# The Value Relevance of Non-Financial Performance Information in Biotechnology Firms

Bixia Xu

A Thesis

in

John Molson School of Business

Presented in Partial Fulfilment of the Requirements
for the Degree of Doctor of Philosophy at
Concordia University
Montreal, Quebec, Canada

December 2002

# ABSTRACT

## The Value Relevance of Non-Financial Performance Information in Biotechnology Firms

*Bixia Xu, Ph. D.*
*Concordia University, 2002*

In this thesis, we investigate the value relevance of non-financial performance information, within the context of the biotechnology industry. We also investigate the interactions between financial information and non-financial performance information. Our purpose is to provide insight into our understanding of the role of financial information in equity valuation and improve the explanatory power of the accounting-based valuation model.

Consistent with prior work in this area, we adopt a valuation approach to assess the value relevance of financial information and the incremental value relevance of non-financial performance information. Non-financial performance information comprises a firm's product market status, R&D innovation and business relations. A firm's product market status is expected to be able to help investors better understand the value relevance of financial information. R&D innovation, as reflected by a firm's ability to get drugs through various clinical trial phases to final approval by government, is the key performance indicator in the biotechnology industry. Business relations, in the forms of drug development or marketing alliances, can speed up the drug development process by allowing firms to share resources and risks associated with drug development. It is expected that measures of R&D innovation and business relations modify investor understanding of a firm's earnings trend and the firm's ability to survive and grow in the changing business world. Therefore, they complement and interact with financial

statement information.

We develop six hypotheses that are specific to the biotechnology industry:

H1: Financial information, after controlling for its sign, is value relevant.

H2: A firm's product market status enhances the value relevance of financial information Reported by biotechnology firms.

H3: Information about R&D expenditures (R&D inputs) has incremental value relevance over financial information.

H4: Clinical trial information about a firm's drug portfolios (R&D outputs) has incremental value relevance over financial and R&D input information.

H5: The incremental value relevance of information on a firm's drug portfolios is greater for drugs at more advanced stages than for drugs at earlier stages.

H6: Information about a firm's business relations has incremental value relevance over its financial and R&D innovation information.

We test these hypotheses using data of biotechnology firms collected from 1998 to 2001. Our findings indicate that, in the biotechnology industry, 1) financial information, after the control for its sign, is value relevant; 2) a firm's product market status can help investors better understand the value relevance of financial information, especially earnings; 3) R&D intensity (proxy for R&D inputs) is incrementally value relevant over financial information; 4) drug portfolios (proxies for R&D outputs) are incrementally value relevant over financial information and R&D intensity; 5) the incremental value relevance of drug portfolios is greater for drugs at more advanced stages than for drugs at earlier stages; 6) Alliances (a proxy for business relations) are incrementally value relevant over financial information, R&D intensity and drug portfolios.

With respect to the interactions between financial information and non-financial performance information, we find that financial information can enhance the value relevance of non-financial performance information, while non-financial performance

information, in turn, can enhance the value relevance of financial information. Based on these interactions, we suggest an interactive perspective for the evaluation and exploration of the value relevance of the two types of information. In addition, we propose a more reliable measurement of R&D innovation.

We provide implications for accounting research, standard setting and corporate disclosure strategy. The knowledge we gain about the value relevance of non-financial performance information as well as about the interactions between financial information and non-financial performance information may inspire research questions that are related to that value relevance and those interactions; it may provide reference for corporate managers in framing their communications with outsiders and for standard setters in regulating accounting information dynamics.

# ACKNOWLEDGEMENTS

This thesis is specially dedicated to my son, Julien, who always shows his concern over my progress in the long journey to the Ph.D. degree. He also expresses his interest in my thesis; even through he does not understand it at all. Without his encouragement and emotional support, I would not have finished this program.

Wholehearted gratitude to my parents and to my sister's family, whose love and enthusiasm have kindled my aspiration for knowledge, and motivated me to pursue advanced academic studies all the way to the Ph.D. degree.

I am very grateful to my thesis supervisor, Dr. Michel Magnan, for his thoughtful supervision and continuous encouragement and support. He brought me into the freedom under which I could think and examine various issues; he also led me to the understanding of how to frame my thoughts and to organize my discussions. His wise instructions provided me with the basis on which I can build up my academic career.

I appreciate Dr. Paul Andre and Dr. Charles Dramin for their insightful comments that substantially improved the content of my thesis. Also thanks to Dr. George Kanaan and Dr. Maureen Gowing, who unselfishly shared their ideas with me when I worked on my theory paper which provides a basis for this thesis.

Table of Contents


1. Introduction

1.1 Motivations and research questions 1

1.2 Current financial reporting framework 2

1.3 Research context 3

1.4 Conceptual framework and expectations 4

1.5 Empirical approach 8

1.6 Summary findings 9

1.7 Concluding remarks 11

2. Literature Review

2.1 Value relevance of accounting information

2.1 a) Earnings-based valuation research 14

2.1 b) Fundamental valuation research 18

2.2 Non-financial performance indicators as value drivers

2.2 a) Underlying arguments concerning the value relevance of non-financial performance information 20

2.2 b) Relations between current non-financial performance and future financial performance 21

2.2 c) Empirical evidence on the value relevance of non-financial performance information 24

2.3 R&D innovation as a value drive 28

2.4 R&D innovation as a value driver: the case of the biotechnology industry

2.4 a) Selection of the biotechnology industry as research setting 32

2.4 b) R&D innovation as the major performance indicator 34

2.5 Business relations: a value enhancer in the biotechnology industry 38

2.6 Summary of the literature review 42

3. Hypotheses Development

3.1 Drug development 44

3.2 Hypotheses

3.2 a) Hypotheses concerning the value relevance of financial information 46
3.2 b) Hypotheses concerning the value relevance of non-financial performance information 51

4. Sample and Data 58

5. Empirical Models

5.1 Valuation theory in accounting 61

5.2 Models for testing the value relevance of financial information

5.2 a) Price-earnings model 64
5.2 b) Return-earnings model 68

5.3 Models for testing the value relevance of non-financial performance information

5.3 a) Price-earnings model 71
5.3 b) Return-earnings model 76

5.4 List of variables 77

6. Results and Interpretations

6.1 Descriptive statistics 80

6.2 Coefficients of correlation 81

6.3 Empirical findings about the value relevance of financial information

6.3 a) Value relevance in the price-earnings model 83
6.3 b) Value relevance in the return-earnings model 85
6.3 c) Summary 87

6.4 Empirical findings about the incremental value relevance of R&D innovation

6.4 a) Incremental value relevance of R&D intensity 87
6.4 b) Incremental value relevance of drug portfolios 88
6.4 c) Summary 91

6.5 Empirical findings about the incremental value relevance of drugs at different stages 91
6.6 Empirical findings about the incremental value relevance of business relations 93

7.Sensitivity Analyses and Robustness Analyses

7.1 Sensitivity analysis

7.1 a) Effect of a firm's financial performance 95
7.1 b) Effect of market rights 97
7.1 c) Effect of drug indications 99

7.2 Further analysis of the effect of a firm's product market status 101

7.3 Robustness analyses

7.3 a) Scale effect 105
7.3 b) Alternative measures of return 110
7.3 c) Alternative definitions of earnings 113

8. Conclusions

8.1 Synthesis 115

8.2 Discussions

8.2 a) Findings regarding the value relevance of financial information 119
8.2 b) Findings regarding the incremental value relevance of non-financial performance information 123

8.2 c) Findings regarding the interactions between financial information and non-financial performance information 126

8.3 Implications 127

8.4 Limitations 129

8.5 Future research 130

References 132

List of Tables xi

# List of Tables


| | |
|---|---|
| Table 1 | Descriptive Statistics |
| Table 2 | Correlation in Price-Earnings Model |
| Table 3 | Correlation in Return-Earnings Model |
| Table 4 | Value Relevance of Financial Information |
| Table 5 | Effect of a Firm's Product Market Status on the Value Relevance of Financial Information |
| Table 6 | Effect of Changes in Financial and Non-Financial Information on Stock Return |
| Table 7 | Value Relevance of R&D intensity Over Financial Information |
| Table 8 | Value Relevance of Information on Drug Portfolios |
| Table 9 | Value Relevance of Information on Drugs at Earlier Stages vs. at More Advanced Stages |
| Table 10 | Value Relevance of Information on Business Relationships in Price-Earnings Model |
| Table 11 | Results From Positive –Earnings Sample vs. Negative Earnings Sample |
| Table 12 | The Effect of Market Rights over Drugs in PIII Clinical Trials |
| Table 13 | The Effect of Drug Indications |
| Table 14 | Effect of a Firm's Product Market Status on the Value Relevance of Non-Financial Information |
| Table 15 | The Value Relevance of Information About Management Experience |
| Table 16 | Regression with Different Deflators |
| Table 17 | Regression with Different Control Variables for Scale Effect |
| Table 18 | Regression with Alternative Definitions of Return |
| Table 19 | Alternative Definitions of Earnings |

# 1. Introduction

## 1.1 Motivations and research questions

The value of financial statements is determined by their ability to adequately reflect a firm's value. However, when capital markets perceive that information provided by financial statements is inadequate, they will incorporate information from other information sources.

The ability of financial statements to adequately reflect a firm's value is increasingly being questioned, especially in contexts where innovation, intellectual capital and R&D are key value drivers. Some researchers discuss and examine the limitation of financial information (e.g., Lev, 1997; Lev et al., 1999; Gu and Lev, 2001). They argue that, in fast changing technology-based industries, financial information is irrelevant because it fails to capture the economic value of investments in intangible assets. They provide evidence on the loss of the value relevance of financial information as well as evidence on the value relevance of non-financial performance information (e.g., Amir and Lev, 1996). They suggest the inclusion of non-financial performance information into the current financial accounting framework which is determined by Generally Accepted Accounting Principles (GAAP). However, a few researchers (e.g., Francis and Schipper, 1999) find that financial information has not lost its value relevance even in high technology industries over the past 25 years.

This debate raises a few questions: (1) Why does there exist such mixed evidence for high-tech industries? A further question is: what contributes to the loss of the value relevance of financial information in these industries? Or, alternatively, what maintains this value relevance? (2) When financial information has become irrelevant or has lost part of its value relevance in these industries, how can non-financial performance information compensate for the limitations of financial information? Is it

appropriate to start a new accounting system for high-tech industries which emphasizes non-financial performance information? (3) How can non-financial performance be measured in order to more reliably capture the value relevance that is missed by financial information? These questions remain unanswered. We explore answers to these questions. One of our major purposes is to make a contribution to our understanding of the role of financial information in equity valuation in high-tech industries. Another major purpose is to identify information usage by investors in high-tech industries. This identification can lead to the improvement of the explanatory power of accounting-based valuation models used by these industries.

In providing answers to the first two questions, we argue that capital markets incorporate non-financial performance information into their valuation models if it can provide incremental value relevance over financial information, or if it can lead to a better understanding of the financial information, or both. Therefore, on the one hand, we explore the ability of non-financial performance information to provide incremental value relevance over financial information; on the other hand, we explore the interactions between financial information and non-financial performance information to see how non-financial performance information can lead to a better understanding of financial information. The two explorations together will provide full insight into our understanding of the value relevance of the two types of information, as well as the ability of non-financial performance information to add value to the accounting-based valuation model.

## 1.2 Current financial reporting framework

A firm communicates with outsiders through the dissemination of firm-specific information, part of which is regulated by business law, government agencies and private accounting bodies. For instance, in the United States, a government agency, the Securities and Exchange Commission (SEC), and a private accounting body, the Financial Accounting Standard Board (FASB), both issue mandated disclosure requirements. However, each has a particular domain of influence. On the one hand,

FASB sets accounting principles that guide all mandatory information dissemination within the scope of corporate financial statements. These principles are called generally accepted accounting principles (GAAP). We call the information dissemination framed by GAAP the current financial reporting framework. In general, GAAP accounting focuses on financial information and does not include non-financial or non-accounting performance information. On the other hand, the SEC sets minimum information disclosure standards regarding a firm's financial position, financial performance, governance and executive compensation, litigations, material changes and business risks. For biotech firms, the SEC requires firms to report management analysis of drug development in annual reports. In these reports, managers assess risks associated with the leading drugs of their firms. However, the SEC does not require firms to report their drug portfolios at different stages, a critical information to assess a firm's value. In fact, most non-financial performance information disclosure is voluntary. Our study focuses on the information provided by firms about their product market status, drug portfolios, business relations, market rights and drug indications. Disclosure of such information is voluntary since it is required neither by GAAP nor by the SEC. We attempt to provide evidence on how capital markets incorporate such information.

## 1.3 Research context

We select the biotechnology industry as our research setting, mainly because this industry exhibits a great potential for financial information to become irrelevant but for non-financial performance information to become substantially value relevant. If we follow Amir and Lev (1996), financial information would be irrelevant in the biotechnology industry because this industry lives in a fast-changing environment and is technology-based. Firms in this industry invest heavily in R&D innovation. These investments create intangible assets (i.e., drug portfolios). These assets can bring firms future benefits. However, U.S. GAAP requires that firms expense most of their R&D investments, rather than capitalize them. As a consequence, corporate balance sheets do not fully recognize the economic value of R&D investments. Thus, it is

reasonable to believe that financial information has lost its value relevance in this industry. However, there is no empirical evidence that justifies this conjecture. If financial information had lost its value relevance in this industry, non-financial performance information should play a more important role than in a case where financial information were still somehow value relevant. Therefore, one purpose of our study is to test whether or not financial information has lost its value relevance in this industry and to test how non-financial performance information add value to the accounting-based valuation model used in this industry.

## 1.4 Conceptual Framework and expectations

*Value Relevance of Financial Information (Hypothesis 1)*

While the issue is hotly debated, we argue that financial information, after controlling for its sign (loss or earnings; deficit or retained earnings), is still value relevant in the biotechnology industry (Hypothesis 1).

*Product Market Status (Hypothesis 2)*

Since our key purpose is to better understand the value relevance of financial information, we argue that a firm's economic characteristics can determine the value relevance of financial information. We specifically hypothesize that a firm's product market status has an influence on the value relevance of financial information, especially on the value relevance of earnings. We select a firm's product market status because it signals fundamental differences among firms, such as differences in financial performance, drug development and management experience. A firm's product market status refers to whether or not the firm has ever developed any products that have been launched into the market. We focus on earnings because their value relevance is much more tentative than that of book value of equity (Hypothesis 2).

*R&D Innovation (Hypotheses 3 and 4)*

Accounting researchers have devoted a great deal of effort to search for value relevant variables that underlie capital markets assessment, but are not included in

financial statements. Recently, the search has extended into the domain of non-financial performance information (e.g., Lev, 1997). The purpose of these investigations is to understand how non-financial performance information incrementally impacts the market expectation of a firm's value. Following this path, our study examines another two non-financial performance indicators. One is R&D innovation; the other is business relations with other firms.

R&D innovation, as reflected by a firm's ability to get drugs through various clinical trial phases to final approval by government, is the major performance indicator in the biotechnology industry (Robbins-Roth, 2000). In fact, biotechnology firms compete heavily in the area of drug development. R&D innovation creates intangible assets (Healy et al., 1999), which bring firms future earnings. As mentioned previously, the economic value of these assets is not fully recognized in GAAP accounting books. Thus, we expect that measures of R&D innovation modify investor understanding of a firm's earnings trend and the firm's ability to survive and grow in the changing business world. In studies that examine the value relevance of R&D innovation (e.g., Alto and Hage, 1999; Moorman and Slotegraaf, 1999; Robbins-Roth, 2000; Kellogg and Charnes, 2000), R&D innovation is essentially measured by R&D expenditures or R&D intensity (e.g., Lev, 1999; Grabowski and Vernon, 1994). R&D expenditures represent R&D inputs. Hence, we investigate whether value-relevant R&D innovation can be appropriately captured by R&D expenditures in the biotechnology industry (Hypothesis 3).

However, from the perspective of intangible assets, R&D expenditures may have limited power in capturing R&D innovation in this industry. This is because, especially compared to other industries, there is high uncertainty associated with the transformation from R&D inputs to R&D outputs in this industry. Drug development, supported by R&D investments, is heavily regulated by government; it also involves complex human reactions to drug designs. If clinical trials show negative results, firms must terminate these trials. The termination results in an inefficacy of R&D investments in terms of creating intangible assets. In other words, when termination

occurs, R&D investments create no intangible assets with the exception of the knowledge gained from past failures. The success rate of drug development is low in the biotechnology industry (DiMasi, 1995). Hence, measures of R&D outputs are critical to understanding the effect of R&D innovation on a firm's value, and they need to be incorporated in the measurement of R&D innovation. Our study assumes that capital markets incorporate information on both R&D inputs and R&D outputs into their valuation models. Therefore, we hypothesize that the measurement that incorporates both R&D inputs and outputs has higher value relevance than in the case where R&D inputs or R&D outputs are addressed alone. This implies that measures of R&D outputs have incremental value relevance over measures of R&D inputs. We use a firm's R&D intensity to proxy for its R&D inputs, and the drug portfolios in its pipeline to proxy for its R&D outputs; we then expand the testing models that are used to examine the value relevance of financial information to include these two measures of R&D innovation (Hypothesis 4).

*Stages of Drug Development (Hypothesis 5)*

In the long drug development process, drugs move through different stages. We further ask if drugs at different stages have equal influence on a firm's value. Biochemists, investors and analysts following biotechnology firms believe that drugs at more advanced stages possess a higher success rate and higher value than drugs at earlier stages (DiMasi, 1995, and Robbins-Roth, 2000). Accordingly, some studies (e.g. Kellogg, 2000) assign higher values to drugs in phase III clinical trials and in the government approval process than to drugs in phase I and phase II clinical trials. Our study focuses on the incremental value relevance of drug portfolios at different stages. We examine whether information concerning drugs at more advanced stages contains higher incremental value relevance over financial information and R&D intensity than information concerning drugs at earlier stages. We argue that, in the value creation chain of drug development, drugs at more advanced stages are closer to the realization of intangible assets than drugs at earlier stages, because they are closer to the final approval process and possess a higher success rate. Based on this

argument, we hypothesize that the incremental value relevance of drugs at more advanced stages is higher than that of drugs at earlier stages.

Since drugs at more advanced stages have a greater impact on a firm's value, capital markets may incorporate detailed information about these drugs. In order to provide evidence on, and insight into the understanding of this information incorporation, we conduct two sensitivity analyses. We first examine if a firm's possession of the market rights over drugs at more advanced stages influences the incremental value relevance of drug portfolios. Secondly, we examine if drug indications influence the incremental value relevance of drug portfolios. Drug indications refer to the specifications of medical uses of drugs (Hypothesis 5).

*Business Relations (Hypothesis 6)*

As mentioned previously, drug development is vital to biotechnology firms. Business relations can enhance this development through the sharing of related resources and risks. In the management and strategy literatures, studies argue that business relations among firms are a type of intangible asset (Wilkinson and Young, 2001; Conhaim, 1999; Sparks, 1999). Other studies discuss the importance of business relations in the biotechnology industry (Whelan, 2000; Budd, 2000; and Chang, 1998). According to these studies, there is a greater need for sharing resources and risks in the biotechnology industry because (1) drug development requires considerable resources, especially money; (2) drug development takes a long time; (3) the speed of drug development is critical; and (4) drug development is risky because of the regulation.

Resource and risk sharing provides biotech firms with (1) research funds; (2) opportunities to earn revenue, to obtain manufacturing capacity, and to get other necessary resources that they do not possess; and (3) market possibilities. Such sharing can also reduce drug development costs. Thus, business relations have a great impact on a firm's drug development, especially on the speed of this development. Hence, we argue that investors need to know a firm's business relations with others

when they predict the firm's ability to bring drugs through different clinical trials to final approval by government. Business relations, as a type of intangible asset, are not fully recognized in financial statements. In addition, they cannot be fully captured by our measures of R&D innovation. Therefore, it is reasonable to expect that business relations contain additional value relevance. Based on this expectation, we hypothesize that information about a firm's business relations has incremental value relevance over financial information and R&D innovation information (Hypothesis 6).

## 1.5 Empirical approach

Our research questions inspire empirical examinations of the value relevance of financial information and of the incremental value relevance of non-financial performance information. We employ two testing models that are widely used by accounting researchers when examining similar issues. One is the so-called price-earnings model, which is used to examine how financial information affects price formation. In this model, market value is specified as the function of book value of equity and earnings. The other is the so-called return-earnings model, which is used to examine how changes in financial information affect stock market returns. In this model, the stock market return is specified as the function of the changes in book value of equity and earnings.

We extract our sample of firms from Compustat under the Standard Industry Classification (SIC) codes 2830 to 2836. Firms with these SIC codes discover, develop, produce and sell drugs that are used to diagnose and treat human diseases. 441 firms are originally identified. Most of them are U.S. firms and traded on Nasdaq. Data availability in Compustat and Recap is the criterion to form the samples. Recap is a web-based server which provides information about biotechnology firms around the world. We employ a price-earnings model and a return-earnings model in our examinations. For the price-earnings model, we form yearly samples for 1998-2001; the numbers of observations in these samples are 220, 234, 266 and 268, respectively.

For the return-earnings model, we form samples for the periods from 1998-1999, 1999-2000 and from 2000-2001, respectively; the numbers of observations in these samples are 214, 229, and 255, respectively. In order to improve the efficiency of the estimates of the regression models, we form a pooled sample for the price-earnings model, and one for the return-earnings model; the numbers of observations in these samples are 748 and 698, respectively. We base our conclusions on the results from these samples.

## 1.6 Summary Findings

We find that book value of equity and earnings, after controlling for their signs, explain 20%-52% of price formation and 14%-29% of stock market return. In particular, positive book value of equity and earnings are significant, while negative book value and earnings are insignificant. These findings suggest that financial information has not lost its value relevance in the biotechnology industry and are consistent with hypothesis 1.

We find that earnings are insignificant before the control for a firm's product market status. After the control, earnings are significantly associated with market value for firms that have products in the market. However, the evidence on the association between market value and earnings is mixed for firms that have no products in the market. Hence, consistent with hypothesis 2, our results indicate that a firm's product market status (a non-financial performance indicator) can have an influence on the value relevance of earnings in the biotechnology industry.

Consistent with hypotheses 3 and 4, our results indicate that our measures of R&D innovation contain incremental value relevance over financial information. More specifically, our results confirm the incremental value relevance of R&D intensity over financial information (hypothesis 3). More importantly, we also show that measures of R&D output (i.e., drug portfolios) have incremental value relevance over R&D intensity and financial information (hypothesis 4). These findings justify our

argument that R&D intensity cannot fully capture the value relevance of R&D innovation in the biotechnology industry.

To further assess the interactions between R&D innovation and financial information, we divide firms into two sub-samples. One contains firms that report positive earnings. The other contains firms that report negative earnings. In the positive earnings samples, the incremental value relevance of drug portfolios over financial information is greater than that of R&D intensity, and the incremental value relevance of drug portfolios over financial information and R&D intensity is highly significant. In the negative earnings samples, the incremental value relevance of R&D intensity over financial information is greater than that of drug portfolios, and the incremental value relevance of drug portfolios over financial information and R&D intensity is weaker than that obtained from the positive earnings samples. These results suggest that capital markets incorporate information about R&D expenditures and information about drug portfolios differently across firms that exhibit differential financial performance characteristics. Hence, financial information can enhance the value relevance of non-financial performance information.

Consistent with hypothesis 5, we find that the value relevance of drugs at more advanced stages is higher than for drugs at less advanced stages of development. Furthermore, we find that information concerning market rights of drugs at more advanced stages is additionally value relevant relative to our measures of drug portfolios. We also find that information concerning drug indications provides additional value relevance relative to our measures of drug portfolios.

Consistent with hypothesis 6, we find that information about a firm's business relations with other businesses is incrementally value relevant over financial and R&D innovation information.

## 1.7 Concluding remarks

We provide an explanation as to why the debate about the value relevance of financial information for high-tech industries exists. Our results regarding the value relevance of financial information imply that whether or not financial information has lost its value relevance may be an industry-specific issue. Financial information may become irrelevant in some high-tech industries, but may still be relevant in other high-tech industries. We also provide a possible solution to this issue, that is, investigating the interactions between financial information and non-financial performance information. We provide evidence that a firm's product market status can help us to better understand the value relevance of financial information. In this regard, we contribute to the accounting literature by introducing a firm's product market status, an economic characteristic measured by a non-financial performance indicator, as a determinant of the value relevance of financial information.

Our study extends prior research by identifying that drug portfolios and business relations are explanatory variables in the valuation model used by investors in biotechnology firms. The disclosure of drug portfolios and business relations is not covered by GAAP. We therefore provide insight into our understanding of the information usage by these investors. Inclusion of the two variables can increase the explanatory power of the accounting-based valuation model of this industry. In addition, we suggest that detailed information concerning market rights and drug indications can further enhance the explanatory power of the accounting-based valuation model. Finally, we propose a more reliable measurement of R&D innovation. We basically suggest that the measurement of R&D innovation in the biotechnology industry should incorporate both R&D inputs and R&D outputs.

We find evidence on the interactions between financial information and non-financial performance information. These interactions give each type of information an indirect ability to explain and predict stock price behaviour. The indirect ability of one type of information refers to its ability to lead to a better interpretation of the other type of

information. It is likely that modelling financial information and non-financial performance information as interactive determinants of a firm's value better reflects how investors assess biotechnology firms. This indirect ability is missed in prior research. Thus, we suggest an interactive perspective for the evaluation of the value relevance of both financial information and non-financial performance information. This perspective suggests an exploration and evaluation of the value relevance of the two types of information via examining the interactions between them.

Within this perspective, researchers need to apply caution when they claim that financial information has lost its value relevance because (1) non-financial performance information can enhance the value relevance of financial information; and (2) the value relevance of financial information can be embedded in its ability to lead to a better interpretation of non-financial performance information. When researchers examine the value relevance of non-financial performance information, they also need to realize (1) financial information can enhance the value relevance of non-financial performance information; and (2) the value relevance of non-financial performance information can be embedded in its ability to lead to a better interpretation of financial information.

Therefore, under this perspective, our study suggests a new research direction: how can financial information enhance the incremental value relevance of non-financial performance information. Prior research only provides evidence that non-financial performance information can enhance the value relevance of financial information. Our study discusses and provides evidence that financial information can also enhance the value relevance of non-financial performance information. Specifically, our study finds that reported earnings enhance the incremental value relevance of the two measures of R&D innovation.

The interactive perspective not only helps researchers to propose research questions that are related to the interactions between the two types of information, but also provides insight into disclosure strategies used by biotechnology firms for financial

information and non-financial performance information. Under this perspective, a firm's communication with outsiders would be more informative if it included both important financial information and non-financial performance information, because such a communication is more adequate than one that contains only financial information, and it allows simultaneous interpretation and incorporation of both types of information. In this communication framework, the disclosure of financial information needs to aid the interpretation of important non-financial performance information; meanwhile, the disclosure of non-financial performance information needs to aid the interpretation of important financial information. Through this means, financial information and non-financial performance information can be integrated as a whole to reflect completely a firm's value.

The value relevance of non-financial performance information and the interactions between the two types of information may have implications for standard setters and capital market regulators. These two groups of people may refer our findings when considering the information dynamics of capital markets.

The organization of the thesis is as follows. Section two reviews the literature; section three develops the hypotheses; the methodological issues are depicted in section four and five; section six reports the empirical results and their interpretations; section 7 includes sensitivity analyses and robustness analyses; and section 8 consists of a summary, discussions, conclusions, limitations, and future research directions.

# 2. Literature Review

In this section, we review the literature that, in general, provides theoretical discussion and empirical evidence on the value relevance of both financial and non-financial performance information. Then, we review the literature that, more specially, discusses and provides evidence as to the value relevance of non-financial performance information in the biotechnology industry. Hypotheses development in section three is based on these reviews.

## 2.1 The value relevance of accounting information

### 2.1 a) Earnings-focused valuation research

Shareholders, investors and creditors have an obvious interest in determining the value of a firm. In an efficient market, a firm's value is determined by the present value of expected future cash flows, discounted at an appropriate risk-adjusted rate of return. A firm's current performance, as summarized in its financial statements, is an important, but not the only, input to capital markets' assessment of the firm's future net cash flows. Financial accounting adopts a decision-usefulness approach, whereby the major function of financial accounting, as specified in the Financial Accounting Standard Board's (FASB) conceptual framework, is to provide capital markets with information about the amount, timing and uncertainty of a firm's future net cash flows. Therefore, an association between current financial performance, as reported by the accounting system, and future net cash flows, as well as an association between reported financial performance and security prices or price changes, is expected. Accordingly, an important objective of market-based accounting research is to provide evidence on these associations. A related important objective of market-based accounting research is to identify fundamental variables that determine a firm's market value, but are omitted in the current financial accounting framework. The

major intention of studies that serve the second objective is to aid market efficiency through providing insight into improvements of the current financial reporting framework as well as investors' decision making.

A few early studies discuss the nature and the measurement of accounting net income as a proxy for a firm's economic performance that leads to a firm's future net cash flow (Chambers, 1964; Ijiri, 1967 and 1975; Beaver and Demski, 1979; and Revisine, 1981). They define net income as revenues, net of expenses. They argue that net income is a cost-efficient measure of a firm's economic value, but has limits when it is used to rank all alternative investment projects in the case where the market is not perfect and complete. According to their arguments, there would be no causality between accounting net income number and stock price, but there would be an association between them. Fama (1965) demonstrates a theoretical linkage between security price and dividends. He expresses security price as the function of present value of future expected dividends. Based on this linkage, Ohlson (1995) analytically discusses the associations among security price, dividends, book value of equity and earnings. His analytical valuation model expresses security price as the function of book value of equity and the present value of future expected abnormal earnings. With this method, he establishes the so-called clean surplus accounting equation. This equation allows him to transfer the valuation model from finance theory into what is represented by accounting data. Accounting data are deemed useful because they can be used to explain and predict future stock market returns.

The usefulness of accounting information is realized when capital markets actually incorporate this information into their valuation model. The work by Ball and Brown (1968) is the first empirical investigation of the usefulness of accounting information. They provide evidence that shows that reported accounting net income contains new information. The sign of the change (increase or decrease) in earnings is positively associated with the sign of stock market returns. Earnings are then confirmed to be useful in explaining stock price behaviour. Since then, following Ball and Brown, capital market researchers examine the value relevance of accounting variables such

as annual earnings, quarterly earnings, earning forecasts, sales, cash flows, accruals, and dividends (Beaver, 1968; Brown and Kennelly, 1972; Campbell and Shiller, 1988; Bernard and Stober, 1989; Anthony and Ramesh, 1992; Ball and Kothari, 1993; Dechow, 1994; Barth, Beaver and Landsman, 1998). They provide empirical evidence on the positive association between market variables and those accounting variables. In this stream of studies, researchers conduct their examinations within a framework where stock market return (or price) appears as the dependent variable and contemporaneous accounting information appears as an independent variable. Within this framework, accounting data are more "value relevant" if they can better explain and predict stock market return (or stock price).

As more accounting variables are found to be value relevant, the properties and components of these variables become of interest to accounting researchers. Researchers examine the effect of these properties and components on the information content of accounting variables. Studies (e.g., Kormendi and Lipe, 1987; Lipe, 1986) in this area enhance our understanding and interpretation of accounting information. In this regard, finance theory describes the effect of a firm's economic characteristics on stock price behaviour. For example, a firm's beta is the sole systematic risk measure in the case of a well-diversified portfolio, and beta is positively related to a firm's stock market return. In the accounting literature, earnings response coefficient (ERC) studies (e.g., Kormendi and Lipe, 1987; Easton and Zmijewski, 1989; Collins and Kothari, 1989) identify the effect of a firm's economic characteristics on the magnitude of the association between earnings and stock price/ return. They find that a firm's economic characteristics influence the value relevance of reported earnings. These characteristics, as well as their influences on ERC, include: (1) a firm's beta is negatively associated with ERC; (2) a firm's leverage is negatively associated with ERC; (3) a firm's growth potential is positively associated with ERC; (4) earnings persistence is positively associated with ERC; (5) earnings quality is positively associated with ERC; and (6) precision of pre-disclosed information is negatively associated with ERC. Ramakrishnan and Thomas (1998) find that the price-earnings link is better described by separating unexpected earnings

into permanent, transitory and price-irrelevant components and multiplying each by a different ERC, rather than applying a single ERC to aggregate the value relevance of unexpected earnings.

Ohlson and Penman (1992) discuss the power of disaggregated accounting data to explain returns. Lipe (1986) investigates the empirical relation between components of earnings and stock returns. He tests to determine if six components---gross profit, general and administrative expense, depreciation expense, interest expense, income tax expense and other items---provide additional information that is not contained in reported earnings. He finds that aggregated earnings lose part of the information contained in the six components. He concludes that the six components possess incremental value relevance over aggregated earnings. Livnat and Zarowin (1990) investigate the value relevance of cash flow components. They argue that cash flows are differentially associated with annual security returns, as predicted by theoretical models in finance and economics. They find that disaggregating net income into cash flow and accruals does not contribute significantly to the association with security returns beyond the contribution of net income alone. However, further disaggregating financing and operating cash flows into their components improves the degree of the association. They do not find evidence on differential association across components of cash flow from investing activities.

While researchers justify the value relevance of major accounting variables such as earnings, cash flows and dividends, they are disappointed by the low explanatory power of these variables. For example, the explanatory power of reported earnings is around 10% in the price–earnings model, and 2%-3% in the return-earnings model (e.g., Lev, 1989). This low explanatory power reflects either our limited understanding of the value relevance of accounting information, or the lack of value relevant information in the current financial accounting framework, or both. Such low explanatory power leads researchers to rethink and explore the usefulness of accounting information. In this regard, some studies (e.g., Lev, 1989; Basu, 1997) discuss and examine the effect of GAAP on the quality of accounting information.

The quality of accounting information is an important determinant of its own value relevance. Lev (1989) argues that GAAP can result in low quality earnings because of conservatism and historical valuation basis. Basu (1997) examines how conservatism affects the extent to which price leads earnings. He argues that conservatism creates the asymmetry in timeliness of earnings. Earnings that capture bad news are a timely information source, compared to earnings that capture good news. When prices reflect more than what is recognized in earnings, price-lead-earnings occurs. His empirical findings imply that the extent to which price leads earnings is greater in a good news case than in a bad news case. This finding can help us to better understand misspecification problems in accounting–based valuation models.

2.1 b) Fundamental analysis

In exploring the usefulness of accounting information, another line of research applies a fundamental analysis approach, and assumes that fundamentals contained in financial statements convey information that is indicative of future earnings and stock market returns, but is not yet reflected in current security prices. Fundamentals refer to factors that underlie a firm's intrinsic value. According to fundamental analysis, the capital market is inefficient, so that stock prices fail to fully reflect information contained in financial statements when such statements are issued to the public. Trading on fundamentals not reflected in stock prices can bring investors an abnormal return (e.g., Ou and Penman, 1989). The results from this line of research support this conjecture. In this line of research, researchers link fundamentals either with future earnings or with future returns. For example, Bernard and Noel (1991), Stober (1993) and Lev and Thiagarajan (1993) provide evidence as to the ability of fundamentals to predict a firm's future sales, earnings and profit margins. Holthausen and Larcker (1992) provide evidence as to the ability of fundamentals to predict future returns. In these studies, fundamentals include inventory, accounts receivable, gross margin, selling expenses, capital expenditure, effective tax rates, inventory methods, and audit qualifications. It is concluded that fundamentals other than earnings have incremental

value-relevance and are associated with future earnings and returns. They can then be used to predict future earnings, to assess the persistence and growth of earnings, and to predict future returns.

Ou and Penman (1989), and Abarnabell and Bushee (1997, 1998) examine whether the application of fundamental analysis can yield a significant abnormal return. They use fundamentals to predict the sign of change in future earnings, and according to this prediction, they form hedged portfolios. Stocks with a positive predicted earnings change are put into the long-position, while stocks with a negative predicted earnings change are put into the short-position. They find that this trading strategy brings about an abnormal return. Based on this finding, they conclude that the identified fundamentals are value relevant to investors' decision-making.

Accounting research provides rich evidence on the value relevance of financial statement information. However, the inclusion of fundamentals far from solves the problem of the low explanatory and predictive power of accounting information. Hence, in recent years, researchers have expanded the search for value relevant variables into the domain of non-financial performance information. Section 2.2 reviews the value relevance of non-financial performance information.

