

**Information Uncertainty, Corporate Disclosure and Stock Return
Volatility**

**Michel Magnan
Concordia University**

**Bixia Xu
Wilfrid Laurier University**

Information Uncertainty, Corporate Disclosure and Stock Return Volatility

Abstract

We investigate the cost of improved disclosure in the context of information uncertainty. We find disclosure degree of uncertain information is positively associated with stock return volatility. Evidence also suggests that drug pipeline maturity and the nature of disclosed news differentiate the observed association. Firms with high information uncertainty face a dilemma. While no or less information disclosure can lead to high information asymmetry, more disclosure of uncertain information can be associated with excess stock return volatility. The prior literature largely suggests that more disclosure is a good thing to do. This study shows that such claim may not be valid under the circumstance of high information uncertainty.

Keywords: information uncertainty, stock return volatility, corporate disclosure, disclosure cost

1. Introduction

Disclosure cost is an important economic issue to corporate disclosure practice. Recent literature has extended the investigation of such cost from some well documented examples (e.g., direct information production costs and indirect proprietary costs due to inter-firm competition) to the capital market field. In this field, one line of research documents the association between analysts' assessment of corporate disclosure practice and stock return volatility (e.g., Lang and Lundholm 1993). Another line of research reveals the linkage between institutional ownership and share price volatility but provides controversial results regarding the direction of such linkage (Potter 1992, Sias 1996, Fox 1997, Serwer 1997 vs. El-Gazzar 1998, Gompers and Metrick 1998). Bushee and Noe (2000) bring the two lines together, and find that the direction of the association between corporate disclosure practice and stock return volatility depends on the type of institutional investors following the firm. That is, corporate disclosure practice and stock return volatility are positively associated for firms heavily followed by transient institutions but negatively associated for firms heavily followed by dedicated institutions and quasi-indexer institutions. They term the increased stock return volatility from improved disclosure practice driven by transient institutions as a type of indirect disclosure cost.

The significant contribution of Bushee and Noe is their raising the concern over indirect disclosure cost captured by important capital market variables (e.g., stock return volatility). In this study, we investigate the same issue but in a new dimension. Specifically, we investigate whether and how disclosure of uncertain information is associated with stock return volatility. According to the recent finance and accounting

literature, information uncertainty is defined as the ambiguity with respect to implications of disclosed information for firm value (Liang 2003, Zhang 2006).

Our empirical examination of the effect of information uncertainty on stock return volatility is motivated by two results in the literature. First, drawn from the argument that people are more psychological biased when facing uncertainty (e.g., Daniel et al. 1998, Hirshleifer 2001), a recent line of research finds information uncertainty has an explanation for market underreaction and the resulting post-announcement drift (e.g., Liang 2003, Zhang 2006). The underlying argument is that investors encounter great difficulties and need longer time when interpreting information that indicates firm value with ambiguity. Secondly, investors are found differential in belief. It is well accepted that investors' belief differentiation causes trading, which, in turn, induces share price volatility. If information uncertainty causes higher psychological bias, it should be reasonable to expect it can also cause higher belief differentiation, assuming that bias leads to differentiation.¹ Logically, more disclosure of uncertain information will be likely associated with higher stock return volatility. Following the spirit of indirect disclosure cost in Bushee and Noe (2000), corporate managers need to consider the stock return volatility driven by disclosures of uncertain information, and carefully balance their disclosure strategies between information asymmetry and stock return volatility.

We select the biotech industry to study the issue of interest mainly for two reasons. First, biotech share prices are overly volatile compared to most other industries.²

¹ It should be noticed that bias does not necessarily lead to differentiation. For example, in the case of post announcement drift, the observed linkage between bias (i.e., underreaction) and post-announcement return indicates homogenous believes.

² The average share price volatility of the sample firms of this study is 4.79.

NASDAQ biotech index declined in value by 16.02% in 2001 and 45.44% in 2002;³ in contrast, the index went up in value by 45.59% in 2003 and 4.38% in 2004. The substantial share price changes reflect high share price volatility, and indeed calls for explanations. Secondly, given the inadequate financial information in high R&D industries (Amir and Lev 1996), biotech firms' news releases in fact are dominated by a rich set of non-financial performance information that reflects drugs' flowing along the multiple-stage drug discovery and development process (e.g., commencements of Phase II human trials and positive Phase III trial results). The drug discovery and development information (DDI hereafter) is characterized by high information uncertainty mainly because of the industry's inherent high R&D failure rate⁴ and the fact that future benefits of scientific innovations are highly unpredictable (e.g., how a discovery can lead to the cure of AIDS?). Hence, given the extent to which biotech firm values are largely reliant on drug-related non-financial performance (Robbins-Roth 2000, Kellogg and Charnes 2000), the biotech industry provides a unique setting for the research question of interest.

We test the association between disclosure of uncertain information and stock return volatility under three testable hypotheses. If information uncertainty causes excess differentiation in belief, one should be able to observe a positive association between disclosure degree of uncertain information and excess stock return volatility. Our first hypothesis generally speaks that firms that disclose more DDI will experience higher excess stock return volatility than firms that disclose less DDI.

To provide in-depth knowledge, we further investigate excess stock return volatilities associated with information disclosures related to drugs at different

³ The biotech index starts in 2001. Information about the index's performance can be collected from www.ishare.com.

