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Value Creation in the Biotechnology Industry

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VALUE CREATION IN THE BIOTECHNOLOGY INDUSTRY

Paper 1: The value relevance of research progress in the European biotechnology industry

In this paper, the stock market's reaction to the progress of individual research projects is examined. The study is based on hand-collected data of all publicly listed companies in the European biotechnology industry from 1998–2009. The study shows that a stock market reacts more strongly to late-stage announcements than to early-stage announcements. These findings are consistent for both positive and negative R&D announcements. Furthermore, the study documents a large asymmetry in the stock market's reaction to positive and negative R&D announcements. The mean abnormal return to negative (positive) phase III clinical trials is −31.8% (7.5%). In addition, market reactions are explained using project- and firm-specific variables. The findings of this study raise two important issues. First, firms may be reluctant to disclose negative information because of the huge impact of adverse news announcements. Second, given the large information asymmetries in the biotech industry, managers may use the value-relevant R&D news announcements as an instrument to time new equity issues when information asymmetries (or adverse selection costs) are low.

Keywords: Event study; Market efficiency; Value relevance; Non-financial information; R&D; Biotechnology

Paper 2: Market timing and equity financing decisions (co-author Mattias Hamberg)

Market timing is a much-discussed topic in the capital structure literature. We study two views of equity market timing, mispricing and adverse selection costs, using a sample of 232 seasoned equity offerings (SEOs) made by publicly listed European biotech firms between 1998 and 2010. To a large extent, equity is issued to sustain operations, and the average survival time at the announcement date is less than 12 months. There is, however, support for both the mispricing and the adverse selection cost hypotheses. Biotech stocks perform significantly better in the months preceding the announcement of an equity issue. However, there is no sign that the issuing biotech firm yields an abnormal return in the same time period. Univariate analyses suggest that adverse selection costs influence the issue of new equity, as both positive and negative news announcements are associated with equity announcements. It seems as though the mispricing and adverse selection cost hypotheses have incremental effects. In particular, negative news announcements are followed by issues of new equity even though negative news carries no obvious investment need (and survival time is controlled for).

Keywords: Market timing; Mispricing; Adverse selection; Equity financing; Seasoned equity offerings (SEOs); R&D; Biotechnology

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“A scientist gone bad” - Cynthia Robbins-Roth

Preface

When I many years from now began my path towards becoming a natural scientist, I never dreamt that I would end up so far from that expected fate. The transition from the research laboratory into business and finance might seem like a huge step, but in fact it is not. My interest in the field of biotechnology has, by *natural* reasons, influenced the topic of this licenciate thesis.

This licenciate thesis would have been incomplete without the help of a number of individuals. I would like to take this opportunity to acknowledge all of them.

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On the personal side, I wish to thank my family, my love Sofia and my friends for their kindness and encouragement. I dedicate this thesis to my idol in life, my grandfather Erland Jeppsson, who deceased two years ago.

Hans Jeppsson
Göteborg, October 2010

Introduction

The biotechnology industry emerged for more than 30 years ago. Since then, more than 100 drugs have been launched, and thereby, improved the quality of life for millions of people (Miller, 2003; Walsh, 2006). Biotechnology is a field of applied biology (e.g. genetics, microbiology, biochemistry and cell biology) that involves the use of living organisms in engineering, technology and medicine. The basic idea was that through improved technology and a better understanding of biological processes, the R&D process would become more efficient, faster, less risky and cheaper (Pisano, 2006). Biotechnology companies are, also, playing an increasingly important role in drug development.[1] While the general business model of pharmaceutical firms has changed considerably in recent years, future innovations and medical treatments to various diseases are likely to move towards the reliance of biotech firms.

From the financial perspective, biologic products (called biologics) are accounting for a growing share of drug revenues. In 2006, sales of biologics were $40 billion in the US and the annual growth between 2001 and 2006 was 20%, which is particularly remarkable compared with the 6-8% annual growth rate of the US pharmaceutical market (Aggarwal, 2007). Recently, it has been argued that the six biggest-selling drugs in 2014 will be biologics. However, the historical financial performance has primarily been driven by relatively few firms. In 2004, fifteen biotech companies represented 93% of total sales, of which two companies (Amgen and Genentech) accounted for 53% of total sales in the US sector (Pisano, 2006). Indeed, the vast majority of biotech firms are still young and at a developmental stage. Hence, most biotech firms are cash-flow negative.