## 2.2 Non-financial performance indicators as value drivers

The inclusion of fundamentals in valuation models expands our understanding of the usefulness of accounting information, in terms of explaining and predicting future earnings and returns. Although the addition of fundamentals increases the explanatory power of accounting information from around 10% to 20% in the price-earnings model (e.g., Lev and Thiagarajan, 1993 and Livnat and Zarowin, 1990), it does not fully solve the problem of the low explanatory and predictive power of accounting information. Accounting research needs to explore a new domain in which they can find variables that can provide additional value relevance, especially in the case where financial information is irrelevant or has lost part of its value relevance. In the

past two decades, there has been increasing criticism of the focus on financial information in both the managerial accounting and financial accounting literatures. Following this criticism, there have been suggestions regarding the inclusion of non-financial performance information into the financial accounting framework. In this section, we review the arguments concerning the value relevance of non-financial performance information in the strategy and the managerial accounting literatures. The review of the financial accounting literature follows.

2.2 a) Underlying arguments concerning the value relevance of non-financial performance information

The strategy and the management accounting literatures provide conceptual arguments concerning the value relevance of non-financial performance. Fisher (1992) argues that firms need to adapt to the fast-changing environment in which they operate by selecting sound strategies and performance measures. Conventional reports about the financial performance of a business are much like the scoreboard in a football game. The scoreboard (financial results) tells a player whether he is winning or losing, but tells little about what he is doing right or wrong regarding the fundamentals of the game (non-financial performance). A player who tries to play by watching the scoreboard will not be successful. He/she should watch for key success factors in the process of the game, since improvement in these factors can lead to final success. Key success factors in operating processes are represented by non-financial performance measures such as innovation and customer satisfaction. Fisher concludes that firms in a fast-changing environment should adopt a non-financial control mechanism.

Kaplan and Norton (1992) propose such an approach for a performance measurement system. It is called "Balanced Scorecard Measures". The essence of Balanced Scorecard Measures is that there is no single measure that can drive sound performance. They argue that traditional performance measurement systems over-emphasize financial measures and pay too much attention to the results, not to the

process by which the results are generated. They further argue that improvements in areas such as quality, employee satisfaction, customer satisfaction, and innovation represent process improvements. Those improvements can lead to a firm's long-term financial success. Therefore, firms not only need measures that indicate the achievements of financial goals but also need measures that can drive performance toward those financial goals. Their design of Balanced Scorecard Measures includes both financial and non-financial measures. They argue that non-financial measures should capture the critical factors that lead to future financial performance.

Atkinson et al. (1997) argue that obtaining the help of stakeholders and satisfying them should be the key issue in strategic performance measurement systems. The increase in shareholders' wealth (financial results) is the primary objective of a firm. However, the achievement of this objective depends on the satisfaction of other stakeholders such as customers, employees and suppliers. Satisfying those stakeholders and obtaining their help are the secondary objectives of the firm, and those secondary objectives can be achieved through the improvement of operating processes. The improvement of operating processes is better represented by non-financial performance measures such as customer satisfaction and employee satisfaction. They conclude that strategic performance measurement should include measures that represent achievements of both primary and secondary objectives.

According to those studies, non-financial performance measures that are related to operating processes are important because they can lead to future financial success, which is essential to the achievement of primary organizational goals.

2.2 b) Relations between current non-financial performance and future financial performance

The review in 2.2 a) exhibits that non-financial performance is important because it is associated with future financial performance. In the strategy and the management accounting literatures, studies (e.g., Rickard, 1990, Banker et al., 2000) specifically

discuss the ways in which non-financial performance affects long-term financial performance.

Customer satisfaction can increase financial results through increased market share, customer loyalty, additional revenue, and reduced transaction costs, and is considered an important strategic target and a critical performance indicator. Rickard (1990) discusses the relationship among quality service, satisfied customers and repeat business. He argues that customer satisfaction stemming from service quality results in repeat business, and then reduces the potential loss of customers, a key business risk. Lambert et al. (1998) provide evidence on the positive association between customer satisfaction and future financial performance. Banker et al. (2000) provide evidence on how the inclusion of customer satisfaction into an incentive plan can enhance a firm's profitability. They conclude that the implementation of a new incentive plan that includes customer satisfaction increases a firm's profitability six months after the adoption of the new plan. Firms with such incentive plans outperform firms without such incentive plans, in terms of financial performance.

Development of new products and technology and improvement in quality can lead to long-term growth and success. Clayton (1999) argues that growth is an important determinant of a firm's long-term survival. He points out that innovation, quality and intellectual property are major contributors to growth. He links growth to profitability, and finds that the key success factors for profitability in European businesses overlap the key success factors for growth, thus implying that good performance in innovation, quality and intellectual properties can lead to growth and to long-term profitability.

Employee satisfaction is another contributor to a firm's long-term survival. Eskildsen and Nussler (2000) point out that the world market is becoming an increasingly difficult place for today's business. This has made creativity a valuable virtue and caused firms to shift their focus from financial resources to intellectual resources. Employees are considered essential assets for long-term business development, since

high employee turnover can prevent firms from pursuing some growth opportunities. Thus, employee satisfaction becomes a critical strategic target. Longoria and Tresslar (2000) argue that as the competitive landscape intensifies for mortgage banking, incentive compensation is becoming an increasingly powerful rewarding tool to build stability and value within a company. Eskildsen and Nussler (2000) establish a theoretical model depicting the positive causal linkages among human resource management (HRM), employee satisfaction and loyalty, and corporate financial performance. They also empirically test this linkage through a survey of 215 human resource managers in Denmark. They find that human resource management can enhance employee satisfaction, which, in return, can increase employee commitment, and lead to improvement of a firm's financial performance. Bernhard et al. (2000) find a positive relationship between employee satisfaction and customer satisfaction, and a positive relationship between customer satisfaction and a firm's financial performance.

Arguments concerning the relationship between non-financial performance and future financial performance have implications for the capital market research. Capital markets particularly base their investments on their expectations of a firm's future value, which is considerably determined by a firm's future financial performance. Thus, investors have incentives to watch selected non-financial performance measures in a firm's strategic performance measurement system. This is because those measures can indicate a firm's prospects, especially a firm's future financial performance. In this sense, selected non-financial performance measures may be value relevant to capital markets. Following the arguments in the strategy and the management accounting literatures, the capital market research explores associations between non-financial performance measures and stock prices/returns, even beyond the strategy and the management accounting literatures. In the next part of this section, we review arguments concerning these associations that appear in the financial accounting literature,

2.2 c) Empirical evidence on the value relevance of non-financial performance information

In the financial accounting literature, there is empirical evidence on the value relevance of non-financial performance information.

Behn et al. (1999) examine the association between financial performance and non-financial performance in the U.S. airline industry. Their study finds that customer satisfaction, load factors, market share, and available ton-miles are associated with operating income and revenue, and that customer satisfaction and available ton-miles are associated with expenses. They conclude that these non-financial performance measures appear to be useful in predicting quarterly revenue, expenses, and operating income. Non-financial performance information is value relevant, in the sense that it serves as a timely information source of future earnings.

Ittner and Larcker (1998) examine the value-relevance of customer satisfaction in the utility industry. They provide evidence that shows that customer satisfaction is positively related to future financial performance. Specifically, they find that customer satisfaction is a leading indicator of customer purchase behaviour, growth in the number of customers, and accounting performance (business-unit revenue, profit margin and return on sales). They also find that firm-level customer satisfaction measures can be economically related to the firm's market value, but are not completely reflected in its accounting book values. Their findings suggest that non-financial performance measures can be used not only to predict a firm's future financial performance, but also to predict a firm's market value.

Lazer and Lev (2001) argue that Internet companies are the "new economy". Most of these companies are in business only a short time prior to going public and have less than a completely reliable track record on which to base future expectations. Furthermore, these companies are operating in a dynamic environment where changing conditions dictate continuous mutations and evolutions of business goals

and practices. Consequently, investors often find it difficult to assess a company's future prospects for valuation purposes; the typical inputs into valuation models, such as sales growth, gross margins, and volatility of future growth rates in revenues (for real-options models), are highly unreliable. Lazer and Lev then examine whether traffic data on sites owned by publicly listed Internet companies provide information about the future of those companies that is useful in portfolio management. They find that when Internet companies are classified into portfolios according to above-median and below-median traffic data, the more popular sites provide significantly better stock returns than the less popular sites. Therefore, traffic data are value relevant. They explain that popular sites may have a superior ability to attract advertising revenues and may extract greater compensation from affiliated sites or have greater network externalities (in which the value of being a part of the network increases with the number of members in the network). This superior ability would then increase their ability to generate higher future profits and cash flows.

The above studies provide evidence concerning the value relevance of non-financial performance information. However, the value relevance of non-financial performance information is partially reflected by financial information. From the perspective of improving the current financial reporting framework, the capital market research is concerned with the incremental value relevance of non-financial performance information over financial information. It is the incremental value relevance that could add value to the current financial reporting framework.

In the financial accounting literature, a line of studies (e.g., Amir and Lev, 1996) examines the incremental value relevance of non-financial performance information from the perspective of intangible assets. The term of intangible assets, for the first time, appears in the management accounting literature.

In the management accounting literature, Kaplan and Norton (1992) argue that improvement in operating processes creates intangible assets that represent critical success factors in these operating processes. The value of these intangible assets is

not fully captured by financial information. According to them, financial information fails to reflect the entire picture of a firm's performance from a performance measurement perspective; and fails to provide insight into future development from a strategic planning perspective.

In the financial accounting literature, the argument made by Kaplan and Norton (1992) inspires a similar argument from a capital market perspective. Lev (1997) and Gu and Lev (2001) argue that in today's changing business world, characterized by intensive competition, globalization and decentralization, tangible assets become less and less important to a firm's survival, and then do not make a significant difference in the firm's value. By contrast, intangible assets, such as R&D innovation and customer-based development become more and more important, and then make a significant difference in the firm's value. Especially in technology-based industries, firms compete on their intangible assets but not on their tangible assets. Thus, a firm's economic performance is a function of its physical assets, financial assets and intangible assets. Under the current financial reporting framework, the evaluation of profitability and performance of a business enterprise (e.g., ROA and ROE) is seriously flawed, since the value of the firm's major assets—intangible assets—is missing from the denominator of these indicators. Omitting the measures of intangible assets can mislead capital markets' assessments of a firm's value. Therefore, learning how to measure and report intangible assets is the key to the improvement of the current financial reporting framework.

The value creation by investments in intangible assets is better represented by non-financial performance measures. Hence, the arguments concerning the economic value of intangible assets provide the foundation for studies that search for empirical evidence on the incremental value relevance of non-financial performance information.

Amir and Lev (1996) provide evidence on the value relevance of non-financial performance information in the wireless communication industry. They argue that in

the time of rapid changes, financial information is of limited value to investors. Telecommunications, biotechnology, software producers, among other growth companies, invest heavily in intangibles such as R&D, customer-based creations, franchises, and brand development. The economic value of these long-lived intangible assets is not fully captured by current financial information because U.S. GAAP requires that firms expense most of these investments, rather than capitalize them. For these industries, significant market value is created by production and investment activities. Yet, key financial variables such as earnings and book value of equity are negative or excessively depressed, and appear unrelated to market values. Amir and Lev empirically examine the value-relevance of financial and non-financial performance information, using quarterly data for 14 companies over 10 years. They find that non-financial performance information is, by itself, value relevant. They also find that traditional financial statement information is largely value-irrelevant, but when combined with non-financial performance information, earnings and the change in earnings become significant. Their findings suggest that non-financial performance information is value relevant, both by itself and incrementally, to market valuation. They conclude that the domain of fundamental variables used to predict a firm's future market value should be expanded to include non-financial performance information for high technology-based industries.

Clarkson et al. (2001) argue, in the context of the pulp and paper industry, that financial information is not sufficient enough to explain the difference between a firm's market value and its book value of equity. In their study, they add a variable that captures a firm's environmental performance into the valuation model used in this industry. Their empirical model specifies market value as a function of book value of equity, earnings and a measure of relative pollution propensity (a non-financial performance measure). They find that capital markets reward firms with a superior environmental performance record by assessing their environmental capital expenditure (ECE) outlays as expected positive NPV outlays. Specifically, they find that the valuation coefficient per dollar of current ECE outlays is zero for firms with relatively weaker environmental performance records. They explain that capital

markets penalize firms with poor environmental performance because relatively high pollution propensity signals unrecognized environmental liabilities.

A dominant argument in the financial accounting literature is that financial information has become irrelevant or has lost much of its value relevance; and therefore, non-financial performance information should be included to complement financial information. However, it is worth noting that there is disagreement on this argument. A few studies, based on long-term observation, argue that financial information has not lost its value relevance, even in technology-based industries. For example, Francis and Schipper (1999) regress the explanatory power of financial information on a time variable, and conclude that the explanatory power does not decline significantly over time. They also find that there is no significant difference in the value relevance of financial information between high-tech and low-tech industries. Francis, Schipper and Vincent (2001) provide evidence showing that earnings are still a dominant explanatory variable of a firm's stock price behaviour, even in industries where earnings are not perceived as a dominant indicator. Hence, evidence regarding the loss of the value relevance of financial information is mixed, and therefore this issue needs further examination. The mixed evidence inspires our examination of the value relevance of financial information, within the context of the biotechnology industry. We come back to this point in the hypothesis development section.

### 2.3 R&D innovation as a value driver

With respect to the value relevance of non-financial performance information, there is an extensive focus on R&D innovation. Researchers in the business world are concerned about what drives a firm's value (e.g., Rickard, 1990; Clayton, 1999; Lev, 1997; Amir and Lev, 1996; Alto and Hage, 1999). Studies in the R&D literature (e.g., Alto and Hage, 1999; Moorman and Slotegraaf, 1999) argue that, in the modern economy that is characterized by globalization and intensive competition, R&D innovation is one of the key value drivers. This is because R&D innovation generates

two types of ability: the ability to adapt to the changing business world and the ability to compete with superior technology and products. The two types of ability are critical for firms to survive and grow in a dynamic and complex business world. Alto and Hage (1999) argue that innovation is the major source of organizational change that is needed for survival in the changing business world. There are three factors that determine organizational innovation: a complex division of labour, an organic structure and a high-risk strategy. Of these three factors, the complexity of the division of labour is the most important because it taps the organizational learning, problem-solving, and creativity capacities. Szeto (2000) argues that a firm's initiation of collaborative projects with other network members can create a cycle of improvement and contribute to the development of innovation capacity. In turn, the development of innovation capacity can improve organizational competitiveness. Moorman and Slotegraaf (1999) develop a framework that proposes a contingency approach to the value of organizational capabilities. They argue that a firm's ability to develop their technology and products is the key component of organizational capabilities. Mitchell (2000) summarizes three trends in R&D strategy in the early 21$^{st}$ century. The first trend relates to the dramatic increase in industrial R&D intensity, and the shift in the overall balance of the U.S. industrial R&D toward the information and health sectors that occurred in the 1980s and 1990s. The second involves the use of the Internet to transform the processes by which companies acquire and develop technical knowledge. The third relates to corporate management's growing recognition of technological innovation as an increasingly important factor in corporate growth and survival.

Innovation creates value for firms. Empirical research supports the argument concerning the significance of R&D innovation as a value driver. For example, Blundell et al. (1999) examine the empirical relationship between technological innovation, market share and stock price. They find that competitiveness is positively associated with innovations across industries; within industries, market share is positively associated with commercialization of innovations. They also find that innovation has a positive impact on stock price. Arndt and Sternberg (2000) examine

how inter-firm linkages in the form of a regional network affect success of innovation. They find that manufacturing firms with strong intraregional ties are more successful, with respect to innovative activities that lead to greater growth rates, than those with little connection to their regions.

In the financial accounting literature, studies discuss and examine the value relevance of information on R&D innovation (e.g., Nakamura, 1999; Gu and Lev, 2001; Zhen et al., 1999). Nakamura (1999) and Gu and Lev (2001) discuss the significance of the measurement of intangible assets to market expectations. They argue that, as a result of intensive competition created by globalization and deregulation of major industries, innovation becomes a matter of life and death. Firms can get innovation by investing in R&D, people and operating processes. Innovation results in intangible assets such as patent and copyrights. In such a business world, physical assets do not make a significant difference in creating value, but intangible assets do. The value created by intangibles exists long before it is recognized in the GAAP accounting system. As a result, the earnings number is less and less informative about what will happen to the firm, while the measurement of intangible assets is more and more informative. Learning how to measure and report intangible assets is one of the major issues in the improvement of the financial reporting framework. This line of studies sheds light on the empirical examination of the value relevance of R&D innovation.

Zhen et al. (1999) argue that innovation and technological changes are the main drivers of a company's productivity and growth. However, public information on a company's efforts to innovate is generally scant and not timely. They argue that patent-related measures may have the ability to help predict stock returns and market-to-book ratios. Their empirical results indicate that patent measures that reflect the volume of a company's' research activity, the impact of companies' research on subsequent innovation, and the closeness of research and development to science are reliably associated with the future performance of R&D-intensive companies in capital markets.

Lev (1999) examines the association between market valuation and R&D expenditures. He finds a positive relationship between the two economic variables. He concludes that R&D expenditures capture unrecognized intangible assets created by R&D investment and can then explain book to market ratio. Aboody and Lev (1998) examine the value relevance of software development capitalization required by SFAS No.86. They find that annually capitalized software development costs are positively associated with stock returns, and that software capitalization data are associated with subsequent reported earnings. They also document a significant association between development costs that are fully expensed by the firms not following SFAS No.86 and subsequent stock returns. This finding is consistent with a delayed investor reaction to product development of these companies.

In this area, there is another line of studies that examines the effect of accounting treatments on the value relevance of R&D innovation. For example, Chan and Sougiannis (1990) argue that accounting treatment of R&D expenditures has an effect on market valuation. They point out that expensed R&D expenditures undervalue the intangible assets created by R&D investments. They provide evidence on the positive association between market valuation and R&D expenditures, and recommend the capitalization of R&D expenditures.

The above studies show that R&D innovation is an important value driver, especially in the context where firms operate in a dynamic environment. The question our study is concerned with is: Is R&D innovation the major performance indicator in the biotechnology industry? Section 2.4 investigates this question. Before doing that, we rationalize the selection of the biotechnology industry as the research setting of our study.

## 2.4 R&D innovation as value driver: the case of the biotechnology industry

### 2.4 a) Selection of the biotechnology industry as research setting

The studies reviewed in Section 2.2 examine different non-financial performance measures in different settings. Amir and Lev (1996) find that realized growth and growth potential are incrementally value relevant in the wireless telecommunication industry. Ittner and Larcker (1998) find that customer satisfaction is value relevant in the airline industry. Lazer and Lev (2001) find that traffic data is value relevant in Internet companies. Clarkson et al (2001) find that information on environmental performance is incrementally value relevant in the pulp and paper industry. The framework underlying these studies implies that the value relevance of non-financial performance information is industry-specific. In a theoretical sense, it is true that different industries have different non-financial performance measures as their major performance indicator. This is because non-financial performance represents operating processes that are substantially product/service oriented. Different industries produce different types of products/services in different operating environments, which requires differential resources, strategies and evaluation criteria. This framework is supported by the strategy and management accounting literatures. Fisher (1992) and Kaplan and Norton (1992) assert that non-financial performance measures capture critical success factors in operating processes. In fact, as the nature of each business varies, different industries have different critical success factors. Moreover, a factor may be more critical in some industries than in others. Hence, when examining the incremental value relevance of non-financial performance information, it is critical to select a specific industry and discuss its major performance indicator.

Our study selects the biotechnology industry. There are two reasons underlying this selection. First, biotechnology firms evolve in a fast changing and high technology-based environment. They invest heavily in R&D innovation. According to the prediction by Amir and Lev (1996), financial information may be irrelevant in this

industry. Non-financial performance information may serve as the dominant performance indicator. Thus, the biotechnology industry forms a typical setting where we can evaluate the role of financial accounting in equity valuation. However, there is no empirical evidence as to the loss of the value relevance of financial information in this industry. Our study attempts to provide evidence on the existence or loss of the value relevance of financial information in this industry; if financial information has lost its value relevance or part of its value relevance, our study further attempts to investigate the factors that cause the loss. Assuming that financial information has lost its value relevance, our study intends to examine the incremental value relevance of non-financial performance information over financial information. The purpose of this examination is to see how non-financial performance information can add value to the accounting-based valuation model for this industry.

Secondly, the biotechnology industry is an interesting industry to investigate. Stock prices of companies in this industry are more volatile, compared to many other industries. For example, in the year 2000, the biotechnology industry performed really well in stock markets. The Nasdaq biotechnology index was 1300 at the end of September 2000, up from 850 at the beginning of the year. However, during the first two quarters of the year 2001, there was a substantial decline in the share prices of many biotechnology companies. The Nasdaq index was 640 at the end of March 2001 and remained at 692 at the end of June 2001, a decline to less than half of its former value, as of September 30, 2000. In contrast, the Nasdaq insurance index was 1888 at the end of September 2000, and increased to 2272 at the end of June 2001. The biotechnology index declined by 87.8% from September 2000 to June 2001, while, in contrast, the insurance index increased by 20.3%. Another interesting puzzle is that many firms have market value but do not have any products in the market. The third interesting attribute is that many firms report negative earnings, some of them even report negative book value of equity. Nevertheless, analysts remain of the opinion that the biotechnology industry is still an attractive investment opportunity because it is both defensive and growing. This industry is defensive because it makes pharmaceutical products that have strong, long-term promise of earnings. It also

promises high growth because it is a relatively new industry. The growing knowledge of human genes provides a broad space for the evolution of this industry. Investors and analysts continue to seek ways to improve their understanding of how fundamentals determine the market value of biotechnology companies. Therefore, we are interested in what drive the market value of biotechnology firms, what is the information usage of investors in these firms, and how non-financial performance information increases the explanatory power of the accounting-based valuation model of this industry. In order to satisfy our interests, we select the biotechnology industry as our research setting.

2.4 b) R&D innovation as the major performance indicator

The R&D literature documents that R&D innovation is one of the major non-performance indicators. In Section 2.3, we review the arguments concerning the value relevance of R&D innovation in general. In this section, we review the arguments on the value relevance of R&D innovation specifically in the biotechnology industry.

Some studies (e.g., Robbins, 2000; Kellogg and Charnes, 2000) extend the arguments concerning the value relevance of R&D innovation into the biotechnology industry. They argue that R&D innovation is the major performance indicator in the biotechnology industry. Robbins-Roth (2000) depicts the development of biotechnology companies. He argues that drug development supported by R&D investments plays a central role in the survival and growth of biotechnology firms. A firm's ability to get drugs through various clinical trial phases to final approval by government is a critical success factor in this industry. This is because drugs in different clinical trial phases are potential sources of future earnings. Once is a new drug approved by government, it can bring the firm a large amount of incremental annual earnings. Therefore, biotechnology firms compete on drug development, especially on resources that are needed in the drug development process and on the speed of this development.

Arnum (1999) observes a great number of mergers and acquisitions occurring in the biotechnology industry. To explain this phenomenon, he argues that keeping the drug pipeline flowing and competitive is critical for biotechnology firms, and doing so requires a great amount of money. Thus, biotechnology firms are under continuous pressure to build the critical mass needed in R&D. This creates incentives for firms to enter into merger or acquisition transactions. Agnew (2000) also argues about the effect of R&D on mergers and acquisitions. He states that staying on top in the global drug market requires doing more and better research, and a firm's R&D performance matters when pharmaceutical firms merge.

Scherer (2001) discusses the link between gross profitability and pharmaceutical R&D spending. From an economic perspective, he argues that firms compete to exploit growing profit opportunities by increasing R&D investment until the increases in cost dissipate most, if not all, supranormal profit returns. His study underlies the importance of R&D spending.

R&D innovation is usually measured by R&D expenditures (e.g., Lev, 1999). This is also the case in the studies of the biotechnology industry. Based on this measurement, a line of research examines the associations between a firm's R&D expenditures, financial performance, and stock market returns.

Grabowski and Vernon (1994) provide evidence on the positive association between stock returns and R&D expenditures, within the context of the biotechnology industry. Their findings confirm the value relevance of R&D expenditures. Healy, Myers and Howe (1999) further argue, based on a stimulation study, that the financial accounting method of R&D expenditures has a significant effect on the market valuation of biotechnology companies. They compare three accounting treatments of R&D expenditures: cash (full expense), full cost (full capitalization), and successful effort (capitalization of successful R&D), and conclude that the successful effort method is the most informative accounting choice.

Based on finance theory, a few authors link drugs in different clinical trial phases (drug portfolios) with future cash flows. They use information on drug portfolios to predict stock price. For instance, Kellogg and Charnes (2000) argue about the value relevance of drug development by applying a Real-Option Valuation model to the biotechnology industry. They argue that capital markets reward drug development because it represents a long-term promise of cash flows. Hence, they imply that there is a linkage between drugs in different clinical trial phases and future cash flows. They then define a firm's market value as a function of the present value of the estimated future cash flows associated with drugs in different clinical trial phases. They provide evidence that shows that their valuation model works well for drugs in earlier trial phases. In their study, drugs in different clinical trial phases represent options that lead to future cash flow. However, in our study, we use drugs in different clinical trial phases to proxy for intangible assets created by R&D innovation.

In practice, analysts following biotechnology firms also use information on drug portfolios in different clinical trial phases to forecast changes in earnings. Valueline analysts use information about drugs in the governmental approval process to forecast short-term changes in earnings. They predict incremental earnings that would be generated if a drug were approved by government. They also use information about drug portfolios in phase III clinical trials and in the government approval process to forecast changes in earnings for a five-year horizon. Analysts' forecasts and recommendations are sensitive to changes in drug portfolios, especially in phase III clinical trials and in the government approval process. For instance, shares of NeoPharm Inc. fell 14 percent on Friday, January 11, 2002. The company delayed the starting of its phase III clinical trial for its lead cancer drug, LEP. The clinical trials were expected to begin in the fourth quarter of 2001, but the company had not yet started them. ``We believe that the perceived delay in initiating a phase III trial introduces some degree of uncertainty as to the Pharmacia's ability to move forward with the product rapidly," said Andrew Gitkin, a UBS Warburg analyst, in a report to investors. In addition, he said the delay gave more room for potential competitors to snatch market share from NeoPharm. Gitkin discussed this issue with the senior

management of the company, and the discussion did not serve to allay these concerns. He then reduced his recommendation on the company's stock from "buy" to 'hold'.

From the studies reviewed above, we conclude that R&D innovation is the major value driver in the biotechnology industry. It is expected that information on R&D innovation shape the market expectations of biotechnology firms. The issue examined in our study is the extent to which information on R&D innovation interacts with and adds value to the current financial accounting framework.

The review in this section suggests that R&D innovation is the major performance indicator in the biotechnology industry. This raises a question: how should we measure R&D innovation for this industry? In the literature, researchers use R&D expenditures to capture the value creation by R&D innovation. However, this measurement is questionable because it does not incorporate the success rate of drug development. Actually, the success rate in drug development is very low. DiMasi (1995) estimates that the success rate of drug development is only 22.5%. A low success rate implies the inappropriateness of R&D expenditures as a measure of R&D innovation. We argue that drug portfolios would be alternative measures of R&D innovation. In the literature, there is no research that shows the limits of R&D expenditures as a measure of R&D innovation, and no research that applies drug portfolios as alternate measures. We develop measures that can compensate for the limits of R&D expenditures by incorporating the success rate of drug development into the measurement of R&D innovation. We come back to this point in the hypothesis development section.

As previously mentioned, Szeto (2000) and Arndt and Sternberg (2000) argue that business linkages can enhance R&D innovation in the biotechnology industry. If this were true, business linkage would serve as a supporting value driver to R&D innovation; as a consequence, the information on a firm's business relations would provide incremental value relevance over the information on R&D innovation. Section 2.5 reviews the discussions on this issue.

## 2.5 Business relations: a value enhancer in the biotechnology industry

Firms operate in the context of business relations and networks. Compared to the traditional economy, establishment and maintenance of business relations with other businesses in the modern economy is increasingly becoming more critical to value creation. Wilkinson and Young (2001) argue that business relations and networks affect the nature and outcomes of a firm's actions, and are potential sources of their competitive advantages. Birchard (2001) points out that ideas and relationships are an important component of intangible assets. Companies today compete on ideas and relationships. Pietras et al. (2001) argue that one of the changes brought about by the New Economy during the past 10 years is the proliferation of strategic business alliances. Strategic alliances are by nature the marriages of companies. They are a way for companies with complementary strengths to enter a given market more effectively and efficiently than either alliance partner could manage alone. Strategic alliances allow companies to minimize risks relating to their technology, market or competitive environment. Conhaim (1999) argues that the essence of creating business relationships lies in the sharing of information, risk and capacity. The major benefit from business relationships is to gain speed when discovering, developing and commercializing ideas, products and services, since speed is a vital success factor in the modern economy. The more successful companies are ones that move faster than others in discovering and satisfying markets.

Business relations exist in all industries. However, as depicted by Sparks (1999), the alliance boom is most prevalent among industries with rapid changes. They include biotechnology and pharmaceuticals, media, entertainment, airline, financial services and other high-tech sectors. In the biotechnology industry, the number of alliances continues to grow. Partnerships and alliances have undergone a radical evolution over the course of the last two decades, and are now an integral part of the competitive landscape. Lucrative deals based on new technologies are playing a key role in the progress of the most successful biotech and pharmaceutical companies.

Alliances often occur between big pharmaceutical companies and small biotech companies. Generally speaking, big pharmaceutical companies have capacities in manufacturing and marketing, while small biotechnology companies have advantages in research and innovation. Thayer (1993) points out that, for small biotechnology firms, the advantages of alliances include access to the marketing, manufacturing, and development power of a large corporation, generally along with funds to sustain product development; for large drug companies, alliances offer them new technology and potential products. Tapon et al. (2001) further argue that strategic alliances with pharmaceutical firms can enhance small biotech firms' ability to become big and established.

The benefits from strategic alliances between big pharmaceutical companies and small biotech firms can be summarized as follows. First of all, strategic alliances can enhance innovation and drug development. As the market becomes ever more complex and uncertain, companies, especially pharmaceutical firms, become increasingly reliant on small biotechnology firms for innovative ideas. Partnering is no longer an option; it is now a business imperative. Whelan (2001) argues that one of the most pressing issues for pharmaceutical companies in the current business climate is the need to improve the productivity of the research and development process. Partnerships can facilitate this process via the sharing of research resources and research capacity. Budd (2000) argues that alliances can foster new ideas in drug discovery. For example, Eckelbecker (2001) reports that Gemin X and Phytera get together for cancer research. Under the alliance between the two companies, Phytera receives initial fees and research funding, while Gemin X screens extracts from Phytera's extensive library of plant and marine microorganism extracts in search of those that may play a role in cell death.

Secondly, strategic alliances are a way for small biotechnology firms to gain a financial backbone (Chang, 1998). Thayer (1993) argues that, as public markets run dry and vast sums of money are still needed to support research, drug development, and commercialization, financing through collaborative agreements, venture capital,

and equity investments becomes increasingly important. Financing from alliances helps to balance out the unpredictable equity market and satisfies firms' capital needs. Gupta (1993) argues that strategic alliances allow small businesses to share technology or resources with others, which helps small companies achieve goals that would otherwise require capital investments that are difficult to obtain.

Thirdly, strategic alliances allow sharing of risks associated with R&D investments and commercialization. Forbes (2001) reports that strategic alliances are embedded in the biotechnology industry's DNA. The risks associated with R&D investments are too great and the time spans involved in drug discovery and development are too long for a single company to bear. Hence, big pharmaceutical firms tie up with small biotech firms for shared research. Frederick (2001) points out that big pharmaceutical firms get together with small biotech firms to develop next-generation products to protect the therapeutic franchises. Clarysse et al. (2001) argue that small biotech firms benefit from the alliances with pharmaceutical firms because they can obtain the economies of scale in R&D investments.

In addition to the above-mentioned benefits, strategic alliances can benefit firms in many other ways. For example, Oliver (2001) argues that strategic alliances in the biotechnology industry are used as an inter-organizational learning device. He observes the relationship between the organizational life-cycle and the formation of strategic alliances. The findings of his study show that the lack of alliances is associated with organizational death.

There is empirical research investigating the effect of alliances on a firm's performance. Baum et al. (2000) hypothesize that startups can enhance their early performance by establishing alliances with companies that have needed resources and capacities. They empirically investigate Canadian biotechnology firms and find supportive results to their hypothesis. Their results show that variation in the alliance networks that startups configure at the time of their founding produces significant differences in their early performance, especially their innovative performance.

George et al. (2001) argue that the structure and knowledge flows with alliances can affect a firm's innovativeness. Alliances should be viewed as a portfolio of strategic agreements. The characteristics of the portfolio would be associated with a high technology firm's innovative and financial performance, and would also influence a firm's absorptive capacity. They test their propositions by using a sample of 2,456 alliances formed by 143 biotechnology firms. Their results indicate that alliance portfolio characteristics and absorptive capacity jointly influence a firm's performance.

Rothaermel (2001) argues that incumbents can enhance their product development via interfirm cooperation with new entrants. He studies 889 strategic alliances of pharmaceutical companies with new biotechnology firms, and finds a positive association between the incumbent's alliance and their new product development and, in turn, a positive association between new product development and firm performance.

In summary, strategic alliances within the setting of the biotechnology industry can foster a firm's competitive advantage, speed up drug development, reduce the risk level associated with R&D investments and product commercialization, and generate research and royalty revenues. It is therefore expected that the information on a firm's strategic alliances can have an impact on capital markets' prediction of the firm's future earnings trend. In the literature, there is no prior research that investigates how information on business relations can add value to the current financial reporting framework for the biotechnology industry. Our study attempts to examine the value relevance of such information. We focus on the incremental value relevance of business relations over both financial information and information on R&D innovation.

## 2.6 Summary of the literature review

The literature review shows that the ability of financial information to adequately reflect a firm's value is being increasingly questioned. However, the evidence concerning the value relevance of financial information is mixed. Thus, we intend to investigate if financial information has lost its value relevance in the biotechnology industry.

In the case where financial information has become irrelevant or lost much of its value relevance, non-financial performance information can compensate for the limitations of financial information. Non-financial performance information is value relevant, because it can indicate a firm's future financial performance; moreover, non-financial performance information is incrementally value relevant when its value relevance is not fully captured by financial information. The incremental value relevance of non-financial performance information over financial information is one of interests of studies in this area. Non-financial performance measures represent key success factors in operating processes. In the biotechnology industry, R&D innovation is the key performance indicator, because R&D innovation creates intangible assets (i.e., drug portfolios), which are the major sources of future earnings. There is no evidence that, in this industry, financial information can substantially capture the value creation by R&D innovation. Our study intends to see if R&D innovation possesses incremental value relevance over financial information in this industry. In addition, resources, risks and speed of drug development are vital factors that determine the success of drug development. Firms can gain competitive advantages in these factors by entering into strategic alliances with other firms. Strategic alliances allow firms to obtain resources that they do not have, and to share risks with other firms, and to be able to speed up their drug development. Therefore, business relations a firm builds with others are a critical factor that can substantially influence R&D innovation. There is no research that examines the incremental value relevance of business relations. We therefore attempt to examine this issue.

The literature shows that drug development is associated with a low success rate. This raises concern about the appropriateness of R&D expenditures being a proxy for value relevance of R&D innovation in the biotechnology industry. In the literature, there is no research that addresses this issue, no matter this issue is related to the biotechnology industry or to other industries. Hence, we intend to discuss and examine the ability of R&D expenditures to capture the value creation by R&D innovation, and propose a better measurement of R&D innovation for this industry.

# 3. Hypotheses Development

## 3.1 Drug Development in the biotechnology industry

Drug development, supported by R&D investments, is the core value driver for biotechnology companies. Biotechnology companies compete on the superiority of, and market capacity for, their drugs, and on their ability to bring these drugs through different phases of clinical trials to final approval by government, at a competitive speed. Biotechnology companies also compete on their ability to launch their drugs, following approval.

Development of a new drug is a risky business. Of the virtually infinite number of molecular compounds that may have pharmacological effects, drug companies must carefully choose the compounds in which to invest the millions of dollars required before launching a new product on the market. The development process comprises several stages, during which drug companies gather evidence to convince government that they can consistently manufacture a safe and effective form of the compound for the medical condition it is intended to treat. At the end of each stage, companies use the technological and market information revealed up to that point to decide whether to abandon or to continue the development of the compound. Any continuation to the next stage must be approved by government. In the U.S., the government agency is the Food and Drug Administration (FDA)

Drugs that reach the market in the U.S. typically pass through six stages: the discovery stage, the pre-clinical trial stage, the IND stage, the clinical trial stage, the FDA filing and review stage and the post-approval stage. We briefly describe these stages in the following part of the thesis.

Discovery stage: in this stage, chemists and biologists expend a significant amount of effort to develop concepts for synthesizing new molecular entities (NMEs). Many such entities are abandoned at this stage.

Pre-clinical trial stage: in this stage, the NME is screened for pharmacological activity and toxicity first in an artificial environment, and then on animals.

IND stage: If the NME is a promising candidate for further development, the company files an Investigational New Drug (IND) application with the FDA. An approved IND allows the company to continue the development by testing the drug on humans in clinical trials.