⁴ The overall success rate for a new drug is around 23% (DiMasi, 1995, 2001).

development stages/phases. A typical drug has to travel several development stages starting from the laboratory and including pre-clinical trial stage, investigational new drug application stage (IND), human trial stage that has three phases, and final new drug application stage (NDA). Our first hypothesis assumes disclosure degree of uncertain information has a constant impact on stock return volatility regardless the news is related to drugs at IND stage or NDA stage. In fact, drug discovery and development has an increasing success rate (i.e., decreasing uncertainty, see hypothesis section for details) as the drug moves from pre-clinical trials toward government final approval for the market (FDA approval in the U.S). The industry practice classifies pre-clinical trial, IND, phases I and II human trials as early development stages/phases whereas phase III human trial and FDA final approval process as late development stages/phases. As late-stage news is accompanied by higher success rate, it indicates future earnings generation with lower ambiguity (Xu 2006). Hence, the information-based differentiation in belief should be lower for late-stage news. Our second testable hypothesis therefore says that disclosure degree of early-stage DDI is associated with higher excess stock return volatility than disclosure degree of late-stage DDI.

Lastly, we hypothesize that differential information uncertainty can be also seen in the nature of the released news. In addition to disclosing favorable news (e.g., positive phase III trial results), biotech firms also disclose unfavorable news (e.g., negative phase III trial results). Favorable news may lead to continuation of the drug discovery and development whereas unfavorable news may result in termination of the drug. To our understanding, while continuation reduces the firm's overall uncertainty level, and makes the firm's prospect prediction be easier and reliable via using drug success rates as

references (see hypothesis section for details), the effect of termination on firm value is extremely hard to estimate. Two alternative thoughts can involve. One may argue termination can kill the uncertainty associated with the failed drug; in contrast, others may argue there is information asymmetry on the pre-trial R&D achievements. As a consequence, investors do not know what will follow the failure, hence, it is difficult to actually ascertain the overall uncertainty will increase or decrease. We believe the second argument is more applicable in reality because it is likely that there is a secret box of pre-trial R&D achievements. The issue is managers know that while outside investors do not. Upon this, our last hypothesis speaks that disclosure degree of unfavorable DDI is associated with higher excess stock return volatility than disclosure degree of favorable DDI.

Results from a sample of 197 U.S. publicly-traded biotech firms in the healthcare sector from the period of 1998-2004 support the hypotheses: 1) firms that disclose DDI more frequently experience a higher excess stock return volatility than firms that disclose such information less frequently; 2) firms that disclose unfavorable DDI more frequently have a higher excess stock return volatility than firms that disclose favorable DDI more frequently; 3) firms that disclose favorable early-stage DDI more frequently have a higher excess stock return volatility than firms that disclose favorable late-stage DDI more frequently.

This study contributes to the literature in several ways. First, it reveals that biotech firms (and other firms with high information uncertainty) in fact face a disclosure dilemma caused by information uncertainty. While no or less information disclosure can cause high information asymmetry, more disclosure of uncertain information can be

associated with high stock return volatility. Stock return volatility is commonly used as a stock risk indicator. In this sense, our findings suggest that more disclosure may not be a good thing to do when information is of high uncertainty. Biotech firm managers may have to incorporate this indirect disclosure cost into their disclosure strategies. Second, prior studies identify the explanatory power of information uncertainty for the post-announcement drift anomaly. This study extends the information uncertainty literature by providing evidence that this information characteristic also has an explanatory power for stock return volatility.

The paper proceeds as follows. Prior literature and biotech disclosure background are provided in section 2 followed by market efficiency analysis in section 3. Information uncertainty and its effect on share price volatility are analyzed in section 4 followed by empirical testing in section 5. Summary and conclusions are provided in the last section.

2. Prior Literature and Biotech Information Disclosure

2.1 Share Price Volatility and Investors' Psychological Behaviour Bias

Share price volatility attracts a great deal of research attention. It can be mainly explained by two groups of factors. One includes factors related to firm-specific attributes such as extents of R&D investments and employee stock option applications. Much of prior research falls into this group. Studies include Allen and Rachim (1996), Ewing (1999), Alvarez (2001), Sadorsky (2003), Hotchkiss and Strickland (2003). In the biotech setting, Xu (2006) finds R&D strategy in terms of drug portfolio diversification has a significant impact on share price volatility.

The other group includes factors related to investors' psychological behaviour biases in terms of response to new information. Two common behaviour biases (i.e., under- and overreaction) are widely identified (e.g., Kahneman and Tversky 1982, De Bondt and Thaler 1985, Bernard and Thomas 1990, Stickel 1991, Jegadeesh and Titman 1993, Chan et al. 1996, Barberis et al 1998, Daniel et al. 1998, Gleason and Lee 2003). Under/overreaction leads to post-announcement price adjustments (e.g., Bartov 1992, Soffer and Lys 1999, Riahi-Belkaoui 2002). Evidence on how psychological behaviour biases affect share price volatility is still limited. In this regard, Shiller (1990) theoretically states that investors' psychological bias can cause share price volatility. Cornell (2001), using a single firm as the research setting (Intel), empirically shows that the market overreaction to failures of meeting analysts' earnings targets causes share price volatility.

When bias is defined as the departure from the "truth", investors' psychological behaviour bias can be alternatively manifested as the differentiation in belief. It is widely accepted that differentiation in belief among investors causes trading and share price volatility. Prior post announcement drift studies find information uncertainty increases the degree of market underreaction. It remains empirically unclear whether this information characteristic can also increase the degree of differentiation in belief, although Barron et al (2002) provide relevant evidence that analysts' consensus is lower when R&D intensity is higher.

