings until such time as they solve the scientific or technical problems they are working on, or go bankrupt. As a result, conventional financial information is inherently limited insofar as investment decisions and valuations of technology-based firms are concerned.

This study investigates the relative value relevance of financial and non-financial information in the biotechnology industry with a particular focus on drug development companies. We also explore the relation between the investment decisions of sophisticated investors and the two information types. This study is motivated by (i) the lack of consensus on the value relevance of financial and non-financial information for technology-based industries in general, and for the biotechnology industry in particular, and (ii) the paucity of empirical evidence regarding the association between the investment decisions of sophisticated investors and financial and non-financial information in the biotechnology industry.

In a seminal study, Amir and Lev (1996) show that earnings, cash flows and book values of equity are not value relevant for a sample of telecommunication firms. Instead, non-financial indicators of success in this industry such as the potential growth in customers and market penetration are highly value-relevant on a stand alone basis. However, when these non-financial indicators are combined with financial metrics, some financial variables become value relevant indicating that financial and non-financial information are complements. Amir and Lev (1996) suggest that their results may generalize to other fast-paced science-based industries that invest significantly in research and development activities and call for further research in this area. The need to investigate the usefulness of accounting information in other science-based industries is also echoed by Shevlin (1996).

Industries that are characterized by industry-specific non-financial information provide a unique setting in which to address the value relevance of financial and non-financial information. Amongst science-based industries, the biotechnology industry has indeed provided such a unique setting for many studies (e.g., Hand, 2004, 2005; Ely et al., 2003; Guo et al., 2005; Xu et al., 2007; Joos and Zhdanov, 2008). According to Hand (2005), biotechnology firms "are among the most intangible-intensive of businesses". Moreover, the value chain of drug development firms typically stretches over many years from research through patenting to FDA approval and marketing. Since the process of drug development is lengthy, about 14 years per drug, many biotechnology firms show little if any revenues.[2] The combination of lengthy development periods with large R&D expenditures – the average cost of drug development is in the order of several hundred millions of dollars – results in large firm losses for prolonged periods of time. Intuition suggests that the long and expensive process of drug development is not only likely to obscure the value relevance of financial information but also to enhance the importance of non-financial information such as the pipeline of drugs under development, their progress through the FDA minefield and the quality of the firm's technology.

This study focuses on three non-financial measures particular to the biotechnology industry. The first measure is the probability adjusted portfolio of drugs in the pipeline (the number of drugs in each clinical trial stage multiplied by the probability that drugs in each stage reach the market). The probability adjusted portfolio of drugs indicates the potential success of drug development and, therefore, has significant value implications. The second measure is the number of collaborations with other firms. Collaborations with pharmaceutical companies or large biotechnology firms for R&D and/or marketing purposes are essential to the survival and success of most biotechnology companies because of the lengthy drug development process and the large costs of drug development. In addition, collaborations provide a signal to the market about the quality of the firm's technology.[3] The third non-financial variable is patent counts or, alternatively, patent citation counts. The operations and competitive advantage of biotechnology companies depend crucially on their ability to protect intellectual property rights and discoveries (e.g., drug targets, tools and compounds) through patents.

We investigate the value relevance and potential complementary nature of financial and non-financial information by examining systematically the association of equity returns (and firm-level equity values) with non-financial variables and financial variables, separately and in tandem. We also examine the association between the degree of investment by sophisticated investors and the information conveyed by financial and non-financial measures. This analysis is particularly germane in the context of the biotechnology industry because of the considerable scientific complexity of drug development and technology. We conjecture that sophisticated investors are better able than less sophisticated investors to evaluate this complexity in terms of ultimate drug success and to understand the value implications of financial and non-financial variables.

The results indicate that both financial and non-financial variables are value relevant in the biotechnology industry on a stand alone basis and in combination with each other. In particular, we find that financial and non-financial information are complements. More specifically, we find positive (negative) abnormal returns around the announcement of collaborations and clinical trial initiations (terminations) and around the announcement of patent grants and patent infringement lawsuits in favor of (against) the company, thereby establishing the value relevance of non-financial information measures. We also

[2] In their simulation of potential accounting approaches to R&D in the pharmaceutical industry, Healy et al. (2002) begin with year 14 as the first year of revenues.

[3] Given that a typical collaboration agreement is quite costly, large biotechnology or pharmaceutical companies engage in collaboration agreements only if they believe that the technology has a high probability of success. In a typical collaboration agreement, the pharmaceutical company pays milestones based on technology achievements and bears the cost of clinical development. In addition, once the drug is approved the pharmaceutical company has to pay royalties.

find that short-window equity returns as well as annual returns are positively associated with changes in earnings. We further document a positive relation between annual returns and changes in the number of collaborations, patents and probability adjusted portfolio of drugs under development; and a positive relation between annual returns and changes in non-financial measures and earnings combined. The price regressions support the findings of the return regressions.

Our analysis also indicates that the investment decision by sophisticated investors is positively and significantly associated with earnings and with non-financial information in the biotechnology industry. We further follow Bushee (2001) and classify institutions according to their investment horizon. We find that the positive and significant association between institutional ownership, earnings and non-financial information is attributable primarily to long term institutional investors, and not to transient institutional investors. These results are consistent with the investment objectives of these two groups of investors. Whereas transient investors focus on short-term investments based on the likelihood of short-term trading profits, long term investors typically hold large stakes in a limited number of firms, and consequently have the incentive to gather and interpret complex information beyond current earnings to assess managers' performance and the firms' prospects.

This study contributes to the literature in a number of ways. First, it investigates comprehensively the value relevance of both financial and non-financial information in the biotechnology industry on a fairly large homogeneous sample of mature drug development firms. Prior studies – see Section 2.2 below – use either small and/or heterogonous samples of young firms from various sub-fields within the biotechnology industry, and/or fail to account for important correlated non-financial variables such as patents. Second, this study shows that the concern expressed by the Jenkins committee regarding the [lack of] value relevance of financial information cannot be generalized across science-based industries. Third, this study shows that both financial and non-financial information in the biotechnology industry are value relevant and complementary. This finding provides justification for including non-financial measures in financial reports. Fourth, this study provides evidence that both financial and non-financial information are value relevant for the investment decisions of sophisticated investors in the biotechnology industry, especially those with a long term horizons. Overall, the results of this study are consistent with the premise of the Jenkins committee that including non-financial information in financial reports enhances the utility of business reporting and improves management performance and equity valuation.[4]

In what follows, Section 2 describes the biotechnology industry and develops the research hypotheses. Section 3 discusses the data and sample selection. Section 4 presents the empirical results and Section 5 concludes.

2. The biotechnology industry and hypotheses development

This section briefly describes the biotechnology industry focusing on the different biotechnology firm types. We then proceed to the literature review and development of the hypotheses.

2.1. The biotechnology industry

Biotechnology firms can be broadly classified into the following six categories: medical devices, diagnostics, information technology, tools and equipment, drug target R&D, and drug development. Medical devices companies engage in the design and production of integrated medical systems of equipment and software for treating diseases. Diagnostics companies develop diagnostic test kits, or assays, and automated systems that are used to aid in the detection of diseases. Information technology firms concentrate primarily on the study of the human genome as well as on the study of the complete set of proteins in an organism (proteomics). The data generated by information technology firms assist other biotechnology firms in their research regarding the etiology of diseases and in the development of potential new drugs. Biotechnology companies that provide research tools are commonly referred to as "Tool Companies". Modern biology research tools facilitate the discovery of factors that contribute to the onset and manifestation of specific disease processes. Drug target R&D companies engage in the discovery of potential aberrant molecules (proteins, carbohydrates, etc.) that are observed to be associated with certain diseases. Drug targets therefore have to be identified and characterized for the development of specific therapeutics.