Clinical trial stage: the clinical trial stage is generally broken down into three phases.

Phase I: testing is conducted on a small number of volunteers to obtain information on toxicity and safe dosing ranges in humans. Data are also collected on the drug's absorption and distribution in the body, the drug's metabolic effects, and the rate and manner in which the drug is eliminated from the body.

Phase II: the drug is administered to a large number of individuals selected from among patients for whom the drug is intended. Successful Phase II trials provide significant evidence on effectiveness and additional data on safety.

Phase III: this final pre-marketing phase involves large-scale trials on patients to obtain additional evidence of efficacy. A large sample size increases the likelihood that actual benefits will be found statistically significant, and that any adverse reactions that may occur infrequently in patient populations will be observed. Phase III trials are designed to approximate the manner in which the drug will be used after marketing approval.

FDA filing and review stage: after the clinical trial phases have been completed and the company believes it has sufficient evidence for approval, it submits a New Drug Application (NDA) to the FDA for review. Marketing for approved uses may begin upon notification from the FDA.

Post-approval stage: while the company is receiving revenues from the sale of its new drug, it conducts and develops extensions of the product. Extensions include alternative formulations and dosages for subsets of patients, such as children.

## 3.2 Hypotheses

### 3.2 a) Hypotheses concerning the value relevance of financial information

From the literature, we learn that there is mixed evidence on the loss of the value relevance of financial information over time. Therefore, the value relevance of financial information needs further examination. Our study, first of all, attempts to examine whether or not financial information has lost its value relevance in the biotechnology industry. If so, it further investigates what contributes to this loss or what prevents financial information from being value relevant. Furthermore, we examine how non-financial performance information can add value to the accounting-based valuation model of this industry. In this examination, we focus on measures of R&D innovation and business relations. A related discussion and examination involves better ways of measuring R&D innovation in this industry.

Biotechnology companies operate in a fast-changing technology-based environment. They invest heavily in R&D innovation that generates drugs in the pipeline. Drugs in the pipeline are intangible assets created by R&D investments. The economic value of these intangible assets is not fully recognized in financial statements, because U.S. GAAP, motivated by conservatism, require that companies expense, rather than capitalize, most of their R&D expenditures. As a consequence, both book value of equity and earnings are distorted; and therefore understate a firm's value. Following Amir and Lev (1996), and Robbins-Roth (2000), market value of a biotech firm is created by its R&D investment activities. Neither book value of equity nor earnings can fully reflect R&D investment activities, especially when they are negative. Thus, it is reasonable to expect that financial information has become irrelevant in this

industry. However, we expect that financial information be still value relevant to an extent, because both book value of equity and earnings, by nature, are fundamentals that determine a firm's value. Many biotechnology firms report negative earnings; some of them even report negative book value of equity. How to interpret the associations between market value and negative book value of equity, and between market value and negative earnings, is still an unsolved issue in the accounting research. Therefore, our study focuses on positive book value and earnings. We intend to examine whether or not positive book value and earnings are value relevant in this industry. In addition, we intend to provide evidence that negative book value of equity and earnings are irrelevant. This leads to the first hypothesis:

**H1: Financial information, after controlling for its sign, is value relevant in the biotechnology industry**

As previously mentioned, we focus on what contributes to the loss of the value relevance of financial information; or alternatively, what maintain this value relevance. The financial accounting literature provides discussion and evidence that a firm's economic characteristics can determine the cross-sectional differentiation in the value relevance of financial information (e.g., ERC studies). According to Amir and Lev (1996) and other researchers in the same area, the value relevance of financial information depends on the extent to which firms invest in intangible assets. They basically suggest that the more firms invest in intangible assets, the more irrelevant their financial information is. We examine the effect of a firm's product market status on the value relevance of financial information. A firm's product market status refers to whether or not the firm has ever developed any drugs that have been launched into the market. If firms have ever developed drugs that have been launched into the market, no matter when these drugs are launched, we call them firms that have products in the market. By contrast, if firms never developed any drugs that have been launched into the market (their drugs are still in the pipeline), we call them firms that do not have products in the market.

We select a firm's product market status because drug development is the major performance indicator in the biotechnology industry, and the great earnings potential in this industry is associated with a drug's launch into the market. It is also because a firm's product market status is associated with its maturity which signals fundamental differences between firms. If firms have ever provided drugs to the market, they can be perceived as mature in terms of research, technology, and management and so on. If firms have never provided any products to the market, they can be perceived as less mature; actually, they are emerging. We come back to the maturity issue when we discuss the effects of a firm's product market status as an independent variable on the market valuation of biotechnology companies in the sensitivity analyses section. In this section, we focus on how a firm's product market status interacts with financial information.

We argue that the value relevance of financial information in the biotechnology industry may depend upon a firm's product market status. Biotechnology firms are different than firms in other industries in five aspects. First, drug development is a long process. On average, a new drug takes 10-15 years to move from discovery to the FDA approval. Secondly, this process is quite costly. A new drug's development cost is between $65 million to $250 million. As a result, many biotechnology companies report negative earnings because of their enormous amount of R&D expenditures. Some firms even report negative book value of equity. Thirdly, drug development is quite risky. This is because drug development is heavily regulated by government and involves complex human reactions to drug designs. If clinical trials show negative results, a firm must terminate the development, no matter how much money it has spent. Fourthly, the market potential of a new drug is quite high. Once is a new drug approved by the FDA, it can bring the company at least $25 million in incremental annual earnings. As argued by Kellogg and Charnes (2000) and Robbins-Roth (2000), this great market potential generates incentives for companies to invest in drug development and for investors to invest in biotechnology firms. Therefore, R&D innovation, which mainly supports drug development, becomes the major value driver of biotechnology companies. Finally, biotechnology firms possess both

"defensive" and "growth" characteristics. Capital markets, to a great extent, value these characteristics. Biotechnology firms are defensive because they produce pharmaceutical products that promise strong and long-term earnings. In addition, pharmaceutical products, since used for the diagnoses and treatment of human diseases, have a higher certainty in demand, compared to other types of product. Biotechnology firms are growing because the biotechnology industry is still a growing industry. It has only been 25 years since it emerged, and the growing knowledge of human genes provides plenty of room for further evolution of this industry.

The combination of these special aspects makes investment in biotechnology firms attractive. It also requires an investor's patience and long-term consideration of their investment return. Investors in biotechnology firms expect a high return to compensate for their bearing of high risks that are substantially associated with the long-term drug development and with the regulation in this industry. Therefore, investors expect a return from future earnings brought about by newly-approved drugs. They pay close attention to the pipeline of drug development because drugs in different clinical trial phases represent options that they can exercise when these drugs move on to the next stage, especially to the FDA approval process. Therefore, they closely watch the movement of drugs from one stage to the next. They also realize that a great amount of R&D expenditures can cause negative earnings, even negative book value of equity. Thus, they may ignore negative book value and earnings reported by a firm that has not yet provided any products to the market, while paying close attention to its drug pipeline when valuing the firm. Therefore, it is reasonable to expect that information on R&D innovation play a greater role than financial information for firms that have no products in the market. In this context, financial information may lose their value relevance for these firms.

However, a dominant argument in the accounting literature (e.g., Easton et al., 1991 and Scherer, 1993) claims that earnings are an important fundamental that determines a firm's value. There is rich evidence that indicates that capital markets reward

positive earnings and penalize negative earnings. This raises concern about the implication of this notion for the valuation model of the biotechnology industry. We interpret that this notion is valid under the assumption that firms have products in the market. Under this assumption, the sign of earnings really makes a difference in market valuation. Positive earnings represent profitable operations, while negative earnings represent deficit operations.

Based on this interpretation, our study argues that, for biotechnology firms that have products in the market, investors pay attention not only to their drug pipeline, but also to their reported earnings when predicting their ability to generate future earnings. In fact, positive earnings are what investors expect and wait for over a long time. Investors like to see firms earn positive earnings after their products are launched into the market. In the case where firms have products in the market, reported negative earnings can undermine an investor's patience and confidence. Investors may perceive negative earnings as a signal of underlying problems. The problems may be either on the marketing side of approved drugs, or on the drug development strategy side, or both. If this argument is valid, reported earnings are expected to be value relevant, as they help investors shape their expectation of a firm's ability to increase the shareholders' wealth. Genzyme tells a story about the importance of earnings for firms that sell their products in the market. Reported by Yahoo FINANCE on June 2002, Genzyme announced that the estimated earnings for 2002 reduced to between $200 million and $210 million. The prior estimate was between $260 million and $280 million. Right after the announcement, its share price fell from $25.87 to $19.80 in mid-morning trading on the Nasdaq. Hence, it is reasonable to expect that financial information be value relevant for firms that have products in the market but be value irrelevant for firms that have no products in the market yet. A firm's product market status may impact the value relevance of financial information in the biotechnology industry. This leads to the second hypothesis:

**H2: A firm's product market status enhances the value relevance of financial information reported by biotechnology firms.**

3.2 b) Hypotheses concerning the incremental value relevance of non-financial performance information

From the literature review, we learn that innovation, as reflected by a firm's ability to get drugs through various clinical trial phases to the FDA final approval, is the major performance indicator in the biotechnology industry. It is expected that information about a firm's drugs in different clinical trial phases (drug portfolios), as well as about their shifts from one phase to the next, modify an investor's appreciation of the firm's earnings trend. Thus, this information is expected to be value relevant on its own. However, the relative value relevance of R&D innovation is not the concern of our study. Our study attempts to examine the incremental value relevance of R&D innovation over financial information. This is because we want to see how information about R&D innovation can complement the current financial reporting framework which is determined by GAAP. We define that a variable's relative value relevance refers to its value relevance when working as a sole variable in a regression model; while a variable's incremental value relevance refers to its value relevance when working as an additional variable in a regression model, which originally contains some other variables. According to these definitions, an independent variable's relative value relevance tells us something about the dependent variable; while an independent variable's incremental value relevance tells us something more about the dependent variable, given that we already learn something from the original variables of the model.

In the R&D literature, researchers use R&D expenditures to proxy for the economic value of unrecognized intangible assets created by R&D investments. R&D expenditures are expected to carry incremental value relevance over financial information. However, in the literature, there is evidence only on the relative value relevance of R&D expenditures in the biotechnology industry, but no evidence on the incremental value relevance of R&D expenditures over financial information. We intend to provide such evidence. This leads to the third hypothesis:

**H3: Information about R&D expenditures has incremental value relevance over financial information reported by biotechnology firms.**

Research in the R&D literature implicitly assumes that R&D expenditures are able to proxy for the value creation by R&D innovation. This assumption may not be valid in the valuation model of the biotechnology industry. R&D expenditures represent R&D inputs; while the value creation by R&D investments is associated with R&D outputs. Thus, the ability of R&D expenditures to carry the value creation by R&D investments depends on the extent to which R&D inputs can be transferred to R&D outputs.

In our study, R&D outputs refer to the creation of intangible assets by R&D investments. These intangible assets are drugs at different stages. These drugs can be called drug portfolios in the pipeline. Hence, the ability of R&D expenditures to carry the value creation by R&D investments depends on whether R&D expenditures can be transferred into drug portfolios. We argue that, in the biotechnology industry, the transformation from R&D inputs to R&D outputs is determined by the success rate of drug development. If the success rate is high, R&D inputs can proxy for R&D outputs; otherwise, they cannot. This is because R&D outputs are generated by successful R&D investments.

Drug development in the biotechnology industry is different from product development in other industries. It is associated with high risk, which results in a high failure rate. One reason for this high risk is that drug development is heavily regulated by government. New drugs or new treatments of existing drugs can go to the market only when they are approved by government. Any clinical trials and their movement to the next phase must be permitted by government. Another reason is that drug development deals with the reactions of human bodies to the drug designs. Human reaction is one of the most complex phenomena; and in most cases, they go far beyond the expectation of chemists and biologists. If clinical trials in any phase

show negative results, the firm must terminate the trials. Termination is forced by government. As a result, the success rate of drug development is quite low. DiMasi (1995) examines success rates for drugs in different clinical trial phases. According to his estimations, drugs in Phase I clinical trials (PI drugs) have a 75% probability of moving on to Phase II clinical trials. Drugs in Phase II clinical trials (PII drugs) have a 50% probability of moving on to Phase III clinical trials. Drugs in Phase III clinical trials (PIII drugs) have a 80% probability of moving on to the FDA approval process. Drugs in the FDA approval process (FDA drugs) have a 75% probability of being approved. Hence, for a new drug development, from PI clinical trial to the final approval by the FDA, the total success rate is only 22.5%. Such a low success rate casts suspicion on the transformation from R&D inputs to R&D outputs.

We then argue that R&D expenditures may not be an appropriate proxy for the unrecognized intangible assets created by R&D investments in the biotechnology industry, due to the low success rate of drug development. R&D expenditures can proxy for the scale of drug development, the technology level used in drug development, the complexity of drug development, and even the market potential of drugs, given that drug development is successful. However, as discussed before, drug development is associated with a low success rate. As a consequence of such a low success rate, PI drugs may not be able to move on to PII clinical trials, and PII drugs may not be able to move on to PIII clinical trials. Termination of clinical trials results in no intangible assets, except for what has been learned from past failures, no matter how much money has been spent on drug development. Thus, we argue that R&D outputs should be taken into account when measuring the value creation by R&D investments, and a better measurement of R&D innovation should be one that incorporates both R&D inputs and R&D outputs.

The limitation of using R&D expenditures as a proxy for the value creation by R&D investments is that it does not incorporate the success rate of drug development. Therefore, we need to find a way to mitigate this limitation. Drug portfolios can somehow signal a firm's success in converting R&D inputs to R&D outputs. Phase I

drugs represent success in the pre-clinical trials and the IND applications; PII drugs represent success in Phase I clinical trials; PIII drugs represent success in PII clinical trials and so on. Drug portfolios represent not only the past successes but also work-in-process that allows a firm to move forward. Work-in-process exactly represents unrecognized intangible assets created by R&D investments. Therefore, information about drug portfolios reflects information on R&D outputs, which is not captured by R&D expenditures, and then complements R&D expenditures. If this argument is valid, information about drug portfolios has incremental power over R&D expenditures to capture the economic value of unrecognized intangible assets created by R&D investments. This leads to the fourth hypothesis:

**H4: Clinical trial information about a firm's drug portfolios has incremental value relevance over financial and R&D expenditures.**

Drug portfolios are expected to be incrementally value relevant. However, drugs at different stages may not have equal value relevance. Drugs at different stages not only bear different failure probabilities, but also possess different levels of economic value. Robbins-Roth (2000) points out that drugs at earlier stages have lower economic value than drugs at more advanced stages. This is because drugs at earlier stages are associated with a greater uncertainty to move on to the next stage toward the FDA approval than drugs at more advanced stages. Jacobs (2001) reports that, in general, Phase I drugs only possess 10%-15% of their final economic value, Phase II drugs possess 35%-45%, Phase III drugs possess 75%, and drugs start to gain significant value when they enter into PII clinical trials. Analysts in the biotechnology industry pay heavy attention to PIII and FDA drugs when they estimate future earnings and growth for biotechnology firms. From the perspective of unrecognized intangible assets, we use FDA approval as a benchmark, and argue that drugs at earlier stages are further away from intangible assets than these at more advanced stages. Thus, information concerning drugs at more advanced stages is expected to be more informative than that concerning drugs at earlier stages. Hence, it is reasonable to expect that information concerning drugs at more advanced stages is more

incrementally value relevant than that concerning drugs at earlier stages. This leads to the fifth hypothesis:

**H5: The incremental value relevance of information on a firm's drug portfolios is greater for drugs at more advanced stages than for drugs at earlier stages.**

As reviewed before, business relations (presented by strategic alliances) provide biotechnology firms with chances to get resources they need in drug development, to reduce the risk level they face in drug development, to speed up their drug development, and to generate revenue. Thus, business relations become an important intangible asset, in the sense that they substantially enhance a firm's drug development and its financial performance as well.

A strategic alliance involves, at least, two companies. They play different roles under the alliance. One company works as a researcher, discovering and developing drugs, while the other company works as a client, providing resources to the researcher and paying for his work. A firm may be involved in a number of alliances. It works as a researcher under some alliances, but is just a client under other alliances. Therefore, a firm's alliances can be divided into two groups. One group includes alliances under which the firm works as a researcher. The other group includes alliances under which the firm works as a client. Firms, when working as a researcher, can receive research funds, milestone payments and royalty revenues and so on; while firms, when working as a client, need to provide research funds, pay for the research work by its counterpart, and share the revenue with its counterpart. Therefore, the first group of alliances is associated with future cash inflows during the period in which the alliances are effective; while the second group of alliances is associated with future cash outflows during the period in which the alliances are effective. However, the second group of alliances can bring firms cash inflows when the drugs developed under the alliances are launched into the market.

In general, capital markets' estimation of a firm's value is based on the firm's net cash flows in a relatively shorter period. For example, the Institutional Brokers Estimates Systems (IBES) tapes include earnings forecasts for periods of up to five years. Since the first group of alliances generates future cash inflows within a relatively shorter period, while the second group of alliance generates future cash inflows within a relatively longer period, for the current moment, we focus on the first group of alliances. Thus, any further reference to alliances in our study is about the first group of alliances. The second group of alliances will be examined in our future studies.

As previously mentioned, direct financial results stemming from alliances, as pointed out by Lunzer (1988), include research and development funds, milestone payments, and royalty revenues on product sales. Other benefits include sharing of research resources, manufacturing and marketing capacities and risks. Alliances can then enhance a firm's product development and its financial performance as well. In this sense, alliances are a type of intangible asset. Because of the limits of GAAP in recognizing intangible assets, it is reasonable to expect that book value of equity fail to fully recognize the value of alliances, and that earnings be unable to fully reflect the power of alliances to indicate future earnings. Book value of equity can reflect alliances only when the earnings from those alliances are realized; and earnings can indicate the economic value of alliances only when alliances start to generate earnings and this generation follows a stationary trend in the future. Thus, we argue that information about a firm's alliances has additional power over financial information to shape an investor's expectation of the firm's value.

However, the incremental value relevance of business relations over financial information is out of our concern in this study. We examine the incremental value relevance of business relations in relation to R&D innovation. R&D innovation is our focus, and we consider business relations because they are the key enhancer of drug development. Therefore, we are interested in the incremental value relevance of business relations over both financial information and information about R&D

innovation. Our purpose is to see if they can carry value relevance, which is not captured by financial information and information about R&D innovation.

In our study, information about R&D innovation (measured by R&D intensity and drug portfolios) is used to capture the economic value of intangible assets created by R&D investments. There is an overlap between R&D expenditures and alliances (proxy for business relations) because current R&D expenditures include R&D investments that are triggered out by alliances. Therefore, current R&D expenditures capture part of the value relevance of alliances. However, they cannot fully capture the value relevance of alliances because they cannot reflect the effect on a firm's value of the unrealized R&D investments triggered out by alliances; furthermore, research work under alliances that do not trigger out clinical trials cannot be reflected in drug portfolios. Based on this analysis, we can conclude that there is only a partial overlap between our measures of R&D innovation and alliances. Hence, it is reasonable to expect that information about business relations be incrementally value relevant over both financial information and information about R&D innovation. This leads to the sixth hypothesis:

**H6: Information about a firm's business relations has incremental value relevance over its financial and R&D innovation information.**

## 4. Sample and Data

Our study conducts empirical examinations of the value relevance of financial information and of the incremental value relevance of non-financial performance information. We extract the list of companies from Compustat under SIC codes 2830 to 2836. Firms with these SIC codes discoverd e veloppr o duce and sell drugs that are used to diagnose and treat human diseases. 441 firms are originally identified. Most of them are U.S. firms and traded on Nasdaq. We employ a price-earnings model and a return-earnings model to examine the value relevance of both financial information and non-financial performance information (the models are addressed in the next section). These two models are well accepted by the accounting literature. The price-earnings model specifies the stock price as the function of book value of equity, earnings and non-financial performance information. For this model, we form yearly samples for 1998-2001. The return-earnings model specifies the stock market return as the function of changes in book value of equity, earnings and non-financial performance information. For this model, we form annual samples for the periods of 1998-1999, 1999-2000 and 2000-2001, respectively. In order to improve the efficiency of the estimates of the regression models, we form a pooled sample for the price-earnings model, and one for the return-earnings model. We base our conclusions on the results from these samples.

Data availability in Compustat and Recap is the criterion to form the samples. Recap is a web-based server, which is owned by Recombinant Capital, Inc., a U.S. company. Recap provides information about biotech firms around the world. The database is updated on a daily basis. The update is based on firms' announcements through press releases. For the price-earnings model, a yearly sample requires data availability in that year; while for the return-earnings sample, data must be available in two consequential years.

Market value, book value of equity, earnings, R&D expenditures, total assets, and number of shares outstanding are collected from Compustat. Number of drugs in the pre-clinical trials, the IND process, the PI clinical trials, the PII clinical trials, the PIII clinical trials, and the FDA approval process are collected from Recap. Number of alliances under which firms work as researchers, a firm's product market status, a firm's market rights over drugs at various stages, and drug indications are collected from Recap. Market value, book value of equity, total assets, number of shares outstanding, number of drugs at different stages, a firm's product market status, information concerning market rights and drug indications are collected as of the last day of each firm's fiscal year. Earnings, R&D expenditures, and number of new alliances are collected for each firm's fiscal year. The changes in both financial and non-financial variables are calculated for each firm's fiscal year.

We apply Scatter Plots to determine outliers in three dimensions. It takes three steps to finish this process. The first step determines outliers among market value (MV), book value of equity (BV) and earnings (EARN); the second step determines outliers among MV, R&D intensity (RD) and drug portfolios; and the final step determines outliers between MV and the measure of business relations (ALLIANCE).

For 1998, among 441 firms, which are originally identified from Compustat, 305 have clinical trial data available, of them, 230 have financial information available; and from 230 firms, 10 outliers are identified. Thus, the final sample for this year contains 220 firms. In this sample, 114 (51.81%) report positive earnings, while 106 (48.19%) report negative earnings. Earnings used in our study are defined as earnings before extraordinary items and R&D expenditures. We explain this definition in the later sections. In the positive earnings sample, 21 have products in the market; and 93 have no products in the market. In the negative earnings sample, 16 have products in the market; and 90 have no products in the market.

For 1999, among 441 firms, 305 have clinical trial data available, of them, 240 have financial data available; and from 240 firms, 6 outliers are identified. Thus, the final

sample contains 234 firms. In this sample, 114 (48.72%) report positive earnings, while 120 (51.28%) report negative earnings. In the positive earnings sample, 29 have products in the market; and 85 have no product in the market. In the negative earnings sample, 17 have products in the market; and 103 firms have no products in the market.

For 2000, among 441 firms, 305 have clinical data available, of them, 273 have financial data available; and from 273 firms, 7 outliers are identified. Thus, the final sample contains 266 firms. In this sample, 141 (53%) report positive earnings, while 125 (47%) report negative earnings. In the positive earnings sample, 38 have products in the market; and 103 have no products in the market. In the negative earnings sample, 17 have products in the market; and 108 have no products in the market.

For 2001, among 441 firms, 305 have clinical trial data available, among them, 278 have financial data available; and from 278 firms, 10 outliers are identified. Thus, the final sample contains 268 firms. In this sample, 142 (52.98%) report positive earnings, while 126 (47.01%) report negative earnings. In the positive earnings sample, 37 have products in the market; and 105 have no products in the market. In the negative earnings sample, 15 have products in the market; and 111 have no products in the market.

We pool these yearly samples for our price-earnings model and obtain a sample with 748 observations.

Based on these yearly samples, we form annual samples for the return-earnings model. For the period from 1998 to 1999, 214 firms have all the necessary information available for the two years; for the period from 1999 to 2000, 229 firms have all the necessary information available for the two years; for the period from 2000 to 2001, 255 firms have all the necessary information available for the two years. We pool these annual samples and obtain a sample with 698 observations.

# 5. Empirical Models

## 5.1 Valuation theory in accounting

We conduct regression analyses to test our hypotheses. The testing models we use are derived from the valuation theory in accounting. Specifically, our price-earnings model is derived from Ohlson's model (1995), and our return-earnings model is derived from our price-earnings model with the methodological assistance from the studies of Easton et al. (1991) and Ohlson (1995).

According to Beaver (2002), the accounting–based valuation model evolves through three approaches, which form the valuation theory in accounting. The first approach is called the earnings-only approach. In this approach, a firm's value is specified as the function of the present value of its permanent earnings (see study of Miller and Modigliani, 1966). The second approach is called the balance sheet approach. This approach bases the valuation model on the balance sheet. In this approach, a firm's value is specified as the function of the fair value of total assets, net of the fair value of total liabilities (see study of Barth et al., 1996). The final approach is the Feltham-Ohlson approach. This approach is the combination of the first two approaches. This approach is the extension of Ohlson's model (1995). In this approach, a firm's value is specified as the function of book value of equity, abnormal earnings, and an " information set" variable. We apply the sprit of this approach.

Ohlson (1995) analytically proposes a way in which one can devise a cohesive theory of a firm's value that relies on the clean surplus relation among three variables: earnings, book value of equity and dividends. The clean surplus relation refers to that the change in book value equals earnings minus dividends. Ohlson's analytical valuation model is based on three assumptions. It starts from the assumption that value equals the present value of expected future dividends. This assumption can be expressed as follows:

$$P_t = \sum_{\tau=1}^{\infty} R_f^{-\tau} E_t [d_{t+\tau}] \qquad \text{(PVED)}$$

where

$P_t$ = the market value, or price, of the firm's equity at data t.

$d_t$ = net dividends paid at date t.

$R_f$ = the risk-free rate plus one.

$E_t[.]$ = the expected value operator conditional on the data t information.

The second assumption is the clean surplus relation. Under this assumption, one can replace dividends with earnings and book values in the present value formula. Clean surplus relation can be expressed as follows:

$$y_{t-1} = y_t + d_t - x_t$$

where

$y_t$ = (net) book value at data t.

$x_t$ = earnings for the period from t-1 to t.

The clean surplus has two restrictions stemming from the notion that says that dividends reduce current book value, but not current earnings. The restrictions can be expressed as follows:

$$\partial y_t / \partial d_t = -1$$

$$\partial x_t / \partial d_t = 1$$

The application of the clean surplus relation leads to the expression of $P_t$ in terms of future (expected) earnings and book values in lieu of the sequence of (expected) dividends in the PVED formula. Define

$$x_t^a \equiv x_t - (R_f - 1)\, y_{t-1}$$

where

$x_t^a$ = abnormal earnings for the period from t-1 to t.

Combined with the clean surplus restrictions, this definition implies:

$$d_t = x^a_t - y_t + R_f\, y_{t-1}$$

Using this expression, one can replace $d_{t+1}$, $d_{t+2}$,.... in the PVED formula to derive the expression of $P_t$:

$$P_t = y_t + \sum_{\tau=1} R_f^{-\tau} E_t [ x^a_{t+\tau}]$$

assuming that $E_t [\ _{t+\tau}] / R^{\tau}_f \quad 0$ as $\tau \quad \infty$.

This model defines a firm's market value as the function of book value of equity and the present value of abnormal earnings. Ohlson (1995) argues that the terminology of abnormal earnings is motivated by the concept that "normal" earnings should relate to the "normal return" on the capital invested at the beginning of the period, that is, net book value of equity at data t-1 multiplied by the interest rate. Thus, abnormal earnings can be interpreted as earnings minus a charge for the use of capital. A positive $x^a_{t+1}$ indicates a "profitable" period since the book rate of return, $x_{t+1}/y_t$, exceeds the firm's cost of capital, $R_f$-1.

Ohlson's model (1995) has a straightforward and intuitively appealing interpretation. It simply suggests that a firm's value equals its book value adjusted for the present value of expected abnormal earnings, which measure the future profitability.

The third and final assumption underlying Ohlson's model (1995) concerns the time-series behaviour of abnormal earnings. Ohlson introduces a concept, that is, information other than abnormal earnings, $V_t$, into his model to capture the dynamics of abnormal earnings. In doing so, he introduces the term of "linear information dynamics" into his valuation model. $V_t$ is called the "information set" variable. He assumes that $\{x^a_{\tau}\}_{\tau\ 1}$ satisfies the stochastic process:

$$x^a_{\tau+1} = \omega\, x^a_{t} + v_t + \varepsilon_{1\,t+1}$$

$$v_{t+1} = \quad + \gamma v_t + \varepsilon_{2\,t+1}$$

According to Ohlson, $V_t$ serves as a summary of value relevant events that have yet to have an impact on the financial statements, and the information, which is contained in

$V_t$, bears upon future (abnormal) earnings independently of current and past (abnormal) earnings. $V_t$ impacts book value of equity via its impact on abnormal earnings through the equation expressed as follows:

$$y_t = x^a_t + R_f y_{t-1} - d_t$$

Based on the three assumptions, Ohlson's model can be finally expressed as follow

$$P_t = y_t + \alpha_1 x^a_t + \alpha_2 v_t$$

Feltham and Ohlson (1995) contribute to Ohlson's model (1995) by separating operating activities from financial activities. They argue that book value equals market value for financial activities; while for operating activities, market value equals book value plus the net present value of future expected abnormal earnings, which is defined as accounting earnings minus an interest charge on operating book value. In their model, value is related to the capital markets' belief about future abnormal operating earnings. Therefore, the information set variable, $V_t$, contains two variables, $V_1$ and $V_2$. $V_1$ has an impact on operating abnormal earnings; while $V_2$ has an impact on operating assets.

5.2 The models for testing the value relevance of financial information

5.2 a) The price-earnings model

Ohlson's model (1995) provides the analytical foundation for empirical studies to derive their own testing models when examining the value relevance of financial information.

Collins et al. (1997) derive their testing models from Ohlson's model (1995). They define the value of a firm's equity as the function of its book value and earnings. They do not incorporate information set variable because they simply focus on financial information. Their empirical model is expressed as follows:

$$P_{jt}=\beta_1+\beta_2 BV_{jt}+\beta_3 EARN_{jt}+\varepsilon_{jt} \quad (a)$$

Where $P_{jt}$ is the share price of firm j at time t, $BV_{jt}$ is the book value per share of equity of firm j at time t, and $EARN_{jt}$ is the earnings per share of firm j for the period from t-1 to t. Earnings is defined as earnings before extraordinary items. Based on this equation, they compare the changes in the value relevance of book value and earnings.

Ohlson's model (1995) is for a specific firm. Collins and his colleagues apply this model in a cross-sectional analysis. The variation in discount rate across firms becomes an issue. In deriving their testing model, Collins and his colleagues delete the term $(1+r_{it})/r_{it}$ for discounting the earnings. They claim that it is based on the argument made by Maydew (1993) that says that allowing discount rates to vary across firms does not significantly improve the explanatory power of the model. As a consequence, they use actual earnings, instead of abnormal earnings.

Barth et al. (1998) also derive their testing model from Ohlson's model (1995). They treat book value of equity and earnings as two primary summary measures that are associated with a firm's market value. Their testing model is expressed as follows:

$$MVE_{it}=\alpha_0+\alpha_1 BVE_{it}+\alpha_2 NI_{it}+\varepsilon_{it} \quad (b)$$

Where MVE is market value of equity, BVE is book value of equity, and NI is net income before extraordinary items. Equation (b) is equivalent to equation (a) with the exception that it uses raw data without any deflation.

In deriving this testing model, Barth and her colleagues use earnings to proxy for unrecognized assets (UNA) defined by Ohlson as "Goodwill". They argue that net income is a proxy for UNA because revenues and expenses relating to UNA, including any excess of values-in-use over entry or liquidation values, can be reflected in net income. In particular, in equation (b), the coefficient on net income

reflects the valuation effects of that portion of net income which is incremental over book value. If net income measured UNA without error, a firm's market value could be fully explained by accounting book value and earnings. Since net income is unable to measure UNA without error, equation (b) includes an intercept and a residual. Through this way, they replace abnormal earnings by actual earnings.

Lev and Zarowin (1999) and Francis and Schipper (1999) apply the model developed by Collins et al. (1997) when examining the change in the value relevance of financial information.

In the literature, some researchers propose a similar valuation model from a financial statements perspective. They argue that book value and earnings are two primary summaries of a firm's value. For example, Penman (1998) argues that GAAP accounting does not typically produce book values that equal the market value; in addition, it does not measure earnings that typically yield normal P/E ratios. However, the combination of the two may provide an indication of price better than book value and earnings are addressed alone. The issue he tries to solve is the weights that can be placed on book value and earnings. His valuation model is expressed as follows:

$$P_t = (1\text{-}w_t)\, B_t + w_t\, [\phi_t X_t] \qquad (c)$$

Where P is stock price; B is book value of equity; and X is earnings.

Following these studies in the literature, our study applies the sprit of Ohlson's model (1995) and uses equation (b) to examine the value relevance of financial information in the biotechnology industry. Since our purpose of using this model is to examine the value relevance of financial information, we also ignore the "information set variable". This examination can provide evidence for hypothesis 1. In this examination, we control the signs of book value of equity and earnings. In addition to the interest in seeing the value relevance of positive book value of equity and

earnings, which is addressed in hypothesis 1, there are two additional reasons for this control. First, negative book value and earnings are not well specified in a price-earnings model. Secondly, according to Hayn (1995), there is a significant difference in coefficients of earnings between positive earnings and negative earnings. Therefore, we are motivated to see if there is such a difference in our samples.

There is a scale effect issue associated with a price-earnings model. With respect to this issue, Barth et al. (1996) and Easton (1999) argues that statistical associations obtained from a price-earnings model may be subject to scale effect. In general, large (small) firms will have a large (small) total market value, large (small) book value of equity, large (small) net income. Additionally, many other variables for large (small) firms will also be large (small), so that a regression of market value on firm attributes will lead to coefficients that may capture no more than scale effect. Therefore, it is necessary to control for this effect.

In the literature, researchers use different scale proxies to control scale effect. For example, Lev and Zarowin (1999) use number of shares outstanding, Lang and Lundholm (1997) use beginning market value, Sougiannis (1994) uses total assets, Barth et al. (1996) examine several choices including total assets, sales, book value, net income, number of shares outstanding, and share price. In our study, we use beginning total assets as a deflator to control scale effect. We argue that total assets are a "scale" in the valuation model that can be used in the biotechnology industry. We discuss this issue in details in section 7.2.

Thus, our testing model for hypothesis 1 is expressed as follows:

$$MV_{jt}=\beta_1+\beta_2 BV_{jt}+\beta_3 BV_{jt}*DBV+\beta_4 EARN_{jt}+\beta_5 EARN_{jt}*DE+\varepsilon_{jt} \quad (1)$$

Where $MV_{jt}$ is the market value of firm j at time t, deflated by the firm's beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by the firm's beginning total assets; $EARN_{jt}$ is annual earnings of firm j in the period from t-1 to t,

deflated by the firm's beginning total assets; Earnings are defined as earnings before extraordinary items and R&D expenditures. In the literature, earnings are defined as earnings before extraordinary items but after R&D expenditures. The reason for our taking a different definition of earnings is that: earnings before R&D expenditures, since they do not reflect investing activities, are consistent with earnings' fundamental attribute, which is defined as its ability to indicate future earnings. Earnings after R&D expenditures are not consistent with this attribute since they reflect a large amount of investing activities. This reflection may cause earnings' irrelevance. We empirically justify our earnings' definition in the robustness analyses section (section 7.3 c), and we theoretically justify this definition in the discussion section (section 8.2 a). DBV is a dummy variable. It equals one when the firm's book value of equity is negative, and zero otherwise; DE is a dummy variable. It equals one if the firm's earnings are negative, and zero otherwise. We predict that both $\beta_2$ and $\beta_4$ are greater than zero.

In order to test hypothesis 2, we extend equation (b) by adding an interactive variable, DM, which is used to control for a firm's product market status. This testing model is specified as follows:

$$MV_{jt}=\beta_1+\beta_2 BV_{jt}+\beta_3 BV_{jt}*DM+\beta_4 EARN_{jt}+\beta_5\, EARN_{jt}*DM+\varepsilon_{jt} \qquad (2)$$

Where $MV_{jt}$, $BV_{jt}$, and $EARN_{jt}$ are defined as before. DM is a dummy variable. It equals one if a firm has products in the market, and 0 otherwise. We predict that both $(\beta_2+\beta_3)$ and $(\beta_4+\beta_5)$ are greater than zero.

5.2 b) The return-earnings model

The price-earnings model used in our study is to explain cross-sectional variation of a firm's market value at a certain time point. It provides insight into the understanding of how accounting information can explain stock price formation. It also provides the foundation for the analysis of the dynamics of stock prices. However, the model itself

per se cannot provide any evidence that shows how the changes in the independent variables included in the price-earnings model determine the stock market return. In order to provide such evidence, we apply a return-earnings model to examine how changes in financial information affect stock market returns. The application of this model is to further test the value relevance of financial information. We also attempt to provide a model that can be used to predict stock returns.