2.2 Information Uncertainty

A more recent line of research explains individual psychological bias using information uncertainty. The basic message of this line of research is that psychological bias is greater when investors face more uncertainty and lack of accurate feedback about underlying fundamentals (Hirshleifer 2001). In the field of capital markets, Liang (2003) shows that when investors receive reliable earnings numbers, their uncertainty about the firm's future performance decreases; hence, the change in perceived uncertainty is negatively associated with the post-announcement drift. Francis et al. (2005) also use information uncertainty to explain the post-announcement drift and document that investors react less and slowly to information that indicates future with ambiguity. Zhang (2006) further explores the drift pattern following “good” vs. “bad” news conditional upon information uncertainty. He finds investors in high uncertain firms earn higher ex post abnormal returns following “good” news announcements but lower ex post abnormal returns following “bad” news announcements than their counterparts in low uncertain firms.

Prior studies into information uncertainty focus on its impact on post announcement drifts via its impact on market underreaction. Different from them, the present study investigates whether and how information uncertainty can be associated with stock return volatility via its impact on market differentiation in belief. The distinct difference between underreaction and differentiation is: the former assumes that investors homogeneously underreact to released news while the latter claims that investors heterogeneously react to released news.

2.3 Biotech Information Disclosure

Drug discovery and development progress (e.g., a drug moves to phase II trials) is the key performance indicator and fundamental value driver in the biotech industry (e.g., Robbins-Roth 2000, Kellogg and Charnes 2000, McConomy and Xu 2004, Xu, Magnan, and Andre 2007). Motivated by inadequate financial information (Amir and Lev 1996), biotech firms disclose a rich set of non-financial information that reflects drugs' movements along the drug discovery and development process as summarized in appendix A. It typically takes an average of twelve years for a drug to travel through the pipeline from laboratory to the marketplace.⁵ In the U.S., drugs travel through several typical stages: discovery and pre-clinical trial stage is aimed at synthesizing “new molecular entities” (NMEs) and screening them for toxicity in artificial environments and then on animals. In IND stage firms file “investigational new drug” (IND) applications with the Food and Drug Administration (FDA) for promising NMEs.⁶ Approved INDs allow continued development of promising new drugs via (human) clinical trials. The clinical trial process is typically performed in three phases. Phase I testing is generally limited to a small number of healthy volunteers to obtain information on toxicity and safe dosing ranges.⁷ Phase II testing is broadened to a large number of individuals selected from the target patient group and provides significant evidence on effectiveness and additional data on safety.

⁵ The time estimates for drug development are based on those reported by Alliance Pharmaceutical Corporation at www.allp.com/drug_dev.html. The timing is broadly consistent with that outlined by Frank (2003, p. 326) and Guo, Lev and Zhou (2004, p. 326).

⁶ Frank (2003) reports that in 2000 the FDA approved 98 new drugs, of which 27 were NME's and the remainder were new formulations and new methods of delivering existing drugs.

⁷ In phase I, 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.

Late stage drug development begins with Phase III testing involving large scale trials on patients to assess the statistical significance of actual benefits, and potential side effects. The company can file a “new drug application” (NDA) with the FDA if the company officials are confident that sufficient supporting evidence for the new drug has been obtained. The FDA then reviews and approves the drug application. After that stage the company can consider to launch the drug to the consumer market. Finally, in the post-approval stage, companies receive revenues or royalties from sales of the new drug, and product extensions may be investigated (e.g., new formulations or dosages for subsets of patients such as children).

A distinct feature of biotech non-financial disclosures lies in information uncertainty. Most biotech non-financial disclosures indicate firm prospects with high uncertainty because of the inherent high risk nature of R&D projects in the industry. For example, success in phase I trials does not necessarily lead to success in phase II trials. It is therefore difficult to translate favourable phase I news into future earnings or cash flow generations. Prior cross-industry studies use aggregate measures to proxy for overall information uncertainty at the firm level, for examples, firm size, firm age and cash flow volatility in Zhang (2006), earnings quality in terms of the association with cash flows from operations in Francis et al. (2005). Differently, we directly analyze and capture information uncertainty for each type of news disclosure. In total, 16 types of non-financial disclosures are analyzed (see per Appendix A-panel A).

3. Hypotheses on Information Uncertainty and Share Price Volatility

Information uncertainty can be understood in its relationship with drug discovery and development success. New drug discovery and development has an overall success rate of 22%-23% (DiMasi 1995, 2001); even if the drug is approved, success in the marketplace remains a challenge (Chidley 2000). Hence, investors encounter great difficulties to interpret information released by biotech firms pertaining to drug progresses for firm future prospect (i.e., future earnings or cash flow generations). Belief differentiation can likely occur. Following the spirit of Hirshleifer (2001) that individual psychological under-/overreaction is higher when there is more uncertainty, we expect the degree of belief differentiation among investors is greater in cases of higher information uncertainty. To the extent investors' differential beliefs are incorporated into share prices, the effect of information uncertainty will be translated into share price volatility. Therefore, our first testable hypothesis generally speaks a positive association between disclosure degree of uncertain information and excess share price volatility.

While biotech information disclosures overall possess information uncertainty, similar type of information related to drugs at development stages (e.g., starting phase I vs. starting phase III, IND approval vs. NDA approval) may possess different degrees of information uncertainty. According to DiMasi (1995, 2001), a drug in the pre-clinical trial has a probability of 19.36% to pass FDA final approval; this probability is 21.52% for a drug in the IND process, 23.91% for a drug in Phase I trial, 31.88% for a drug in Phase II trial, 63.75% for a drug in Phase III trial, and finally, 75% for a drug in the NDA process. Those rates indicate that once a drug moves into the next stage/phase, its overall success is increased. The increase becomes substantial when the drug enters into Phase

III trial. Biochemists find drugs become valuable after entering into Phase II trial. Consistently, Kellogg and Charnes (2000) apply real option models to value drugs at different development stages/phases, and claim that drugs at different stages/phases have different option values due to different underlying uncertainties.