Drug development companies engage in the research and development of new drugs. The process of drug development consists of the following stages: research, pre-clinical, phase I, phase II, phase III and regulatory approval for marketing. The research stage consists of the identification of the drug target and the development of the drug. Once the drug is developed, the company starts pre-clinical studies in which the drug is tested on animals to examine the safety and efficacy of the drug. Human studies follow once the drug demonstrates its potential in pre-clinical studies. Phase I is a small-scale trial with a limited number of patients or volunteers. Its main goal is to evaluate the safety of the drug at dosages that are clinically significant. Phase II is also a small-scale trial but its goal is to determine efficacy of the drug (whether the drug warrants further investigation and development). Phase III is a pivotal large-scale multi-centered study to evaluate the compound in comparison to a control group (i.e. a group being prescribed an established treatment or a placebo). Once the drug demonstrates safety and efficacy, it may receive regulatory approval, allowing the company to start marketing the drug.

[4] In addition, the results confirm the importance of our non-financial measures, namely the probability adjusted portfolio of drugs in the pipeline, number of collaborations and number of patents, as valuation attributes, thereby providing some guideline for market participants who do not know what non-financial information to look for or how to interpret the information when they have it. We thank the anonymous referee for this observation.

Given the heterogeneity in operations among biotechnology firms and the nature of our study, we focus on the largest homogeneous group of biotechnology companies, namely drug development companies.[5]

2.2. Prior literature and hypotheses development

2.2.1. The value-relevance of financial information

Science-based (high-tech) industries are characterized by large investments in R&D and other intangible assets such as customer-base, patents, and intellectual capital that are largely expensed in the financial statements. The expensing of these investments has raised concerns that financial accounting may be unsuitable for a changing economy in which there is a growing number of science-based emerging industries (AICPA, 1994; Stewart, 1997). These concerns generated two strands of research. The first investigates the time-series properties of the value-relevance of accounting information for firms in general (Lev and Zarowin, 1999; Brown et al., 1999; Francis and Schipper, 1999). The second strand examines the value-relevance of accounting information for high-tech firms.

Lev and Zarowin (1999), Brown et al. (1999) and Francis and Schipper (1999) suggest that the value-relevance of financial information, measured by the association of stock returns with earnings and book value of equity, has been consistently declining over the past 20 years. They attribute this result to the growth and importance of intangibles in the economy that are either not recorded on the balance sheet or are treated improperly by GAAP.

Studies that examine the value relevance of financial information for high-tech firms yield mixed results. Amir and Lev (1996) show that earnings, cash flows and book values of equity are not value-relevant for a sample of telecommunication firms. Core et al. (2003) find that the market values of high-tech firms are unrelated to book values of equity but significantly positively (negatively) related to earnings (losses). In contrast, Hirschey et al. (2001), find a significant positive relation between both book value and earnings and the market values of high-tech firms. Hand (2003) finds that accounting data are highly value relevant for the pricing of internet stocks but in a nonlinear fashion; market values are linear and increasing with respect to book values, but concave and increasing (decreasing) in positive (negative) earnings. In contrast, Trueman et al. (2001) show that net income is unrelated to equity prices of internet firms, although gross profit is significantly positively associated with equity prices. Jorion and Talmor (2001) and Rajgopal et al. (2003) find that book values of equity of internet and e-commerce firms are associated with market value whereas the association of market values and earnings is not significantly different from zero.

The value relevance of financial information in the biotechnology industry is examined by Amir and Lev (1996), Hand (2004, 2005), Ely et al. (2003), Guo et al. (2005), Xu et al. (2007) and Joos and Zhdanov (2008). Virtually all studies show that book value of equity and R&D expenditure are positively associated with market value of equity. However, the results concerning earnings are contradictory. Amir and Lev (1996) find a negative and significant association between earnings and market values. Ely et al. (2003) shows that market values are not significantly related to earnings before R&D. Similarly, Guo et al. (2005) document that among many financial indicators only R&D expense is significantly related to market value at the time of the IPO.

In contrast to these findings, several papers document that earnings and other financial information are associated with market value of equity. Hand (2004) shows that earnings are significantly and positively related to market values.[6] In addition, he finds that financial statements based measures, such as size and sales growth rates, explain most of the variance (about 70%) of the log of market value. Hand (2005) further finds that financial statement information is value relevant in the pre-IPO venture capital market, and becomes more value relevant as the firm matures, consistent with financial statements capturing the intensity of assets-in-place relative to future investment options. Joos and Zhdanov (2008) also document changes in the relationship between price and earnings as biotechnology companies mature. Xu et al. (2007), show that market values are positively related to earnings before R&D as well as to book values and R&D expenses.

The lack of consensus on the value relevance of financial information (especially earnings) may be explained by differences among the various studies including the investigated industry or sub-industry (e.g., drug development firms vs. medical equipment firms); life cycle stage of the sample firms; types of non-financial information items used; and sample size. Hence, our first hypothesis, expressed in the alternative, is:

H1: Financial information is value-relevant for drug development companies.

2.2.2. The value-relevance of non-financial information in biotechnology

The long process of drug development, which may obscure the value relevance of financial information, and the availability of natural quantifiable measures of non-financial information, have generated research on the value relevance of non-financial information, in particular the impact of information concerning the portfolio of drugs under development.

[5] Different sub-sets of firms within the biotech industry differ in attributes such as type of products, technologies used to develop the products, length of process from R&D to marketing, R&D intensity, reliance on collaboration with other companies, lifecycle stage, etc. As such, each sub-set of firms (e.g., drug development vs. medical equipment) is characterized by different key non-financial items and, therefore, a study of non-financial information requires a homogeneous group of firms.

[6] Although the sample sizes of Hand's (2004, 2005) studies dominate the other two studies cited in this paragraph, his samples are heterogeneous and include, for example, tool companies that operate similarly to other manufacturers and are profitable. We focus on drug development companies that are rarely profitable.

Huberman and Regev (2001) investigate the market reaction to non-financial information events for a biotechnology company. They document overreaction to the publication of "no-new-news" (based on spurious publicity) and under reaction to the publication of "new news" (based on hard, solid information). Ely et al. (2003) show that investors appear to treat drugs under development as value-relevant only when these drugs reach the Phase II stage.[7] They also find that there is no relation between market values and collaborations, a counter-intuitive result that they attribute to the small size of their sample.[8] However, their study does not control for patent data which are known to be highly correlated with the number of drugs under development. Guo et al. (2004) focus on *product-related* information disclosed by biotechnology companies before their IPO.[9] They document that this type of non-financial information is value relevant to investors and that the extant of its disclosure is determined by "competitive costs of disclosure" (proxied by the stage of product development; availability of patent protection; venture capital backing; and ownership stake retained by pre-IPO owners). In similar vain, Guo et al. (2005) find that IPO prices are positively associated with the stage of product development (average development stage of the pipeline), the number of products under development (from research initiation to FDA approval) and intellectual property protection (percentage of products with patents).[10] In a comprehensive study of non-financial information, Xu et al. (2007) identify seven attributes of drug portfolios which underlie the conversion of a biotechnology firm's R&D expenditures into value. These measures include, *inter alia*, the status of the drug portfolio[11]; drug portfolio diversification (the number of different diseases the firm targets and the number of drug indications the firm pursues for each disease); alliance intensity (cumulative alliances divided by total drug indications); patents (cumulative patents divided by total number of drug indications); and whether the firm targets high profile diseases (e.g., cancer, AIDS, diabetes). Their main findings show that inclusion of these non-financial measures increases significantly the incremental value relevance of R&D over the baseline financial variables (book value and earnings). Moreover, alliances and targeting high profile diseases (drug development status and product diversification) are shown to have greater value for emerging (mature) firms. On the other hand, Hand (2005) finds that non-financial information is value relevant only prior to filing for an IPO and becomes irrelevant after the IPO, controlling for the value relevance of financial information. Overall, notwithstanding Hand (2005), there appears to be a consensus regarding the value relevance of non-financial information.