We take the sprit of the study by Easton et al. (1991) as the theoretical foundation of our driving a return-earnings model.

Easton et al. (1991) define the relation between price and book value as follows:

$$P_{jt} = BV_{jt} + U_{jt} \qquad (d)$$

Where $P_{jt}$ is the price per share of firm j at time t, $BV_{jt}$ is the book value per share of firm j at time t, and $U_{jt}$ is the difference between price and book value at time t.

Easton and his colleagues argue that the difference between market value and book value can result from many factors including the choice of conservative accounting practices and other information incorporated in price but not yet reflected in accounting values. Between market value and book value---two measures of the "Stock" value of shareholders' equity, there are two "flow Variables"--- security return and accounting earnings. The relation between the two "flow" variables may be obtained by taking the first difference of the valuation model (d). This yields:

$$\Delta P_{jt} = \Delta BV_{jt} + u_{jt}' \qquad (e)$$

In general,

$$BV_{jt} = A_{jt} - d_{jt} \qquad (f)$$

Where $A_{jt}$ is accounting earnings per share of firm j over the time period t-1 to t; $d_{jt}$ is dividends per share of firm j over the time period from t-1 to t.

Substituting (f) into (e), rearranging, and dividing by $P_{jt-1}$, yields:

$$(\Delta P_{jt} + d_{jt}) / P_{jt-1} = A_{jt} / P_{jt-1} + u_{jt}'' \qquad (g)$$

Thus, Easton and his colleagues conclude that earnings can be an explanatory variable of returns.

If we follow the sprit of their methodology and apply the "first difference" method into equation (b), and define $(NI_{it} + \varepsilon_{it})$ in this equation as the difference between market value and book value, we can obtain the following equation:

$$\Delta MVE_{jt} = \beta_1 + \beta_2 \Delta BVE_{jt} + \beta_3 \Delta EARN_{jt} + \varepsilon_{jt}' \qquad (h)$$

To be consistent with our price-earnings model, we divide equation (h) by beginning total assets. This yields:

$$CMV_{jt} = \beta_1 + \backslash\beta_2 CBV_{jt} + \beta_3 CEARN_{jt} + \varepsilon_{jt} \qquad (3)$$

Where $CMV_{jt}$ is the change in market value of firm j from t-1 to t, deflated by beginning total assets of period t; $CBV_{jt}$ is the change in book value of equity of firm j from t-1 to t, deflated by beginning total assets of period t; $CEARN_{jt}$ is the change in annual earnings of firm j from period t-1 to period t, deflated by beginning total assets of period t. We predict that $\beta_2$ and $\beta_3$ are greater than zero.

Equation (3) is the return-earnings model that we use to further test the value relevance of financial information. The way we derive this model is also consistent with the way Ohlson (1995) derives his return model. Ohlson (1995) derives a return model from his price-levels model, which is shown before, to see what determines

abnormal return. He also applies the first-difference approach. His way can be expressed as follows:

$$(P_{t+1} + d_{t+1} - R_f P_t)/P_t = (y_{t+1} + d_{t+1} + \alpha_1 x^a_{t+1} + \alpha_2 v_{t+1})/P_t - R_f(y_t + d_t + \alpha_1 x^a_t + \alpha_2 v_{t+1}) / P_t = R_f + (a_1 + 1)\, \varepsilon_{1\,t+1}/P_t + \alpha_2 \varepsilon_{2\,t+1}/P_t$$

In his model, the return is defined as the abnormal return. He demonstrates how $\varepsilon_1$ and $\varepsilon_2$ in the two stochastic processes determine abnormal return. If we follow his way and define the return as the stock market return, assuming no dividends are involved, our return-earnings model can be derived as follows:

$$(MV_t - MV_{t-1}) / MV_{t-1} = (BV_t + EARN_t) / MV_{t-1} - (BV_{t-1} + EARN_{t-1}) / MV_{t-1}$$

This equation is equivalent to equation (3) with the exception that they use different deflators. This equation uses beginning market value as the deflator, while equation (3) uses beginning total assets as the deflator. We address this issue in section 7.3 b).

5.3 The models for testing the incremental value relevance of non-financial performance information

5.3 a) The price-earnings model

In the study of Ohlson (1995), the purpose of adding an "information set" variable, $V_t$, into the model is to develop a simple model that captures key characteristics that are likely to influence the observed contemporaneous relation between a firm's market value and its accounting numbers. Through $V_t$, Ohlson introduces the concept of " linear information dynamics" into his accounting-based valuation model. As previously mentioned, this information set variable is a group variable. It is designed to capture the economic value of unrecognized assets; in other words, to capture the effect of variables that affect future expected abnormal earnings. Thus, it includes all

incrementally value relevant variables over book value and earnings. These variables could be other accounting variables or non-accounting variables.

Following Ohlson (1995), the capital market research searches variables to explain the difference between a firm's market value and its book value of equity in the domain of non-financial performance. This line of research adds variables represented by non-financial performance measures into the "information set" variable, defined by Ohlson (1995). For example, Clarkson et al. (2001) explain the difference between a firm's market value and its book value of equity, within the context of the pulp and paper industry. They add a variable that captures a firm's environmental performance into Ohlson's model (1995). Their empirical model specifies a firm's market value as the function of its book value of equity, abnormal earnings and a measure of relative pollution propensity.

Consistent with prior studies, our study uses measures of R&D innovation and business relations as additional variables to explain the difference between a firm's market value and its book value of equity, within the context of the biotechnology industry. As discussed previously, R&D innovation and business relations qualify as "information set" variables because they represent intangible assets that can generate future earnings. Thus, we extend equation (b) to include these measures. The testing of hypotheses 3 through 6 is based on this extension.

In order to test hypotheses 3 through 5, we extend equation (b) to include R&D innovation as an additional explanatory variable. The testing model for those hypotheses is then expressed as follows:

$$MV_{jt}=\beta_1+\beta_2 BV_{jt}+ \beta_3 EARN_{jt} +\beta_4 RDIN_{jt} + \varepsilon_{jt} \quad (4)$$

Equation (4) specifies a firm's value as a function of its book value of equity (BV), earnings (EARN) and R&D innovation (RDIN). In our study, there are two measures of R&D innovation. R&D intensity is used to proxy for R&D inputs, and drug

portfolios are used to proxy for R&D outputs. From equation (4), under the consideration of controlling for signs of BV and EARN, we derive equations (4a) and (4b) to test hypotheses 3 and 4, and equation (4c) to test hypothesis 5.

Equation (4a) is expressed as follows:

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 RD_{jt} + \varepsilon_{jt} \quad (4a)$$

Where $MV_{jt}$, $BV_{jt}$, DBV, $EARN_{jt}$ and DE are defined as before. RD is R&D expenditures relative to beginning total assets of the period t. We predict that $\beta_6$ is greater than zero.

Equation (4b) is expressed as follows:

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 RD_{jt} + \beta_7 DPRE_{jt} + \beta_8 DIND_{jt} + \beta_9 DPI_{jt} + \beta_{10} DPII_{jt} + \beta_{11} DPIII_{jt} + \beta_{12D} FDA_{jt} + \varepsilon_{jt} \quad (4b)$$

Where $MV_{jt}$, $BV_{jt}$, DBV, $EARN_{jt}$, DE and $RD_{jt}$ are defined as before. $DPRE_{jt}$, $DIND_{jt}$, $DPI_{jt}$, $DPII_{jt}$, $DPIII_{jt}$ and $DFDA_{jt}$ are independent dummy variables that portray a firm's drug portfolios in the pipeline. They equal one if firms have drugs at a certain stage, and zero otherwise. For example, DPIII equals one if a firm has drugs in PIII clinical trials, and zero otherwise. We predict that the coefficients on those variables in equation (4b) are all greater than zero.

We use dummy variables to capture drug portfolios in the pipeline. There are two reasons for this treatment. One reason is that our study is concerned about the incremental value relevance of drug portfolios over R&D intensity. As discussed before, R&D intensity, as a proxy for R&D innovation, misses the success rate of drug development. Thus, we need a measure that captures the success rate and incorporates it into the measurement of R&D innovation. In this case, we need a

"signal" of success in drug development. Dummy variables can be a good choice in this regard.

The second reason is a methodological consideration. As mentioned previously, drug portfolios not only signal previous success, but also represent work-in-process. In order to capture this work-in-process, we may use either proxies for economic value of drugs at different stages or actual numbers of drugs at different stages. Economic value of drugs at different stages are the best measures of drug portfolios, but they are difficult to predict. Using actual numbers of drugs at different stages can involve a methodological problem. Drugs move from the pre-clinical trial onto the next stage till they reach the FDA final approval process. Firms may have more drugs in PI clinical trials but fewer drugs in PII clinical trials, and again more drugs in PIII clinical trials and in the FDA approval process. In this situation, firms' market value may be higher, due to the drugs in PIII clinical trials and in the FDA approval process. When using actual numbers of drugs in different clinical trial phases to represent drug portfolios, a negative regression coefficient on PII drugs can occur. It is difficult to interpret this negative coefficient. This negative coefficient implies the lack of control for the differences in the economic value of drugs within a certain stage, across stages within a firm, and across firms. Using dummy variables can partially avoid this methodological problem. This is because the value of a dummy variable for a certain clinical trial phase is not affected by the number of drugs in that phase. A dummy variable can tell the difference between two categories—a firm has drugs in a certain clinical trial phase or not. Thus, it does not contain any measure error. However, its limitation is that it cannot tell the difference between firms that have different number of drugs in a certain clinical trial phases.

Equation (4c) is expressed as follows:

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 RD_{jt} + \beta_7 EP_{jt} \text{ or } \beta_8 LP_{jt} + \varepsilon_{jt} \quad (4c)$$

Where $MV_{jt}$, $BV_{jt}$, DBV, $EARN_{jt}$, DE and $RD_{jt}$ are defined as before. $EP_{jt}$ represents drug portfolios at earlier stages, including DPRE, DIND, DPI and DPII. $LP_{jt}$ represents drug portfolios at more advanced stages, including DPIII and DFDA. $DPRE_{jt}$, $DIND_{jt}$, $DPI_{jt}$, $DPII_{jt}$, $DPIII_{jt}$ and $DFDA_{jt}$ are defined as before.

Equation (4c) is used to test the difference in the incremental value relevance between drug portfolios at more advanced stages and drug portfolios at earlier stages. We predict that $\beta_8$ is greater than $\beta_7$, or alternatively, $R^2$ change brought about by $LP_{jt}$ is greater than that brought about by $EP_{jt}$.

In order to test hypothesis 6, we add another variable, ALLIANCE, into equation (4b). This specification is expressed as follows:

$$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPI_{jt}+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\beta_{12}DFDA_{jt}+\beta_{13}ALLIANCE_{jt}+\varepsilon_{jt} \quad (5)$$

Where ALLIANCE is the number of new alliances in the period t. Under these alliances, firms work as researchers. The rest of the variables are defined as before. We expect that $\beta_{13}$ is greater than zero.

Business relations in equation (5) are measured by the actual number of new alliances, not by a dummy variable. The reason for this measurement is that a dummy variable cannot capture the value relevance of business relations, because almost all the firms in the samples involve alliances. A dummy variable fails to distinguish them. In addition, actual number of alliances can make a difference in the benefits firms can obtain from alliances. Generally speaking, the more alliances, the bigger benefits. Another reason is that, in the area of R&D innovation, dummy variables complement R&D expenditures. R&D expenditures can capture the scale of drug development. Thus, using dummy variables to capture drug portfolios and to reflect the success of drug development is reasonable. In the case of business alliances, there is no measure like R&D expenditures to capture the scale of business relations. Thus,

a dummy variable may not be an appropriate measure of business relations, but the actual number of alliances may be an appropriate one. With respect to the deflation of the measure of business relations, we analyze the correlations between number of alliances and total assets, number of shares outstanding, and market value, respectively. Results show that the correlations of number of alliances with the three possible scale proxies are -.044, -.043 and -.045, respectively. All these correlations are insignificant. Thus, our study does not deflate the number of alliances by beginning total assets, the deflator that we choose for market value, book value of equity, earnings and R&D expenditures. The actual number of alliances can somehow proxy for the benefits associated with alliances. However, this measurement puts a strict assumption on the model, that is, the economic value is the same across alliances. If this assumption is not satisfied, measurement error occurs.

5.3 b) The return-earnings model

Like the case where we define a return-earnings model to further test the value relevance of financial information, here we define a return-earnings model to further test the incremental value relevance of non-financial performance information. This model is the extension of our return-earnings model that is used to test the value relevance of changes in financial information. In this extension, we include variables that represent changes in the non-financial performance variables included in our price-earnings model. The model is expressed as follows:

$$CMV_{jt} = \beta_1 + \beta_2 CBV_{jt} + \beta_3 CEARN_{jt\ t} + \beta_4 CRD_{jt} + \beta_5 DSPRE_{jt} + \beta_6 DPIND_{jt} + \beta_7 DINDPI_{jt} + \beta_8 DPIPII_{jt} + \beta_9 DPIIPIII_{jt} + \beta_{10} DPIIIFDA_{jt} + \beta_{11} DFDAM_{jt} + \beta_{12} ALLIANCE_{jt} + \varepsilon_{jt} \quad (7)$$

Where $CMV_{jt}$,$CBV_{jt}$, and $CEARN_{jt}$ are defined as before; $CRD_{jt}$ is the change in R&D expenditures of firm j from period t-1 to period t, deflated by beginning total assets of period t; DSPRE is a dummy variable; it equals one if the firm starts a new pre-clinical trial during the period t, and zero otherwise; DPIND is a dummy variable;

it equals one if the firm has drugs moving from the pre-clinical trial to the FDA approval process of investigational new drug application (IND process) during the period of t, and zero otherwise; DINDPI is a dummy variable; it equals one if the firm has drugs moving from the IND process to PI clinical trial, and zero otherwise; DPIPII is a dummy variable; it equals one if the firm has drugs moving from PI clinical trials to PII clinical trials during the period of t, and zero otherwise; DPIIPIII is a dummy variable; it equals one if the firm has drugs moving from PII clinical trials to PIII clinical trials during the period of t, and zero otherwise; DPIIIFDA is a dummy variable; it equals one if the firm has drugs moving from PIII clinical trials to the FDA approval process during the period of t, and zero otherwise; DFDAM is a dummy variable; it equals one if the firm has drugs moving from the FDA approval process to the market during the period of t, and zero otherwise; ALLIANC is the number of new alliances in the period t. Under these alliances, firms work as researchers.

5.4 The list of variables

$MV_{jt}$ = the market value of firm j at time t, deflated by the firm's beginning total assets.

$BV_{jt}$ = the book value of equity of firm j, deflated by the firm's beginning total assets.

$EARN_{jt}$= annual earnings of firm j in the period t, deflated by the firm's beginning total assets; Earnings are defined as earnings before extraordinary items and R&D expenditures.

DBV = a dummy variable, one if the firm's book value of equity is negative, and zero otherwise.

DE = a dummy variable, one if the firm's earnings are negative, and zero otherwise.

DM = a dummy variable, one if a firm has products in the market, and zero otherwise.

$CMV_{jt}$ = the change in market value of firm j from t-1 to t, deflated by the firm's beginning total assets of period t.

$CBV_{jt}$ = the change in book value of equity of firm j from t-1 to t, deflated by the firm's beginning total assets of period t.

$CEARN_{jt}$= the change in annual earnings of firm j from period t-1 to period t, deflated by the firm's beginning total assets.

$RD_{jt}$ =the R&D expenditures of firm j in period t relative to beginning total assets of period t .

DPRE = a dummy variable, one if a firm has drugs in the pre-clinical trials, and zero otherwise.

DIND = a dummy variable, one if a firm has drugs in the IND process, and zero otherwise.

DPI = a dummy variable, one if a firm has drugs in PI trials, and zero otherwise.

DPII = a dummy variable, one if a firm has drugs in PII trials, and zero otherwise.

DPIII = a dummy variable, one if a firm has drugs in PIII trials, and zero otherwise.

DFDA = a dummy variable, one if a firm has drugs in the FDA process, and zero otherwise.

$ALLIANCE_{jt}$ = the number of new alliances of firm j in the period of t. Under those alliances, firms work as researchers.

$CRD_{jt}$ = the change in R&D expenditures of firm j from period t-1 to period t, deflated by the firm's beginning total assets of period t.

DSPRE =a dummy variable, one if the firm starts a new pre-clinical trial during the period t, and zero otherwise.

DPIND = a dummy variable, one if the firm has drugs moving from the pre-clinical trials to the IND process, and zero otherwise.

DINDPI= a dummy variable, one if the firm has drugs moving from the IND process to PI clinical trials, and zero otherwise.

DPIPII = a dummy variable, one if the firm has drugs moving from PI clinical trials to PII clinical trials, and zero otherwise.

DPIIPIII = a dummy variable, one if the firm has drugs moving from PII clinical trials to PIII clinical trials, and zero otherwise.

DPIIIFDA = a dummy variable, one if the firm has drugs moving from PIII clinical trials to the FDA approval process, and zero otherwise.

DFDAM = a dummy variable; one if the firm has drugs moving from the FDA approval process to the market, and zero otherwise.

Notes: Earnings are defined as earnings before extraordinary items and R&D expenditures. We calculate so-defined earnings in the following way: earnings before extraordinary items and R&D expenditures = earnings before extraordinary items + (1-effective tax rate) * R&D expenditures.

## .6. Results and Interpretations

We use the equations discussed in Section 5 to test our hypotheses. The results reported in the tables are from the OLS model. We test the heteroskedasticity for all the regressions. If the test shows the existence of heteroskedasticity, we apply the GLS model to get White-adjusted standard errors and p-values, and report the p-values in the corresponding tables. Therefore, all the p-values reported in the tables can be considered as White-adjusted p-values. For the pooled sample (panel data) formed for our price-earnings model, we assume a fixed effect model. We take first difference to remove the time-invariant component in error term. First difference treatment is consistent with our return-earnings model. We introduce time dummy variables for the panel data to allow for the differences in intercepts over time, and leave coefficients of variables of interest constant. Time dummy variables capture the difference in behaviour of macro-factors over time. It is assumed these macro-factors have the same effect on all firms.

### 6.1 Descriptive statistics

Descriptive statistics are calculated for all the samples. They are reported in Table 1. Panel A of the table shows the statistics for the price-earnings model. Panel B of the table shows the statistics for the return-earnings model. From Panel A, we learn that the sample firm size goes up across the years. There are consistent co-movements among MV, BV, EARN, RD and ALLIANCE. This consistency represents positive correlations among those variables. Higher BV, EARN, RD and ALLIANCE are associated with greater market value. By looking at the means, standard deviation, minimum and maximum, we learn that all the variables have a reasonable degree of variation across observations, and all samples are well controlled for outliers.

Panel B represents the consistent co-movements among variables in the return-earnings model. Higher changes in the explanatory variables lead to higher changes in the market variables. However, the co-movement between CMV and CBV, CEARN,

CRD and ALLIANCE is stronger than that between CMV and drug portfolios. This seems to indicate that the changes in book value of equity, earnings, R&D expenditures and business relations play a more important role in the changes of stock prices than the shifts in drug portfolios. However, this interpretation should be cautiously accepted, because drug portfolios reported in this table are actual numbers of shifts from one stage to the next, without the deflation by beginning total assets, while CMV, CBV, CEARN and CRD are all deflated by beginning total assets. In our testing models, we actually use dummy variables to capture the movements in the pipeline, not actual numbers of shifts. We explain why we use dummy variables when we interpret the results from the return-earnings model. The comparison among means, standard deviation, minimum and maximum also roughly indicate that all the variables in the return-earnings model have a reasonable degree of variation across observations, and all samples are well controlled for outliers.

(Insert Table 1 here)

6.2 Coefficients of correlation

The coefficients of correlation are calculated for all the samples. The coefficients for the price-earnings model are reported in Table 2. The coefficients for the return-earnings model are reported in Table 3. In Table 2, Panels A, B, C and D show the coefficients for the yearly samples of 1998, 1999, 2000 and 2001, respectively. From this table, we learn that market value is, in general, significantly associated with positive book value, positive earnings, R&D intensity, drug portfolios and alliances. These correlations are the basis for the value relevance of both financial information and non-financial performance information. There are some correlations among explanatory variables. In general, book value is significantly correlated with earnings; earnings is significantly correlated with alliance; RD is correlated with drug portfolio variables except for DFDA; and drug portfolio variables are correlated among themselves. Alliance is correlated with BV, EARN and RD. However, financial variables are not apparently and strongly correlated with non-financial performance

variables; in fact, the correlations are quite low. These low correlations suggest that non-financial performance information may possess incremental value relevance over financial information.

In Table 3, Panels A, B, C, and D show the coefficients from the samples of the three time periods and from the pooled sample, respectively. From this table, we learn, in general, that the change in market value is significantly associated with the changes in book value of equity, earnings, R&D expenditures, drug movements in the pipeline, and alliances. There are correlations among the explanatory variables. CBV is significantly correlated with RD and drug portfolio variables; RD is correlated with drug portfolio variables; and there are correlations among drug portfolio variables. Alliances are correlated with BV in the sample for the period from 2000-2001 and in the pooled sample. Like the case in the price-earnings model, the correlations between the dependent variable and the independent variables provide a basis for the value relevance of both financial and non-financial performance information. The lack of an apparent and strong correlation between financial variables and non-financial performance variables provides the basis for the existence of the incremental value relevance of non-financial performance information. Actually, the correlation between financial and non-financial performance variables is weaker in the return-earnings model than in the price-earnings model.

Comparing Table 2 with Table 3, we learn that there is a consistency in the associations between the dependent variable and the independent variables across the price-earnings model and the return earnings model. There is even a consistency in the correlations among independent variables between the two models. This finding confirms the argument in the literature that only variables that are value relevant in a price-earnings model can be expected to be value relevant in a return earnings model.

Since there are significant correlations between independent variables in both the price-earnings model and the return-earnings model, collinearity tests are conducted. Results (not reported) from the tests for the price-earnings model show that there is

no collinearity problem because all VIFs in the regressions for 1998, 1999, 2000 and 2001, respectively, are lower than 5 except that VIFs for EARN and EARN*DE in the 2001 sample are 11.044 and 11.258, respectively, which are slightly higher than 10, the critical value.

Results (not reported) from the tests for the return-earnings model show that there is no collinearity problem because VIFs in the return-earnings model for the three time periods, respectively, and for the pooled sample, are all around 1.5.

(Insert Tables 2 and 3 here)

6.3 Empirical findings about the value relevance of financial information (tests of hypotheses 1 and 2)

6.3 a) The value relevance of financial information in the price-earnings model

We run equation (1) to test the value relevance of financial information. Results from this test are shown in Table 4. From this table, we learn that financial information is still value relevant in the biotechnology industry. Book value and earnings together, after control for their signs, explain 23.8%, 38.7%, 51.5%, 20% and 45.5% of cross-sectional variance in market value for 1998, 1999, 2000, 2001, and in the pooled sample, respectively. Coefficients of positive book value and earnings are both positive and significant. Hypothesis one is fully supported. We conduct t tests to see if negative boo value an earnings are significant. Results (not reported) show that none of them are significant.

Our finding is consistent with the study of Francis and Schipper (1999), in the sense that financial information has not lost its value relevance even in high-tech industries. However, our finding is inconsistent with the argument made by Amir and Lev (1996) that financial information, especially earnings, has become irrelevant in high-tech industries. One explanation to this inconsistence may be that Amir and Lev

(1996) use earnings after R&D expenditures. High-tech industries invest heavily in R&D; and U.S. GAAP requires that companies expense, rather than capitalize, most of their R&D investments. Thus, earnings after R&D expenditures incorporate investing activities. Since earnings, by nature, are a measure of the economic performance of operating activities, earnings after R&D expenditures do not represent the true meaning of earnings. Hence, it is not surprising that Amir and Lev (1996) find that earnings are irrelevant in their samples. Our study uses earnings before R&D expenditures. This measurement of earnings is not affected by investing activities, and therefore can better represent the true economic performance of a firm's operating activities. This may explain why we find that earnings are still value relevant. As mentioned previously, we address this issue in detail in both the robustness analyses section and discussion section.

Our results confirm the necessity of the control for the signs of book value of equity and earnings. The control does not have any effect on the significance of book value. However, before the control, earnings are insignificant; while after the control, positive earnings are significant; in addition, the control increases Adj. $R^2$ by 7.5%, 7.6%, 3.1%, 13% and 5.2% in the yearly samples of 1998, 1999, 2000, 2001, and in the pooled sample, respectively, and all the $R^2$ changes are significant ($P \leq 0.05$).

(Insert Table 4 here)

In order to better understand the value relevance of financial information, especially earnings, we run equation (2) to test whether the value relevance of financial information is affected by a firm's product market status. Results are shown in Table 5. In this table, results from the pooled sample are reported in the last column. From this column, we learn that the coefficient of book value is positive and significant before, as well as after, the control for a firm's product market status, suggesting that a firm's product market status has no effect on the value relevance of book value. This finding is consistent with the results from yearly samples. Earnings before the control are negative and insignificant. However, after the control, earnings are

positive and significant for firms that have products in the market. This finding supports the prediction by hypothesis 2 for firms that have products in the market. This finding is confirmed by the results from the yearly samples of 1998, 1999, 2001, but by 2000. The prediction by hypothesis 2 for firms that have no products in the market is not supported by the pooled sample, but is supported by the yearly samples of 2000 and 2001. The evidence is mixed. This issue needs further investigation. Therefore, hypothesis 2 is partially supported.

Hypothesis 2 can be supported in an alternative way. A firm's product market status is a measure of non-financial performance. The addition of this variable interacting with financial information increases Adj. $R^2$ by 6.4% in 1998, by 9.5% in 1999, by 3.4% in 2000, by 1 % in 2001 and by 6.3% in the pooled sample. The F tests show that the $R^2$ changes in 1998, 1999, 2000 and the pooled sample are significant ($P \leq 0.05$, see Table 5). The $R^2$ change in 2001 is insignificant ($p = .138$). In addition, as mentioned above, before the control for a firm's product markets status, earnings are insignificant. After the control, earnings are significant for firms that have products in the market. These findings support hypothesis 2, in the sense that the interaction between non-financial performance information and financial information can help us to identify the value relevance that we would miss otherwise; and it also increases the explanatory power of the model.

(Insert Table 5 here)

6.3 b) The value relevance of financial information in the return-earnings model

In addition to running the price-earnings model, we run equation (3) to further examine the value relevance of financial information. There are two reasons for running this equation. First, we remove time-invariant error component in the penal data; second, also most important, we investigate to see how changes in financial information can determine stock market returns. Results are shown in Table 6. From this table, we learn that the changes in book value of equity are positive and

significant in all the three periods and in the pooled sample. The change in earnings is positive and significant ($P \leq 0.11$) in the period from 1998 to 1999, negative and significant in the period from 2000 to 2001, and insignificant in the period from 1999 to 2000 and in the pooled sample. This evidence indicates that, in general, the change in earnings is irrelevant. However, when we treat book value of equity and earnings as a group of information, overall, the changes in financial information are significant. The changes in BV and EARN from 1998 to 1999 explain 20% of the stock return of the period; the changes from 1999 to 2000 explain 28.6 % of the stock return of the period; the changes from 2000 to 2001 explain 14.2% of the stock return of the period; and the changes explain 29.1% of the stock return in the pooled sample. The insignificance of changes in earnings can be interpreted as that changes in earnings are not a timely information source or changes in earnings contains noise.

Results from the return-earnings model imply that, among sets of financial information, book value of equity is the most value relevant accounting variable in the biotechnology industry. It is clear that changes in book value of equity play a substantial role in stock price changes. This finding is consistent with the finding from the price–earnings model. In that model, book value of equity also plays a central role in the formation of stock prices. This phenomenon could be explained by the new issuance of shares. In the biotechnology industry, an increase in book value typically results from new issuance of common shares. The new issuance reflects managers' confidence in their firms' prospects. Capital markets react to this confidence. Thus, it is reasonable to expect a strong association between market value and book value, or stock market return and change in book value.

Results regarding the value relevance of other two groups of information, reported in table 6, further support the notion that financial variables are dominating variables in the biotechnology industry. From this table, we learn that changes in financial information are the major determinant of stock return among the three groups of information investigated by our study. The three groups are financial information, information concerning R&D innovation and information concerning business

relations. In the period from 1998 to 1999, the total explanatory power of all groups of information is 26.1%. The changes in financial information contribute 76.62% (20%/26.1%) to this explanation power. The same percentages for the periods from 1999 to 2000, from 2000 to 2001 and in the one-year pooled sample are 93.46% (28.6%/30.6%), 102% (14.2%/13.9%), 96.04% (29.1/30.3), respectively.

(Insert Table 6 here)

6.3 c) Summary of the findings concerning the value relevance of financial information

Our study provides evidence that financial information still has a great power to explain and predict stock price behaviour in the biotechnology industry. Book value of equity has a higher explanatory and predictive power than earnings, especially in the case of predicting stock returns. Earnings are insignificant before controlling for their sign; while after the control, positive earnings are significant. A firm's product market status can enhance the value relevance of earnings. Earnings before controlling a firm's product market status are insignificant; while after the control, earnings are significant for firms that have products in the market. Thus, this non-financial performance measure can help capital markets better interpret earnings.

6.4 Empirical findings about the incremental value relevance of R&D innovation (tests of hypotheses 3 and 4)

6.4 a) Incremental value relevance of R&D intensity over financial information

We run equation (4a) and equation (7) to test the incremental value relevance of R&D intensity over financial information. The results from equation (4a) are shown in Table 7, and the results from equation (7) are shown in Table 6. From Table 7, we learn that RD is incrementally significant over financial information in all the yearly samples and in the pooled sample. The addition of RD increases Adj. $R^2$ by 1.4% in

1998, 3.2% in 1999, 1.4% in 2000, 4.7% in 2001 and 0.8 % in the pooled sample. The F tests show that the increases in $R^2$ are all significant ($P \leq 0.05$). These findings fully support hypothesis 3 that R&D intensity is incrementally value relevant over financial information in the biotechnology industry. Results from running equation (7) (shown in Table 6) indicate that the change in R&D expenditures is only significant in the period from 1998 to 1999. This phenomenon may be explained by the argument in the literature that the change in R&D expenditures does not necessarily represent an improvement in innovative activities. The change may be a result of inefficiency in managerial decisions and activities related to R&D innovation, or a result of the increase in prices of R&D inputs. To better understand the value relevance of the change in R&D expenditures, efficient change in R&D expenditures should be separated from inefficient change in R&D expenditures. Efficient change in R&D expenditures, referred by our study, would be the change in R&D expenditures that facilitate the movement of drugs from one stage to the next. For example, a change in R&D expenditures that is associated with a starting of a new pre-clinical trial, or with a movement of drugs from PI clinical trials to PII clinical trials. However, in reality, it is difficult to really separate efficient change in R&D expenditures from its inefficient counterpart. Thus, our study, at this stage, does not take into account the efficiency of change in R&D expenditures when examining the incremental value relevance of change in R&D expenditures. However, future work in this area needs to consider how to separate efficient R&D inputs from its inefficient counterpart.

(Insert Table 7 here)

6.4 b) Incremental value relevance of drug portfolios

In order to examine the incremental value relevance of drug portfolios over financial information, we run equation (4a), but replacing RD with drug portfolio variables. We also run equation (4b) to directly test the incremental value relevance of drug portfolios over both financial information and R&D intensity. Results are shown in Table 8. From the first five columns of the table, we learn that the inclusion of drug

portfolios as additional independent variables increases Adj.$R^2$ by 8.8% in 1998, 3.3% in 1999, 1.9 % in 2000, 1.0% in 2001 and 2.8 % in the pooled sample. The F tests show that $R^2$ changes in the years 1998, 1999, and 2000, as well as in the pooled sample, are all significant ($P \leq 0.05$). $R^2$ change in 2001 is insignificant ($p = 0.168$). These results indicate that drug portfolios are incremental value relevant over financial information. Among the drug portfolio variables, DPIII and DFDA are both significant in all the samples, except for DPIII in 2000 and DFDA in 1999. In addition, DIND is significant in 2000 and in the pooled sample. The rest of the variables in the regressions are insignificant. These results indicate that drugs at earlier stages are much less valuable than drugs at more advanced stages. This finding is consistent with the argument made by biochemists. For example, Jacobs (2001) reports his interview with Tan, a biochemist, in *Business Times*. In the interview, Tan points out that drugs start to gain value when they enter into PII clinical trials. Capital markets may follow this notion, and then respond much less to drugs at earlier stages than to drugs at more advanced stages. It may explain why drug portfolios at earlier stages are not significant.

We compare the incremental value relevance of drug portfolios over financial information with that of R&D intensity (shown in Table 7). Results from the comparison indicate that drug portfolios may be a better measurement of R&D innovation in the biotechnology industry. The increases in Adj. $R^2$ by the addition of drug portfolios are higher than these by the addition of R&D intensity (compare Table 7 and Table 8). These findings support our argument that R&D outputs should be considered when measuring the value creation by R&D innovation. From Panel B of Table 8, we learn that the inclusion of drug portfolios into the regression model, that originally have financial information and R&D intensity, as additional independent variables increases Adj. $R^2$ by 7.8% in 1998, 1.3% in 1999, 1.4 % in 2000, 1.2% in 2001 and 2.7 % in the pooled sample. The F tests show that $R^2$ changes in 1998, 1999, 2000, and in the pooled sample are all significant ($P \leq 0.05$). $R^2$ change in 2001 is insignificant at conventional level ($p = 0.11$). In this regression model, BV, RD, DPIII and DFDA remain significant. EARN is significant in 1998, 2000, 2001

and in the pooled sample, but insignificant in 1999. These results support hypothesis 4 that information concerning drug portfolios has incremental value relevance over both financial information and R&D intensity. Therefore, we can infer that, in the biotechnology industry, R&D intensity alone cannot fully capture the value creation by R&D innovation, and a better measurement of R&D innovation is the combination of R&D intensity with drug portfolios.

(Insert Table 8 here)

We run equation (7) to see how changes in drug portfolios affect the stock return. Results are shown in Table 6. These results can also to an extent provide support to the notion that the combination of R&D intensity with drug portfolios is a better measurement of R&D innovation in the biotechnology industry. From Table 6, we learn that the inclusion of drug portfolios as additional explanatory variables into the model that already has financial information and R&D intensity increases Adj. $R^2$ by 5.4 % in the period from 1998 to 1999, by 0.6% in the period from 1999 to 2000, by 0.4% in the period from 2000 to 2001, and by 1.7 % in the pooled sample. The F tests show that $R^2$ changes are significant in the period from 1998 to 1999 and in the pooled sample ($P \leq 0.05$). In addition, these results also support the notion that drug portfolios may be better measures of R&D innovation than R&D intensity in the biotechnology industry, because the incremental value relevance of R&D innovation is mainly brought about by drug portfolios.

As previously mentioned, the incremental value relevance of R&D intensity and drug portfolios can be determined by a firm's economic characteristics. In the sensitivity analysis section, we examine how firms' financial performance can affect the incremental value relevance of R&D intensity and drug portfolios, respectively.

6.4 c) Summary of findings concerning the incremental value relevance of R&D innovation

Our study provides evidence that R&D intensity has incremental value relevance over financial information. However, it is not an adequate measure of R&D innovation. Drug portfolios contain incremental value relevance over R&D intensity, in terms of capturing value creation by R&D innovation. Therefore, the combination of R&D intensity with drug portfolios is a better means to measure the value relevance of R&D innovation in the biotechnology industry. In addition, our results indicate that drug portfolios may have higher explanatory power than R&D intensity. We further examine this issue in the sensitivity analyses section.

6.5 Empirical findings about the incremental value relevance of drug portfolios at different stages (test of hypothesis 5)

Results in Table 8 indicate that capital markets may not value drugs at earlier stages in the same way as they value drugs at more advanced stages. To further examine this issue, we run equation (4c) to test the difference in the incremental value relevance between drug portfolios at more advanced stages and drug portfolios at earlier stages. In this test, the pre-clinical trial, the IND process, PI clinical trial and PII clinical trial are treated as earlier stages. Phase III clinical trial and the FDA approval process are treated as more advanced phases. This classification is consistent with the classification made by biochemists and analysts in the biotechnology industry. For example, Valueline analysts, when estimating a firm's earnings, only pay attention to drugs in PIII clinical trial and the FDA approval process. Others assign higher weights to drugs at these stages but lower weights to drugs at earlier stages. For example, Travers, an analyst, who follows biotechnology firms, and is the owner of Ionoainvesting. Inc, gives no points to drugs in the pre-clinical trial and the IND process, but gives one point to a PI drug, 2 points to a PII drug, 4 points to a PIII drug and 6 points to a FDA drug. He also gives one point for each $25 million of sales.

Based on these points, he predicts a firm's market value and issues investment recommendations.