Success rates can be typically interpreted as proxies for information uncertainty. For example, drawn from success rates, entering into phase I trial indicates future benefit (i.e., government final approval and possible earnings generation) with 76.09% uncertainty (1-.2391) while entering into phase III trial indicates future benefit with 36.25% uncertainty (1-.6375). It is reasonable to expect individual believes based on high success rates (i.e., low uncertainty) are less differential than based on low success rates (i.e., high uncertainty). Drug stages are practically classified as early- vs. late-stages. The former includes pre-clinical trial, IND and phases I and II human trials while the latter includes phase III human trial and the FDA final approval process. Based on the success rates, news related to early stages should possess higher information uncertainty than news related to late stages. Following the same logic underlying the first hypothesis, our second testable hypothesis specifically speaks that disclosure degree of early-stage news is associated with higher excess share price volatility than disclosure degree of late-stage news.

The drug approval process in the United States is very protracted, and poor results at any stage of the process could result in the abandonment of seemingly promising treatments. In reality, negative results at any stage of drug development will likely halt development of the new drug therapy while positive results will signal the continuation of the drug development. For example, positive results in phase I will generally lead to

phase II testing and, if successful, may lead to phase III testing and an application for FDA final approval. Alternatively, negative Phase I results may lead to discontinuation of further testing. In the former case, investors can have success rates as references to predict where the firm's overall drug development will go and correspondingly the firm value. Indeed, continuation is always accompanied by a certain degree of uncertainty; however, in the latter case, investors can be extremely uncertain about where the firm's overall drug development will go and what will be the firm's future especially in cases of small firms with just a couple of drugs under early stage development. In this sense, firms that disclose more negative results (i.e., "bad" news) should look more uncertain than firms that disclose more positive results (i.e., "good" news). Therefore, our last testable hypothesis speaks that disclosure degree of "bad" news is associated with higher excess share price volatility than disclosure degree of "good" news.

4. Empirical Testing

4.1 Sample and Data

The sample of this study consists of COMPUSTAT firms with SIC codes between 2830-2836 and required data available in the period of 1998-2004. These firms discover, develop, produce and sell drugs for either treatment or diagnosis of human diseases. Non-financial disclosure data was then hand-collected from company web press releases and biospace, an internet server that discloses information of biotech firms around the world. Stock prices and returns were collected from CRSP. Needed financial data was collected from COMPUSTAT. The final sample covers 197 firms. Total and types of disclosures are summarized in table 1.

(Insert Table 1 here)

4.2 Measurement of Disclosure Frequency

Belief differentiation drives share price volatility. If a biotech firm releases uncertain information less frequently, belief differentiation will have fewer chances to occur. Consequently, the differentiation-driven share price volatility will be lower. In contrast, if a firm releases uncertain information more frequently, belief differentiation will have more chances to occur. As a result, the differentiation-driven share price volatility will be higher. To empirically test the effect of disclosure degree of uncertain information on stock return volatility, we create five measures of disclosure frequency following the three hypotheses. They are: (i) total number of the firm's drug development news announcements (total number, hereafter) divided by total number of drugs under development. Using number of drugs under development as a deflator is to control for the possible size effect driven by the fact that more drugs under development lead to more disclosures; (ii) number of early-stage "good" drug development news announcements over the total number; (iii) number of late-stage "good" drug development news announcements over the total number; (iv) number of early-stage "bad" drug development news announcements over the total number; and (v) number of late-stage "bad" drug development news announcements over the total number.

4.3 Empirical Model

Share price volatility is determined by multivariate factors. To rule out the effects of other factors, we perform a multivariate regression analysis. Variables identified in prior

studies to have an effect on share price volatility are controlled. Building upon on Bushee and Noe (2000), our empirical model is specified as below:

$$\text{STDRET}_t = [\text{Fixed cycle effects}] + \beta_1 \text{DISC}_t + \beta_2 \text{RDE}_t + \beta_3 \text{AR}_t + \beta_4 \text{VOLS}_t + \beta_5 \text{SIZE}_t + \beta_6 \text{LEV}_t + \beta_7 \text{EP}_t + \beta_8 \text{BM}_{jt} + \beta_9 \text{DIVE}_t + \beta_{10} \text{RDM}_t + \varepsilon_{jt} \quad (1)$$

where

- STDRET* is excess share price volatility measured as daily share price standard deviation minus the industry's average in t
- DISC* is a disclosure frequency measure in year t;
- RDE* is R&D expenditure over market value in year t;
- AR* is the size and book-to-market adjusted excess return in year t;
- VOLS* is annual mean of monthly trading volume relative to shares outstanding at the end of each month;
- SIZE* is a firm size indicator at year t measured as natural log of beginning-of-period market value;
- LEV* is financial leverage in year t measured as long-term debt over long-term debt plus market value of equity;
- EP* is earnings-to-price ratio in year t, zero if negative;
- BM* is book-to-market ratio at year t;
- DIVE* is number of drug indications under development over number of target diseases in year t;
- RDM* is a dummy variable, one if the firm has non-zero sales, zero otherwise

The main difference between equation (1) and Bushee and Noe (2000) are: 1) including the disclosure frequency measure (*DISC*), the variable of interest. Two models under equation (1) are estimated. Model (1) has *DISC* as the total number of drug development news announcements divided by total number of drugs under development [measure (i)]; Model 2 has *DISC* as the set of measures [measures (ii) through (v)]; 2) dividend variable in Bushee and Noe is absent as most biotech firms do not declare any dividends due to their early life-cycle stages; 3) sales growth in Bushee and Noe are not included as

many firms do not have sales as they do not have products in the market (their drugs are still under development). Instead, we introduce a dummy variable (*RDM*) to incorporate the potential effect of sales (i.e., R&D commercial maturity); and 4) a drug portfolio diversification measure (*DIVE*) is included (Xu 2006).