While the literature focuses primarily on investigating the value relevance of either financial or non-financial information, there is little evidence on the value relevance of financial and non-financial information after controlling for the other type of information. Amir and Lev (1996) show that financial data on a stand alone basis are not value relevant in the telecommunications industry whereas non-financial information are value-relevant. However, when controlling for non-financial information, at least some financial information are value relevant. Xu et al. (2007) suggest that the value of R&D expenditures can be better understood from their interactions with non-financial data that capture the uncertainty surrounding the transformation of R&D into firm value. Dedman et al. (2008) present evidence that drug development announcements by UK biotechnology firms have a much higher price impact than earnings announcements.[12] In contrast, Hand (2005) finds that non-financial data do not provide incremental information beyond financial data. He shows that the value relevance of (non) financial statement information increases (decreases) as firms mature, and concludes that financial and non-financial information are substitutes, not complements. While Hand (2005) addresses the relation between the two types of information, our study differs in a number of ways. First, our database is constructed from a panel of all public firms across the sample period regardless of their age or time of IPO whereas Hand's data consist of young pre-IPO firms up until three years after they go public. Thus, our sample better reflects the industry. Second, to ensure a homogeneous sample, we restrict our sample to drug development companies only. In contrast, Hand's sample is heterogonous and includes firms from various

[7] They cite working papers by Bowen and Shores (2000) and Shortridge (2004) that show that R&D expenditures have a greater association with market values for firms with more approved drugs in the pharmaceutical industry.

[8] This result contradicts the literature on collaborations. Rodriguez (1998) finds that R&D partner firms (usually the biotechnology firm) experience significant positive cumulative abnormal returns of 4.4% around the announcement of R&D strategic alliances among biotechnology and pharmaceutical firms. Anand and Khanna (2000) find that prior (joint venture) alliance experience leads to abnormal stock price returns at the time of the alliance announcement, suggesting that firms learn to create more value through alliances as they accumulate experience with joint ventures. They also find that the effect of prior experience on returns depends on the type of alliance activities – R&D, production or marketing – and suggest that alliances with more ambiguous activities are more likely to benefit from past experience. Das et al. (1998) find that announcements of technological (marketing) alliances enjoy greater (lower) abnormal returns. This is consistent with technological alliances perceived as increasing firm value because they involve cooperation in upstream value chain activities (e.g., R&D and engineering). On the other hand, marketing alliances involve cooperation in downstream value chain activities (e.g., sales and distribution) appear to signal to the market that the firm's products have entered the mature/decline phase of their life cycles. In addition, they show that investors perceive more (less) profitable, larger (smaller) firms as capturing less (more) gain from alliances. Danzon and Towse (2003) find that pharmaceutical products developed in an alliance tend to have a higher probability of success, at least for the more complex phase II and phase III trials, particularly if the licensee is a large firm.

[9] Guo et al. (2004) construct an index for product-related information which reflects product specifications, information about target diseases, clinical trial results, future product development plans, and market-related information (such as the number of patients affected by the disease).

[10] There is likely a large discrepancy between information existing up to the listing date of the IPO and information existing in the years subsequent to the listing date due to the probability of significant changes in the company (i.e., the company probably undertook the IPO to access capital for growth). We thank the anonymous referee for this observation.

[11] Xu et al.'s (2007) measure of a drug portfolio's status differs from that of Ely et al. (2003) by including all development stages and using other probabilities to weigh each stage. Whereas Ely et al. multiply drugs in phase I, phase II, phase III and post phase III by the probability of eventual FDA regulatory approval as provided by the Standard & Poor's 1997 Biotechnology Industry Analysis, Xu et al. also include in their measure the pre-clinical trial stage and the investigational new drug filing stage and use the probabilities of eventual approval taken from DiMasi (2001).

[12] Similarly to US GAAP, SSAP 13 requires that UK firms immediately expense most of their R&D expenditures.

sub-fields within the biotechnology industry. Third, our sample size is about three times larger than his – 1211 firm-years as compared to 449 firm-years. These considerations lead to our next hypothesis stated in the alternative.

H2: Non-financial information is complementary to financial information for drug development companies.

2.2.3. Non-financial information and investor sophistication

Findings in the accounting literatures indicate that sophisticated investors have superior abilities and, consequently, learn better from experience (Beaver, 1998; Bonner and Walker, 1994). Price (1998) finds that informed investors make greater use of accounting disclosures and non-earnings information to form more precise earnings expectations. Bonner et al. (2003) document that sophisticated investors incorporate the information inherent in the relative accuracy of analyst forecasts to a greater extent than less informed investors, consistent with sophisticated investors (institutions) having greater abilities and exhibiting more adaptive strategies. Economic incentives are potentially important as well. Institutional investors have much larger investment portfolios and, therefore, have much more to gain or lose in absolute dollar terms from their investment decisions. Furthermore, the costs to engaging in more in-depth firm analysis are lower for institutions, in part because of their superior access to databases and analytical tools (Bonner et al., 2003). Finally, the efficiency of a firm's stock price appears to be associated with the degree of sophistication of the firm's marginal investor (e.g., Walther, 1997; Bartov et al., 2000; Jimbalvo et al., 2002; Battalio and Mendenhall, 2003).

While prior studies document significant association between institutional ownership and financial information, there are no studies that examine the association between institutional ownership and non-financial information. Given the considerable scientific complexity of drug development and technology, sophisticated investors may be better able than less sophisticated investors to evaluate this complexity in terms of ultimate drug success, and hence one should expect significant association between non-financial information and institutional ownership. This leads to our third hypothesis (stated in the alternative):

H3: The investment by sophisticated investors in drug development companies is significantly related to both non-financial and financial variables.

2.2.4. Short-term versus long-term institutional investors

We follow the extant accounting literature and use institutional ownership (both the percentage of shares held by institutions and the number of institutions holding shares) as a proxy for investor sophistication: (e.g., Hand, 1990; Walther, 1997; Bartov et al., 2000; Bradshaw et al., 2004). These institutions consist of banks, insurance companies, investment companies and their managers, independent advisors, and others.

Prior research has documented that there are distinct groups among institutions that differ in their objectives and information needs. Specifically, Bushee (1998) classifies institutions into three groups – transient, dedicated, and quasi-indexer. "Transient" institutions are characterized as having high portfolio turnover and highly diversified portfolio holdings (Bushee, 2001). They are short-term focused investors whose investments are based on the likelihood of short-term trading profits. In contrast, "dedicated" investors and "quasi-indexers" both provide long-term, stable ownership to firms. Dedicated institutional investors hold large stakes in a limited number of firms. Such ownership creates incentives to monitor management by investing in informational resources beyond current earnings to assess managers' performance. In addition, long-term investors have better access to private information about their portfolio firms (Porter, 1992). Quasi-indexers generally follow indexing and buy-and-hold strategies, and are characterized by high diversification.[13] Given the divergence in objectives and information needs, our final hypothesis (stated in the alternative) examines whether ownership by long-term (short-term) sophisticated investors is related (not related) to financial and non-financial information[14]:

H4: The investment by long-term (short-term) institutional investors in drug development companies is positively related (not related) to non-financial and financial variables.

3. Data

We start by identifying all US domiciled "life sciences" biotechnology companies that are listed on the Compustat Database with a primary SIC code of 2834, 2835 or 2836 for the years 1994–2001. We limit our study to US domiciled firms in order to facilitate extraction of non-financial information from the 10-K annual reports.[15] The initial sample consists of 567 (3128) firms (firm-years). We then compare this list of companies with the list of biotechnology companies on Bioworld Online, which is a leading provider of information related to worldwide biotechnology companies, and add an additional 44 (169) firm (firm-years) to the sample, bringing the total number of firms (firm-years) in our sample to 611 (3297). We then restrict the

[13] Although quasi-indexers follow a passive investment strategy, Monks and Minow (1995) argue that these investors have strong incentives to monitor management to ensure that it is acting in the best interest of the firm.

[14] There is potential self-selection bias in the investment decision of the three categories of institutional investors. An examination of this issue is outside the scope of this study and one we leave for future research.