Results from running equation (4c) with the pooled sample formed for the price-earnings model are shown in Table 9. We run this equation for drugs at earlier stages and for drugs at more advanced stages, respectively. Panel A reports the results from the regressions that have drug portfolios at earlier stages as independent variables; and Panel B reports results from the regressions that have drug portfolios at more advanced stages as independent variables. The table reports three regressions. The first column reports the regressions with only drug portfolios as independent variables. They indicate the relative value relevance of drug portfolios. The second column reports the regressions with both financial information and drug portfolios as independent variables. They indicate the incremental value relevance of drugs over financial information. The last column reports the regressions with financial information, R&D intensity and drug portfolios as independent variables. They indicate the incremental value relevance of drug portfolios over financial information and R&D intensity. From this table, we learn that the coefficients of DPRE, DPI and DPII are insignificant and lower in all the regressions. The exception is DIND, which is significant in all the regressions. The reason for this significance may be that firms can enter into human trials only when FDA grants their investigational new drug (IND) applications. So the IND process is also critical to value creation by R&D innovation. However, it is much less critical than the FDA approval process, since the IND process is still far away from the final approval. Compared to drugs at earlier stages, the coefficients of DPIII and DFDA are significant and higher in all the regressions.

From this table, we also learn that, compared to drugs at earlier stages, drugs at more advanced stages generate much higher Adj. $R^2$ in all the regressions. They also lead to higher and significant $R^2$ changes. It is evident that both the relative and the incremental value relevance of drug portfolios are mainly generated by drugs at more advanced stages. These findings fully support hypothesis 5 that drugs at different

stages do not have equal incremental value relevance. That is, drugs at more advanced stages have greater incremental value relevance than these at earlier stages. Results from yearly samples (not reported) are consistent with the results reported in Table 9.

(Insert Table 9 here)

6. 6 Empirical findings about the incremental value relevance of business relations (test of hypothesis 6)

We run equation (6) to test the incremental value relevance of business relations in the price-earnings model. Business relations are measured by ALLIANCE in our study. Results are reported in Table 10. Panel A of this table shows the estimated regression model. Panel B of this table shows the Adj. $R^2$ of the regression model, with vs. without ALLIANCE. The last column of this panel shows $R^2$ change brought about by the addition of ALLIANCE into the regression model.

From Panel A of this table, we learn that ALLIANCE is significant in 1998, 1999, 2000, respectively, and in the pooled sample, but insignificant in 2001. From Panel B, we learn that the addition of ALLIANCE increases Adj. $R^2$ by 5.7% in 1998, by1.1 % in 1999, by 0.7 % in 2000, and by 0.7% in the pooled sample. The addition decreases Adj. $R^2$ by 0.3% in 2001. The F tests show that all the increases are significant ($P \leq 0.05$), but the decrease is insignificant.

(Insert Table 10 here)

We also run equation (7) to test the value relevance of ALLIANCE in the return-earnings model. The results from the return-earnings model (shown in Table 6) indicate that ALLIANCE is significant in the period from 1999 to 2000 and in pooled sample. The $R^2$ changes brought about by ALLIANCE are also significant in these

two samples. ALLIANCE is insignificant in the periods from 1998 to 1999 and from 2000 to 2001. This insignificance needs further examination.

In summary, the results from the price-earnings model strongly support hypothesis 6 that information concerning a firm's business relations has incremental value relevance over financial information, R&D intensity and drug portfolios. The results from the return-earnings model partially support this hypothesis. Overall, we can infer that information concerning a firm's business relations is incrementally value relevant.

# 7. Sensitivity Analyses and Robustness Analyses

## 7.1 Sensitivity Analyses

### 7.1 a) The effect of a firm's financial performance on the incremental value relevance of drug portfolios

The significance of drug portfolios and $R^2$ changes brought about by them is consistent with the valuation practice of biotechnology firms. Capital markets care about drugs in the pipeline and their shifts from one clinical trial phase to the next. Results, discussed in section 6.4, imply that drug portfolios may better capture the value creation by R&D innovation than R&D intensity. To confirm this implication, we further examine the value relevance of drug portfolios in the context where a firm's financial performance is considered. The purpose of this examination is to see how a firm's financial performance affects the value relevance of drug portfolios. Results from this examination can then provide insight into our understanding of incremental value relevance of drug portfolios. In addition, they can provide insight into our understanding of the interactions between financial information and non-financial performance information.

As previously mentioned, a firm's ability to bring drugs through various clinical trial phases to the FDA approval process is the major performance indicator. Many factors can contribute to this ability. A firm's financial performance can enhance this ability because it can financially support drug development and reduce the pressure faced by firms when they plan for new trials. Robbins-Roth (2000) argues that financial strength is one of the important factors that drive a biotechnology firm. According to him, financial strength includes solid balance sheet, profitability and financing. Therefore, we argue that a firm's financial performance may have an influence on the incremental value relevance of drug portfolios. In order to test this, we divide firms in all the samples that are formed for our price-earnings model into two sub-samples: a positive-earnings sample and a negative-earnings sample. We obtain 10 sub-

samples. We examine the difference in the incremental value relevance of drug portfolios vs. R&D intensity over financial information between the two types of sub-samples. Results are shown in Table 11.

(Insert Table 11 here)

From this table, we learn that in 1998, drug portfolios are a better measure of R&D innovation in the positive-earnings sample, because their incremental value relevance over financial information is positive and significant. By contrast, the incremental value relevance of R&D intensity over financial information is negative and insignificant; in the negative-earnings sample, the incremental value relevance of drug portfolios and that of R&D intensity are both significant. However, drug portfolios have higher incremental value relevance than R&D intensity, because $R^2$ change brought about by drug portfolios is greater than that by R&D intensity. In 1999, the incremental value relevance of drug portfolios and that of R&D intensity are both positive and significant in the positive-earnings sample. However, according to $R^2$ changes, drug portfolios have much higher incremental value relevance than R&D intensity. In the negative-earnings sample, the incremental value relevance of R&D intensity is positive and significant, while the incremental value relevance of drug portfolios is negative and insignificant. In 2000, the incremental value relevance of R&D intensity is positive and significant in both samples, while drug portfolios are positive but insignificant in both samples. Results from the year 2001 show that drug portfolios are positive and significant in positive-earnings sample, while R&D intensity is positive and significant in negative-earnings sample. From these results, we can infer that drug portfolios are more value relevant than R&D intensity in the positive earnings samples; while R&D intensity is more value relevant than drug portfolios in the negative-earnings samples. Results from the pooled sample confirm this inference. We obtain additional support to this inference by looking at the number of years in which R&D intensity (or drug portfolios) is significant. In the positive-earnings samples, drug portfolios are significant in three years, while R&D

intensity is significant in two years; in the negative-earnings samples, R&D intensity is significant in all the years, while drug portfolios are significant only in one year.

In conclusion, our results indicate that capital markets may interpret information concerning drug portfolios and information concerning R&D intensity differently across firms that display different characteristics in their financial performance. Investors may focus on drug portfolios for firms that report positive earnings, while focusing on R&D intensity for firms that report negative earnings. In the literature, researchers (e.g., Amir and Lev, 1996) find evidence that non-financial performance information can enhance the value relevance of important financial information. Our study provides evidence that financial information can in turn enhance the value relevance of important non-financial performance information. We then open a new research direction. Future studies may examine the effect of other financial variables on the value relevance of non-financial performance information.

7.1 b) The effect of market rights on the incremental value relevance of drug portfolios

Results, reported in Table 8, indicate that information concerning drug portfolios is incrementally value relevant over financial information and R&D intensity. Results, reported in Table 9, further indicate that information concerning drugs at more advanced stages is more value relevant than information concerning drugs at earlier stages. Thus, the understanding of the value relevance of drugs at more advanced stages is more essential to the understanding of how capital markets incorporate the information concerning a firm's drug portfolios. With respect to market rights over drugs at more advanced stages, there is a variation across firms. Some firms have the market rights over drugs in PIII clinical trials and in the FDA approval process, while others do not have such rights. These firms conduct clinical trials for other firms and earn research funding, milestone payments and royalty revenues. As previously discussed, the benefit from drug development, measured by earnings from approved drugs, is great. Once is a drug approved, it can bring the firm that has the market right

over this drug at least $25 million in incremental annual earnings. Therefore, for firms that have market rights over drugs in PIII clinical trials and in the FDA approval process, drugs in the two phases represent a higher amount of unrecognized intangible assets, other things being equal. By contrast, for firms that do not have the market rights over drugs in the two phases, such benefit is much lower. In this case, drugs in PIII and the FDA approval process represent a lower amount of unrecognized intangible assets, other things being equal. Therefore, the possession of market rights may have an effect on the incremental value relevance of drugs in PIII clinical trials and in the FDA approval process. We examine this effect. In doing so, we add a dummy variable---DPIIIM --- into equation (5). DPIIIM is the product of DPIII and DMR. DPIII is defined as before. DMR is a dummy variable; it equals one if the firm has the market rights over drugs in PIII clinical trials, and zero otherwise. Results from the pooled sample, which is formed for the price-earnings model, are reported in Table 12.

(Insert Table 12)

We conduct t test to see the significance of DPIIIM, and find it is significant. However, the inclusion of this variable makes DPIII insignificant. The inclusion also increases Adj. $R^2$ by 0.9 %. The F test shows that the increase in $R^2$ is significant ($P \leq 0.05$). Results from yearly samples (not reported) are consistent with results that are reported in this table.

These results indicate that the significance of DPIII may depend on whether or not a firm has market rights over drugs in PIII clinical trials. When valuing firms, capital markets seem to pay attention to information about a firm's market rights. This finding is consistent with analysts' behaviour. When making an earnings forecast for a firm, analysts predict what would be the potential incremental earnings if a drug in PIII clinical trials could be finally approved by the FDA and launched by the firm. This finding suggests that, when disclosing information concerning drugs in PIII

clinical trials, firms should consider the disclosure of information concerning their market rights over these drugs.

The analysis of the effect of market rights over drugs in the FDA approval process (results are not reported) shows that, overall, information concerning market rights over drugs in the FDA approval process has no effect on the incremental value relevance of drugs in this process. It may be because that capital markets incorporate this information when drugs enter into PIII clinical trials.

7.1 c) The effect of drug indications on the incremental value relevance of drug portfolios

Every drug is specified to treat a certain disease or a certain group of diseases. This specification is called drug indication. The regression models used so far do not control for the economic value of a drug. These regressions implicitly assume that there is no difference in economic value across drugs within a certain clinical trial, across clinical trial phases, and across firms. In this section, we relax this assumption by considering the effect of drug indications on the incremental value relevance of drug portfolios.

The economic value of a drug is associated with the drug's market potential. A drug's market potential can be determined by the number of people who need this drug and by the market competition on this drug. A drug's indication can signal information as to the number of people who need this drug. For example, drugs that are used to treat influenza, diabetes, and myocardial infarction have a bigger market than drugs that are used to treat Parkinson and Alzhemier. Drug indications can also signal the complexity of drug development and post-market competition, which, in turn, is associated with drugs' earnings potential. For example, anti-cancer drugs are not as easy to develop as drugs that are used to treat fever, and the competition on anti-cancer drugs is less intensive than drugs that are used to treat high blood pressure. Therefore, since capital markets pay attention to a drug's market potential, it is

reasonable to expect that drug indications may contain additional information over the measures of drug portfolios applied by our study. This motivates our study to examine this additional information. At the current stage, we focus only on three types of drug indication. They are: anti-cancer, anti-infection and anti-AIDS. Anti-cancer drugs include all drugs that are intended to specifically treat various types of cancer. Anti-infection drugs include all drugs that are intended to specifically treat infections caused by bacteria, viruses, and fungi. Anti-AIDS drugs include drugs that are intended to specifically treat HIV infections. The reason for this focus is that these three types of drug attract investors' attention because of their great market potential and relatively low level of competition. In addition, the development of these three types of drug is complex, takes longer time, and requires a relatively bigger amount of R&D investments. Thus, we separate these three types of drug from other types of drug to see whether or not drug indications have an effect on the incremental value relevance of drug portfolios.

We add three dummy variables into equation (5). They are CAN, ANTI and AIDS. CAN is a dummy variable, it equals one if the firm has anti-cancer drugs in its PIII clinical trials or in the FDA approval process, and zero otherwise. ANTI is a dummy variable, it equals one if the firm has anti-infection drugs in its PIII clinical trials or in the FDA approval process, and zero otherwise. AIDS is a dummy variable, it equals one if the firm has anti-AIDS drugs in its PIII clinical trials or in the FDA approval process, and zero otherwise.

Results from running equation (5) with CAN, ANTI and AIDS as additional variables are reported in Table 13. These results are obtained from the pooled sample, which is formed for the price-earnings model. From this table, we learn that Both CAN and ANTI are positive and significant. AIDS is negative and insignificant. The addition of the three variables increases Adj. $R^2$ by 0.9% and the F test shows that the increase is significant. Results from yearly samples (not reported) are consistent with results shown in this table.

(Insert Table 13 here)

These results suggest that capital markets care about drug indications when they value firms' drug portfolios. The incremental value relevance of drugs in PIII clinical trials and in the FDA approval process is enhanced by adding drug indications into the regression model. Among the three types of drug indication, capital markets value anti-cancer and anti-infection drugs much more than anti-AIDS drugs. This may be because the market for anti-cancer and anti-infection drugs is bigger, or the risk associated with the development of the two types of drug is lower, or both. Thus, investors perceive that their investment in firms that develop anti-cancer and anti-infection drugs has better prospects. From the perspective of a firm's communication with outsiders, these results suggest the disclosure of drug indications for drugs in PIII clinical trials and in the FDA approval process.

7.2 Further analysis of the effect of a firm's product market status

As discussed in Section 6, a firm's product market status (DM) has an effect on the value relevance of financial information. In that analysis, DM is treated as an interactive variable with financial information. We provide evidence that says that a firm's product market status (a non-financial performance measure) interacts with financial information. In this part of our study, we have two concerns. First, we wonder if DM can have an influence on the value relevance of non-financial performance information. Secondly, we wonder if DM can work as a separate variable in our price-earnings model. In other words, we like to examine if DM conveys a piece of information that is useful to capital markets but not yet captured by the firm's financial information and information concerning the firm's R&D innovation and business relations.

With respect to the information that DM may convey, we argue that a firm's product market status signals its maturity, which can reflect differences in fundamentals, such as research, technology, management and financing, between mature firms and less

mature firms. These fundamentals determine a biotechnology firm's success. Jacobs (2001) outlines four critical success factors in the biotechnology industry: (1) drug development; (2) technology and market potential; (3) management experience; and (4) venture capital or private financing. Parkinson (1987) outlines four key ingredients for business success in the biotechnology industry: (1) technical excellence; (2) experienced management; (3) reasonable financing; and (4) a sense of urgency. In the literature, some studies discuss and examine the differences, as well as their effect on market valuation, between mature and less mature firms. Danielson and Dowdell (2001) propose a return-stages valuation model to see how price to book value of equity and price to earnings ratios affect market expectation of a firm's future return on equity. They provide evidence that says that the operating performance consistent with a given stock return differs between growth firms and mature firms. Spalding (1988) conducts a survey concerning the profitability of biotechnology firms. He reports that more commercially mature companies have greater product sales and spend a smaller percent of sales on R&D than less commercially mature firms. These studies imply that maturity may be a matter to the market valuation of a biotechnology firm.

In the previous sections, we argue about the incremental value relevance of R&D innovation and business relations. R&D innovation covers drug development and technology, while business relations cover financing and speed of drug development. Thus, we here argue about the incremental value relevance of information about management experience. Management experience, as outlined by Jacobs (2001) and Parkinson (1987), is a critical success factor. In the drug market, the competition is global and intensive, and government regulation is strict. Therefore, management of a biotechnology firm needs to possess superior ability to, as well as do a great job in, grant new ideas, form research teams, raise funds, enter strategic alliances, convince the FDA, and commercialize approved drugs. Therefore, it is reasonable to expect that information concerning a firm's management experience have an influence on capital markets' expectation of a firm's value. We use DM to capture information concerning management experience since it can proxy for differences in fundamentals

including management experience. In our price-earnings model, we include financial information, R&D innovation and business relations. In general, they are all associated with management experience, and then can capture information concerning management experience. However, they cannot fully capture this information because the effects of managerial actions go beyond what can be represented by them. In fact, we expect that DM can capture the residual information concerning management experience, that is, information, which is not captured by financial information, R&D innovation and business relations.

In order to provide evidence for our first concern, we divide the pooled sample, which is formed for the price-earnings model, into two sub-samples. One contains firms that have products in the market. The other contains firms that do not have products in the market. We run equation (5) for the two sub-samples, respectively, and report results in Table 14.

(Insert Table 14 here)

From this table, we learn that financial information is value relevant in the both sub-samples, which is consistent with our previous findings regarding the value relevance of financial information. Results also indicate that, for firms that have products in the market, drug portfolios are significant, while R&D intensity is not. By contrast, for firms that do not have products in the market, R&D intensity is significant, but drug portfolios are not. This finding indicates that capital markets incorporate a firm's product market status when they interpret information concerning the firm's R&D innovation. They pay attention to drug portfolios for firms that have products in the market, while paying attention to R&D intensity for firms that have products only in the pipeline.

This finding is also consistent with our previous findings regarding the value relevance of R&D intensity vs. drug portfolios between positive-earnings sample and negative-earnings sample. This consistence rests on the fact that, in the positive-

earnings sample, there is a higher percentage of firms that have products in the market, while in the negative-earnings sample, there is a higher percentage of firms that do not have products in the markets. From these findings, we learn that the incremental value relevance of R&D intensity vs. drug portfolios can be jointly determined by two important economic characteristics--a firm's financial performance and its product market status.

In summary, our analyses indicate that a firm's product market status has an effect not only on the value relevance of financial information, but also on the incremental value relevance of non-financial performance information. In addition, they provide evidence that shows the interaction between non-financial performance indicators.

In order to provide evidence for our second concern, we add DM to equation (5) as a separate independent variable, and run this regression with the pooled sample, which is formed for the price-earnings model. Results are reported in Table 15.

(Insert Table 15 here)

From this table, we learn that DM is positive and significant. The addition of DM into the regression model increases $R^2$ by 1.6 %, and the F test shows that the increase is significant (p 0.005). Results from the yearly samples (not reported) are consistent with results reported in this table. In addition, we examine the incremental value relevance of DM over (1) financial information; (2) financial information and R&D intensity; and (3) financial information, R&D intensity, and drug portfolios, respectively (results are not reported). DM is significant in all the regressions as well as in all the yearly samples.

These results indicate that DM does convey a piece of information, which is not captured by financial information, R&D intensity, drug portfolios and business relations. We argue that DM conveys residual information concerning management experience. Thus, our results show that information about management experience,

conveyed by DM, is incrementally value relevant over financial information, R&D intensity, drug portfolios and business relations.

## 7.3 Robustness analyses

### 7.3 a) Scale effect

As previously mentioned, there is a scale effect associated with a cross-sectional price-earnings model. Control for this effect is essential. According to Barth et al. (1996) and Easton (1999), scale is an omitted variable in a regression model. Both dependent and independent variables are affected by "scale". Scale differences across firms arise because large (small) firms have large (small) values of many variables. These differences can results in heteroscedastic regression error variances, and, if the magnitude differences are unrelated to the research question, scale-related coefficients are biased. There are three ways to control scale effect: (1) deflate all variables in a regression model by a scale proxy; (2) include a scale proxy as an independent variable into the regression; and (3) conduct White adjustment. In our study, we calculate White-adjusted standard errors. Through this means, we control the scale effect on regression errors. We also deflate all variables in our models by beginning total assets. Through this means, we control the scale effect on regression coefficients. In this part of our study, we discuss the selection of the deflator, along with the discussion of the inclusion of a scale proxy as an independent variable into the regression. We conduct these discussions with the pooled sample, which is formed for our price-earnings model.

The application of the first two ways outlined by Barth et al. (1996) requires careful selection of a scale proxy. Incorrect selection can make regression coefficients even more biased. Accounting researchers either base their selection on a theoretical argument or on an empirical analysis. For example, Easton (1999) argues that expressing all variables on a per-share basis will not overcome scale effect. This is because that management has discretion over the number of shares outstanding. They

may choose to split their firms' stock, to offer stock dividends and or undertake a reverse stock split. These splits could conceivably be used to change the prices of shares without changing the economic characteristics of the firm. As a consequence, the magnitude of the dependent variable in price-levels regressions may reflect no more than the choice by management of the number of shares outstanding. He also argues that this management choice will also affect the magnitude of the per-share measures of many firm attributes. Therefore, a regression of share price on the firm attributes will lead to coefficients that may simply capture the fact that, at the per-share level, all variables have the same scale and scale differs across firms.

Based on a simulative analysis, Barth et al. (1996) provide evidence that shows that using net income, number of shares, and stock price as deflators generally does not mitigate coefficient bias; using total assets, sales and book value of equity can reduce a small amount of coefficient bias. Their study provides evidence that says that market value is a good scale proxy. Easton et al. (2002) also find that market capitalization is a scale factor in their sample. The two studies imply that scale proxy is case-specific.

We follow the argument by Easton (1999) that says that number of shares is not an appropriate deflator as it is subject to management manipulation. We further argue that market value as a deflator also has limits to control scale effect. This is because the resulted variables will be subject to the past behaviour of a firm's market value. If there is a significant volatility in a firm's market value, values of variables deflated by beginning market value may simply reflect the change in market value. Therefore, coefficients resulted from this so-deflated regression will be biased. As previously mentioned, a biotechnology firm's stock price is quite volatile. Hence, beginning market value is not an appropriate deflator, within the context of the biotechnology industry.

We argue that total assets in nature bear much lower magnitude/extent of manipulation by managers than number of shares outstanding, and they are relatively

stable, compared to market value. Thus, it can serve as a good scale proxy. In our samples, large (small) biotech firms, measured by total assets, have higher (lower) market value, book value of equity, and R&D expenditures. Therefore, in the prior analyses of our study, we select beginning total assets as a deflator.

In order to see if we select the right scale proxy, in this section, we deflate the actual numbers of market value, book value of equity, earnings, and R&D expenditures by alternative scale proxies including year-of-end total assets ($TA_t$), beginning market value ($MV_{t-1}$), year-of-end book value of equity ($BV_t$), beginning book value of equity ($BV_{t-1}$), year-of-end number of common shares outstanding ($SHARES_t$), and beginning number of common shares outstanding ($SHARES_{t-1}$), respectively. We also include these proxies into our price-earnings model as an independent variable, respectively. Drug portfolios and business relations do not involve this deflation issue, because we use dummy variables to portray drug portfolios; and our statistical analysis shows, as mentioned before, that there is no correlation between firm size (measured by total assets) and number of alliances. In the pooled sample, 56 firms report negative book value of equity, and 692 firms report positive book value of equity. Since negative book value of equity cannot serve as a deflator, we form a positive book value sample from this pooled sample, which contains all firms (692) that report positive book value of equity. We use this sample to analyze the effect of book value of equity as a deflator. We run equation (5) and report results in Table 16.

(Insert table 16 here)

As mentioned before, an alternative way to control scale effect is to include the scale proxy into the regression model. Following this way, we include $TA_t$, beginning total assets ($TA_{t-1}$), $MV_{t-1}$, $SHARES_t$, $SHARES_{t-1}$, and $BV_{t-1}$ into equation (5), respectively, as an independent variable. Results from these regressions are reported in Table 17. In the case of book value of equity as a scale variable, we use the same sample as we use in the case where book value works as a deflator. As mentioned before, this sample includes firms that report positive book value.

(Insert Table 17 here)

Table 16 and Table 17 indicate that using different deflators, as well as including different scale variables, yields similar results as to the significance of variables. All the regressions reported in the two tables show that financial information is value relevant, and R&D intensity, drug portfolios (except for drug portfolios in Table 17) and business relations are incrementally value relevant over financial information. These results are consistent with results from the regression that uses beginning total assets as a deflator. In order to explain the insignificance of drug portfolios in Table 17, we replace dummy variables with actual numbers of drugs at different stages. Results (not reported) show that drug portfolios, measured by these actual numbers, are also insignificant. This implies that the measurement of drug portfolios may not be well specified in these regressions that include a scale variable as an independent variable. How to measure drug portfolios in such regressions needs further examination. This may also imply that there is high correlation between drug portfolios and size. Thus, scale variable captures the value relevance of drug portfolios. We calculate the correlations of coefficients for regressions including competing scale variables. Results (not reported) indicate that

However, regression coefficients are different across regressions with different deflators/scale variables. Therefore, we need to discuss whether or not beginning total assets, which we use as a deflator in our previous analyses, is a good deflator in our samples. We also need to discuss which one, deflation or inclusion, is a better way to control scale effect on regression coefficients.

Kothari and Zimmerman (1995) provide criteria to evaluate alternative models. According to them, we can look at the extent to which the estimated slopes and intercepts approximate their predicted values, when we evaluate alternative deflators/scale variables. In particular, Kothari and Zimmerman argue that the intercept in both price-earnings model and return-earnings model should be zero; the

slope, commonly referred to as earnings response coefficient, should be the reciprocal of the firm's expected rate of return, 1/r. They apply 10%-12% as the benchmark for the expected rate of return. They claim that this benchmark is observed in the past 38 years. Table 16 shows that the regressions using $MV_{t-1}$, $SHARES_t$, and $SHARES_{t-1}$ can meet the criterion about the coefficient of earnings, because they can yield a rate of return of 9.5% (1/10.519), 9.7% (1/10.239) and 11.2% (1/8.924), respectively, and these rates of return are close to the benchmark used by Kothari and Zimmerman. Table 16 also shows that none of the deflators can meet the criterion about the intercept. From Table 10, we learn that using $TA_{t-1}$ as a deflator yields a rate of return of 32.06% (1/3.119), which is quite high.

From Table 17, we learn that all scale variables meet the criterion about the coefficient of earnings because they all yield a rate of return, which is in the range of 10%-12%; again, none of them can meet the criterion about the intercept. In addition, Table 17 shows the similarity among the coefficients of positive earnings. This similarity is not apparent in Table 16. It also shows the similarity in Adj. $R^2$, which is not the case in Table 16. By comparing the coefficients of earnings and Adj. $R^2$ between Tables 16 and 17, we argue that inclusion might be a better way to control the scale effect on coefficients than deflation. However, this issue needs further investigation.

Barth and Kallapur (1996) take another approach to evaluate alternative deflators. They calculate coefficient bias and use it to evaluate alternative deflators. They define coefficient bias as the difference between the estimated regression coefficient and the assumed true coefficient. We apply their formula to calculate coefficient bias to evaluate alternative deflators considered by our study. For simplicity, we use equation (1) to calculate coefficient bias for book value of equity and earnings, respectively. Results are shown in the following table.

Coefficient Biases

| | $TA_t$ | $TA_{t-1}$ | $MV_{t-1}$ | $SHARES_t$ | $SHARES_{t-1}$ | $BV_t$ | $BV_{t-1}$ |
|---|---|---|---|---|---|---|---|
| Book value | 0.0004 | 0.0003 | 0.0001 | 0.0004 | 0.0001 | 0.0003 | -0.00005 |
| Earnings | 0.0008 | 0.0005 | 0.0002 | 0.0007 | 0.0002 | 0.0005 | -0.00008 |

From this table, we learn that $BV_{t-1}$ yields the lowest coefficient biases. $MV_{t-1}$ and $SHARE_{t-1}$ can yield the second lowest coefficients biases. $TA_{t-1}$ and $BV_t$ can yield the third lowest coefficient biases. However, there is almost no significant difference in the magnitude among these coefficients biases.

In summary, based on our analysis, since there is no inconsistency regarding the significance of our three groups of information across regressions that use different deflators/ scale variables, and there is almost no difference in the magnitude among the coefficient biases shown in the above table, it is reasonable to conclude that our results from the regressions that use beginning total assets as a deflator are acceptable. However, deflation/inclusion is an empirical issue. This issue needs further investigation.

7.3 b) Alternative measures of return

In our return-earnings model, we define stock market return as the first difference of market value, deflated by beginning total assets. We take this definition, or in other words, we use beginning total assets as a deflator of first differences of market value, book value of equity, earnings and R&D expenditures, because we want to be consistent with our price-earnings model. Theoretically, return is defined as the change of market value (or stock price) relative to beginning market value (or stock price), given that there are no dividends paid yet. Here, we investigate to see if the

way we define return has an effect on our results from the return-earnings model. In order to do it, we apply two alternative definitions of return. Return is first defined as:

$$R_{jt} = ( MV_{jt} - MV_{j\,t-1})/ MV_{j\,t-1} \qquad \text{(definition 1)}$$

Where $R_{jt}$ is stock market return of firm j at time t. $MV_{jt}$ is market value of firm j at time t.

And secondly, return is defined as:

$$R_{jt} = (P_{jt} - P_{j\,t-1}) / P_{j\,t-1} \qquad \text{(definition 2)}$$

Where $P_{jt}$ is stock price of firm j at time t.

In these definitions, we do not incorporate dividends because most of biotechnology firms do not pay dividends.

We run equation (7) with definitions 1 and 2, respectively, using pooled sample, which is formed for the return-earnings model. Under definition 1, changes in book value of equity, earnings and R&D expenditures are deflated by beginning market value; and under definition 2, book value of equity, earnings, and R&D expenditures are measured on a per share basis. The changes in these per-share numbers are deflated by beginning stock price. We report results in Table 18.

(Insert Table 18 here)

From this table, we learn that the regressions applying the two definitions of return have lower explanatory and predictive power, especially in the case of the definition 2, than the regression using beginning total assets as a deflator. Adj. $R^2$ is 14.2% under definition 1, and 6.3 % under definition 2. In the case where we focus on the explanatory and predictive power, these results indicate that both market value and stock price may not be appropriate deflators.

Change in earnings is insignificant in the regression using beginning total assets as a deflator, and the same under definitions 1 and 2. Thus, we cannot apply the criterion about the coefficient of earnings posited by Kothari and Zimmerman (1995). Regarding the intercept, the regression, which uses beginning total assets as a deflator, yields an intercept (.346) between interpret under definition 1 (.466) and that definition 2 (.293).

Alternatively, we can apply the approach of Barth and Kallapur (1996). Thus, we run equation (3), but using $TA_t$, $MV_{t-1}$, $SHARES_t$, $SHARES_{t-1}$, $BV_t$, and $BV_{t-1}$ as alternative deflators to deflate the first differences in market value, book value of equity, and earnings, respectively. We then calculate coefficient biases for book value of equity and earnings, respectively. Results are shown in the following table.

Coefficient Biases and Adj. $R^2$ of the Regressions

| | $TA_t$ | $TA_{t-1}$ | $MV_{t-1}$ | $P_{t-1}$ | $SHARES_t$ | $SHARES_{t-1}$ | $BV_t$ | $BV_{t-1}$ |
|---|---|---|---|---|---|---|---|---|
| Book value | 0.2664 | 0.2526 | 02292 | 0.0146 | 0.1823 | 0.1322 | -0.00006 | 0.0005 |
| Earnings | 0.3330 | 0.0318 | 0.1436 | 0.0779 | 0.2705 | 0.3396 | -0.00011 | 0.0001 |
| Adj.$R^2$ (%) | 26.4 | 26.4 | 12.2 | 5.3 | 13 | 13.2 | 21.4 | 9.5 |

From this table, we learn that definition 2 of return may be appropriate to the examination of the value relevance of financial information, because $P_{t-1}$ yields lower coefficient biases. However, as shown in this table and also in Table 18, the regression under this definition yields a low explanatory and predictive power. $BV_t$ and $BV_{t-1}$ yield the lowest coefficient biases, but the positive book value samples are not the representatives of our full sample. Therefore, we cannot claim that they are good deflators. $TA_{t-1}$ yields lower coefficient biases, especially the coefficient bias of earnings, than $TA_t$, $MV_{t-1}$, $SHARES_t$ and $SHARES_{t-1}$. In addition, it yields a higher

Adj. $R^2$ than all other deflators. Based on these analyses, we conclude that our results from the return-earnings model, which uses beginning total assets as a deflator, are acceptable. As mentioned before, deflation is an empirical issue, thus, this issue needs further investigation.

7.3 c) Alternative definition of earnings

As mentioned before, our study defines earnings as earnings before extraordinary items and R&D expenditures. In the accounting literature, Amir and Lev (1996), as well as many other similar studies, use earnings before extraordinary items but after R&D expenditures. They examine the value relevance of financial information and non-financial performance information, within the telecommunication industry. They find that financial information has lost its value relevance. In the sensitivity analysis section of their study, they examine the value relevance of financial information in the biotechnology industry. They find that financial information is irrelevant in this industry, and that R&D expenditures do not cause the irrelevance of earnings. Here, we duplicate their study but using our samples to see if earnings after R&D expenditures are irrelevant in our samples; and if they are, we are to see whether or not R&D expenditures cause this value irrelevance. Our purpose is to see which definition of earnings is appropriate in the valuation model of the biotechnology industry. Results from the pooled sample formed for our price-earnings model are reported in Table 19.

(Insert Table 19 here)

Panel A of this table reports regressions that include all the three groups of information defined by our thesis. Panel B reports regressions that include only financial information. From panel A, we learn that there are no differences in the significance of variables other than earnings between the regression using earnings before R&D expenditures and the regression using earnings after R&D expenditures. However, positive earnings after R&D expenditures are insignificant, while positive

earnings before R&D expenditures are significant. Results reported in panel B are consistent with this notion. The difference between the two definitions of earnings is R&D expenditures. Therefore, our results indicate that R&D expenditures cause the irrelevance of earnings after R&D expenditures. This finding is inconsistent with the finding by Amir and Lev (1996). However, this finding justifies our selection of earnings before R&D expenditures, in the sense that earnings before R&D expenditures reflect operating activities, while earnings after R&D expenditures reflect both operating and investing activities. In the discussion section (section 8.2 a), we theoretically justify the selection of earnings before R&D expenditures in detail.

# 8. Conclusions

## 8.1 Synthesis

Accounting researchers have made a great effort to provide insight into the role of financial accounting in equity valuation. This role is positively associated with the extent to which financial information is value relevant. Therefore, the issue of the value relevance of financial information attracts the attention of many accounting researchers. There is a debate on the value relevance of financial information. Some researchers (e.g., Amir and Lev, 1996; Easton, 1999) argue that financial information has lost its value relevance since it fails to keep track of the changing business world, especially in contexts where innovation, intellectual capital and R&D are key value drivers. In these contexts, financial information alone is unable to completely reflect a firm's value. Non-financial performance information captures the improvement in operating processes, an improvement that can lead to future financial performance. Thus, non-financial performance information can shape an investor understanding of a firm's prospects. The addition of non-financial performance information provides additional explanatory and predictive power to the accounting-based valuation model. Based on these arguments, non-financial performance information possesses incremental value relevance over financial information. By contrast, other researchers (e.g., Francis and Schipper, 1999) argue that financial information has not lost its value relevance even in high-tech industries. Their studies imply that financial information is still adequate.

This debate inspires our investigation into the value relevance of financial information and that of non-financial performance information. It also inspires our investigation into the effect of a firm's economic characteristics on the value relevance of both financial information and non-financial performance information.

Our study conducts these investigations in the context of the biotechnology industry. We hypothesize that financial information, after control for its sign, is still value

relevant, and we find consistent results: positive book value is significant; and earnings before the control are insignificant. After the control, however, positive earnings become significant. We conduct statistical tests for negative book value and earnings, and find that they are both insignificant.

We then investigate the effect of a firm's product market status, a non-financial performance indicator, on the value relevance of financial information, especially earnings. We find that this economic characteristic has no effect on the value relevance of book value of equity but has an effect on the value relevance of earnings. Before controlling for a firm's product market status, earnings are insignificant. After the control, however, earnings are significant for firms that have products in the market, and $R^2$ increases significantly. The evidence on this effect for firms that have no products in the market is mixed. This issue needs further examination. However, it is clear that a firm's product market status can help us to better recognize the value relevance of financial information, and it can also increase the explanatory power of the accounting-based valuation model.

Even though financial information is found to be value relevant in the biotechnology industry, our results suggest that relying solely on financial information is inappropriate because financial information alone can only explain 20%-50% of stock price formation and 20%-27% of stock return. This phenomenon points out that capital markets actually incorporate much more than just reported financial information. Understanding how capital markets incorporate other information becomes critical for our understanding of the equity valuation model used by investors in this industry. Thus, we investigate the incremental value relevance of non-financial performance indicators. We focus on R&D innovation and business relations because R&D innovation is the major performance indicator in this industry, and business relations substantially enhance R&D innovation. We wonder if R&D innovation and business relations convey incremental value relevance over financial information. Results support our hypotheses that information concerning R&D innovation is incrementally value relevant over financial information, and information

concerning business relations is incrementally value relevant over financial information and R&D innovation information.