One may argue that the market can change its views or attitudes toward fundamentals (e.g., Keating et al 2003). These view or attitude changes can lead to changes in market valuations of fundamentals, which can have an influence on share price volatility. To deal with this potential, excess share price volatility is used. It is defined as the difference between a firm's share price volatility and the industry average, and calculated for each sample firm.

4.4 Empirical Analysis

Descriptive statistics and correlations for variables in equation (1) are reported in tables 2 and 3, respectively. Per table 2, sample firms have a mean excess share price volatility of 1.78 (*STDRET*). An average firm reports .386 news for one drug (*DISC*). Among non-financial drug development disclosures, 49.2% are early-stage “good” news (*DISC^a*), 47% are late-stage “good” news (*DISC^b*), .6% are early-stage “bad” news (*DISC^c*), and 3.2% are late-stage “bad” news (*DISC^d*). A mean size measure reaches 5.245 (*SIZE*). Debt financing is rather low with a mean leverage of .012 (*LEV*). Sample firms exhibit high growth potential with a mean market-to-book ratio of 3.091 (*MB*). Among them, 42.8 % of firms have non-zero sales (*RDM*).

(Insert Table 2 here)

Per Table 3, as expected, *STDRET* is positively correlated with all the disclosure degree measures at the 5% significant level. In addition, it is significantly positively correlated with *AR*, *VOLS*, *SIZE*, *MB* and *DIVE* while significantly negatively correlated with *EP*, but insignificantly correlated with *LEV* and *RDM*. Further VIFs analysis does not show multilinearity is a problem with all VIF being lower than 3.

(Insert Table 3 here)

The fit of equation (1) using GLS is summarized in Table 4. Per Model 1, as expected, *DICS* is positively associated with *STDRET* for the coefficient being .072 significant at the 1% level. Consistently, per model 2, all disclosure degree measures are positively associated with *STDRET* at the 5% significant level. As hypothesized, reporting early-stage “good” news induces higher increase in *STDRET* than reporting late-stage “good” news (.037 vs. .012), consistent with the view that early-stage news are more uncertain than their late-stage counterparts. This finding holds for “bad” news disclosures. That is, reporting early-stage “bad” news induces higher increase in *STDRET* than reporting late-stage “bad” news (.761 vs. .21). Moreover, as hypothesized, the effect on *STDRET* is asymmetric depending on the nature of the news (“good” vs. “bad”). Reporting early-stage “bad” news increases *STDRET* by .761 while reporting early-stage “good” news increases *STDRET* only by .037. This finding holds for late-stage news. That is, reporting late-stage “bad” news increases *STDRET* by .21 while reporting late-stage “good” news increases *STDRET* only by .012.

(Insert Table 4 here)

6. Concluding Remarks

To mitigate the inadequacy of financial information (Amir and Lev, 1996), biotech firms disclose a rich set of non-financial information to reflect drugs' flowing along the multiple-stage drug discovery and development process. While firms benefit generally from more information disclosures (i.e., reduced information asymmetry) information-related characteristics (e.g., information uncertainty in this study) may incur disclosure costs. Using the biotech industry as the research setting, this study provides evidence on how information uncertainty increases disclosure costs as measured by increased share price volatility. Moreover, we find the effect of disclosures on share price volatility is asymmetric depending on i) the nature of the released news ("good" vs. "bad" and ii) the underlying drug development stage. More disclosures of early-stage news as well as "bad" news are associated with higher excess share price volatility. The prior literature largely suggests that more disclosure is a good thing to do. This study suggests such claim may not be valid under the circumstance of high information uncertainty.

References

- Aboody, D. and B. Lev. Information asymmetry, R&D, and insider gains. *The Journal of Finance* 55, 2747-2767.
- Ackert, F.L. 1994. Uncertainty and volatility in stock prices. *Journal of Economics and Business* 46, 239-253.
- Allen, E. and V. Rachim. 1996. Dividend policy and stock price volatility: Australian evidence. *Applied Financial Economics* 6,175-188.
- Alvarez, T. 2001. Heavy use of stock options linked to stock price volatility. *Workspan* 44, 13-15.
- Amir, E. and B. Lev. 1996. Value-relevance of non-financial information: The wireless communications industry. *Journal of Accounting and Economics* 22, 3-30.
- Arnum, P.V., 2004. US biotechnology industry: on the rebound, Chemical Market Reporter. New York, Jun 7. FR8.
- Barberis, N., A. Shleifer and R. Vishny. 1998. A model of investor sentiment. *Journal of Financial Economics*. 49, 307-343.
- Bartov, E.1992. Patterns in unexpected earnings as an explanation for post-announcement drift, *The Accounting Review* 67, 610-622.
- Berger, D. 2004. Use scorecard to improve your CMMS system. *PEM (Oakville)* 28, 14-22.

- Bernard, V. and J. Thomas. 1990. Evidence that stock prices do not fully reflect the implications of current earnings for future earnings. *Journal of Accounting and Economics* 13, 305-340.
- Bernard, V. 1987. Cross-sectional Dependence and Problems in Inference in Market-Based Accounting Research. *Journal of Accounting Research* 35, 1-48.
- Boehmer, E., J. Musumeci and A. Poulsen. 1991. Event-study methodology under conditions of event-induced variance. *Journal of Financial Economics* 30, 253-272.
- Bushee, B.J., and C.F. Noe. 2000. Corporate disclosure practices, institutional investors, and stock return volatility. *Journal of Accounting Research* 38: 171-203.
- Chan, L.K.C., N. Jegadeesh and J. Lakonishok. 1996. Momentum strategies. *The Journal of Finance* 51, 1681-1713.
- Chidley, J. 2000. "Investing for Daredevils." *Canadian Business* 73, 46-50.
- Collins, D. and S. Kothari. 1989. An analysis of intertemporal and cross-sectional determinants of earnings response coefficients. *Journal of Accounting and Economics* 11, 143-181.
- Cornell, B. 2001. Is the response of analysts to information consistent with fundamental valuation? The case of Intel. *Financial Management* 30, 113-136.
- Cumby, J and J. Conrod, 2001. Non-financial Performance Measures in the Canadian Biotechnology Industry. *Journal of Intellectual Capital* 2, 261-72.
- Daniel, K.; D. Hirshleifer and A. Subrahmanyam. 1998. A theory of overconfidence, self-attribution and security market under-and over reactions. *The Journal of Finance* 53,1839-1886.