[15] Non US firms are not required to file 10-K reports, although they may have to file form 20-F which is often not as detailed as the 10-K.

sample firms to drug development companies only. This restriction ensures that our sample consists of a sufficiently large and homogeneous sample. We further exclude pharmaceutical companies and companies that develop primarily generic drugs since these companies tend to be much larger than the average biotechnology company, and oftentimes their 10-K disclosures are too aggregated to tease out the required non-financial information.

For each firm-year we collect the following non-financial information: the number of products and indications under development in each clinical phase, the number of collaborations and the number of patents and patent citations.[16] Except for the patent related data, these data are collected from "Item 1: Business" section of the 10-K report. The patent data are obtained by downloading the patents owned by each firm and their patent number from the Lexis–Nexis Database. The citation data for each patent are then obtained from the United States Patents and Trademark Office patent citation database.

Merging the non-financial information database with Compustat and CRSP, and requiring non-missing net income before extraordinary items (DATA18), book value of equity (DATA60), research and development expense (DATA46), and valid market value of equity three months after fiscal year-end, results in a final sample size of 282 (1211) firms (firm-years).[17] Table 1, Panel A shows the data selection procedure.

To enable our event-study analyses of non-financial information, news (press releases) pertaining to the non-financial variables are collected for each firm. For collaborations we collect the date of initiation and termination of collaboration agreements. Regarding patents, we record the dates of each application, grant of patents, lawsuits filed against or initiated by the company for patent infringements, and court decisions in such cases. In addition, we collect the announcement dates of success or failure of each of the clinical drug phases. Finally, data on institutional ownership are obtained from Thompson's CDA/Spectrum database.

Table 1, Panels B and C show descriptive statistics of the sample firms. Panel B shows the mean and median of selected financial variables for our sample of drug development companies as well as for all other companies in the industry with the required data. The statistics of our sample firms show that drug-development firms are relatively small with a mean (median) market value of equity of $817 ($149) million. As expected, most companies report losses (mean EPS scaled by price is −0.14 and mean ROE is −0.64) and negative cash flows from operations (mean cash flows scaled by price is −0.11). The book-to-market is low (mean and median of 0.29 and 0.22, respectively) consistent with depressed book values of equity (a result of the expensing of R&D outlays) and with the growth option nature of these companies. The mean (median) R&D intensity, computed as R&D expense divided by total sales, is very high at 9 (2), consistent with the large costs of drug development and minimal revenues for most biotechnology firms. Mean (median) revenue is $58 ($5) million. The corresponding statistics for the non drug-development companies in the industry reveal that they are larger and have higher, more profitable sales, although they predominantly report losses. The differences across the mean and median statistics are all significant at the 1% level. This result is consistent with the conjecture that drug development companies are primarily research and development companies with little revenues.

Panel C shows the mean and median statistics of the non-financial variables. The average number of compounds in phase I and II is close to one, and the average number of compounds in phase III is 0.5. Following Ely et al. (2003) we compute a measure of the firm's drug portfolio potential (WGHTDR) by multiplying each drug in-process by the probability of eventual FDA regulatory approval (Joy, 1997).[18] The mean and median of WGHTDR is 0.44 (0.26). The mean and median number of collaboration is 4 and 3, respectively. Finally, the mean (median) number of patents and citations per patent are 22 (10) and 3.5 (1.7), respectively.

4. Results

We investigate the value-relevance of financial and non-financial information using event study, return, and price level analyses. In addition, we examine whether financial and non-financial information are associated with the level of institutional ownership.

4.1. Event study and return analyses

This section establishes the value-relevance of non-financial information using an event study methodology where we examine the cumulative abnormal returns around the announcement of news related to earnings and our non-financial information variables. In addition, we examine the association of annual returns with financial and non-financial information.

[16] A compound (potential drug) may be tested for more than one disease (indication). For example, Abgenix had a compound in phase I for rheumatoid arthritis. The same compound was in phase II clinical trial for psoriasis in the same year.

[17] In order to mitigate the effects of outliers, we further delete observations in the top and bottom one percent of the dependent and independent variables in the regressions that follow.

[18] The probabilities of eventual approval as provided by the Standard & Poor's 1997 Biotechnology Industry Analysis are 1 in 20 for phase I, 1 in 13 for phase II, 1 in 9 for phase III, and 1 in 2 for drugs in post phase III. These translate into standardized weights of 0.068, 0.104, 0.151 and 0.677, respectively (see Ely et al., 2003) so that WGHTDR = (0.068 * PH_I) + (0.104 * PH_II) + (0.151 * PH_III) + (0.677 * POST_III), where PH_I, PH_II, and PH_III is the number of drugs in phase I, II, III, respectively, and POST_III is the number of drugs under review for FDA approval.

Table 1
Data selection and descriptive statistics.

	Firms	Firm-years
Panel A: data selection		
US Domiciled firms in SICs 2834–2836 for the years 1994–2001	567	3128
Add: additional companies on BioWorld	44	169
Total number of observations available	611	3297
Excluding observations of companies that are not classified as drug development companies	339	2079
Initial sample of drug development companies	282	1218
Remove observations with missing R&D expenditures, earnings, book value of equity or market value of equity	0	7
Final sample	282	1211
	Drug development	Other biotech
Panel B: financial variables		
MV ($mm)	817 (149)	3321 (114)
EPS/Price	−0.14 (−0.09)	−0.1 (−0.03)
CFO/Price	−0.11 (−0.07)	−0.06 (−0.01)
R&D/Sales	9.33 (1.97)	3.10 (0.18)
SALES ($mm)	58 (5)	785 (17)
Book-to-market	0.29 (0.22)	0.33 (0.26)
ROE	−0.64 (−0.36)	−0.44 (−0.12)
Observations	1671	1211
Variable	Mean	Median
Panel C: non-financial variables		
COL	4.18	3.00
PH_I	1.10	1.00
PH_II	1.00	1.00
PH_III	0.51	0.00
POST_PH_III	0.29	0.00
DRUGS	0.96	0.00
WGHTDR	0.44	0.26
PAT	21.93	10.00
AVG_CIT	3.45	1.68

The above table provides descriptive statistics on the data selection process (Panel A) and main variables used in the analyses (Panels B and C). Panel B shows the mean (median) of selected financial variables for our sample of drug development companies as well as for all other companies in the industry. MV is market value of equity three months after fiscal year-end. EPS/Price (CFO/Price) is earnings per-share before extraordinary items (cash flows from operations per-share) divided by share price three months after fiscal year-end. R&D/Sales is R&D intensity measured as R&D expense divided by total sales. SALES is total revenues. Book-to-Market is book value divided by market value. ROE is the return on equity computed as earnings before extraordinary items scaled by book value of equity. Panel C shows the mean and median statistics of the non-financial variables. COL is the number of collaborations. PH_i is the number of drugs under development in phase i (i = I, II, III). POST_PH_III is the number of drugs post phase III, which are under review by the Food and Drug Administration for approval. DRUGS is the number of marketed drugs. WGHTDR is the probability-adjusted portfolio of drugs in the pipeline. PAT is the number of patents, and AVG_CIT is the total number of citations in granted patents divided by the number of granted patents.

4.1.1. Abnormal returns and non-financial information

Table 2 shows mean and median cumulative abnormal returns around the announcement dates of news related to the relevant non-financial information, including initiation and termination of collaboration agreements, initiation of a new phase in clinical trials and termination of clinical trials, granting of patents, litigation related to patent infringements by and against the company, and court decisions for and against the company in litigation involving patents. The short (long) window abnormal returns are computed by summing the size-adjusted abnormal returns in the three (seven) days centered on the announcement date of the news. Since the short three-day and long seven-day window returns are similar we discuss the short window returns only.

Table 2 shows that abnormal returns are significant and consistent with expectations.[19] The mean abnormal return around the announcement of initiation (termination) of a collaboration agreement is 3% (−8%). The mean abnormal return around the

[19] It should be noted that the results presented here are conditional on events that management has chosen to disclose to the public.

Table 2
Mean (median) abnormal returns around the announcement of news related to non-financial information.