The measurement of R&D innovation then becomes an issue. In the literature, R&D innovation is measured by R&D expenditures. We argue that this measurement is not appropriate in the context of the biotechnology industry. In this industry, drug development is associated with high risk due to government regulation and complex human reactions to drug designs. Therefore, the success rate of drug development is very low. This low success rate leads to high uncertainty associated with the transformation from R&D inputs to R&D outputs. When R&D investments fail to generate R&D outputs, they create no intangible assets except for what has been learned from past failures. Therefore, we argue that R&D outputs should be taken into account when measuring R&D innovation. We hypothesize that the combination of R&D inputs and R&D outputs can better measure the value creation by R&D innovation. We find that both R&D inputs and R&D outputs are value relevant on their own; however, the combination of them is a better measurement of R&D innovation in the biotechnology industry.

We further assess if drug portfolios at different stages are equally informative. We hypothesize, and find, that drug portfolios at more advanced stages have greater incremental value relevance over financial information and R&D intensity than those at earlier stages. We also find that detailed information on drug portfolios at more advanced stages is useful to investors. In the sensitivity analyses section, we provide evidence that detailed information about market rights and drug indications can increase the value relevance of drug portfolios at more advanced stages.

The following table summarizes the findings.

## Summary of findings

| Hypotheses | Findings | Conclusions |
|---|---|---|
| H1: Financial information, after controlling for its sign, is value relevant. | Positive book value and earnings are significant. (Tables 4 and 6) | H1 is supported. |
| H2: A firm's product market status enhances the value relevance of financial information reported by biotechnology firms. | Financial information is significant for firms that have products in the market; while financial information may or may not be significant for firms that have no products in the market. (Table 5) | H2 is partially supported. |
| H3: Information about R&D expenditures (R&D inputs) has incremental value relevance over financial information. | R&D intensity is significant. (Table 7) | H3 is supported. |
| H4: Clinical trial information about a firm's drug portfolios (R&D outputs) has incremental value relevance over financial and R&D input information. | Drug portfolios are significant. (Table 8) | H4 is supported. |
| H5: The incremental value relevance of information on a firm's drug portfolios is greater for drugs at more advanced stages than for drugs at earlier stages. | Drugs in PIII clinical trials and FDA approval process are significant, while drugs in pre-clinical trials, IND process, PI and PII clinical trials are insignificant. (Table 9) | H5 is supported. |
| H6: Information about a firm's business relations has incremental value relevance over its financial and R&D innovation information. | Alliances are significant. | H6 is supported. |

## 8.2 Discussions

### 8.2 a) Findings regarding the value relevance of financial information

Scott (2000) points out that financial accounting, as an information system, faces competition from other information sources such as analysts' forecasts and firms' voluntary disclosure. Therefore, financial accounting needs to survive and prosper through continuous improvement of its usefulness.

Accounting researchers have been questioning the value relevance of financial information for about two decades. They provide evidence that financial information has lost its value relevance, especially within the contexts where non-financial performance is the key value driver. They suggest the incorporation of non-financial performance information into the current financial reporting framework.

Determining whether or not financial information has lost its value relevance is a serious issue. On the one hand, keeping irrelevant financial information alive can undermine the competitive ability of financial accounting as an information system which aids decision-making. On the other hand, moving away from financial information, which is still value relevant, and starting a new system could be costly to both society and individuals including companies because the new system would require a lot of standard setting.

One line of prior studies (e.g., Gu and Lev, 2001 and Amir and Lev, 1996) argues that financial information has lost its value relevance and suggests that learning how to measure and report intangible assets is the key to the improvement of the current financial reporting framework. Firms in the biotechnology industry invest heavily in R&D innovation. However, our study finds that financial information is still value relevant in this industry. This finding makes us think about the external validity of the arguments made, and findings obtained, by Gu and Lev (2001), Amir and Lev (1996)

and some other similar studies. From our study, we learn that investments in intangible assets could be one determinant of the decline of the value relevance of financial information. However, the effectiveness of this determinant could be conditional on many other factors that we may not even know. Researchers need to apply caution when they accept the research findings by these studies. We suggest that learning how to measure and report intangible assets may be one way to improve the current financial reporting framework, but it may not serve as the key to the improvement.

Prior studies (e.g., Ittner and Larcker, 1998; Lazer and Lev, 2001) find evidence on the loss of value relevance of financial information and suggest a shift of focus from financial information to other information sources (e.g., non-financial performance information) before going through a thorough examination of the value relevance of financial information. We argue that a thorough examination is essential because shifting our focus from financial information to non-financial performance information is a big step, which relies on many changes in thoughts, concepts, frameworks, methodologies, reporting mechanisms and so on. We make an effort to explore the factors that can explain the loss or the maintenance of the value relevance of financial information. We find that a firm's product market status can help us to identify the value relevance of financial information, especially earnings in the biotechnology industry. Prior studies imply that earnings have lost their fundamental attribute in high-tech industries. Our study suggests that earnings would always be a fundamental; however, the exhibition of this fundamental attribute may rely on a firm's other economic characteristics. When these characteristics are in a weak form, the fundamental role of earnings could be diluted; however, when these characteristics become strong, earnings' fundamental role could reappear.

A methodological issue, that is how to define earnings in accounting-based valuation models, needs to be discussed. Prior studies (e.g., Amir and Lev, 1996) in this area define earnings as earnings before extraordinary items but after R&D expenditures, and show evidence that earnings have lost their value relevance. These studies

actually seek evidence on earnings' power to explain and predict stock price behaviour after they cover R&D investments. Earnings defined in this way are not consistent with earnings as a fundamental that determines a firm's value.

In economics, earnings are defined as the change in economic value of assets during a period. They are the results of economic performance of operating activities. As reviewed in the literature, the economic value of assets is unobservable in the imperfect and incomplete market. Thus, in accounting, earnings are defined as revenue in excess of expense. Accounting earnings basically are a summary measure of operating performance. They reflect a firm's financial performance (e.g. profitability). Because of this, earnings can be used to indicate a firm's ability to generate future earnings in the accounting-based valuation model.

Earnings can be distributed to different groups of people, or can be used to finance different activities. R&D investments, if financed by earnings, belong to the distribution category of earnings. If we define earnings as earnings after covering R&D expenditures, we can also define earnings as earnings after covering all the distributions, even after covering dividend payments. If we do so, we will observe zero earnings or a large amount of negative earnings, no matter how well a firm actually performs. Earnings defined as such have arbitrary components, and therefore cannot serve as a variable in a valuation model because their ability to indicate future earnings is substantially reduced.

Ohlson (1995) argues that accounting information can play a role in market valuation because it provides information concerning the generation and distribution of earnings. In his concept of earnings, it is clear that earnings refer to the generation of earnings. According to Ohlson, the definition of earnings that can be applied in accounting-based valuation models should be one that reflects the generation of earnings, not one that also reflects the distribution of earnings. In his clean surplus equation, earnings and dividends are separate items. Earnings represent the generation

of earnings, and dividends represent the distribution of earnings. Earnings increase shareholders' equity, while dividends decrease the equity.

GAAP allow earnings to cover R&D expenditures. This is because conservatism is a major principle of financial accounting. In our understanding, from the capital market perspective, conservatism can avoid legal costs; from a contracting perspective, it can provide a more solid basis for managerial performance evaluation. Conservatism understates earnings. It contributes to the difference between market value and book value. From an equity valuation perspective, we should reconcile this understatement by allowing earnings to purely reflect earnings generation. Through this means, we can reduce the noise in earnings caused by conservatism. There is another justification for earnings being defined as earnings before R&D expenditures. In the biotechnology industry, R&D investments are mainly financed by strategic alliances, not by earnings. The majority of R&D expenditures do not even belong to earnings distribution. Hence, in this case, earnings after R&D expenditures are much less meaningful than in the case where R&D investments are fully or mainly financed by earnings.

Prior studies in this area claim that current earnings are used to predict a firm's ability to generate future earnings. However, the way these studies define earnings is not consistent with earnings' ability to indicate future earnings. This may explain why they find earnings are irrelevant. We examine the significance of earnings before and after R&D expenditures. We find that earnings before R&D expenditures are significant, while earnings after R&D expenditures are insignificant. These findings point out the inappropriateness of using earnings after R&D expenditures in equity valuation models. Our findings also suggest that the assertion by Amir and Lev (1996) that R&D expenditures do not cause the irrelevance of earnings in the biotechnology industry is not valid in our sample.

In summary, we provide an explanation as to why the debate regarding the value relevance of financial information exists. We suggest that whether or not financial

information has lost its value relevance may be an industry-specific issue. In some high-tech industries, financial information may have become irrelevant, while in other high-tech industries, such as the biotechnology industry, financial information is still value relevant. Another possible explanation we provide is that the definition of earnings used in prior studies causes earnings irrelevance. We suggest that earnings be defined as earnings before R&D expenditures. We also provide a possible solution to the debate, that is, investigating the effect of non-financial performance on the value relevance of financial information.

8.2 b) Findings regarding the value relevance of non-financial performance information

In the valuation research, when researchers use market variables (e.g., stock market return or stock price, or change in trading volume) as benchmarks to evaluate the explanatory and predictive power of accounting variables, they investigate how capital markets apply accounting information to their valuation models. The significant associations between market variables and financial accounting variables are the basis on which they make conclusions of the usefulness of accounting information. Using market variables as benchmarks can be validated by the assumption of market efficiency. In our examination of the value relevance of non-financial performance information, we apply the same mechanism. We seek evidence on how capital markets incorporate non-financial performance information into their valuation of biotechnology firms. This search can help us to establish a more powerful accounting-based valuation model for this industry. It may also provide insight into the improvement of the current financial reporting framework used by this industry.

Prior studies related to the biotechnology industry (e.g., Grabowski and Vernon, 1994) examine the association between R&D expenditures and stock returns, and find a positive association between them. These studies treat R&D expenditure as a fundamental, and explore its value relevance. They attempt to establish a valuation

model that solely relies on the value relevance of R&D expenditure for the biotechnology industry. They do not examine this issue from the perspective of incremental value relevance. Hence, these studies provide little evidence to suggest about the improvements in the accounting-based valuation model for this industry.

In attempting to improve the accounting-based valuation model, one needs to explore the ability of financial information to summarize all the value relevant events on a timely basis. Non-financial performance information, or other information sources, can gain incremental value relevance only when this ability of financial information is considerably weak. Thus, in order to explore what is not captured by financial information, research in this area needs to explore the incremental value relevance of non-financial performance information. The difference in our study from prior studies is that we provide evidence that financial information is unable to capture the full value relevance of R&D investments in the biotechnology industry. R&D intensity is found incrementally value relevant over financial information.

In other research fields, a few studies related to the biotechnology industry (e.g., Robbins-Roth, 2000; Kellogg and Charnes, 2000, and Tapon et al. 2001) discuss the value relevance of drug portfolios and business relations. These studies shed light on the accounting research by providing a theoretical basis for drug portfolios and business relations to stand as incrementally relevant variables. In accounting research, there are no studies that address how capital markets incorporate information concerning drug portfolios and business relations and how this information can add value to the accounting-based valuation model. Our study empirically examines, and provides evidence on the incremental value relevance of drug portfolios and business relations over financial information. As a result, we establish a valuation model that includes both financial variables and variables that capture R&D innovation and business relations. Our empirical results show that this model has greater explanatory and predictive power than a model that contains only financial accounting variables. Therefore, we have improved the accounting-based valuation model for this industry.

We also discuss a measurement issue associated with R&D innovation. Accounting practice, as stated by the Conceptual Accounting Framework, requires the reporting of both relevant and reliable information. According to SFAC (No.2, paragraph 59), the reliability of a measure rests on the faithfulness with which it represents what it purports to represent. From the literature, we learn that R&D innovation is the key performance indicator in the biotechnology, and researchers use R&D expenditures or R&D intensity to proxy for its value. However, there is no research that questions the reliability of R&D expenditures as a proxy for R&D innovation. Prior studies related to the biotechnology industry (e.g., Grabowski and Vernon, 1994 and Healy, Myers and Howe, 1999) just implicitly assume that R&D expenditures are able to capture the value relevance of R&D innovation in the biotechnology industry. In our study, we raise a question: Are R&D expenditures reliable in terms of capturing the value relevance of R&D innovation in the biotechnology industry? We theoretically discuss and empirically examine this issue, and we find that R&D expenditures cannot faithfully represent the value relevance of R&D innovation in this industry because they do not incorporate the success rate of drug development, which determines the outcome of R&D innovation. In the case where drug development bears a very low success rate, R&D expenditures are not a reliable measure of R&D innovation. Based on the conceptual discussions of R&D innovation and intangible assets in the literature, we propose a measure that incorporates both R&D inputs and R&D outputs. Our empirical evidence indicates that this measurement has a greater power to capture the value relevance of R&D innovation in the biotechnology industry than a measure that addresses either R&D inputs or R&D outputs, and therefore is more reliable in terms of faithful representation. Thus, our study makes a contribution to the measurement of R&D innovation. Even though our discussion and examination focus on the biotechnology industry, studies in the same area but related to other industries can use our study for reference.

8.2 c) Findings regarding the interactions between financial information and non-financial performance information

The most important contribution made by our study to accounting research is our discussion of, and empirical evidence on the interactions between financial information and non-financial performance information.

When we examine the value relevance of financial information, we find that a firm's product market status, a non-financial performance indicator, has an influence on the value relevance of financial information. When we examine the incremental value relevance of non-financial performance information, we find that a firm's financial performance, measured by earnings, has an influence on the value relevance of R&D intensity and drug portfolios. It seems that financial information and non-financial performance information not only complement, but also interact with, each other in capital markets. Prior studies (e.g., Amir and Lev, 1996) only provide evidence that non-financial performance information can enhance the value relevance of financial information. Our study, in addition to providing similar evidence, shows that financial information can, in turn, enhance the incremental value relevance of non-financial performance information. Thus, our study suggests a new research direction: how financial information impacts the value relevance of non-financial performance information. Moreover, we provide evidence that the incremental value relevance of the two measures of R&D innovation can be jointly determined by a firm's financial performance and its product market status.

The interactions between the two types of information bring each type of information an indirect ability to explain and predict stock price behaviour. The indirect ability of one type of information refers to its ability to lead to a better interpretation of the other type of information. This indirect ability constitutes an integral part of the value relevance of information because the better interpretation resulting from this ability makes a difference to investor decision-making. This indirect ability is ignored by prior research. Thus, we suggest an interactive perspective for the evaluation of the

value relevance of both financial information and non-financial performance information. This perspective allows an exploration and evaluation of the value relevance of the two types of information via examining the interactions between them.

Within this perspective, researchers need to apply caution when they claim that financial information has lost its value relevance because (1) non-financial performance information can enhance the value relevance of financial information; and (2) the value relevance of financial information can be embedded in its ability to lead to a better interpretation of non-financial performance information. When they examine the value relevance of non-financial performance information, they also need to realize (1) financial information can enhance the value relevance of non-financial performance information; and (2) the value relevance of non-financial performance information can be embedded in its ability to lead to a better interpretation of financial information.

## 8.3 Implications

Our study has implications for accounting researchers, standard setters and corporate managers.

As addressed in section 8.2.c), our study may have a profound influence on the accounting research. The interactive perspective may allow researchers to find the value relevance which could otherwise be missed. In addition, we suggest detailed disclosure of market rights and drug indications for drugs at more advanced stages. If our suggestions are followed, future accounting research needs to study the effects of these disclosures on studies in other areas. For example, what would be the effects of these disclosures on market efficiency, on earnings response coefficients, on earnings management, on financial analysts' earnings forecasts, and so on.

Our study also has implications for standard setters. We imply that, due to the interactions between financial information and non-financial performance information, standard setters may be interested in considering the integration of financial information and non-financial performance information. This is because the presence of important non-financial performance information can enhance the interpretation of financial information; and the presence of important financial information can enhance the interpretation of non-financial performance information. Such a reporting framework allows users to interpret the two types of information simultaneously. Simultaneous interpretation has an advantage over separate interpretation in terms of capturing the interactions between the two types of information. In this sense, it can be further concluded that the current financial reporting framework is inadequate since it is missing non-financial performance information. Investors will have a very hard time if they face an inadequate information system and have to do a private information search.

Standard setters are concerned about the efficiency of capital markets operations. One motivation in standard setting is to reduce information asymmetry and to allow everybody to have equal access to the information he/she needs. Our study provides evidence on the value relevance of R&D innovation and business relations. This evidence can serve as a basis on which standard setters can further consider issues that are related to the disclosure of value relevant non-financial performance information. For instance, what is the cost-benefit equilibrium of this disclosure, and what would be the mechanism and principles through which this information is processed and reported. Scott (2000) points out that the fundamental problem of financial accounting theory is how to reconcile the roles financial accounting plays for capital markets with the roles it plays for contracting. Thus, standard setters may also consider how to reconcile the interests of capital markets in this disclosure with the interests of corporate managers.

Our study provides insight into corporate disclosure strategies that can be used by biotechnology firms. Corporate managers of biotechnology firms can learn from our

analyses of the value relevance of R&D innovation and business relations. They can also learn from our detailed analyses of the value relevance of market rights and drug indications. These analyses can help them to focus on the disclosure of critical non-financial performance information. Our analyses of the interactions between financial information and non-financial performance information can help them work out a comprehensive and integral disclosure strategy that covers both financial information and non-financial performance information. If they follow such a strategy in their annual reports, their annual reports would be more informative.

## 8.4 Limitations

One limitation of our analysis is that we do not address issues that are related to the reliability of our measures of R&D innovation and business relations in detail. Thus, our study may not be able to provide much value relevance to standard setting. Holthausen et al. (2001) point out that value-relevance studies must provide evidence on the relevance and reliability of the measures of interest in order to be value relevant to standard setting. According to SFAC No.2 paragraphs 47 and 59, relevance refers to the ability of the item to make a difference to decisions of financial statement users and reliability refers to the ability of the measure to represent what it purports to represent, coupled with an assurance for the user, which comes through verification, that it has representational quality. We provide evidence on the value relevance of measures of R&D innovation and business relations. We also propose a more reliable measurement of R&D innovation. However, we do not analyze how the current financial reporting framework can assure the reliability of these measures; and nor do we provide possible remedies if the current financial reporting framework falls short of this assurance. A related limitation is that we do not link our argument to other functions of financial accounting such as contracting. According to Holthausen et al. (2001), our underlying theory is not descriptive to financial accounting practice and standard setting.

Another limitation is our assumptions that the associations between our dependent variables and independent variables in both the price-earnings model and return-earnings model are linear. We do not examine the economic reasons for, and econometric consequences of, these linearity assumptions. However, most value relevance studies have the same assumptions. This, to an extent, justifies the validity of the assumptions.

The third limitation is that we do not examine the volatility of $R^2$ across years in our price-earnings model. In theory, many factors, not only conservative accounting and earnings management, can cause price-lead-earnings. The explanatory power of accounting information is adversely related to the extent to which price leads earnings. The volatility of $R^2$ can occur when there are big changes in economy-wide, industry-wide and firm-specific factors. Our testing models do not include all variables that determine stock price behaviour. Therefore, it is not surprising to observe this volatility.

There are two econometric issues that need to be addressed. One issue is omitted correlated variables. The other issue is measurement error. Most value relevance studies have these issues. Our study is no exception. When there exists omitted correlated variables, or when there exist measurement errors of independent variables, or both, regression coefficients as well as standard errors are biased. We partially correct biased coefficients and standard errors through deflation and White's adjustments. Our results indicate that our model specifications still have either or both of these issues. In theory, the coefficient of book value of equity is 1, and the coefficient of earnings is 1/r, and the intercept is zero. Our regressions generate coefficients higher than these benchmarks, implying the existence of omitted correlated variables, or of measurement errors, or of both.

## 8.5 Future Research

Our study raises a number of issues for future research. First, we demonstrate that a firm's economic characteristics have a great impact on the interpretation of both

financial and non-financial performance information. Our study addresses the firm's product market status and the firm's earnings performance. Future research in this area may examine other economic characteristics such as strategy, leverage, and financial health. Second, the two measures of R&D innovation do not strongly control for several factors that affect a firm's value. These factors include: (1) differences in the economic value of drugs across firms; (2) differences in the economic value of drugs within a clinical trial phase or across clinical trial phases within a firm; (3) differences in the speed at which firms shift drugs from one clinical trial phase to the next. Speed is a critical success factor in the biotechnology industry. Future research may find a better way to control for these factors. Third, there are many other firm-specific factors that affect the firm's value, such as mergers and acquisitions, and announcements of positive or negative clinical trial results. Following such events, a firm's stock price may change significantly, especially after announcements of negative clinical results by small firms. Future research needs to find a way to incorporate mergers and acquisitions, as well as announcements of clinical trial results, into the valuation models used in our study. Finally, our findings suggest the disclosure of non-financial performance information would be mandatory. However, this disclosure should be cost-effective. Therefore, future research needs to discuss issues related to this disclosure.

# References


Abarbanell, J.S. and B.J. Bushee. (1997). Fundamental analysis, future earnings, and stock prices. *Journal of Accounting Research* 35: 1-24.

Abarbanell, J.S. and B.J. Bushee. (1998). Abnormal return to a fundamental analysis strategy. *The Accounting Review* 73: 19-45.

Abraham, T. and B. Sidhu. (1998). The role of R&D capitalization in firm valuation and performance measurement. *Australian Journal of Management* 23: 169-183.

Aboody, D. and B. Lev. (1998). The value relevance of intangibles: the case of software capitalization. *Journal of Accounting Research* 36:161-191.

Agnew, B. (2000). When pharma merges, R&D is the dowry. *Science* 287:1952-1953.

Alto, P. and J.T. Hage. (1999) Organizational innovation and organizational change. *Annual Review Sociology* 25:597-622.

Amir, E. and B. Lev. (1996). Value-relevance of non-financial information: The wireless communications industry. *Journal of Accounting and Economics* 22: 3-30.

Anthony, J. and K. Ramesh. (1992). Association between accounting performance measures and stock prices: a test of the life cycle hypothesis. *Journal of Accounting and economics* 15:203-217.

Arndt, O. and R. Sternberg. (2000). Do manufacturing firms profit from intraregional innovation linkages? An empirical based answer. *European Planning Studies* 8: 465-485.

Arnum, P.V. (2000). Is pharma M&A the key to strengthening the pipeline? *Chemical Market Reporter* 258: 3-6.

Arnum, P.V. (1999). The R&D race is on. *Chemical Market Reporter* 256:3-8.

Atkinson, A.; H. Waterhouse and R.B. Wells. (1997). A stakeholder approach to strategic performance measurement. *Sloan Management Review* 38: 25-37.

Ball, R; S. Kothari and R. Watts. (1993). Economics determinants of the relation between earnings changes and stock return. *The Accounting Review* 68:622-638.

Ball, R. and P. Brown. (1968). An empirical evaluation of accounting income numbers. *Journal of Accounting Research* 6: 159-178.

Banker, R. D.; G. Potter and D. Sirinivasan. (2000). An empirical investigation of an incentive plan that includes non-financial performance measures. *The Accounting Review* 75: 65-92.

Barth, M.; W. Beaver and W. Landsman. (1992). The market valuation implications of net periodic pension cost components. *Journal of Accounting and Economics* 15: 27-62.

Barth, M.; W. Beaver and W. Landsman. (1996). Value relevance of banks' fair value disclosure under SFAS 107. *The Accounting Review* 71: 513-537.

Barth M.; and W. Beaver and W. Landsman. (1998) Relative valuation role of equity book value and net incomes as a function of financial health. *Journal of Accounting and Economics* 25:1-34.

Barth, M. and S. Kallapur. (1996). The effects of cross-sectional scale differences on regression results in empirical accounting research. Contemporary Accounting Research 13: 527-567.

Basu, S. (1997). The conservative principle and the asymmetric timeliness of earnings. Journal of Accounting and Economics 24: 3-37.

Baum, J.A.; T. Calabrese and B.S. Silverman. (2000). Don't go it alone: Alliance network composition and stratups' performance in Canadian biotechnology. *Strategic Management Journal* 21: 267-294.

Beaver, W. and J. Demski. (1979). The nature of net income measurement. *The Accounting Review* 54: 38-46.

Beaver, W. 2002. Perspectives on recent capital market research. *The Accounting Review* 77: 453-477.

Behn, B. K. and R. A. Riley, Jr. (1999). Using non-financial information to predict financial performance: The case of the U.S. Airline Industry. *Journal of Accounting, Auditing & Finance* 14: 29-56.

Berand, V. and T. Stober. (1989). The nature of amount of information in cash flows and accruals. *The Accounting Review* 64:624-652.

Bernard, V. and J. Noel. (1991). Do inventory disclosure predict sales and earnings? *Journal of Accounting, Auditing & Finance* 6: 145-181.

Bernhard, K. L.; N. Donthu and P. A. Kennett. (2000). A longitudinal analysis of satisfaction and profitability. *Journal of Business Research* 47: 161-171.

Birchard, B. (1994). The call for the full disclosure. *CFO Magazine* 10: 31-42.

Birchard, B. (2001). Intangible assets plus hard numbers equals soft finance. *FC Learning*. 28:316-326.

Blundell, R. et al. (1999). Market shares, market value and innovation in a panel of British manufacturing. *The Review of Economic Studies* 66: 529-554.

Bonner, S. (1999). Judgement and decision-making research in accounting. *Accounting Horizons* 13:385-398.

Brown, P. and Kennelly. (1972). The information content of quarterly earnings: An extension and some further evidence. *Journal of Business* 45: 403-415.

Budd, T. (2000). Competitive technical intelligence at applied biosystems: Attracting, monitoring, and exploiting technology-based opportunities. *Competitive Intelligence Review* 11:5-11.

Campbell, J. and R. Shiller. (1988b). Stock prices, earnings, and expected dividends. *Journal of Finance* 43: 661-676.

Chambers, R.J. (1964). Measurement and objective in accounting. *The Accounting Review* April 264-274.

Chan et al. (1990). Corporate research and development expenditure and share Value. *Journal of Finance Economics* 26: 255-276.

Chang, J. (1998). A new blueprint in biotech financing. *Chemical Market Reporter* 254: FR3-FR6.

Clarysse, B. and K.Debackere. (2001). Getting an insight in the determinants of new product introductions of US biopharmaceutical start-ups. *International Journal of Biotechnology* 3:33-56.

Clayton, T. (1999). The Performance of Europe-wide businesses: Has the single market led to scale economies? *Business Strategy Review* 10: 15-19.

Clarkson et al. (2001). The market valuation of environmental capital expenditures by pulp and paper companies. Working paper. University of Waterloo.

Collins, D. and S. Kothari. (1989). An analysis of inter-temporal and cross-sectional determinants of earnings response coefficients. *Journal of Accounting and Economics* 11: 143-181.

Collins, D., E.L. Maydew and I. S. Weiss. (1997). Changes in the value relevance of earnings and book values over the past forty years. *Journal of Accounting and Economics* 24: 39-67.

Conhaim, W.W. (1999). New rules for the new economy; 10 radical strategies for a connected world. *Link-up* 16:26.

Danielson , M.G. and T. D. Dowdell. (2001). The return-stages valuation model and the expectation within a firm's P/B and P/E ratios. *Financial Management* 30: 93-124.

Dechow, P. (1994). Accounting earnings and cash flows as measures of firm performance: an empirical investigation. *Journal of Accounting and Economics* 18: 3-42.

DiMasi J.A. et al. (1991). Cost of innovation in the pharmaceutical Industry. *Journal of Health Economics* 10:107-142.

DiMasi, J.A. (1995). Success Rate for New Drug Entering Clinical Testing in the United States. *Clinical Pharmacology & Therapeutics* 58: 1-14.

Easton, P. and G. Sommers. (2002) Scale and scale effect in market-based accounting research. Working paper. Fisher College of Business, The Ohio State University.

Easton, P. (1999). Security returns and the value relevance of accounting data. *Accounting Horizons* 13: 399-412.

Easton, P. and T. Harris. (1991). Earnings as an explanatory variable for returns. *Journal of Accounting Research* 29:19-36.

Easton, P. and M. Zmijewski. (1989). Cross-sectional variation in the stock market response to accounting earnings announcements. *Journal of Accounting and Economics* 11: 117-141.

Edwards. E.O. and P. W. Bell. (1961). The theory and measurement of business income. Berkeley, Cal.: The University of California Press.

Eskildsen, J. K. and M. L. Nussler. ( 2000). The management drivers of employee satisfaction and loyalty. *Total Quality Management* 11: 581-560.

Fama, E.F. (1965). The behavior of stock market prices. *Journal of Business* January, 34-105.

Feltham, G.A. and J. Ohlson. (1995). Valuation and clean surplus accounting for operating and financial activities. *Contemporary Accounting Research* (Spring): 689-731.

Fisher, J. (1992). Use of Non-financial Performance Measures. *Cost Management* Spring 31-38.

Francis, J. and K. Schipper. (1999). Have financial statements lost their relevance? *Journal of Accounting Research* 37:319-352.

Francis, J; K. Schipper and L.Vincent. (2001). The Relevance and Incremental Information in Alternative (to Earnings) Performance Measures. Working paper, presented in 16th CAR conference.

Frederick, J. (2001). Drug giants eye biotech alliances. *Drug Store News*. 23: 24, 64.

George, G; S.A. Zajra; K.W. Wheatley and R. Khan. (2001). The effects of alliance portfolio characteristics and absorptive capacity on performance: A study of biotechnology firms. *Journal of High Technology Management Research* 12: 205-226.

Grabowski, H.L. and J. Vernon. (1994). Return to R&D on New Drug Introduction in the 1980s. *Journal of Health Economics* 13:383-406.

Gu, S. and B. Lev. (2001). Intangible Assets. Working paper.

Gupta, U. (1993). Financing small business: Strategic alliances. *Wall Street Journal* April 20 B2.

Hage, J.T. (1999). Organizational innovation and organizational change. *Annual Review of Sociology* 25: 597-622.

Hayn, C. (1995). The information content of losses. *Journal of Accounting and Economics* 20: 125-153.

Healy, P. M.; S.C. Myers and C.D. Howe. (1999). R&D Accounting and the Tradeoff Between Relevance and Objectivity. Working paper, presented at NYU Conference.

Holthausen, R.W. and R. Watts. 2001. The relevance of the value relevance literature for financial accounting standard setting. *Journal of Accounting and Economics* 31: 3-75.

Holthausen, R.W. and D.F. Larcker. (1992). The prediction of stock returns using financial statement information. *Journal of Accounting and Economics* 15: 373-411.

Ittner, C. D. and D. F. Larcker. (1998). Are nonfinancial measures leading indicators of financial performance? An analysis of customer satisfaction. *Journal of Accounting Research* 36: 1-35.

Ijiri, Y. (1967). The Foundations of accounting measurement. Englewood Cliffs, N.J.: Prentics-Hall.

Ijiri, Y. (1975). Theory of Accounting Measurement. American Accounting Association, Studies in Accounting Research #10. Chapter 4, 5, 6.

Jacobs, J. 2001. Creating a successful biotech firm. *Business Times* August 2, page 5.

Jennings, R., M. LeClere and R. B. Thompson II. ( 2001). Goodwill amortization and the usefulness of earnings. *Financial Analysts Journal* 57: 20-28.

Kaplan, R. S. and D. P. Norton. (1992). The Balanced Scorecard- Measures that drive performance. *Harvard Business Review* 70: 71-79.

Kellogg, D. and J.M. Charnes. ( 2000). Real-Option Valuation for a Biotechnology Company. *Financial Analysts Journal* May/June 76-84.

Kormendi, R. and R. Lipe. (1987). Earnings innovations, earnings persistence and stock returns. *Journal of Business* 60:323-345.

Kothari, P. and J. Zimmerman. (1995). Price and return models. *Journal of Accounting and Economics* 20: 155-192.

Lang, M. and R. Lundholm.(1996). The relation between security returns, firm earnings, and industry earnings. *Contemporary Accounting Research* 13: 607-629.

Lambert, R. A. (1998). Customer satisfaction and future financial performance: Discussion of " Are non-financial measures leading indicators of financial performance ? An analysis of customer satisfaction. *Journal of Accounting Research* 36: 37-46.

Lazer, R. and B. Lev . (2001). Internet Traffic and Portfolio Return. *Financial Analysts Journal* May/June 30-40.

Lev, B. (1989). On the usefulness of earnings and earnings research: lessons from two decades of empirical research. *Journal of Accounting Research* 27:153-201.

Lev, B. and R. Thiagarajan. (1993). Fundamental information analysis. *Journal of Accounting Research* 31: 190-215.

Lev, B. (1999). Penetrating the book to market black box: The R&D effect. *Journal of Business Finance and Accounting* 26: 419-449.

Lev, B. (1997). The old rules no longer apply. *Forbes* 7: 34-36.

Lev, B. and P. Zarowin. (1999). The boundaries of financial reporting and how to extend them. *Journal of Accounting Research* 37: 353-385.

Lipe, R. (1986). The information contained in the components of earnings. *Journal of Accounting Research* 24: 37-64.

Livnat, J. and P. Zarowin. (1990). The incremental information content of cash flow components. *Journal of Accounting and Economics* 13: 25-46.

Longoria, G. and L. G. Tresslar. ( 2000). Building long-term company value. *Mortgage Banking* 60: 102-110.

Lunzer, Francesca. (1988). Cash crisis creates biotech alliances. *High Technology Business* 8:18-24.

Miller, M.H. and F. Modigliani. 1966. Some estimates of the cost of capital to the electric utility industry, 1954-1957. *The American Economic Review* 56: 333-391.

Moorman, C. and R. J. Slotegraaf. (1999). The contingency value of complementary capabilities in product development. *Journal of Management Research* 36: 239-257.

Mitchell, G.R. (2000). Industrial R&D strategy for early 21st century. *Research Technology Management* 43: 31-35.

Nakamura, L. (1999). Intangibles: What put the new in the new economy ? *Business Review* Jul/Aug: 3-16.

Ohlson, J. (1989). Accounting earnings, book value, and dividends: The theory of the clean surplus equation. Working paper, Columbia University, March 1989a.

Ohlson, J. (1995). Earnings, book value, and dividends in equity valuation. *Contemporary Accounting Research* 11: 661-687.

Ohlson, J. and S. Penman. (1992) Disaggregated accounting data as explanatory variables for returns. *Journal of Accounting, Auditing and Finance* 7: 553-573.

Oliver, A. L. (2001). Strategic alliances and the learnings life-cycle of biotechnology firms. *Organizational Studies* 22: 467-489.

Ou, J. and S. Penman. (1989). Financial statements analysis and the prediction of stock returns. *Journal of Accounting & Economics* 11: 295-329.

Parkinson, G. (1987). How to succeed in biobusiness. *Chemical Week* 141: 46- 48.

Pietras, T. and C. Stormer. (2001). Marketing strategic alliance work. *Business and Economic Review* 47: 9-12.

Penman, S. (998). Combining earnings and book value in equity valuation. *Accounting Research* 15: No.3.

Ramakrishnan, R. and R. Thomas. (1998). Valuation of permanent, transitory, and price-irrelevant components of reported earnings. *Journal of Accounting, Auditing, and Finance* 13.

Redmond, C. (2001). Branding: Change & challenge, *Pharmaceutical Executive* 21: 58-66.

Revisine, L. (1981) The theory and measurement of business income. *Accounting Review* 56: 342-354.

Rickard, N. E. (1990). Customer satisfaction = Repeat business. *Creating customer satisfaction* edited by Bailey, EariI L. Conference Board. New York. 41-44.

Robbins-Roth, C. (2000). From Alchemy to IPO: The Business of Biotechnology. Perseus Publishing.

Rothaermel, F. T. (2001). Incumbent's advantage through exploiting complementary assets via interfirm cooperation . *Strategic Management Journal* 22:687- 699.

Scherer, F.M. (1993). Pricing profits, and technological in the Pharmaceutical Industry. *Journal of Economics Perspectives* 7: 97-115.

Scherer, F.M. (2001). The link between gross profitability and pharmaceutical spending, *Health Affairs* 20: 216-220.

Scott, W. R. (2000). Financial Accounting Theory, 2ed. Canadian Edition, Prentice Hall Canada Inc.

Sougiannis, T. (1994). The accounting based valuation of corporate R&D. *The Accounting Review* 44-68.

Spalding, B.J. (1988). Biotech steps closer to profitability. *Chemical Weeks* 143: 37.

Sparks, D. (1999). Partners. *Business Week.* Oct 25. 106.

Stober, Thomas L. (1993). The information content of receivables in predicting sales, earnings, and profit margins. *Journal of Accounting and Economics* 8: 447-473.

Szeto, E. (2000). Innovation capacity: working towards a mechanism for improving innovation within an inter-organizational network. The TQM magazine 12: 149.

Tapon, F.; M.Thong; M. Bartell. (2001). Drug discovery and development in four Canadian biotechnology companies. *R&D management* 31: 77-90.

Thayer, A. M. (1993). Biotechnology industry looks to more creative financing options. *Chemical & Engineering News* 71: 10-14.