- De Bondt, W. F. M. and Thaler, R. 1985. Does the stock market overreact? *The Journal of Finance* 40, 793-805.
- Diamond, D. and R. Verrecchia. 1991. Disclosure, liquidity and the cost of capital. *The Journal of Finance* 46, 1325-1360.
- DiMasi, J., 1995. Success Rates for New Drugs Entering Clinical Testing in the United States. *Clinical Pharmacology & Therapeutics* 58, 1-14.
- DiMasi, J.A. 2001. New drug development in the United States from 1963 to 1999. *Clinical Pharmacology & Therapeutics* 69, 286-296.
- Ely, K., P. Simko and L. Thomas. 2003. The usefulness of biotechnology firms' drug development status in the development of research and development costs. *Journal of Accounting, Auditing and Finance* 18, 163-196.
- Ewing, T. 1999. Small-stock focus: Nasdaq stock's price ricochet is for the books. *Wall Street Journal* February 17, pp.C1.
- Fama, F. 1998. Market efficiency, long-term returns and behavioral finance. *Journal of Financial Economics* 49, 283-306.
- Francis, J.; R. Olsson and K. Schipper. 2005. Accounting anomalies and information uncertainty. Working paper. MIT, Duke University, Financial Accounting Standard Board (U.S.)
- Francis, J., K. Schipper and L. Vicent. 2003. The relative and incremental explanatory power of earnings and alternative (to earnings) performance measures for returns. *Contemporary Accounting Research* 20, 121-165.
- Frank, R. 2003. "New Estimates of Drug Development Costs." *Journal of Health Economics* 22, 325-330.
- Gleason, C.A. and C.M.C. Lee. 2003. Analysts forecast and market price discovery. *The Accounting Review* 78, 193-225.

- Guo, R., B. Lev and N. Zhou. 2004. Competitive Costs of Disclosure by Biotech IPOs. *Journal of Accounting Research* 42, 319-355.
- Hand, J., 2005. The Value Relevance of Financial Statements in the Venture Capital Market. *The Accounting Review* 80, 613-648.
- Heal, P. and R. Palepu. 2001. Information asymmetry, corporate disclosure, and the capital markets: A review of the empirical disclosure literature. *Journal of Accounting and Economics* (September) 405-440.
- Hirshleifer, D. 2001. Investor psychology and asset pricing. *The Journal of Finance* 56, 1533-1596.
- Hotchkiss, E. and D. Strickland. 2003. Does shareholder composition matter? Evidence from the market reaction to corporate earnings announcements. *The Journal of Finance* 58, 1469-1499.
- Jegadeesh, N. and S. Titman. 1993. Returns to buying winners and selling losers: implications for stock market efficiency. *The Journal of Finance* 56, 699-720.
- Kahneman, D. and A. Tversky. 1982. Intuitive prediction: Biases and corrective procedures. In *Judgment under uncertainty: Heuristics and Biases* (Kahneman, D.; P. Slovic and A. Tversky, eds). London: Cambridge University Press
- Keating, E.K., T.Z. Lys and R.P. Magee. 2003. Internet downturn: finding valuation factors in Spring 2000. *Journal of Accounting and Economics* 34,189-236.
- Kellogg, D. and J.M. Charnes. 2000. Real-Option valuation for a biotechnology company. *Financial Analysts Journal* (May/June) 76-84.
- Kothari, S. P. and C. Wasley. 1989. Measuring Security Price Performance in Size-Clustered Samples. *The Accounting Review* 64, 228-249.

- Liang, L. 2003. Post-earnings announcement drift and market participants' information processing biases. *Review of Accounting Studies* 8, 321-345.
- Liu, Q. 2000. How good is good news? Technology depth, book-to-market ratios, and innovative events. Working paper. University of California.
- Liu J., D. Nissim and J. Thomas. 2002. Equity valuation using multiples. *Journal of Accounting Research* 40, 135-172.
- McConomy, B. and B. Xu. 2004. Value creation in the biotechnology industry. *CMA Management* (April) 29-31.
- Mikkelson, W. and M. Partch. 1988. Withdrawn Security Offerings. *Journal of Financial and Quantitative Analysis* 23, 119-134.
- Otley, D. 2001. Accounting performance measurement: A review of its purpose and practices. *International Journal of Business Performance Management* 3, 245-275.
- Patell, J. 1976. Corporate Forecasts of Earnings Per Share and Stock Price Behaviour: Empirical Tests. *Journal of Accounting Research* 14, 246-274.
- Riahi-Belkaoui, A. 2002. Level of multinationality as an explanation for post announcement drift. *The International Journal of Accounting* 37, 413-419.
- Robbins-Roth, C. 2000. *From Alchemy to IPO: The Business of Biotechnology*. Perseus Publishing.
- Sadorsky, P. 2003. The macroeconomic determinants of technology stock price volatility. *Review of financial Economics* 12, 191-205.
- Shiller, R.J. 1990. *Market Volatility*. Cambridge, MA: The MIT Press.
- Soffer, L. and T. Lys, 1999. Post-earnings-announcements drift and the discussions of predictable information. *Contemporary Accounting Research* Summer, 305-274.