Non-financial variables	News	N	Short window	Long window
Collaboration	Initiation	1443	0.031 (0.016)	0.033 (0.018)
	Termination	46	−0.083 (−0.043)	−0.048 (−0.057)
Clinical trials	Termination	27	−0.228 (−0.203)	−0.207 (−0.15)
	Initiation (PH. I)	344	0.013 (0.009)	0.024 (0.006)
	Initiation (PH. II)	409	0.022 (0.015)	0.039 (0.023)
	Initiation (PH. III)	251	0.030 (0.014)	0.035 (0.019)
Patents	Grant	985	0.033 (0.012)	0.036 (0.011)
	Litigation by	15	0.030 (0.018)	−0.011 (−0.016)
	Litigation against	19	−0.035 (−0.013)	−0.056 (−0.043)
	Court decision for	36	0.084 (0.049)	0.076 (0.038)
	Court decision against	13	−0.053 (−0.028)	−0.075 (−0.123)

The above table shows the mean (median in parentheses) cumulative abnormal returns around the announcement of news related to the non-financial information variables of collaborations, clinical trials and patents. Short (long) window cumulative abnormal returns are accumulated over three (seven) days surrounding the news release date. The daily abnormal returns are computed based on the market model and are size adjusted. Collaboration refers to strategic alliance for R&D, production or marketing purposes. Clinical Trials refers to news related to drugs under development. "Litigation by" refers to litigation by the patent holder against other firms. "Litigation Against" refers to litigation by other firms against the patent holder. "Court Decision For" refers to litigation decision in favor of the patent holder and against other firms. "Court Decision Against" refers to litigation decision against the patent holder and in favor of other firms. Except for the returns around Litigation By and Litigation Against, the return statistics are significant usually at less than 5% significance level. N denotes the number of observations.

Table 3
Panel regressions of abnormal returns surrounding earnings announcements on earnings and change in earnings.

	Quarterly	Annual
Intercept	0.0009 (0.002)	−0.004 (0.003)
E	0.215*** (0.065)	0.155 (0.122)
Δ*E*	0.174*** (0.055)	0.232** (0.096)
F-value	16.56***	5.84***
Adj. R^2	0.013	0.029
N	3003	855

Table presents the estimation results of the following regression:

$$R_{it} = \alpha_0 + \alpha_1 E_{it} + \alpha_2 \Delta E_{it} + \varepsilon_{it}$$

The dependent variable is the size adjusted cumulative abnormal return in the three days centered on earnings announcements. *E* is earnings per-share before extraordinary items and Δ*E* is the change in earnings per share, both deflated by beginning of period price per share. The change in earnings per share is computed as current earnings per share minus the earnings per share reported in the same quarter in the prior year. The quarterly column shows the regression results of abnormal returns on (deflated) quarterly earnings and change in earnings. The annual column shows the same regressions with the sample restricted to the fourth fiscal quarter (annual report). We include in the analysis firm-quarters for which we were able to identify the earnings announcement date. In addition, we remove the top and bottom 1% of the regressions variables to mitigate the effect of outliers. *N* denotes the number of observations in each regression. Standard errors of the coefficients are presented in parenthesis. The regressions are estimated using panel data including firm and year fixed effects.

* Indicates significance level of 10%.
** Indicates significance level of 5%.
*** Indicates significance level of 1%.

announcement of the initiation of the three phases of clinical trials is positive and increasing from 1.3% for Phase I to 3% for Phase III. As expected, investors react negatively to announcements of termination of clinical trials: the mean (median) abnormal return is −23% (−20%). The strong market reaction to the announcement of the termination of clinical trials testifies to the economic importance of each drug under development for drug-development firms.

As far as patent news is concerned, we find that investors react positively to the granting of a patent (mean abnormal return of 3.3%), to the announcement of litigation by the company of a patent infringement (mean abnormal returns of 3%), and to court decisions related to patent disputes in favor of the company (mean abnormal returns of 8.4%). In contrast,

Table 4
Regressions of annual returns on non-financial variables, financial variables, and combination of non-financial and financial variables.

	Non-financial	Financial	Combined	Index
Intercept	1.142** (0.585)	1.243** (0.565)	1.075* (0.566)	1.244** (0.564)
E		−3.221*** (−0.398)	−2.577*** (−0.487)	−2.657*** (0.477)
ΔE		1.982*** (0.396)	1.282*** (0.461)	1.299*** (0.453)
ΔPAT	0.262*** (0.052)		0.174*** (0.055)	
ΔCOL	0.430*** (0.146)		0.323** (0.147)	
$\Delta WGHTDR$	1.713* (0.949)		1.522* (0.952)	
$\Delta INDX$				0.250*** (0.060)
Adj. R^2	0.251	0.293	0.278	0.279
F-value	2.158***	2.578***	2.297***	2.313***
N	900	1056	878	878

The above table shows the regression of annual returns on financial variables (financial column), non-financial variables (non-financial column) and financial and non-financial variables (combined column):

$$Ann\_R_{it} = \alpha_0 + \alpha_1 E_{it} + \alpha_2 \Delta E_{it} + \alpha_3 \Delta PAT_{it} + \alpha_4 \Delta COL_{it} + \alpha_5 \Delta WGHTDR_{it} + u_{it}$$

The index column shows the regression where all non-financial variables are combined into an index of non-financial information. The dependent variable is the annual return computed from 9 months prior to fiscal year-end to 3 months after fiscal year-end. E is annual earnings per-share before extraordinary items, ΔE is the change in E, ΔPAT is the change in number of granted patents during the year, ΔCOL is the change in the number of collaborations during the year, and $\Delta WGHTDR$ is the change in the probability adjusted portfolio of drugs in the pipeline during the year. $\Delta INDX$ is the change in the index of non-financial information. The index is computed using factor analysis of the three proxies for non-financial information. All independent variables are deflated by the beginning of year stock price. Computing first-differences in the financial and non-financial variables results in a loss of the first-year observation for each firm. In addition, we remove the top and bottom 1% of the regressions variables to mitigate the effect of outliers. N denotes the number of observations in each regression. Standard errors of the coefficients are presented in parenthesis. The regressions are estimated using panel data with firm and year fixed effects.

* Indicates significance level of 10%.
** Indicates significance level of 5%.
*** Indicates significance level of 1%.

the market reaction is −3.5% to the announcement of a lawsuit against the company for a patent infringement. Similarly, when the court decides against the company in a patent dispute the market reaction is −5.3%. Thus, these results are indicative of the importance of patents to biotechnology firms. Overall, Table 2 shows that news related to all three non-financial information variables are statistically and economically value-relevant.

4.1.2. Abnormal returns and quarterly financial information

We initially analyze the value relevance of financial information by regressing returns on (deflated) earnings and the change in earnings, following the Easton and Harris (1991) return version of the Ohlson (1995) model:

$$R_{it} = \alpha_0 + \alpha_1 E_{it} + \alpha_2 \Delta E_{it} + \varepsilon_{it} \qquad (1)$$

where i is the firm index and t is the time index; R is the size adjusted cumulative abnormal returns in the three days centered on the earnings announcement; E is the quarterly earnings per share (before extraordinary items) deflated by beginning of quarter price per share; ΔE is the change in earnings per share (before extraordinary items) from the same quarter of the prior year deflated by beginning of quarter price per share; and ε is a white noise error term.

Table 3 shows the return regressions estimated using panel data with fixed time and firm effects. The quarterly column shows the regression results for quarterly earnings. The annual column shows the same regression where the sample is restricted to the fourth fiscal quarter (annual report). Both regressions are significant at the 1% level. The coefficient on the change in earnings is positive and significant in the quarterly (annual) regressions at the 1% (5%) level; the coefficient on earnings is positive and significant in the quarterly regression but not in the regression restricted to the fourth fiscal quarter. These results contradict the general implications of the Amir-Lev findings and demonstrate that earnings are value relevant for firms that spend significant amounts on R&D.[20]

4.1.3. Annual returns analysis and annual non-financial information

Table 4 shows the annual return regression estimated using panel data with fixed time and firm effects:

[20] Since the biotechnology industry is now a relatively mature industry, it makes economic sense that earnings are value relevant. The expensing of R&D is only likely to depress earnings for young growth firms at their initial stage of operations. In steady state, absent significant *growth* in R&D expenditures, reported earnings will be similar whether the firm expenses or capitalizes R&D. Capitalization of R&D requires amortization of the R&D asset and, in steady state, amortization expense will equal annual R&D expenses. As a result, the change in earnings – the variable that drives returns – should not overly depend on the accounting for R&D.