Whelan, Jo. (2001). Partnerships in drug discovery. *Pharmaceutical Technology* Supplement : Outsourcing Resources for the Pharmaceutical industry 28-34.

Wilkinson, I. And L. Young. (2001). On cooperating: Firms, relations and networks. *Journal of Business Research*. 55: 123-132.

Zhen, D. and B. Lev and F. Narin. (1999). Science and technology as predictors of stock performance. *Financial Analysts Journal* 55: 20-32.

Biotech / Broadcasting & Cable. *Forbes* May 21, 2001. 074.

Table 1 Descriptive Statistics

Panel A: Price-earnings model

| Variables | Mean | | | | Std Dev | | | | Minimum | | | | Maximum | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 98 | 99 | 00 | 01 | 98 | 99 | 00 | 01 | 98 | 99 | 00 | 01 | 98 | 99 | 00 | 01 |
| MV | 3.825 | 8.070 | 11.534 | 4.415 | 4.008 | 11.596 | 13.413 | 3.775 | 0.213 | 0.111 | 0.092 | 0.065 | 25.046 | 82.481 | 73.116 | 29.637 |
| BV | 0.656 | 0.835 | 1.827 | 0.691 | 0.499 | 0.993 | 2.280 | 0.713 | -0.664 | -1.402 | -2.478 | -4.048 | 3.284 | 7.072 | 13.120 | 5.510 |
| BV*DBV | -0.012 | -0.027 | -0.008 | -0.058 | 0.065 | 0.147 | 0.547 | 0.331 | -0.664 | -1.402 | -2.478 | -4. 048 | 0 | 0.084 | 8.133 | 0 |
| EARN | -0.012 | -0.013 | -0.024 | 0.412 | 0.261 | 0.348 | 0.451 | 0.412 | -0.955 | -1.646 | -1.837 | -4.512 | 0.816 | 1.734 | 2.388 | 1.070 |
| EARN*DE | -0.106 | -0.127 | -0.161 | -0.124 | 0.174 | 0.229 | 0.301 | 0.361 | -0.955 | -1.646 | -1.83 | -4.512 | 0 | 0 | 0 | 0 |
| RD | 0.358 | 0.424 | 0.561 | 0.331 | 0.255 | 0.324 | 0.646 | 0.330 | 0.006 | 0.008 | -0.005 | 0 | 1.372 | 1.638 | 5.364 | 2.184 |
| PRE | 0.590 | 0.824 | 0.785 | 0.738 | 1.506 | 1.593 | 1.493 | 1.488 | 0 | 0 | 0 | 0 | 1 | 16 | 16 | 16 |
| IND | 0.350 | 0.256 | 0.233 | 0.145 | 0.708 | 0.650 | 0.625 | 0.446 | 0 | 0 | 0 | 0 | 1 | 4 | 4 | 3 |
| PI | 1.500 | 1.367 | 1.218 | 1.116 | 2.127 | 1.928 | 1.792 | 1.712 | 0 | 0 | 0 | 0 | 1 | 10 | 8 | 9 |
| PII | 1.127 | 1.209 | 1.191 | 1.171 | 1.907 | 2.068 | 2.080 | 2.066 | 0 | 0 | 0 | 0 | 1 | 15 | 14 | 15 |
| PIII | 0.568 | 0.671 | 0.612 | 0.641 | 1.204 | 1.276 | 1.205 | 1.208 | 0 | 0 | 0 | 0 | 1 | 10 | 10 | 10 |
| FDA | 0.336 | 0.278 | 0.263 | 0.261 | 0.924 | 0.714 | 0.648 | 0.658 | 0 | 0 | 0 | 0 | 1 | 4 | 4 | 4 |
| ALLIANCE | 0.068 | 0.095 | 0.146 | 0.057 | 0.148 | 0.261 | 0.396 | 0.148 | 0 | 0 | 0 | 0 | 1.476 | 3.144 | 3.906 | 1.552 |
| TOTAL ASSET | 830.3 | 978.3 | 1087.2 | 1466.1 | 3732.1 | 4163.3 | 4592.8 | 5753.4 | 1.034 | 0.249 | 0.488 | 0.249 | 31853.4 | 35634.9 | 39910.4 | 44705.6 |
| N of Obs. | 220 | 234 | 266 | 268 | | | | | | | | | | | | |

Panel B: Return-earnings model

| Variables | Mean | | | | Std Dev | | | | Minimum | | | | Maximum | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 99 | 00 | 01 | Pooled | 99 | 00 | 01 | Pooled | 99 | 00 | 01 | Pooled | 99 | 00 | 01 | Pooled |
| CMV | 3.643 | 4.463 | -0.207 | 2.505 | 8.489 | 10.991 | 3.052 | 8.324 | -7.257 | -39.741 | -18.921 | -39.741 | 47.190 | 67.908 | 12.972 | 67.908 |
| CBV | 0.119 | 0.935 | 0.005 | 0.345 | 0.865 | 1.935 | 0.465 | 1.305 | -2.450 | -1.515 | -1.753 | -2.450 | 6.481 | 12.193 | 2.988 | 12.193 |
| CEARN | 0.050 | 0.064 | -0.556 | -0.166 | 0.352 | 0.335 | 8.610 | 5.213 | -1.241 | -1.238 | -137.3 | -137.388 | 1.759 | 1.952 | 1.422 | 1.952 |
| CRD | 0.011 | 0.064 | 0.030 | 0.035 | 0.231 | 0.347 | 0.269 | 0.288 | -0.931 | -1.770 | -1.557 | -1.770 | 0.893 | 2.413 | 1.515 | 2.413 |
| SPRE | 0.369 | 0.065 | 0.015 | 0.140 | 0.698 | 0.265 | 0.124 | 0.448 | 0 | 0 | 0 | 0 | 3 | 2 | 1 | 3 |
| PI-IND | 0.135 | 0.052 | 0.007 | 0.061 | 0.417 | 0.291 | 0.088 | 0.294 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 3 |
| IND-PI | 0.261 | 0.082 | 0.086 | 0.138 | 0.570 | 0.306 | 0.308 | 0.414 | 0 | 0 | 0 | 0 | 4 | 2 | 2 | 4 |
| PI-PII | 0.668 | 0.227 | 0.149 | 0.333 | 1.262 | 0.538 | 0.445 | 0.839 | 0 | 0 | 0 | 0 | 8 | 3 | 2 | 8 |
| PII-PIII | 0.406 | 0.174 | 0.152 | 0.237 | 0.887 | 0.473 | 0.439 | 0.629 | 0 | 0 | 0 | 0 | 6 | 3 | 3 | 6 |
| PIII-FDA | 0.074 | 0.074 | 0.043 | 0.063 | 0.312 | 0.348 | 0.203 | 0.291 | 0 | 0 | 0 | 0 | 3 | 3 | 1 | 3 |
| FDA-M | 0.093 | 0.043 | 0.031 | 0.054 | 0.494 | 0.204 | 0.215 | 0.325 | 0 | 0 | 0 | 0 | 6 | 1 | 2 | 6 |
| N of Obs. | 214 | 229 | 255 | 698 | | | | | | | | | | | | |

Table 2 Correlations in Price –Earnings Model

Panel A: 1998

| | MV | BV | BV*DBV | EARN | EARN*DE | RD | DUMPRE | DUMIND | DUMPI | DUMPII | DUMPIII | DUMFDA | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MV | 1 | | | | | | | | | | | | |
| BV | 0.4123*** | 1 | | | | | | | | | | | |
| BV*DBV | 0.0206 | 0.3933*** | 1 | | | | | | | | | | |
| EARN | 0.1063*** | 0.3132*** | 0.1094*** | 1 | | | | | | | | | |
| EARN*DE | -0.0328 | 0.2533*** | 0.1909*** | 0.8858*** | 1 | | | | | | | | |
| RD | 0.1869*** | -0.015 | -0.2370*** | -0.0799 | -0.1368*** | 1 | | | | | | | |
| DUMPRE | 0.099 | 0.007 | -0.0312 | 0.0013 | -0.0275 | 0.1944*** | 1 | | | | | | |
| DUMIND | 0.1056* | 0.1086* | -0.0373 | 0.1499*** | 0.1366*** | 0.1569*** | 0.2769*** | 1 | | | | | |
| DUMPI | -0.0053 | -0.0882 | -0.1061* | 0.0067 | -0.0226 | 0.2285*** | 0.4243*** | 0.3092*** | 1 | | | | |
| DUMPII | -0.0245 | -0.1039* | 0.0027 | -0.0432 | -0.0570 | 0.1944*** | 0.3564*** | 0.3346*** | 0.5631*** | 1 | | | |
| DUMPIII | 0.1243*** | -0.0868 | -0.1502** | 0.0332 | 0.0149 | 0.1420*** | 0.2962*** | 0.2209*** | 0.3737*** | 0.3702*** | 1 | | |
| DUMFDA | 0.2196*** | -0.1138** | -0.0786 | 0.0362 | 0.0111 | -0.03625 | 0.1951*** | 0.037 | 0.3002*** | 0.2147*** | 0.2487*** | 1 | |
| ALLIANCE | 0.1738*** | 0.0885 | 0.0022 | -0.2689*** | -0.3091*** | 0.1478*** | -0.0279 | -0.0651 | -.00651 | -0.0391 | -0.02356 | -0.1070* | 1 |

Panel B: 1999

| | MV | BV | BV*DBV | EARN | EARN*DE | RD | DUMPRE | DUMIND | DUMPI | DUMPII | DUMPIII | DUMFDA | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MV | 1 | | | | | | | | | | | | |
| BV | 0.549*** | 1 | | | | | | | | | | | |
| BV*DBV | -0.0438 | 0.3064*** | 1 | | | | | | | | | | |
| EARN | -0.0422 | 0.1411*** | 0.2308*** | 1 | | | | | | | | | |
| EARN*DE | -0.1813*** | 0.0822 | 0.2738*** | 0.8401*** | 1 | | | | | | | | |
| RD | 0.3676*** | 0.1577*** | -0.2358*** | -0.1265*** | -0.2385*** | 1 | | | | | | | |
| DUMPRE | 0.0406 | -0.0181 | -0.0877 | -0.0409 | 0.0096 | 0.2777*** | 1 | | | | | | |
| DUMIND | 0.1703*** | 0.0195 | 0.0195 | 0.0139 | -0.0638 | 0.1515*** | 0.3102*** | 1 | | | | | |
| DUMPI | 0.1071* | 0.0301 | 0.0301 | 0.0219 | 0.0040 | 0.2269*** | 0.5474*** | 0.3524*** | 1 | | | | |
| DUMPII | 0.0895 | -0.0069 | -0.0069 | 0.0065 | 0.0695 | 0.2229*** | 0.4528*** | 0.3378*** | 0.5443*** | 1 | | | |
| DUMPIII | 0.1693*** | 0.0135 | 0.0135 | 0.0662 | 0.0808 | 0.2178*** | 0.3665*** | 0.2976*** | 0.3287*** | 0.3750*** | 1 | | |
| DUMFDA | 0.066 | -0.0439 | -0.0439 | 0.0085 | 0.0163 | -0.0191 | 0.2300*** | 0.1359*** | 0.2490*** | 0.2124*** | 0.2866*** | 1 | |
| ALLIANCE | 0.1915*** | 0.1177** | 0.1177** | -0.1502*** | -0.2995*** | 0.2149*** | -0.0455 | -0.0601 | 0.1251*** | -0.0120 | -0.0399 | -0.0897 | 1 |

Table 2 Correlations in Price –Earnings Model (Cont)

Panel C: 2000

| | MV | BV | BV*DBV | EARN | EARN*DE | RD | DUMPRE | DUMIND | DUMPI | DUMPII | DUMPIII | DUMFDA | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MV | 1 | | | | | | | | | | | | |
| BV | 0.6981*** | 1 | | | | | | | | | | | |
| BV*DBV | 0.2031*** | 0.2510*** | 1 | | | | | | | | | | |
| EARN | -0.0319 | -0.0658 | -0.1619*** | 1 | | | | | | | | | |
| EARN*DE | -0.2294*** | -0.2023*** | -0.2486*** | 0.8305*** | 1 | | | | | | | | |
| RD | 0.4435*** | 0.4150*** | 0.3867*** | -0.1974*** | -0.3785*** | 1 | | | | | | | |
| DUMPRE | 0.1427*** | 0.0403 | -0.0441 | 0.0437 | 0.0273 | 0.1549*** | 1 | | | | | | |
| DUMIND | 0.1226*** | 0.0511 | -0.0249 | 0.0532 | 0.1172*** | 0.0652 | 0.2965*** | 1 | | | | | |
| DUMPI | 0.087 | -0.0482 | -0.0655 | 0.2092*** | 0.1474*** | 0.0678 | 0.5308*** | 0.2807*** | 1 | | | | |
| DUMPII | 0.0542 | 0.0028 | -0.0533 | 0.0674 | 0.0748 | 0.0352 | 0.4896*** | 0.3080*** | 0.4621*** | 1 | | | |
| DUMPIII | 0.0465 | -0.0187 | -0.0378 | 0.0077 | 0.0570 | 0.0640 | 0.3694*** | 0.1915 | 0.3089*** | 0.3714*** | 1 | | |
| DUMFDA | 0.1205*** | 0.0018 | -0.0223 | 0.1600*** | 0.1338*** | -0.0172 | 0.2729*** | 0.1453*** | 0.2706*** | 0.1849*** | 0.2842*** | 1 | |
| ALLIANCE | 0.1799*** | 0.0843 | -0.0760 | -0.2630 | -0.4105*** | 0.2838*** | 0.0020 | -0.0671 | 0.0552 | -0.0368 | -0.0391 | -0.1177*** | 1 |

Panel D: 2001

| | MV | BV | BV*DBV | EARN | EARN*DE | RD | DUMPRE | DUMIND | DUMPI | DUMPII | DUMPIII | DUMFDA | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MV | 1 | | | | | | | | | | | | |
| BV | 0.2694*** | 1 | | | | | | | | | | | |
| BV*DBV | -0.0635 | 0.6515*** | 1 | | | | | | | | | | |
| EARN | -0.0269 | 0.1427*** | 0.0979* | 1 | | | | | | | | | |
| EARN*DE | -0.0986* | 0.1693*** | 0.1710*** | 0.9461*** | 1 | | | | | | | | |
| RD | 0.3194*** | -0.0197 | -0.1913*** | -0.1503*** | -0.2132*** | 1 | | | | | | | |
| DUMPRE | 0.0334 | 0.0112 | -0.0375 | 0.0547 | 0.0497 | 0.1164*** | 1 | | | | | | |
| DUMIND | 0.0537 | 0.0009 | -0.0277 | 0.0217 | 0.0132 | 0.0775 | 0.2341*** | 1 | | | | | |
| DUMPI | 0.0599 | 0.0235 | -0.0536 | 0.0187 | 0.0218 | 0.1916*** | 0.3545*** | 0.1690*** | 1 | | | | |
| DUMPII | 0.0442 | 0.0151 | -0.0450 | 0.1276 | 0.1351 | 0.0347 | 0.4468*** | 0.2643*** | 0.3770*** | 1 | | | |
| DUMPIII | 0.1078*** | -0.0335 | -0.0582 | 0.0233 | 0.0155 | 0.090* | 0.4048*** | 0.1372*** | 0.3006*** | 0.3839*** | 1 | | |
| DUMFDA | 0.1253*** | 0.0013 | -0.0017 | 0.0939* | 0.09233* | -0.02811 | 0.2421*** | 0.1307*** | 0.1470*** | 0.2293*** | 0.1820*** | 1 | |
| ALLIANCE | 0.0925* | -0.4438*** | -0.6856*** | -0.2762*** | -0.3653*** | 0.2211*** | -0.010 | -0.0217 | 0.0751 | -0.0532 | -0.0376 | 0.0858 | 1 |

Table 3 Correlations in Return-Earnings Model

Panel A: 1998-1999

| | CMV | CBV | CEARN | CRD | SPRE | P-IND | IND-PI | PI-PII | PII-PIII | PIII-FDA | FDA-M | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CMV | 1 | | | | | | | | | | | |
| CBV | 0.4523*** | 1 | | | | | | | | | | |
| CEARN | 0.0480 | -0.0110 | 1 | | | | | | | | | |
| CRD | 0.1697*** | 0.1773*** | -0.3237*** | 1 | | | | | | | | |
| SPRE | 0.0330 | 0.0790 | -0.1000* | 0.2399*** | 1 | | | | | | | |
| P-IND | 0.2026*** | 0.1375*** | 0.0186 | 0.1135** | 0.2548*** | 1 | | | | | | |
| IND-PI | 0.1198** | 0.2011*** | -0.0318 | 0.1255*** | 0.3635*** | 0.3980*** | 1 | | | | | |
| PI-PII | 0.1548*** | 0.1010* | -0.0221 | 0.1633*** | 0.4211*** | 0.1857*** | 0.3121*** | 1 | | | | |
| PII-PIII | 0.0962 | 0.0161 | -0.0470 | 0.0852 | 0.4109*** | 0.1639*** | 0.2448*** | 0.3046*** | 1 | | | |
| PIII-FDA | 0.2547*** | 0.0547 | -0.1191** | 0.0839 | 0.2680*** | 0.2653*** | 0.2344*** | 0.2515*** | 0.3561*** | 1 | | |
| FDA-M | 0.0682 | 0.0310 | 0.0957 | 0.0795 | 0.2450*** | 0.1576*** | 0.2528*** | 0.1915*** | 0.0977* | 0.2491*** | 1 | |
| ALLIANCE | 0.1336*** | 0.0524 | 0.0773 | 0.0313 | -0.0411 | 0.0007 | -0.0628 | -0.0548 | -0.0479 | -0.04304 | -0.0744 | 1 |

Panel B: 1999-2000

| | CMV | CBV | CEARN | CRD | SPRE | P-IND | IND-PI | PI-PII | PII-PIII | PIII-FDA | FDA-M | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CMV | 1 | | | | | | | | | | | |
| CBV | 0.5405*** | 1 | | | | | | | | | | |
| CEARN | 0.1026* | 0.1688*** | 1 | | | | | | | | | |
| CRD | 0.1996*** | 0.3162*** | -0.0235 | 1 | | | | | | | | |
| SPRE | 0.0242 | 0.0345 | -0.0338 | 0.0721 | 1 | | | | | | | |
| P-IND | 0.0410 | 0.0661 | -0.0388 | 0.0214 | 0.2298*** | 1 | | | | | | |
| IND-PI | 0.1597*** | 0.0495 | -0.0005 | 0.0142 | 0.0736 | 0.3853*** | 1 | | | | | |
| PI-PII | 0.1438*** | 0.1278 | 0.0777 | 0.1234*** | 0.1126*** | 0.2029*** | 0.0994* | 1 | | | | |
| PII-PIII | 0.0893 | 0.0969* | 0.0460 | 0.0848 | -0.0502 | 0.0481 | 0.0377 | 0.1463*** | 1 | | | |
| PIII-FDA | 0.0589 | 0.1598*** | 0.0718 | 0.1356*** | 0.0217 | -0.0475 | 0.0124 | 0.0982* | 0.1878*** | 1 | | |
| FDA-M | 0.0073*** | -0.0284 | -0.0547 | -0.0357 | -0.0545 | -0.0432 | -0.0585 | 0.1268*** | 0.2220*** | 0.0456 | 1 | |
| ALLIANCE | 0.1031** | 0.0841 | 0.0565 | -0.0701 | 0.0030 | -0.0506 | -0.0784 | -0.0119 | -0.0515 | 0.0243 | -0.0692 | 1 |

Table 3 Correlations in Return-Earnings Model (Cont)

Panel C: 2000-2001

| | CMV | CBV | CEARN | CRD | SPRE | P-IND | IND-PI | PI-PII | PII-PIII | PIII-FDA | FDA-M | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CMV | 1 | | | | | | | | | | | |
| CBV | 0.3579*** | 1 | | | | | | | | | | |
| CEARN | -0.0343 | 0.0121 | 1 | | | | | | | | | |
| CRD | 0.2101*** | 0.2934*** | -0.099 | 1 | | | | | | | | |
| SPRE | 0.0243*** | 0.0245 | 0.0091 | 0.000 | 1 | | | | | | | |
| P-IND | 0.0690 | 0.0730 | 0.0053 | -0.0121 | -0.0112 | 1 | | | | | | |
| IND-PI | 0.0692 | 0.0364 | 0.0180 | -0.0099 | 0.0805 | 0.1394*** | 1 | | | | | |
| PI-PII | -0.0445 | 0.0363 | 0.0255 | -0.0554 | 0.0541 | 0.1081*** | 0.0333 | 1 | | | | |
| PII-PIII | 0.1526*** | 0.0927* | 0.0254 | -0.0049 | 0.2334*** | 0.0981* | 0.3220 | 0.1562*** | 1 | | | |
| PIII-FDA | 0.0657 | 0.1485 | -0.2940*** | 0.0429 | -0.0268 | 0.1999*** | 0.0816 | 0.0455 | 0.0906* | 1 | | |
| FDA-M | 0.0208 | 0.0384 | 0.0106 | -0.1689*** | 0.1886 | -0.0138 | 0.0509 | -0.0556 | 0.0943* | 0.2217*** | 1 | |
| ALLIANCE | -0.0314 | -0.2432*** | 0.0150 | -0.0477 | -0.0206 | -0.0267 | -0.0629 | -0.0626 | -0.0603 | -0.0269 | -0.0448 | 1 |

Panel D: Pooled

| | CMV | CBV | CEARN | CRD | SPRE | P-IND | IND-PI | PI-PII | PII-PIII | PIII-FDA | FDA-M | ALLIANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CMV | 1 | | | | | | | | | | | |
| CBV | 0.5152*** | 1 | | | | | | | | | | |
| CEARN | 0.0103 | 0.0192 | 1 | | | | | | | | | |
| CRD | 0.1795*** | 0.2710*** | -0.010 | 1 | | | | | | | | |
| SPRE | 0.0728*** | 0.0159 | 0.0111 | 0.0902*** | 1 | | | | | | | |
| P-IND | 0.1422*** | 0.0688*** | 0.0093 | 0.0386 | 0.2806*** | 1 | | | | | | |
| IND-PI | 0.1255*** | 0.0492 | 0.0131 | 0.0293 | 0.2931*** | 0.3676*** | 1 | | | | | |
| PI-PII | 0.1460*** | 0.0796*** | 0.0224 | 0.3324*** | 0.3324*** | 0.2114*** | 0.2187*** | 1 | | | | |
| PII-PIII | 0.1021*** | 0.0495 | 0.0174 | 0.0480 | 0.2619*** | 0.1307*** | 0.2293*** | 0.2341*** | 1 | | | |
| PIII-FDA | 0.1284 | 0.1078*** | -0.1600*** | 0.0883*** | 0.1450*** | 0.1507*** | 0.1338*** | 0.1517*** | 0.2258*** | 1 | | |
| FDA-M | 0.0464 | 0.0022 | 0.0099 | -0.0364 | 0.1595*** | 0.0837*** | 0.1263*** | 0.1277*** | 0.1438*** | 0.1750*** | 1 | |
| ALLIANCE | 0.1234*** | 0.090*** | 0.0141 | -0.0339 | -0.01526 | -0.01906 | -0.0661** | -0.0286 | -0.0486 | -0.00464 | -0.0585* | 1 |

Table 4 Value Relevance of Financial Information

$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV_{jt} + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \varepsilon_{jt}$

| | 1998 | | 1999 | | 2000 | | 2001 | | Pooled | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No control for signs | Control for signs | No control for signs | Control for signs | No control for signs | Control for signs | No control for signs | Control for signs | No control for signs | Control for signs |
| Intercept | 1.607 | .106 | 2.485 | -.476 | 4.031 | 2.323 | 3.368 | 1.645 | .861 | -.242 |
| | (.000) | (.836) | (.003) | (.622) | (.000) | (.007) | (.000) | (.000) | (.095) | (.642) |
| **BV** | **3.373** | **3.698** | **6.617** | **7.039** | **4.112** | **3.806** | **1.476** | **2.813** | **4.512** | **4.853** |
| | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** | **(.000)** |
| BV*DBV | | -9.035 | | -14.079 | | -.0765 | | -4.050 | | -7.207 |
| | | (.024) | | (.002) | | (.945) | | (.000) | | (.000) |
| **EARN** | **-.388** | **6.966** | **-4.076** | **7.561** | **.420** | **8.858** | **-.612** | **4.631** | **-.851** | **4.237** |
| | **(.698)** | **(.001)** | **(.027)** | **(.1017)** | **(.750)** | **(.000)** | **(.546)** | **(.004)** | **(.232)** | **(.001)** |
| EARN*DE | | -11.992 | | -18.831 | | -15.362 | | -6.324 | | -8.123 |
| | | (.000) | | (.000) | | (.000) | | (.001) | | (.000) |
| Adj. $R^2$ (%) | 16.3 | 23.8 | 31.1 | 38.7 | 48.4 | 51.5 | 7.0 | 20.0 | 40.3 | 45.5 |
| $R^2$ change (%) | | 7.5 | | 7.6 | | 3.1 | | 13.0 | | 5.2 |
| | | (.000) | | (.000) | | (.000) | | (.000) | | (.000) |

Notes: For each variable, the number not in brackets is the regression coefficient. The number in brackets is the p-value (two-tailed) from White's adjusted t statistic. $R^2$ change is the difference in Adj $R^2$ between the regression that controls for the signs and one that does not control for the signs. P-value below $R^2$ change indicates the significance of the change in Adj. $R^2$. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets. Earnings is defined as earnings before extraordinary items and R&D expenditures; DBV is a dummy variable, one if the firm's book value of equity is negative, zero otherwise; DE is a dummy variable, one if the firm's earnings before extraordinary items and R&D expenditure is negative, zero otherwise.

Table 5 Effect of a Firm's Product Market Status on the Value Relevance of Financial Information

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DM + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DM + \varepsilon_{jt}$$

| | 1998 | | 1999 | | 2000 | | 2001 | | Pooled | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No control for market status | Control for market status | No control for market status | Control for market state | No control for market status | Control for market status | No control for market status | Control for market status | No control | Control |
| Intercept | 1.607 | 1.422 | 2.485 | 1.646 | 4.031 | 3.64 | 3.368 | 3.273 | 2.305 | .675 |
| | (.000) | (.001) | (.003) | (.036) | (.000) | (.000) | (.000) | (.000) | (.000) | (.174) |
| BV | 3.373 | 3.223 | 6.617 | 5.906 | 4.112 | 3.876 | 1.476 | 1.352 | 4.651 | 4.229 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| BV*DM | | 1.881 | | 6.680 | | 3.087 | | 1.212 | | 3.400 |
| | | (.065) | | (.000) | | (.000) | | (.099) | | (.000) |
| EARN | -.388 | -2.191 | -4.076 | -7.684 | .420 | -.374 | -.612 | -.859 | -.856 | -2.255 |
| | (.698) | (.039) | (.027) | (.000) | (.750) | (.788) | (.264) | (.129) | (.237) | (.003) |
| EARN*DM | | 7.275 | | 8.786 | | -2.131 | | 1.290 | | 3.314 |
| | | (.006) | | (.072) | | (.574) | | (.580) | | (.075) |
| Adj.$R^2$ (%) | 16.3 | 22.7 | 31.1 | 40.6 | 48.4 | 51.8 | 7.0 | 8.0 | 38.4 | 44.7 |
| $R^2$ change | | 6.4 | | 9.5 | | 3.4 | | 1.0 | | 6.3 |
| | | (.000) | | (.000) | | (.000) | | (.138) | | (.000) |

Notes: For each variable, the number not in brackets is the regression coefficient. The number in brackets is the p-value (two-tailed) from White's adjusted t statistic. $R^2$ change is the difference in Adj $R^2$ between the regression that controls for the market status and one that does not control for the market status. P-value below $R^2$ change indicates the significance of the change in Adj. $R^2$. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets. Earnings is defined as earnings before extraordinary items and R&D expenditures; DM is a dummy variable, one if the firm has products in the market, zero otherwise.

# Table 6 Effect of Changes in Financial and Non-Financial Information on Stock Return

$CMV_{jt}=\beta_1+ \beta_2 CBVjt +\beta_3 CEARN_{jt\ t} +\beta_4 CRD_{jt} +\beta_5 DSPRE_{jt} +\beta_6 DPIND_{jt} +\beta_7 DINDPI_{jt} +\beta_8 DPIPII_{jt}+\beta_9 DPIIPIII_{jt}$
$+\beta_{10} DPIIIFDA_{jt} +\beta_{11} DFDAM_{jt} +\beta_{12} ALLIANCE_{jt} + \varepsilon_{jt}$

| | Regression Coefficients | | | |
|---|---|---|---|---|
| | 1998-1999 | 1999-2000 | 2000-2001 | Pooled Sample |
| Intercept | 2.201 | .132 | -.285 | .346 |
| | (.004) | (.880) | (.187) | (.354) |
| **CBV** | **4.076** | **2.825** | **2.059** | **2.989** |
| | **(.000)** | **(.000)** | **(.000)** | **(.000)** |
| CEARN | 2.507 | -.441 | -.848 | -.022 |
| | (.105) | (.815) | (.060) | (.976) |
| CRD | 4.303 | .806 | 2.31 | .962 |
| | (.075) | (.666) | (.738) | (.329) |
| DSPRE | -2.651 | .673 | -.223 | -1.385 |
| | (.062) | (.798) | (.867) | (.164) |
| DPIND | 2.704 | -4.468 | 1.400 | 1.894 |
| | (.132) | (.207) | (.428) | (.157) |
| DINDPI | -1.134 | 6.481 | .122 | 1.220 |
| | (.436) | (.013) | (.846) | (.187) |
| DPIPII | 1.557 | 1.358 | -.711 | .941 |
| | (.201) | (.427) | (.167) | (.193) |
| DPIIPIII | .573 | 1.058 | 1.195 | .679 |
| | (.680) | (.567) | (.025) | (.382) |
| DPIIIFDA | 7.605 | -2.897 | -.146 | 1.397 |
| | (.001) | (.293) | (.852) | (.268) |
| DFDAM | -.272 | -.123 | -.022 | .440 |
| | (.905) | (.969) | (.984) | (.747) |
| ALLIANCE | .272 | .884 | -1.298 | .364 |
| | (.504) | (.017) | (.819) | (.031) |
| Adj. $R^2$ in the regression with Financial information only | 20.0 | 28.6 | 14.2 | 29.1 |
| $R^2$ change (p-value) by | | | | |
| R&D | 0.9 (.061) | -0.2 (.577) | -0.3 (.641) | 0.0 (.250) |
| Drug portfolios | 5.4 (.003) | 0.6 ( .156) | 0.4 (.327) | 0.8 (.036) |
| Business Relations | -0.2 (.504) | 1.6 (.017) | -0.4 (.819) | 0.4 (.031) |
| Total Adj.$R^2$ | 26.1 | 30.6 | 13.9 | 30.3 |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value (two-tailed) from White's adjusted t statistic. $R^2$ change by R&D intensity is the difference in Adj. $R^2$ between the regression model with financial information and R&D intensity and one with only financial information. $R^2$ change by drug portfolios is the difference in Adj. R2 between regression model with financial information, R&D intensity and drug portfolios and one with only financial information and R&D intensity. $R^2$ change by business relation is the difference in Adj. R2 between regression model with financial information , R&D intensity , drug portfolios and business relations and one with only financial information, R&D intensity and drug portfolios. CMVjt is the change in firms' market value from t-1 to t, deflated by beginning total assets of period t; CBVjt is the change in firms' book value of equity from t-1 to t, deflated by beginning total assets of period t; CEARN is the change in firms' annual earnings before extraordinary items and R&D expenditure from t-1 to t, deflated by beginning total assets of period t; CRDjt is the change in R&D expenditures from t-1 to t, deflated by beginning total assets of period t; DSPRE is a dummy variable, one if firms start new pre-clinical trials during the period t, 0 otherwise; DPIND is a dummy variable, one if firms have drugs moving from pre-clinical trials to FDA approval of investigational new drug application (IND process), 0 otherwise; DINDPI is a dummy variable, one if firms have drugs moving from IND process to PI trials, 0 otherwise; DPIPII is a dummy variable, one if firms have drugs moving from PI trials to PII trials, 0 otherwise; DPIIPIII is a dummy variable, one if firms have drugs moving from PII trials to PIII trials, 0 otherwise; DPIIIFDA is a dummy variable, one if firms have drugs moving from PIII trials to FDA approval process, 0 otherwise; DFDAM is a dummy variable, one if firms have drugs moving from FDA approval process to the market, 0 otherwise; ALLIANC is the number of new alliances under which companies work as researchers for the period from t-1 to t.

Table 7 Value Relevance of R&D Intensity Over Financial Information

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 RD_{jt} + \varepsilon_{jt}$$

| | 1998 | | 1999 | | 2000 | | 2001 | | Pooled | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Financial information | R&D included | Financial information | R&D included | Financial information | R&D included | Financial information | R&D included | Financial Information | R&D Included |
| Intercept | .106 | -.473 | -.476 | -2.523 | 2.323 | 1.472 | 1.645 | 1.094 | -.242 | -.6108 |
| | (.836) | (.408) | (.622) | (.021) | (.007) | (.100) | (.000) | (.007) | (.642) | (.1769) |
| BV | 3.698 | 3.590 | 7.039 | 6.478 | 3.806 | 3.557 | 2.813 | 2.582 | 4.853 | 4.644 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| BV*DBV | -9.035 | -6.893 | -14.079 | -9.990 | -.0765 | -.832 | -4.050 | -3.371 | -7.207 | -6.482 |
| | (.024) | (.090) | (.002) | (.025) | (.945) | (.464) | (.000) | (.000) | (.000) | (.000) |
| EARN | 6.966 | 6.600 | 7.561 | 6.260 | 8.858 | 7.708 | 4.631 | 3.847 | 4.237 | 3.628 |
| | (.001) | (.001) | (.107) | (.2041) | (.000) | (.001) | (.004) | (.014) | (.001) | (.0575) |
| EARN*DE | -11.992 | -11.160 | -18.831 | -15.259 | -15.362 | -12.135 | -6.324 | -4.989 | -8.123 | -6.753 |
| | (.000) | (.000) | (.000) | (.002) | (.000) | (.001) | (.001) | (.006) | (.000) | (.0136) |
| **RD** | | **2.122** | | **7.212** | | **3.189** | | **2.666** | | **2.320** |
| | | **(.028)** | | **(.000)** | | **(.003)** | | **(.000)** | | **(.0218)** |
| Adj.$R^2$ | 23.8 | 25.2 | 38.7 | 41.9 | 51.5 | 52.9 | 20.0 | 24.7 | 45.5 | 46.3 |
| $R^2$ change | | 1.4 | | 3.2 | | 1.4 | | 4.7 | | 0.8 |
| | | (.000) | | (.000) | | (.031) | | (.000) | | (.000) |

Notes: For each variable, the number not in brackets is the regression coefficients. The numbers in brackets are p-value (two-tailed) from White's adjusted t statistic. $R^2$ change is the difference in Adj $R^2$ between the regression that includes R&D intensity as a separate independent variable and one that does not include R&D intensity. P-value below $R^2$ change indicates the significance of the change in Adj. $R^2$. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t.