- Stoll, H.R. 1978. The pricing of security dealer services: An empirical study of Nasdaq stock. *The Journal of Finance* 33, 1153-1172.
- Stickel, S. 1991. Common stock returns surrounding earnings forecast revisions: more puzzling evidence. *The Accounting Review* 66, 402-416.
- Verrecchia, R. 2001. Essays on disclosure. *Journal of Accounting and Economics* 32, 97-180.
- Yeoh, P. and K. Roth, 1999. An Empirical Analysis of Sustained Advantage in the U.S. Pharmaceutical Industry: Impact of Firm Resources and Capabilities. *Strategic Management Journal* 20, 637-53.
- Zhang, X.F. 2006. Information uncertainty and stock returns. *The Journal of Finance* LXI 105-136.
- Xu, B. 2006. R&D strategy and stock price volatility in the biotechnology industry. *Review of Accounting and Finance* 5, 71-86.
- Xu, B, Magnan, Michel, and Andre, Paul. The Stock Market Valuation of R&D Information in Biotech Firms, *Contemporary Accounting Research*, forthcoming in Vol 24, Issue 4, 2007

Appendix A
Disclosure Description

Panel A: Drug development events - Early stage events

Event	Description
SPRE	Start pre-clinical trial
PRPRE	Announce positive pre-clinical trial results
SIND	Submit investigational new drug to FDA
AIND	FDA approval of IND
SPI	Start PI clinical trial
PRPI	Announce positive PI clinical trial results
SPII	Start PII clinical trial
PRPII	Announce positive PII clinical trial results
NRPII	Announce negative PII clinical trial results

Panel B: Drug development events - Late stage events

Events	Description
SPIII	Start PIII clinical trial
PRPIII	Announce positive PIII clinical trial results
SFDA	Submit to FDA for final approval
AFDA	FDA or other (non-U.S.) government approval
NRPIII	Announce negative PIII clinical trial results
NAFDA	FDA non-approval or delayed approval
TFDA	Terminate application to FDA for final approval

Panel C: Financial events

Events	Description
PNI	Announce positive earnings
NNI	Announce negative earnings

Table 1
Information Disclosure in Up, Downturn and Rebound Market Cycles

This table describes disclosure frequencies and proportions of information events as summarized in Appendix A for each market cycle (i.e., up, downturn and rebound). Reported in Panels A and B are actual numbers of announcements of all types of information events examined. Reported in Panel C are disclosure proportions of certain types of events in each market cycle. Up cycle = 1998-March 2000; Downturn cycle = April 2000-2002; Rebound cycle = 2003-2004.

Panel A: Total drug development disclosures in the period of 1998-2004

Period	Early-Stage Disclosure									Late-Stage Disclosure									
	"Good"									"Bad"		"Good"				"Bad"			
	SPRE	PRPRE	SIND	AIND	SPI	PRPI	SPII	PRPII	NRPII	SPIII	PRPIII	SFDA	AFDA	NRPIII	TPIII	NAFDA	TFDA		
Rise	19	53	26	21	65	60	75	125	7	40	50	57	269	6	5	6	5		
Downturn	37	163	58	25	132	157	166	325	13	84	212	106	436	22	12	23	8		
Rebound	20	73	16	15	89	106	87	123	4	82	139	121	351	19	13	8	6		
Total	76	289	100	61	286	323	328	573	24	206	401	284	1056	47	30	37	19		

Panel B: Total financial disclosures in the period of 1998-2004

Period	Quarterly Earnings Disclosures	
	PNI	NNI
Rise	322	754
Downturn	595	1247
Rebound	358	854
Total	1275	2855

Table 2
Descriptive Statistics

This table reports descriptive statistics for variables in equation (1) that regresses *STDRET* on a set of firm-specific variables. *STDRET* is excess share price volatility measured as daily stock price standard deviation minus the industry's average in year *t*; *DISC* is number of drug development disclosures divided by number of drugs under development in year *t*; *DISC^a* is number of early-stage “good” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^b* is number of late-stage “good” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^c* is number of early-stage “bad” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^d* is number of late-stage “bad” drug development news announcements over the total number of drug development disclosures in year *t*; *RDE* is R&D expenditure over market value in year *t*; *AR* is the size and book-to-market adjusted excess return in year *t*; *VOLS* is annual mean of monthly trading volume relative to shares outstanding at the end of each month; *SIZE* is a firm size indicator at year *t* measured as natural log of beginning-of-period market value; *LEV* is financial leverage in year *t* measured as long-term debt over long-term debt plus market value of equity; *EP* is earnings-to-price ratio in year *t*, zero if negative; *MB* is market-to-book ratio at year *t*; *DIVE* is number of drug indications under development over number of target diseases in year *t*; *RDM* is a dummy variable, one if the firm has non-zero sales, zero otherwise.