Table 5
Regressions of market value of equity on non-financial variables, financial variables, and combinations of non-financial and financial variables.

	Non-financial	Financial	Combined	R&D	Index
Intercept	4.122 (5.252)	3.757 (4.611)	−9.271* (5.374)	−5.597 (4.716)	0.966 (4.323)
BV		1.722*** (0.166)	1.754*** (0.188)	1.773*** (0.172)	1.771*** (0.171)
E		17.905*** (3.032)	16.351*** (3.228)		
NEG_E		1.022 (1.521)	−0.773 (1.565)		
*NEG_E*E*		−18.970*** (3.057)	−17.678*** (3.256)		
R&D				2.028*** (0.415)	1.992*** (0.414)
ADJ_E				0.553 (0.533)	0.571 (0.533)
LN(*PAT*)	1.768** (0.789)		2.189*** (0.705)	1.827*** (0.706)	
COL	0.756*** (0.179)		0.498*** (0.162)	0.407*** (0.164)	
WGHTDR	4.051*** (1.010)		1.901** (0.932)	1.916** (0.939)	
INDX					2.723*** (0.636)
N	1167	1136	1129	1123	1123
Adj. R^2	0.452	0.544	0.543	0.536	0.536
F-value	4.311***	5.815***	5.629***	5.533***	5.567***

Table shows the regressions results of market value of equity on non-financial variables, financial variables and combination of non-financial and financial variables:

$$P_{it} = \beta_0 + \beta_1 BV_{it} + \beta_2 E_{it} + \beta_3 NEG\_E_{it} + \beta_4 NEG\_E_{it} * E_{it} + \beta_5 LN(PAT_{it}) + \beta_6 COL_{it} + \beta_7 WGHTDR_{it} + v_{it}$$

The dependent variable is price per share three months after fiscal year-end. *BV* is book value per share at fiscal year-end; *E* is annual earnings per share before extraordinary items; *NEG_E* is an indicator variable with 1 if earnings before extraordinary items are negative, zero otherwise; *NEG_E*E*, the product of *NEG_E* and *E*; *LN*(*PAT*) is the natural logarithm of the number of granted patents, *COL* is the number of collaborations, and *WGHTDR* is the probability adjusted portfolio of drugs in the pipeline. We add 1 to zero patents observations so that they are not discarded by the log-transformation**.** In the R&D Column, earnings are decomposed into R&D expense and earnings before R&D; specifically, *R&D* is research and development expenditures per share and *ADJ_E* is annual earnings per share before R&D and extraordinary items. The index column shows the regression where all non-financial variables are combined into an index of non-financial information. *INDX* is the index of non-financial information; it is computed using factor analysis of the three proxies for non-financial information. We remove the top and bottom 1% of the regressions variables to mitigate the effect of outliers. *N* denotes the number of observations in each regression. The regressions are estimated using panel data with firm and year fixed effects. Standard errors of the coefficients are presented in parenthesis.
* Refer to significance at the 10% confidence level.
** Refer to significance at the 5% confidence level.
*** Refer to significance at the 1% confidence level.

$$Ann\_R_{it} = \alpha_0 + \alpha_1 E_{it} + \alpha_2 \Delta E_{it} + \alpha_3 \Delta PAT_{it} + \alpha_4 \Delta COL_{it} + \alpha_5 \Delta WGHTDR_{it} + u_{it} \quad (2)$$

where *Ann_R* is the annual return. *Ann_R* is computed based on monthly returns from 9 months before fiscal year-end to three months after fiscal year-end; *E* is the annual earnings per share before extraordinary items; ΔE is the change in *E*; ΔPAT is the change in the number of granted patents; ΔCOL is the change in the number of collaborations; and $\Delta WGHTDR$ is the change in drug portfolio potential. All of the independent variables are scaled by beginning of year share price.

The "Non-financial" column shows the results of annual returns regressed on the change in non-financial variables only. The regression is significant at the 1% level (*F*-value = 2.2). The coefficients on the change in the number of patents and on the number of collaborations are positive and significant at less than 1%. The coefficient on the change in the probability adjusted portfolio of drugs is also positive but only significant at the 10% level. Overall, the regression indicates that non-financial variables are value-relevant in explaining annual returns. The "Financial" column shows the results of the regression of returns on earnings and the change in earnings only. The coefficient on earnings (change in earnings) is negative (positive) and significant at the 1% level. [21]

Consistent with hypotheses H1 and H2, the results thus far based on event study and return analyses indicate that, on a stand-alone basis, both non-financial information and financial information are value-relevant for biotech firms. To examine whether these two alternative sources of information are complements or substitutes (H3), we include both the financial and non-financial variables as independent variables. The estimated regression is presented in the "Combined" column. The coefficients on all five variables retain the same sign as before and are statistically significant.

As a sensitivity analysis, we combine the non-financial information variables into a single index of non-financial information using principal components analysis in case the non-financial metrics measure the same construct. The "Index" column shows the regression of returns on earnings, change in earnings and change in the index of non-financial information. The

[21] Note that the coefficient on the change in earnings is consistently positive and highly significant across all specifications of the return regressions – abnormal returns surrounding quarterly and annual earnings announcements and annual returns. However, while the coefficient on the level of earnings is significantly positive in the regression of abnormal returns surrounding quarterly earnings announcements, it is significantly negative in the annual returns regressions. Given that the change in earnings – not the level of earnings – drives returns (the latter is used in the return regressions as a control variable), our hypothesis concerns the change in earnings alone; we do not form expectations regarding the sign and significance of the level of earnings.

results indicate that the coefficient on the index variable is positive and significant. In addition, the coefficient on the change in earnings variable remains positive and significant.[22] Taken together, financial and non-financial information are highly value relevant in explaining annual returns. In addition, financial (non-financial) information provides incremental explanatory power over and above that of non-financial (financial) information. These results confirm that financial and non-financial information in drug development companies are complements.

4.2. Price level analysis

Table 5 presents the results for the price regressions estimated using panel data with fixed time and firm effects. The price regressions are based on a version of the Ohlson (1995) model supplemented by additional non-financial information items:

$$P_{it} = \beta_0 + \beta_1 BV_{it} + \beta_2 E_{it} + \beta_3 NEG\_E_{it} + \beta_4 NEG\_E_{it} * E_{it} + \beta_5 LN(PAT_{it}) + \beta_6 COL_{it} + \beta_7 WGHTDR_{it} + \upsilon_{it} \quad (3)$$

where *P* is price per share three months after fiscal year-end; *BV* is book value of equity per share; *E* is earnings per share before extraordinary items; *NEG_E* is a dummy that takes the value 1 if *E* is negative and zero otherwise; *NEG_E*E* is the product of *E* and *NEG_E*; *LN(PAT)* is the natural log of the number of patents; *COL* is the number of collaborations; and *WGHTDR* is the drug portfolio potential.[23]

As in the return analysis, we first regress price on the non-financial variables alone. The regression results are presented in the "Non-Financial" column of Table 5. Consistent with the results obtained in the return regression, we find a positive and significant relationship between all three non-financial variables and stock prices.