# Table 8 Value Relevance of Information on Drug Portfolios

$MV_{jt}=\beta_1+\beta_2 BV_{jt}+\beta_3 BV_{jt}*DBV_{jt}+\beta_4 EARN_{jt}+\beta_5 EARN_{jt}*DE_{jt}+\beta_6 RD_{jt}+\beta_7 DPRE_{jt}+\beta_8 DIND_{jt}+\beta_9 DPIjt+\beta_{10} DPII_{jt}+\beta_{11} DPIII_{jt}+\beta_{12} DFDA_{jt}+\varepsilon_{jt}$

| Panel A: | Regression model with both Financial information and drug portfolios | | | | | Panel B: | Regression model with financial information, R&D intensity and drug portfolios | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 2001 | Pooled | 1998 | 1999 | 2000 | 2001 | Pooled |
| Intercept | -.311 | -1.982 | .308 | 1.267 | -1.169 | -.873 | -3.242 | -.128 | .793 | -1.665 |
| | (.000) | (.091) | (.770) | (.004) | (.0127) | (.137) | (.000) | (.904) | (.073) | (.004) |
| BV | 3.825 | 6.955 | 3.752 | 2.832 | 4.872 | 3.692 | 6.453 | 3.554 | 2.617 | 4.685 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| BV*DBV | -7.218 | -11.824 | .174 | -4.014 | -6.792 | -4.653 | -8.664 | -.602 | -3.377 | -6.111 |
| | (.064) | (.009) | (.873) | (.000) | (.000) | (.236) | (.053) | (.593) | (.000) | (.000) |
| EARN | 6.197 | 6.971 | 8.447 | 4.520 | 4.103 | 5.799 | 5.401 | 7.475 | 3.693 | 3.509 |
| | (.001) | (.030) | (.000) | (.005) | (.035) | (.002) | (.2580) | (.002) | (.017) | (.005) |
| EARN*DE | -11.621 | -18.916 | -16.147 | -6.314 | -8.456 | -10.673 | -14.718 | -13.399 | -4.922 | -7.118 |
| | (.000) | (.000) | (.000) | (.001) | (.0021) | (.000) | (.003) | (.000) | (.006) | (.000) |
| RD | | | | | | 2.656 | 6.997 | 2.630 | 2.765 | 2.177 |
| | | | | | | (.006) | (.001) | (.016) | (.000) | (.001) |
| DPRE | .391 | -.983 | 1.412 | -.447 | -.0690 | .250 | -1.957 | .961 | -.577 | -.917 |
| | (.480) | (51.7) | (.341) | (.384) | (.2721) | (.648) | (.195) | (.516) | (.246) | (.113) |
| DIND | .626 | 1.805 | 3.077 | .306 | 1.616 | .548 | 2.146 | 2.795 | .183 | 1.542 |
| | (.290) | (.302) | (.068) | (.650) | (.042) | (.374) | (.211) | (.095) | (.780) | (.019) |
| DPI | -.957 | -.014 | 1.331 | -.0163 | -.0167 | -1.125 | -.128 | 1.171 | -.198 | -.231 |
| | (.108) | (.992) | (.358) | (.959) | (.7774) | (.056) | (.933) | (.414) | (.529) | (.689) |
| DPII | -.464 | .517 | -.951 | -.0947 | -.2959 | -.597 | .108 | -.772 | -.010 | -.284 |
| | (.428) | (.731) | (.503) | (.852) | (.675) | (.302) | (.941) | (.584) | (.984) | (.622) |
| **DPIII** | **1.020** | **3.311** | **.438** | **.808** | **1.901** | **.986** | **2.640** | **.204** | **.752** | **1.767** |
| | **(.076)** | **(.020)** | **(.746)** | **(.098)** | **(.001)** | **(.081)** | **(.060)** | **(.879)** | **(.112)** | **(.001)** |
| **DFDA** | **2.644** | **1.737** | **2.956** | **1.243** | **2.732** | **2.868** | **2.374** | **3.195** | **1.367** | **2.857** |
| | **(.000)** | **(.287)** | **(.062)** | **(.026)** | **(.000)** | **(.000)** | **(.140)** | **(.043)** | **(.012)** | **(.000)** |
| Adj $R^2$ | 34 | 43.1 | 53.4 | 21 | 45.5 | 33.0 | 43.2 | 54.3 | 25.9 | 46.3 |
| $R^2$ change by drug portfolios | 8.8 | 3.3 | 1.9 | 1.0 | 2.8 | 7.8 | 1.3 | 1.4 | 1.2 | 2.7 |
| | (.000) | (.047) | (.011) | (.168) | (.000) | (.000) | (.090) | (.031) | (.119) | (.000) |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value (two-tailed) from White's adjusted t statistic. In Panel A, $R^2$ change is the difference in Adj $R^2$ between the regression model with both financial information and drug portfolio and one with financial information only. In Panel B, $R^2$ change is the difference in Adj $R^2$ between the regression model with financial information, R&D and drug portfolio and one with financial information and R&D only. P-value below $R^2$ change indicates the significance of the change in Adj. $R^2$. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditures; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise.

## Table 9 Value Relevance of Information on Drugs at Earlier Stages vs. at More Advanced Stages

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 RD_{jt} + \beta_7 DPRE_{jt} + \beta_8 DIND_{jt} + \beta_9 DPI_{jt} + \beta_{10} DPII_{jt} + \beta_{11} DPIII_{jt} + \beta_{12} DFDA_{jt} + \varepsilon_{jt}$$

| | Regression with drug portfolios only | Regression with financial information and drug portfolios | Regression with financial information, R&D intensity and drug portfolios |
|---|---|---|---|
| Panel A: Earlier stages | | | |
| DUMPRE | .428 | -.026 | -.263 |
| | (.569) | (.964) | (.650) |
| DUMIND | 1.705 | 1.600 | 1.540 |
| | (.053) | (.054) | (.022) |
| DUNPI | .749 | 0.401 | .333 |
| | (.295) | (.510) | (.567) |
| DUMPII | .231 | .312 | .308 |
| | (.759) | (.645) | (.593) |
| **$R^2$ Change by drug portfolios** | **8.1 (.000)** | **0.5 (.031)** | **0.3 (.087)** |
| Panel B: More advanced stages | | | |
| DUMPIII | 1.973 | 1.770 | 1.48 |
| | (.003) | (.000) | (.003) |
| DUMFDA | 2.107 | 2.488 | 2.657 |
| | (.007) | (.000) | (.000) |
| **$R^2$ Change by drug portfolios** | **9.5 (.000)** | **2.6 (.000)** | **2.4 (.000)** |

Notes: For each variable, the number not in the brackets is the regression coefficient, and the number in the brackets is p-value ( two-tailed) from White's adjusted t statistic. $R^2$ change is the difference in Adj. R2 between the regression model with drug portfolio and one without drug portfolio. The study runs the regression model for drugs at earlier stage and drugs at more advanced stage, respectively. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DB is a dummy variable, one if book value of equity is negative, 0 otherwise, $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise, RD is R&D intensity which is R&D expenditures relative to beginning total assets during the period from t-1 to t; DPRE is a dummy variable, one if firms have drugs in pre-clinical trial, 0 otherwise; DIND is a dummy variable, one if firms have drugs waiting for FDA approval of human clinical trial. 0 otherwise; PI is a dummy variable, one if firms have drugs in PI clinical trial, otherwise 0, PII is a dummy variable, one if firms have drugs in PII clinical trial, otherwise 0, PIII is a dummy variable, one if firms have drugs in PIII clinical trial, otherwise 0, FDA is a dummy variable, one if firms have drugs in the FDA approval process, 0 otherwise; Pre-clinical trial through phase II trial are treated as earlier stages; Phase III trial and FDA approval process are treated as more advanced stages. For the earlier stages, regression model contains only DPRE, DIND, DPI and DPII. For the more advanced stages, regression model contains only DPIII and DFDA.

## Table 10 Value Relevance of Information on Business Relationships in Price-Earnings Model

$$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPIjt+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\beta_{12}DFDA_{jt}+\beta_{13}Alliance_{jt}+\varepsilon_{jt}$$

Panel A

Regression Coefficients
( p-value)

| | Intercept | BV | BV*DBV | EARN | EARN*DE | RD | DPRE | DIND | DPI | DPII | DPIII | DFDA | ALLIANCE | Adj. $R^2$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1998 | -1.038 | 3.719 | -4.832 | 4.511 | -9.489 | 2.978 | .257 | .584 | -1.052 | -.583 | .957 | 2.744 | **.220** | 38.7 |
| | (.029) | (.000) | (.211) | (.019) | (.001) | (.002) | (.633) | (.309) | (.070) | (.306) | (.086) | (.000) | **(.006)** | |
| 1999 | -3.809 | 6.243 | -8.808 | (5.468 | 15.062 | 6.705 | -2.197 | 2.080 | -.464 | .192 | 2.685 | 2.358 | **.976** | 44.3 |
| | (.002) | (.000) | (.047) | (.081) | (.002) | (.001) | (.143) | (.220) | (.760) | (.895) | (.054) | (.139) | **(.024)** | |
| 2000 | -.886 | 3.474 | -.435 | 6.774 | -12.618 | 2.591 | .956 | 2.692 | 1.111 | -.764 | .331 | 3.187 | **.683** | 55.0 |
| | (.424) | (.000) | (.698) | (.005) | (.001) | (.017) | (.515) | (.105) | (.435) | (.585) | (.804) | (.042) | **(.030)** | |
| 2001 | .783 | 2.617 | (-3.38) | 3.684 | -4.912 | 2.766 | -.576 | .180 | -.199 | -.011 | .754 | 1.368 | -4.912 | 25.6 |
| | (.094) | (.000) | (.000) | (.019) | (.007) | (.000) | (.247) | (.783) | (.528) | (.981) | (.113) | (.012) | (.950) | |
| Pooled | -1.978 | 4.598 | -6.038 | 3.119 | -6.739 | 2.251 | -.962 | 1.534 | -.197 | -.304 | 1.820 | 2.754 | **.357** | 49.7 |
| | (.000) | (.000) | (.000) | (.012) | (.0145) | (.026) | (.125) | (.019) | (.738) | (.662) | (.002) | (.000) | **(.012)** | |

Panel B

Adj. $R^2$ and $R^2$ Change ( p-value )

| | Adj $R^2$ of the regression with financial information, R&D and drug portfolios | Adj $R^2$ of the regression with financial information, R&D, drug portfolios and business relations | $R^2$ Change ( p-value ) |
|---|---|---|---|
| 1998 | 33.0 | 38.7 | 5.7 (.000) |
| 1999 | 43.2 | 44.3 | 1.1 (.024) |
| 2000 | 54.3 | 55.0 | 0.7 (.030) |
| 2001 | 25.9 | 25.6 | -.3 (.950) |
| Pooled | 46.3 | 49.7 | 3.4 (.000) |

Notes: in Panel A, the numbers not in the brackets are regression coefficients; the numbers in the brackets are p-value (two-tailed) from White's adjusted t statistic. . In Panel B, numbers not in the brackets are Adj. $R^2$ and the numbers in the brackets are p-value (two-tailed) that indicates the significance of $R^2$ change at 0.05 significance level. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is firms' actual number of new alliances under which forms work as researchers for the period from t-1 to t

Table 11 Results From Positive-Earnings Sample vs. Negative-Earnings Sample

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 R\&D + \varepsilon_{jt}$$

$$MV_{jt} = \beta_1 + \beta_2 BV_{jt} + \beta_3 BV_{jt}*DBV + \beta_4 EARN_{jt} + \beta_5 EARN_{jt}*DE + \beta_6 DPRE_{jt} + \beta_7 DIND_{jt} + \beta_8 DPI_{jt} + \beta_9 DPII_{jt} + \beta_{10} DPIII_{jt} + \beta_{11} DFDA_{jt} + \varepsilon_{jt}$$

Incremental value relevance of R&D vs. drug portfolio over financial information

| | 1998 | | 1999 | | 2000 | | 2001 | | Pooled | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Positive | Negative | Positive | Negative | Positive | Negative | Positive | Negative | Positive | Negative |
| Financial information (Adj.$R^2$) | 25.1 | 28.8 | 36.7 | 42.3 | 62.0 | 45.4 | 14.4 | 28.6 | 40.0 | 54.7 |
| **R&D: $R^2$ change** | **-.7** | **3.0** | **1.8** | **7.8** | **0.6** | **1.4** | **0.3** | **6.1** | **1.1** | **0.5** |
| | **(.907)** | **(.022)** | **(.043)** | **(.000)** | **(.090)** | **(.042)** | **(.220)** | **(.001)** | **(.001)** | **(.04)** |
| **Drug portfolios: $R^2$ change** | **4.4** | **5.8** | **6.9** | **-1.5** | **0.9** | **1.5** | **6.7** | **-.90** | **4.6** | **0.6** |
| | **(.055)** | **(.028)** | **(.006)** | **(.800)** | **(.168)** | **(.157)** | **(.009)** | **(.615)** | **(.000)** | **(.140)** |

Notes: In the row labelled by R&D, the numbers not in brackets are $R^2$ change which is the difference in Adj. $R^2$ between regression model with both financial information and R&D intensity and one with financial information only. In the row labelled by Drug portfolio, the numbers not in brackets are $R^2$ change which is the difference in Adj. $R^2$ between regression model with financial information and drug portfolios and one with financial information only. The numbers in brackets are p-value (two-tailed) at 0.05 significance level, that indicate the significance of the change in Adj. $R^2$. Drug portfolio includes DPRE, DIND, DPI, DPII, DPIII and DFDA. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t.

# Table 12 The Effect of Market Rights over Drugs in PIII Clinical Trials

$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPIjt$
$+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\quad+\beta_{12}DFDA_{jt}\quad+\beta_{13}ALLIANCE_{jt}+\beta_{14}DPIIIM_{jt}+\varepsilon_{jt}$

| | Regression<br>No control for the market rights over drugs in PIII | Regression<br>Control for the market rights over drugs in PIII |
|---|---|---|
| Intercept | -1.978 | -2.291 |
| | (.000) | (.000) |
| BV | 4.598 | 4.571 |
| | (.000) | (.000) |
| BV*DBV | -6.038 | -5.719 |
| | (.000) | (.000) |
| EARN | 3.119 | 2.914 |
| | (.012) | (.017) |
| EARN*DE | -6.739 | -6.027 |
| | (.014) | (.001) |
| RD | 2.251 | 2.590 |
| | (.026) | (.000) |
| DPRE | -.962 | -.979 |
| | (.125) | (.086) |
| DIND | 1.534 | 1.303 |
| | (.019) | (.045) |
| DPI | -.197 | -.161 |
| | (.738) | (.777) |
| DPII | -.304 | -.408 |
| | (.662) | (.472) |
| **DPIII** | **1.820** | **.217** |
| | **(.002)** | **(.752)** |
| DFDA | 2.754 | 2.676 |
| | (.000) | (.000) |
| ALLIANCE | .357 | .355 |
| | (.012) | (.001) |
| **DPIIIM** | | **2.858** |
| | | **(.000)** |
| Adj $R^2$ | 49.7 | 50.6 |
| $R^2$ change | | 0.9 |
| | | (.000) |

Notes: The numbers not in brackets are the coefficients of the regression model. The numbers in brackets are p-value ( two-tailed) at 0.05 significance level. $R^2$ change is the difference in Adj $R^2$ between the regression model with control for the market right of drugs in PIII and one without the control for the market right of drugs in PIII. P-value (two-tailed) below $R^2$ change indicates the significance of $R^2$ change at 0.05 significance level. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of now alliances for the current period, under which firms work as researchers. DPIIIM is a dummy variable, one if firms have the market right of drugs in PIII, 0 otherwise;

Table 13 The Effect of Drug Indications

$$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7RD+\beta_8DPRE_{jt}+\beta_9DIND_{jt}+\beta_{10}DPIjt+\beta_{11}DPII_{jt}+\beta_{12}DPIII_{jt}+\beta_{13}DFDA_{jt}+\beta_{14}ALLIANCE_{jt}+\beta_{15}CAN_{jt}+\beta_{16}ANTI_{jt}+\beta_{17}AIDS_{jt}+\varepsilon_{jt}$$

| | Regression No control for drug indications | Regression Control for drug indications |
|---|---|---|
| Intercept | -1.978 | -2.337 |
| | (.000) | (.000) |
| BV | 4.598 | 4.557 |
| | (.000) | (.000) |
| BV*DBV | -6.038 | -6.017 |
| | (.000) | (.000) |
| EARN | 3.119 | 3.044 |
| | (.012) | (.013) |
| EARN*DE | -6.739 | -6.761 |
| | (.014) | (.000) |
| RD | 2.251 | 2.335 |
| | (.026) | (.000) |
| DPRE | -.962 | -1.487 |
| | (.125) | (.011) |
| DIND | 1.534 | 1.530 |
| | (.019) | (.020) |
| DPI | -.197 | -.062 |
| | (.738) | (.286) |
| DPII | -.304 | -.778 |
| | (.662) | (.184) |
| DPIII | 1.820 | 1.260 |
| | (.002) | (.024) |
| DFDA | 2.754 | 2.427 |
| | (.000) | (.000) |
| ALLIANCE | .357 | .322 |
| | (.012) | (.000) |
| **CAN** | | **1.499** |
| | | **(.009)** |
| **ANTI** | | **1.845** |
| | | **(.003)** |
| AIDS | | -.508 |
| | | (.506) |
| Adj $R^2$ | 49.7 | 50.6 |
| $R^2$ change | | 0.9 |
| | | (.002) |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value ( two-tailed) from White's adjusted t statistic.. $R^2$ change is the difference in Adj $R^2$ between the regression model with control for the indications and one without the control for the indications. P-value (two-tailed) below $R^2$ change indicates the significance of $R^2$ change. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of new alliances for the current year, under which firms work as researchers. CAN, ANTI and AIDS are dummy variables, one if the drugs are anti-can, anti-infection and anti-aids, 0 otherwise.

# Table 14 Effect of a Firm's Product Market Status on the Value Relevance of Non- Financial Information

$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPIjt$
$+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\beta_{12}DFDA_{jt}+\beta_{13}ALLIANCE_{jt}+\varepsilon_{jt}$

| Panel A | Regression Model | |
|---|---|---|
| | Firms with products in the market | Firms without products in the market |
| Financial information | | |
| BV | 8.121 | 4.198 |
| | (.000) | (.000) |
| BV*DBV | -11.464 | -5.502 |
| | (.123) | (.000) |
| EARN | 1.911 | 1.198 |
| | (.537) | (3.51) |
| EARN*DE | -3.414 | -4.843 |
| | (.599) | (.010) |
| R&D innovation | | |
| R&D intensity | 4.092 | 2.821 |
| | (.196) | (.000) |
| DRUG Portfolio | | |
| DPRE | -1.318 | -0.040 |
| | (.327) | (.947) |
| DIND | 4.528 | .540 |
| | (.006) | (.420) |
| DPI | -.646 | -.620 |
| | (.683) | (.276) |
| DPII | -1.444 | -.445 |
| | (.337) | (.442) |
| DPIII | 1.454 | 1.233 |
| | (.278) | (.031) |
| DFDA | 2.916 | 1.136 |
| | (.032) | (.100) |
| Business relation | | |
| ALLIANCE | -.248 | .518 |
| | (.415) | (.000) |
| Panel B | $R^2$ change | |
| Financial information | 44.8% | 52.8 |
| | (.000) | (.000) |
| R&D | 0.6 | 1.9 |
| | (.206) | (.019) |
| Drug portfolio | 5.3 | 0.7 |
| | (.019) | (21.7) |
| Business relation | 0.2 | 1.7 |
| | (.415) | (.000) |

Notes: In Panel A, for each variable, the numbers that is not in the brackets is the regression coefficient. The number in the brackets is p-value (two tailed) from White's adjustment t statistic. In Panel B, the numbers not in the brackets are R2 changes. The numbers in the brackets are p-value (two tailed) indicating the significance of $R^2$ change by adding new information into the regression model. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is firms' actual number of new alliances under which forms work as researchers for the period from t-1 to t.

Table 15 The Value Relevance of Information About Management Experience

$$MV_{jt}=\beta_1+ \beta_2BV_{jt} + \beta_3BV_{jt}*DBV_{jt} + \beta_4EARN_{jt} + \beta_5EARN_{jt}*DE_{jt} + \beta_6RD_{jt} + \beta_7DPRE_{jt} + \beta_8DIND_{jt} + \beta_9DPIjt + \beta_{10}DPII_{jt}+ \beta_{11}DPIII_{jt} + \beta_{12}DFDA_{jt} + \beta_{13}ALLIANCE_{jt} +\beta_{14}DM_{jt} + \varepsilon_{jt}$$

| | Regression without DM | Regression with DM |
|---|---|---|
| Intercept | -1.978 | -2.434 |
| | (.000) | (.000) |
| BV | 4.598 | 4.624 |
| | (.000) | (.000) |
| BV*DBV | -6.038 | -6.118 |
| | (.000) | (.000) |
| EARN | 3.119 | 2.241 |
| | (.012) | (.068) |
| EARN*DE | -6.739 | -5.806 |
| | (.014) | (.002) |
| RD | 2.251 | 2.762 |
| | (.026) | (.000) |
| DPRE | -962 | -.653 |
| | (.125) | (.252) |
| DIND | 1.534 | 1.557 |
| | (.019) | (.015) |
| DPI | -.197 | -.393 |
| | (.738) | (.488) |
| DPII | -.304 | -.730 |
| | (.662) | (.201) |
| DPIII | 1.820 | 1.374 |
| | (.002) | (.012) |
| DFDA | 2.754 | 1.996 |
| | (.000) | (.001) |
| ALLIANCE | .357 | .349 |
| | (.012) | (.001) |
| **DM** | | **2.987** |
| | | **(.000)** |
| Adj $R^2$ | 49.7 | 51.3 |
| $R^2$ change | | 1.6 |
| | | (.000) |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value ( two-tailed) from White's adjusted t statistic.. $R^2$ change is the difference in Adj $R^2$ between the regression model with DM and one without DM. P-value (two-tailed) below $R^2$ change indicates the significance of $R^2$ change. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre-clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of new alliances for the current year, under which firms work as researchers. DM is a dummy variable, one if the firm has products in the market, zero otherwise.

Table 16 Regressions with Different Deflators

$MV_{jt}=\beta_1+ \beta_2BV_{jt} + \beta_3BV_{jt}*DBV_{jt} + \beta_4EARN_{jt} + \beta_5EARN_{jt}*DE_{jt} + \beta_6RD_{jt} + \beta_7DPRE_{jt} + \beta_8DIND_{jt} + \beta_9DPIjt+ \beta_{10}DPII_{jt}+ \beta_{11}DPIII_{jt} + \beta_{12}DFDA_{jt} + \beta_{13}ALLIANCE_{jt} + \varepsilon_{jt}$

Regressions with Alternative Deflators

| | $TA_t$ | $MV_{t-1}$ | $SHARES_t$ | $SHARES_{t-1}$ | $BV_t$ | $BV_{t-1}$ |
|---|---|---|---|---|---|---|
| Intercept | 2.299 | -2.507 | -4.017 | -1.407 | -.320 | -1.577 |
| | (.000) | (.000) | (.002) | (.217) | (.865) | (.349) |
| 98A | -1.357 | -.334 | 4.156 | -2.315 | -1.699 | 1.231 |
| | (.001) | (.631) | (.002) | (.117) | (.450) | (.527) |
| 99A | .918 | -.938 | 7.756 | 6.602 | -.545 | -1.027 |
| | (.017) | (.169) | (.000) | (.000) | (.806) | (.587) |
| 2000A | -.590 | -.275 | 3.152 | 1.113 | -.042 | -1.450 |
| | (.123) | (.693) | (.020) | (.452) | (.985) | (.450) |
| BV | 1.414 | 6.081 | 2.007 | 2.466 | | 2.114 |
| | (.008) | (.000) | (.000) | (.000) | | (.000) |
| BV*DBV | -1.746 | -10.840 | -8.996 | -12.258 | | |
| | (.027) | (.000) | (.000) | (.000) | | |
| EARN | 1.648 | 10.519 | 10.239 | 8.924 | 4.732 | 4.998 |
| | (.101) | (.000) | (.000) | (.000) | (.000) | (.000) |
| EARN*DE | -3.335 | -10.257 | -12.600 | -12.465 | -9.952 | -11.341 |
| | (.008) | (.000) | (.000) | (.000) | (.000) | (.000) |
| RD | 1.516 | 7.646 | 3.965 | 2.471 | 6.792 | 7.496 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| DPRE | -.682 | -.554 | -2.712 | -1.213 | -1.502 | -1.481 |
| | (.044) | (.326) | (.019) | (.317) | (.444) | (.373) |
| DIND | 1.166 | .824 | 1.646 | .362 | 4.752 | -1.568 |
| | (.003) | (.200) | (.214) | (.795) | (.041) | (.424) |
| DPI | -.396 | -.365 | -.907 | -1.560 | -.940 | 1.830 |
| | (.246) | (.518) | (.436) | (.200) | (.638) | (.278) |
| DPII | .110 | .259 | 1.292 | 1.470 | .292 | -1.126 |
| | (.746) | (.645) | (.261) | (.223) | (.885) | (.506) |
| DPIII | .831 | 1.001 | 1.916 | 1.161 | .564 | 1.133 |
| | (.010) | (.063) | (.083) | (.315) | (.768) | (.485) |
| DFDA | 1.244 | 1.610 | 5.924 | 5.044 | 5.435 | 5.336 |
| | (.001) | (.007) | (.000) | (.000) | (.010) | (.003) |
| ALLIANCE | .203 | .278 | .740 | .751 | .819 | .639 |
| | (.002) | (.010) | (.001) | (.001) | (.026) | (.042) |
| Adj $R^2$ (%) | 11.6 | 98.6 | 59.5 | 62.6 | 83.3 | 63.8 |

Notes: The numbers not in brackets are the coefficients of the regression model. The numbers in brackets are p-value ( two-tailed) from White's adjusted statistic at 0.05 significance level. $MV_{jt}$ is the market value of firm j at time t, deflated by different deflators, $BV_{jt}$ is the book value of equity of firm j at time t, deflated by different deflators; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by different deflators; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to different deflators during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of now alliances for the current period, under which firms work as researchers. $TA_{tt}$ is yea-of-end total assets; $MV_{t-1}$ is beginning market value; $SHARES_t$ and $SHARES_{t-1}$ are year-of-end and beginning number of shares outstanding, respectively; $BV_t$ and $BV_{t-1}$ are year-of-end and beginning book value of equity, respectively.

## Table 17 Regressions with Different Control Variables for Scale Effect

$TMV_{jt}=\beta_1+\beta_2TBV_{jt}+\beta_3TBV_{jt}*DBV_{jt}+\beta_4TEARN_{jt}+\beta_5TEARN_{jt}*DE_{jt}+\beta_6TRD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPIjt+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\beta_{12}DFDA_{jt}+\beta_{13}ALLIANCE_{jt}+\beta_{14}SCALE+\varepsilon_{jt}$

| | Alternative Scale Proxies | | | | | |
|---|---|---|---|---|---|---|
| | $TA_t$ | $TA_{t-1}$ | $MV_{t-1}$ | $SHARES_t$ | $SHARES_{t-1}$ | $BV_{t-1}$ |
| Intercept | -426.46 | 364.43 | -505.33 | 785.17 | -532.26 | 509.97 |
| | (.573) | (.584) | (.449) | (.120) | (.432) | (.478) |
| 98A | -470.60 | -815.238 | 240.79 | -950.63 | -188.70 | -896.58 |
| | (.550) | (.300) | (.761) | (.111) | (.814) | (.295) |
| 99A | 817.476 | -919.281 | 966.12 | -1498.52 | 1024.21 | -1431.50 |
| | (.300) | (.237) | (.218) | (.011) | (.197) | (.094) |
| 2000A | -1768.43 | -2552.22 | -1668.87 | -1837.63 | -1728.71 | -2711.92 |
| | (.028) | (.001) | (.036) | (.002) | (.056) | (.001) |
| BV | 1.969 | 2.177 | 2.842 | 1.544 | 2.865 | 3.037 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| BV*DBV | -3.322 | -4.232 | -7.031 | -11.376 | -6.844 | |
| | (.885) | (.816) | (.700) | (.408) | (.709) | |
| EARN | 9.281 | 9.096 | 9.253 | 8.608 | 10.717 | 10.272 |
| | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| EARN*DE | -6.346 | -13.477 | -17.436 | -14.932 | -24.159 | -19.608 |
| | (.715) | (.430) | (.308) | (.247) | (.164) | (.281) |
| RD | 13.911 | 15.682 | 14.622 | -1.993 | 15.354 | 15.466 |
| | (.000) | (.000) | (.000) | (.176) | (.000) | (.000) |
| DPRE | -134.87 | -219.51 | -237.94 | -180.03 | -268.96 | -195.55 |
| | (.844) | (.749) | (.730) | (.729) | (.699) | (.793) |
| DIND | 302.768 | 247.04 | 145.05 | 171.75 | 182.58 | 172.41 |
| | (.704) | (.756) | (.856) | (.775) | (.820) | (.845) |
| DPI | -18.882 | -82.142 | -124.28 | -202.23 | -113.53 | -22.603 |
| | (.978) | (.906) | (.858) | (.700) | (.871) | (.976) |
| DPII | 80.425 | 10.580 | -50.58 | -99.73 | -26.492 | -63.461 |
| | (.907) | (.988) | (.942) | (.848) | (.970) | (.934) |
| DPIII | 232.694 | 282.04 | 235.26 | -66.36 | 229.74 | 178.67 |
| | (.724) | (.668) | (.722) | (.894) | (.730) | (.806) |
| DFDA | 759.793 | 725.74 | 495.56 | 666.86 | 576.73 | 633.76 |
| | (.301) | (.322) | (.500) | (.229) | (.436) | (.430) |
| ALLIANCE | 370.463 | 323.916 | 367.29 | -27.408 | 340.36 | 398.85 |
| | (.000) | (.016) | (.006) | (.790) | (.025) | (.006) |
| SCALE | .831 | .870 | .092 | 28.333 | -.058 | -.173 |
| | (.000) | (.000) | (.001) | (.000) | (.025) | (.706) |
| Adj $R^2$ (%) | 92.4 | 92.4 | 92.4 | 95.7 | 92.3 | 92.2 |

Notes: The numbers not in brackets are the coefficients of the regression model. The numbers in brackets are p-value ( two-tailed) from White's adjusted statistic at 0.05 significance level. $MV_{jt}$ is the market value of firm j at time t, deflated by different deflators, $BV_{jt}$ is the book value of equity of firm j at time t, deflated by different deflators; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by different deflators; Earnings is defined as earnings before extraordinary items and R&D expenditure; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditures relative to different deflators during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of now alliances for the current period, under which firms work as researchers. TA is yea-of-end total assets;$TA_{t-1}$ is beginning total assets;
$MV_{t-1}$ is beginning market value; $SHARES_t$ and $SHARES_{t-1}$ are year-of-end and beginning number of shares outstanding, respectively; $BV_{t-1}$ is beginning book value of equity; SCALE is the scale proxy.

# Table 18 Regressions with Alternative Definitions of Return

$$R_{jt}=\beta_1+\beta_2 CBVjt+\beta_3 CEARN_{jt\,t}+\beta_4 CRD_{jt}+\beta_5 DSPRE_{jt}+\beta_6 DPIND_{jt}+\beta_7 DINDPI_{jt}+\beta_8 DPIPII_{jt}+\beta_9 DPIIPIII_{jt}+\beta_{10} DPIIIFDA_{jt}+\beta_{11} DFDAM_{jt}+\beta_{12} ALLIANCE_{jt}+\varepsilon_{jt}$$

| | Regression Coefficients | |
|---|---|---|
| | Definition 1 | Definition 2 |
| Intercept | .446 | .293 |
| | (.000) | (.000) |
| CBV | 1.988 | 1.248 |
| | (.000) | (.000) |
| CEARN | -.039 | -.233 |
| | (.880) | (.307) |
| CRD | 1.344 | -.062 |
| | (.004) | (.853) |
| DSPRE | -.019 | -.056 |
| | (.934) | (.785) |
| DPIND | .818 | .575 |
| | (.028) | (.046) |
| DINDPI | -.014 | -.031 |
| | (.955) | (.875) |
| DPIPII | .183 | .118 |
| | (.360) | (.446) |
| DPIIPIII | .314 | .247 |
| | (.147) | (.142) |
| DPIIIFDA | -.243 | -.143 |
| | (.488) | (.599) |
| DFDAM | -.0039 | -.148 |
| | (.992) | (.616) |
| ALLIANCE | .075 | .072 |
| | (.100) | (.043) |
| Adj. $R^2$ in the regression with Financial information only | 12 | 5.3 |
| $R^2$ change (p-value) by | | |
| R&D | 1.3 (.000) | -0.1 (.956) |
| Drug portfolios | 0.7 (.095) | 0.7 (.101) |
| Business Relations | 0.2 (.100) | 0.4 (.043) |
| Total Adj.$R^2$ | 14.2 | 6.3 |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value (two-tailed) from White's adjusted t statistic. Rjt is the change in firms' market value (or price) from t-1 to t, deflated by beginning market value (or price) of period t; CBVjt is the change in firms' book value of equity from t-1 to t, deflated by beginning market value, or the change in per share book value of equity, deflated by beginning share price; CEARN is the change in firms' annual earnings before extraordinary items and R&D expenditure from t-1 to t, deflated by beginning market value, or the change in earnings per share, deflated by beginning share price; CRDjt is the change in R&D expenditures from t-1 to t, deflated by beginning market value, or the change in per-share R&D expenditures, deflated by beginning share price; DSPRE is a dummy variable, one if firms start new pre-clinical trial during the period t, 0 otherwise; DPIND is a dummy variable, one if firms have drugs moving from pre-clinical trial to FDA approval of investigational new drug application (IND process), 0 otherwise; DINDPI is a dummy variable, one if firms have drugs moving from IND process to PI trial, 0 otherwise; DPIPII is a dummy variable, one if firms have drugs moving from PI to PII, 0 otherwise; DPIIPIII is a dummy variable, one if firms have drugs moving from PII to PIII, 0 otherwise; DPIIIFDA is a dummy variable, one if firms have drugs moving from PIII to FDA approval process, 0 otherwise; DFDAM is a dummy variable, one if firms have drugs moving from FDA approval process to market, 0 otherwise; ALLIANC is the number of new alliances under which companies work as researchers for the period from t-1 to t.

# Table 19 Alternative Definitions of Earnings

$$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\beta_6RD_{jt}+\beta_7DPRE_{jt}+\beta_8DIND_{jt}+\beta_9DPIjt+\beta_{10}DPII_{jt}+\beta_{11}DPIII_{jt}+\beta_{12}DFDA_{jt}+\beta_{13}ALLIANCE_{jt}+\varepsilon_{jt}$$

Panel A — Regressions

| | Earnings before R&D expenditures | Earnings after R&D expenditures |
|---|---|---|
| Intercept | -1.978 | -1.339 |
| | (.000) | (.023) |
| BV | 4.598 | 4.657 |
| | (.000) | (.000) |
| BV*DBV | -6.038 | -6.608 |
| | (.000) | (.000) |
| **EARN** | **3.119** | **3.439** |
| | **(.012)** | **(.177)** |
| EARN*DE | -6.739 | -4.583 |
| | (.014) | (.108) |
| RD | 2.251 | 1.853 |
| | (.026) | (.059) |
| DPRE | -962 | -1.086 |
| | (.125) | (.060) |
| DIND | 1.534 | 1.537 |
| | (.019) | (.019) |
| DPI | -.197 | -.049 |
| | (.738) | (.931) |
| DPII | -.304 | -.336 |
| | (.662) | (.559) |
| DPIII | 1.820 | 1.699 |
| | (.002) | (.002) |
| DFDA | 2.754 | 2.715 |
| | (.000) | (.000) |
| ALLIANCE | .357 | .389 |
| | (.012) | (.000) |
| Adj $R^2$ | 49.7 | 49 |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value ( two-tailed) from White's adjusted t statistic. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure or earnings before extraordinary items but after R&D expenditures; DE is a dummy variable, one if earnings is negative, 0 otherwise. RD is R&D intensity calculated as R&D expenditure relative to beginning total assets during the period from t-1 to t. DPRE is a dummy variable, one if the firm has drug candidates in pre clinical trial, 0 otherwise; DIND is a dummy variable, one if the firm has drug candidates waiting for FDA approval for human clinical trial; DPI is a dummy variable, one if the firm has drug candidates in phase I clinical trial, 0 otherwise; DPII is a dummy variable, one if the firm has drug candidates in phase II clinical trial, 0 otherwise; DPIII is a dummy variable, one if the firm has drug candidates in phase III clinical trial, 0 otherwise; DFDA is a dummy variable, one if the firm has drug candidates in the FDA approval process, 0 otherwise. ALLIANCE is the number of new alliances for the current year, under which firms work as researchers.

Table 19 Alternative Definitions of Earnings (cont')

$MV_{jt}=\beta_1+\beta_2BV_{jt}+\beta_3BV_{jt}*DBV_{jt}+\beta_4EARN_{jt}+\beta_5EARN_{jt}*DE_{jt}+\varepsilon_{jt}$

Panel B Regressions

| | Earnings before R&D expenditures | Earnings after R&D expenditures |
|---|---|---|
| Intercept | -.242 | .671 |
| | (6.42) | (.080) |
| BV | 4.583 | 4.884 |
| | (.000) | (.000) |
| BV*DBV | -7.207 | -7.147 |
| | (.000) | (.000) |
| **EARN** | **4.237** | **4.776** |
| | **(.001)** | **(.129)** |
| EARN*DE | -8.123 | -8.069 |
| | (.000) | (.005) |
| Adj. $R^2$(%) | 45.5 | 43.8 |

Notes: For each variable, the number not in brackets is the regression coefficient, and the number in brackets is p-value ( two-tailed) from White's adjusted t statistic. $MV_{jt}$ is the market value of firm j at time t, deflated by beginning total assets; $BV_{jt}$ is the book value of equity of firm j at time t, deflated by beginning total assets; DBV is a dummy variable, one if book value of equity is negative, 0 otherwise; $EARN_{jt}$ is the annual earnings of firm j for the period from t-1 to t, deflated by beginning total assets; Earnings is defined as earnings before extraordinary items and R&D expenditure or earnings before extraordinary items but after R&D expenditures; DE is a dummy variable, one if earnings is negative, 0 otherwise.