	Mean	5 th	Median	75 th	Std
<i>STDRET</i>	1.780	.167	1.923	2.761	1.912
<i>DISC</i>	.386	.189	.357	.634	.312
<i>DISC^a</i>	.492	.123	.396	.574	.156
<i>DISC^b</i>	.470	.109	.383	.601	.197
<i>DISC^c</i>	.006	.000	.004	.008	.023
<i>DISC^d</i>	.032	.000	.028	.047	.016
<i>RDE</i>	.061	.023	.052	.106	.073
<i>AR</i>	.005	-.099	.003	.007	.006
<i>VOLS</i>	1.116	0.261	1.072	1.287	1.032
<i>SIZE</i>	5.254	2.122	4.998	6.298	1.826
<i>LEV</i>	.012	.000	.009	.064	.092
<i>EP</i>	.059	-.218	.022	.076	1.211
<i>MB</i>	3.091	2.107	3.953	5.512	12.173
<i>DIVE</i>	1.763	1.000	1.652	2.001	.932
<i>RDM</i>	.428	0.000	.397	.621	.307

Table 3
Correlation Matrix

This table reports correlations among variables in equation (1) that regresses *STDRET* on a set of firm-specific variables. *STDRET* is excess share price volatility measured as daily stock price standard deviation minus the industry's average in year *t*; *DISC* is number of drug development disclosures divided by number of drugs under development in year *t*; *RDE* is R&D expenditure over market value in year *t*; *AR* is the size and book-to-market adjusted excess return in year *t*; *VOLS* is annual mean of monthly trading volume relative to shares outstanding at the end of each month; *SIZE* is a firm size indicator at year *t* measured as natural log of beginning-of-period market value; *LEV* is financial leverage in year *t* measured as long-term debt over long-term debt plus market value of equity; *EP* is earnings-to-price ratio in year *t*, zero if negative; *MB* is market-to-book ratio at year *t*; *DIVE* is number of drug indications under development over number of target diseases in year *t*; *RDM* is a dummy variable, one if the firm has non-zero sales, zero otherwise. **, * is significant at the 1% and 5% level, respectively.

	<i>STDRET</i>	<i>DISC</i>	<i>RDE</i>	<i>AR</i>	<i>VOLS</i>	<i>SIZE</i>	<i>LEV</i>	<i>EP</i>	<i>MB</i>	<i>DIVE</i>	<i>RDM</i>
<i>STDRET</i>	1										
<i>DISC</i>	.246**	1									
<i>RDE</i>	.113**	.128**	1								
<i>AR</i>	.108**	.076*	.090*	1							
<i>VOLS</i>	.207**	.136**	-.026	.112**	1						
<i>SIZE</i>	.353**	.412**	.028	-.026	2.27**	1					
<i>LEV</i>	.006	.119**	-.007	.102*	1.06**	2.93**	1				
<i>EP</i>	-.092*	.087*	-.015	-.092*	.09	4.12**	.122**	1			
<i>MB</i>	2.01**	.162**	.106*	.023	1.26**	.150*	.096*	.037	1		
<i>DIVE</i>	.094**	-.062	.044*	.113*	.018	-1.67**	.162**	1.09**	.119**	1	
<i>RDM</i>	-.019	.89*	-.052	-.025	1.12**	3.14**	.173**	1.54**	-.161**	-.201**	1

Table 4**Disclosure Degree and Share Price Volatility—multivariate analysis**

This table reports the estimation of equation (1) that regresses *STDRETR* on a set of firm-specific variables. *STDRETR* is excess share price volatility measured as daily stock price standard deviation minus the industry's average in *t*; *DISC* is number of drug development disclosures divided by number of drugs under development in year *t*; *DISC^a* is number of early-stage “good” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^b* is number of late-stage “good” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^c* is number of early-stage “bad” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^d* is number of late-stage “bad” drug development news announcements over the total number of drug development disclosures in year *t*; *DISC^e* is the total disclosure score from the multivariate approach as described in the text of the paper; *RDE* is R&D expenditure over market value in year *t*; *AR* is the size and book-to-market adjusted excess return in year *t*; *VOLS* is annual mean of monthly trading volume relative to shares outstanding at the end of each month; *SIZE* is a firm size indicator at year *t* measured as natural log of beginning-of-period market value; *LEV* is financial leverage in year *t* measured as long-term debt over long-term debt plus market value of equity; *EP* is earnings-to-price ratio in year *t*, zero in negative; *MB* is market-to-book ratio at year *t*; *DIVE* is number of drug indications under development over number of target diseases in year *t*; *RDM* is a dummy variable, one if the firm has non-zero sales, zero otherwise. ***, **, * is significant at the 1%, 5% and 10% level, respectively. One-tailed test is used in cases of directional estimation. White (1980) standard errors are used to test for the significance of variables.

	Model 1		Model 2		Model 3	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Intercept	1.195	11.622***	1.174	10.567***	1.182	11.143***
<i>Downturn</i>	0.218	2.857**	0.215	2.338**	0.209	2.186**
<i>Rebound</i>	0.531	3.142***	0.501	3.072***	0.522	3.114***
<i>DISC</i>	.072	3.923***				
<i>DISC^a</i>			0.037	2.681**		
<i>DISC^b</i>			0.012	2.597**		
<i>DISC^c</i>			0.761	3.132**		
<i>DISC^d</i>			0.210	2.264**		
<i>DISC^e</i>					.013	3.624***
<i>RDE</i>	0.278	2.813**	0.273	2.746**	0.265	2.101**
<i>AR</i>	0.019	.281	0.016	.309	0.011	.413
<i>VOLS</i>	0.0096	8.426***	0.0091	7.329***	0.0082	7.653***
<i>SIZE</i>	-0.0082	2.684***	-0.0081	2.701***	-0.0081	2.706***
<i>LEV</i>	-0.014	-1.792*	-0.012	-1.810*	-0.013	-1.796*
<i>EP</i>	-0.0312	-1.625	-0.0307	-1.124	-0.0282	-1.483
<i>MB</i>	0.0047	4.293***	0.0028	3.371***	0.0034	4.062***
<i>DIVE</i>	0.0216	2.395**	0.0211	2.208**	0.0213	2.264**
<i>RDM</i>	-0.0005	-.0478	-0.0005	-.0422	-0.0004	-.0453
Adj. R ²	.211		.219		.208	