When regressing prices on the financial variables alone, we separate earnings into positive and negative earnings. This separation is required because the coefficient on earnings in a sample of firms that predominately report losses is negative, indicating that the greater are the losses, the greater is the market value (see for example Amir and Lev, 1996; Hand, 2004; and Callen et al., 2008 among many others). The results are presented in the "Financial" column of Table 5. The coefficients on book value and on positive earnings are positive and significant at the 1% level. The coefficient on negative earnings (sum of *E* and *NEG_E*E*) is significantly negative (at the 1% level), but much smaller in absolute value than the coefficient on positive earnings. These findings are in contrast to those of Amir and Lev (1996), who show that neither book value per share nor earnings are relevant in explaining the market value of cellular companies. Rather, our findings are consistent with Hand (2004) who also documents that the coefficient of positive (negative) earnings is positive (negative) and highly significant for biotechnology firms.[24] Our findings are also consistent with Hand (2005) who shows that major components of the balance sheet and income statement are highly value relevant in pre-and post-IPO biotechnology firms.

In the third regression presented in the "Combined" column in Table 5 we include both financial and non-financial variables. All coefficients maintain their sign and are significant. This result provides further evidence that financial and non-financial information are complements and that both are value-relevant for drug development companies.

Although the signs of the coefficients of positive and negative earnings are consistent with findings in the literature, the coefficient on negative earnings is still counter-intuitive. This result, combined with the evidence that most biotechnology firms report losses, suggests that earnings per se are not particularly useful in explaining the market value of equity. An alternative approach is to decompose earnings into R&D expense (*R&D*) and earnings before R&D (*ADJ_E*), as do Amir and Lev (1996) and Ely et al. (2003). Given the extensive literature on R&D valuation, we expect the coefficient on *R&D* to be positive.[25] We make no predictions regarding the sign of the coefficient on earnings before R&D. This analysis allows us to verify the Ely et al. (2003) finding that earnings before R&D is significant and positively related to market value only for biotechnology firms that have approved drugs; that is, firms that generate revenues and are beyond the development stage.[26] This regression also allows us to examine whether the patent counts lose significance after controlling for R&D expenses. Tiovanen et al. (2002) and Griliches (1990) show that the coefficient on the number of patents is insignificant once R&D and patent counts are included in their empirical specification.[27]

The regression results are presented in the column labeled "R&D". As expected, the coefficient on R&D expense is positive and significant (at the 1% level). The coefficient on earnings before R&D is positive but not significantly different from zero, and the difference between the coefficients on R&D and on earnings before R&D is significantly different from zero (at the 5% level), consistent with Ely et al. (2003). These results indicate that the disaggregation of earnings into these two components

[22] As a sensitivity analysis we examined whether the coefficients on the change in earnings and on the change in the index of non-financial information are related to the level of the index of non-financial information. The results (untabulated) indicate that there is no such relation; the coefficients are independent of the level of the index.

[23] We linearly combine financial and non-financial variables in the regression absent theoretical guidelines for an alternative model specification (see also Amir and Lev, 1996). *Counts* of non-financial variables may not perfectly reflect the way in which investors truly value this type of information. Determination of an alternative "formation" of these variables deserves consideration in future research.

[24] Core et al. (2003), Hand (2003), and Penman and Zhang (2009) also document negative coefficients on negative earnings in levels regressions for high-tech firms, internet firms and small fast growing firms, respectively.

[25] See for example Hand (2005), Ely et al. (2003), Bowen and Shores (2000), Shortridge (2004), Chambers et al. (1998), Amir and Lev (1996), and Lev and Sougiannis (1996).

[26] Hand (2005) finds that revenues (cost of sales and SG&A) are value-(ir)relevant for post-IPO biotech firms, but he does not provide evidence on earnings before R&D.

[27] Interestingly, Griliches (1990) finds that patent count is not value relevant beyond R&D in all industries save the pharmaceutical industry where it is value relevant.

provides additional information to the market and that earnings components have differential valuation implications. Interestingly, the coefficient on patent counts is positive and significant suggesting that patent count is value relevant even after controlling for R&D. The coefficients on book value and the other non-financial variables remain positive and significant.

Similar to the returns analysis, the "Index" column shows the regression where we combine the three non-financial variables into an index of non-financial information and separate earnings into earnings before R&D expense and R&D expense. The coefficient on the index variable is positive and significant (at less than 1%). The coefficients on book value of equity and R&D expense are still positive and significant whereas the coefficient on earning before R&D expense remains insignificant.

To further examine the robustness of the results, we conduct the following separate sensitivity analyses. First, we replace earnings with cash flows from operations. Second, we deflate all variables by beginning of the period book value of equity, thereby estimating a market-to-book regression. Third, we employ log-linear regression models, consistent with Hand (2005). Fourth, we replace the drug portfolio by an indicator portfolio (the number of drugs in each phase is replaced by the number of the diseases for which the drugs are tested). Fifth, we replace the number of patents with the average citation per patent, a measure of patent importance.[28] The results across all specification (non-tabulated) are similar to those reported. Finally, we replace the portfolio of drugs with the number of drugs in each clinical phase. The regression results indicate that the coefficient on the number of drugs in phase III is positive and significant, whereas the coefficients on the number of drugs in phase I and II are not significant. The coefficients on number of collaborations and patents are still positive and significant.

4.3. Institutional ownership

In this section we investigate the association of financial and non-financial information with the level of (institutional) investor sophistication. Given that biotechnology firms generally realize value over the [very] long term, we expect to find no relation between the investment decision of institutions and the (short-term) earnings of the firm. We further examine whether the investment decision of "transient" investors, whose investments are based on the likelihood of short-term trading profits, and "dedicated" and "quasi-indexers" investors, who typically rely on information beyond current earnings to assess the firm's performance (Bushee, 2001), are related to non-financial information. Given that dedicated and quasi-indexers have better access to private information and superior tools to analyze complex information, we expect to find a significant association between the level of the investment of these investors with non-financial information.

Following Bushee (2001) and Callen et al. (2005) we incorporate the following control variables in our regressions: size (*SIZE*) measured as the natural log of market value of equity at the end of the fiscal year; liquidity (*LIQ*) measured as the log of average monthly trading volume divided by the average number of shares outstanding over prior year; the market-model beta (*BETA*), a measure of risk, estimated from up to 36 prior monthly returns; leverage (*LEV*) measured as total debt divided by total assets; market – adjusted returns for the previous year (*MAR*) to capture return momentum; R&D intensity (*R&D_INT*) measured as R&D expense scaled by total assets.[29] In addition, we include book value scaled by market value of equity at the beginning of the year (*BV*) and earnings before extraordinary items scaled by market value of equity at the beginning of the year (*E*) as proxies for financial variables.

Table 6, Panel A presents the regressions results estimated using panel data with fixed time and firm effects. The first two columns show the regression results of the two proxies for investor sophistication – institutional ownership (INS_HOL) and number of institutions holding the stock (INS_NUM). The coefficients of the non-financial variables are positive and significant (with the exception of the coefficient on collaborations in the INS_HOL regression) indicating that our proxies for non-financial information are important in explaining the investment decision by sophisticated investors. In addition, the coefficient on earnings is also positive and significant, suggesting that earnings are also value relevant for sophisticated investors; the higher the earnings, the higher is their investment in the firm.

The last three columns show the regression results where the dependent variables are the level of transient investor ownership, quasi-indexer investor ownership, and dedicated investor ownership. The transient investor regression shows that the level of transient investor ownership is significantly associated (at the 10% level) with collaborations only. The coefficients on the number of patents and probability adjusted portfolio of drugs under development are not significant. Consistent with Bushee (2001), the coefficient on *BV* is negative and significant. The coefficient on earnings, however, is not significant. The coefficients on the control variables are also broadly consistent with Bushee (1998). The dedicated investor regression shows positive and significant coefficients on the number of patents and the probability adjusted portfolio of drugs under development (at the 1% and 5% level, respectively). Consistent with Bushee (2001) the coefficient on *BV* is not significant. The coefficient on earnings, however, is positive and significant (at the 10% level). Finally, we find that the coefficient on the number of patents is positive and significant in the quasi-indexers regression. The coefficients of the other non-financial variables as well as of *BV* and *E* are not significant. Overall, the regression results indicate that non-financial information is significant in explaining variation in institutional ownership in general, and these variables are mostly significant in explaining the level of dedicated investor ownership.

Panel B of Table 6 replicates Panel A except that we combine the three proxies for non-financial information into a single index of non-financial information. The results are consistent with the results in Panel A. Specifically, the coefficient on the

[28] However, this measure of citations is biased towards older patents since, *ceteris paribus*, the older the patent the greater is the number of citations.

[29] R&D intensity is generally measured as R&D expense scaled by total sales. We scale by total assets because for many firm-years in our sample total sales are very low (and often zero).

Table 6
Non-financial information and the degree of investor sophistication.

	INS_HOL	INS_NUM	TRA	QIX	DED
Panel A: regressions of institutional ownership on financial and non-financial variables					
Intercept	−0.017 (0.074)	0.451 (0.339)	−0.196*** (0.071)	−0.062 (0.053)	−0.017 (0.074)
SIZE	0.005 (0.006)	0.192*** (0.027)	0.021*** (0.006)	0.009** (0.004)	0.005 (0.006)
MAR	−0.038 (0.06)	−0.294 (0.274)	0.001 (0.057)	−0.009 (0.043)	−0.038 (0.06)
RDS	−0.006 (0.015)	0.009 (0.07)	0.002 (0.014)	−0.003 (0.011)	−0.006 (0.015)
LEV	0.006 (0.025)	−0.156 (0.115)	−0.009 (0.024)	0.014 (0.018)	0.006 (0.025)
BETA	0.006 (0.005)	0.121*** (0.022)	0.016*** (0.005)	−0.005 (0.003)	0.006 (0.005)
LIQ	13.471*** (3.764)	66.046*** (17.15)	16.887*** (3.566)	6.093** (2.665)	13.471*** (3.764)
BV	0.004 (0.021)	−0.343*** (0.094)	−0.068*** (0.02)	0.007 (0.015)	0.004 (0.021)
E	0.068* (0.04)	0.461*** (0.182)	−0.004 (0.038)	0.034 (0.028)	0.068* (0.04)
LN(*PAT*)	0.027*** (0.009)	0.174*** (0.04)	0.012 (0.008)	0.015*** (0.006)	0.027*** (0.009)
COL	0.012 (0.01)	0.128*** (0.045)	0.018* (0.009)	0.01 (0.007)	0.012 (0.01)
WGHTDR	0.018** (0.009)	0.067* (0.04)	−0.002 (0.008)	0.001 (0.006)	0.018** (0.009)
Adj. R^2	0.34	0.66	0.30	0.30	0.28
F-value	19	54	19	9	4
Panel B: regressions of institutional ownership on financial variables and an index of non-financial information					
Intercept	−0.057 (0.097)	1.126*** (0.329)	−0.139** (0.068)	−0.003 (0.051)	0.086 (0.072)
SIZE	0.027*** (0.008)	0.192*** (0.027)	0.022*** (0.006)	0.009** (0.004)	0.004 (0.006)
MAR	−0.001 (0.021)	−0.26 (0.285)	−0.015 (0.059)	−0.012 (0.044)	−0.029 (0.063)
RDS	−0.038 (0.084)	0.014 (0.070)	0.003 (0.015)	−0.002 (0.011)	−0.005 (0.015)
LEV	0 (0.035)	−0.125 (0.118)	−0.005 (0.025)	0.016 (0.018)	0.010 (0.026)
BETA	0.023*** (0.007)	0.122*** (0.022)	0.017*** (0.005)	−0.004 (0.003)	0.008 (0.005)
LIQ	30.602*** (5.140)	63.264*** (17.420)	16.324*** (3.608)	7.158*** (2.695)	13.833*** (3.826)
BV	−0.076*** (0.028)	−0.369*** (0.096)	−0.071*** (0.020)	0.004 (0.015)	0.001 (0.021)
E	0.052 (0.055)	0.468*** (0.186)	−0.007 (0.039)	0.036 (0.029)	0.063 (0.041)
INDX	0.033*** (0.010)	0.153*** (0.035)	0.011 (0.007)	0.013*** (0.005)	0.023*** (0.008)
Adj. R^2	0.34	0.59	0.31	0.29	0.30
F-value	19	55	21	10	4

The above table Panel A shows the regressions results of the institutional ownership variables on financial and non-financial variables:

$$y_{it} = \beta_0 + \beta_1 SIZEit + \beta_2 MAR_{it} + \beta_3 RDS_{it} + \beta_4 LEV_{it} + \beta_5 BETA_{it} + \beta_6 LIQ_{it} + \beta_7 BV_{it} + \beta_8 E_{it} + \beta_9 LN(PAT_{it}) + \beta_{10} COL_{it} + \beta_{11} WGHTDR_{it} + v_{it}$$

The dependent variables include INS_HOL – the proportion of shares held by institutional investors, INS_NUM – the number of institutions holding the shares, DED – "dedicated" institutional investors, QIX – "quasi-indexer" institutional investors, and TRA – "transient" institutional investors. The independent variables include the following variables: *SIZE* is the log of market value of equity at the end of the fiscal year; *MAR* is market adjusted returns for the previous year; *RDS* is the firm's R&D intensity measured as R&D expense divided by total assets; *LEV* is debt to assets ratio; *BETA* is the market-model beta estimated from up to 36 prior monthly returns; *LIQ* is the log of average monthly trading volume divided by the average number of shares outstanding over prior year; *E* is earnings before extraordinary items scaled by market value of equity at the beginning of the year; *BV* is book value scaled by market value of equity at the beginning of the year; *LN*(*PAT*) is the natural logarithm of the number of granted patents; *COL* is the number of collaborations; and *WGHTDR* is the probability adjusted portfolio of drugs in the pipeline. We add 1 to zero patents observations so that they are not discarded by the log-transformation.
Panel B shows the regression results of institutional ownership on financial variables and index of non-financial information (*INDX*). *INDX* is derived from factor analysis of the three proxies of non-financial information – number of patents, number of collaborations and the probability adjusted portfolio of drugs in the pipeline. The regressions are estimated using panel data with firm and year fixed effects. The regressions are estimated using 806 observations. The number of observations is determined by availability of institutional ownership data and the deletion of outliers in the dependent and independent variables (top and bottom 1%). Standard errors of the coefficients are presented in parenthesis.
* Refer to significance at the 10% confidence level.
** Refer to significance at the 5% confidence level.
*** Refer to significance at the 1% confidence level.

index variable (*INDX*) is positive and significant in the regressions of INS_HOL and INS_NUM, suggesting that both institutional ownership and the number of institutions holding the share are positively and significantly associated with non-financial information. When we separate INS_HOL into the three categories based on investment objectives, we find that the coefficient on *INDX* in the regression of transitory investors (TRA_HOL) is not significantly different from zero, indicating, again, that the investment decision by transitory investors is not motivated by non-financial information. In the regressions of dedicated investors and quasi-indexers (DED and QIX), however, the coefficient on *INDX* are positive and significant, consistent with long-term investors investing based on fundamentals rather than on technical analysis.

5. Conclusion

The drug development segment of the biotechnology industry provides an ideal setting to study the value relevance of financial and non-financial information. This is because of the large capital investments involved and the long process of drug development during which most companies earn little if any revenues and, consequently, report large losses which can be attributed primarily to the expensing of R&D.

Using patent counts, number of collaborations and probability adjusted portfolio of drugs under development as non-financial information metrics, we first show that news related to these measures are significantly associated with abnormal returns. We also show that abnormal returns of drug development biotechnology companies around the announcement date of earnings are positively and significantly associated with the change in earnings. To examine whether financial and non-financial information are complements or substitutes, we estimate regressions of annual returns and of market values of equity on changes and levels of financial and non-financial variables, respectively. The results suggest that the two types of information are complements.

To further assess the value relevance of financial and non-financial information, we investigate their association with the investment decision of sophisticated investors. The results indicate that both types of information are value relevant and are complementary to each other. Finally, we show that the latter results hold primarily for long-term institutional investors who are likely to rely on information beyond current earnings to assess performance. We also document an insignificant association between the level of ownership of short-term institutional investors and non-financial information, consistent with an investment strategy based on the likelihood of short-term trading profits.

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