The core business of biotech firms is to engage in research and development of drugs. The drug development process consists of different stages, which are linked to each other. These different stages are broadly classified as: discovery, pre-clinical, clinical phase I, clinical phases II, clinical phase III, and regulatory review (see Appendix 1). The movement from one stage to the next must be built on the success of the previous stage. In addition, regulatory authorities closely monitor the drug development process and the movement from one stage to the next must be approved by these regulatory authorities (such as the EMA in Europe and the FDA in the US).

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[1] Biotechnology companies engaged in drug development is commonly referred to as biopharmaceutical (henceforth: biotech) companies.

Drug development is certainly a long and expensive process. The length of the development life cycle for a successful product is usually between 10-15 years and the costs of developing a drug exceed $800 million (Kaitin, 2003). The high uncertainty in drug development has immediate implications on the financial statements of biotech firms. Large investments in intangibles, such as R&D, are generally expensed as they occur and are less frequently capitalized. In addition, sales revenues are generally low (or even zero) because few firms have marketable products. As a result, bottom-line net income is usually (large) negative. In the balance sheet, few intangible assets are capitalized, and the asset side is generally dominated by cash and cash equivalents, which firms' burn at a high pace. Although biotech firms hold substantial growth opportunities, banks generally do not provide loans due to the absence of assets in place (Tan and Lim, 2007) . Therefore, biotech firms are generally 100 percent equity-financed. To finance large investments in R&D, biotech firm managers have to turn to capital markets in order to sustain operations.

Research problems

From a valuation perspective, accounting information is only value-relevant if the future resembles the past. However, for firms in R&D intensive industries, such as the biotechnology, accounting information is a poor indicator of firm value. McConomy and Xu (2004) suggest that non-accounting information, such as clinical trial results, are key drivers of value and better indicators of a firm's future earnings potential. Studying the stock market's reaction to clinical trial results has two major advantages. First, disclosures of R&D information for biotech firms are generally mandatory and unbiased. Security laws require firms to disclose price-sensitive information as soon as possible and, thereby, limits the ability of firms to manage and time corporate disclosures. Second, regulatory authorities heavily regulate and monitor the drug development process. Firms work in close collaboration in the design of clinical trials with the regulatory authorities, and have pre-defined goals. As a result, disclosures are generally non-discretionary. In this setting with the regulatory authority as a gatekeeper, events are rather exogenous. Hence, this environment overcomes the common criticism of the presence of endogenous events in the event study literature (Schultz, 2003, Viswanathan and Wei, 2008).

The first research paper uses a unique hand-collected dataset of all publicly listed firms in the European biotechnology industry from 1998-2009, and examines how the stock market

responds to when uncertainty is resolved at different stages. For example, how does the market react when a project is allowed to enter clinical trials? Is there a difference in the market's reaction between different type of announcements (e.g., phase I, phase II and phase III), between announcements of positive and negative results, and between different type of companies?

The biotech industry is, arguably, different from other industries in the sense that firms usually operate with large negative free cash flows, and they have no other choice but to regularly ask investors for (equity) financing of their research projects. Studying market timing and external financing decisions for a sample of biotech firms has two advantages. First, external financing is not a choice between debt or equity, but only equity (Guo and Mech, 2000). Second, while earnings announcements are biased in the case that managers deliberately disclose information that is at their advantage, i.e. earnings announcements can be manipulated, R&D announcements are credible announcement news and are, generally, not subject to manipulation. However, when to access the capital markets is a balancing act that depends on both firm- and market-specific factors.

An example of market timing is exemplified by the following paragraph from a press release on March 23, 2010, for the French biotech firm Transgene, which went public in 1998: "In light of its net cash position at December 31, 2009, of €64.7 million, the Company is able to determine the timing of the fund raising and its announcement when it deems the conditions most appropriate".

While the primary motive to issue new equity is driven by a need to sustain operations, this study examines the incremental effect whether firms' access capital markets when investors understand the firm's prospects better (i.e., the information asymmetry between investors and management is low), or whether the equity issue decision is driven by the belief that managers see a "window-of-opportunity" in the market. Credible R&D announcement disclosures are used in this study as a measure of the information asymmetry.

Data and methodology

The two research papers are based on a sample of 87 publicly listed European biotechnology firms between 1998 and 2010. The first research paper uses a complete sample of 1,089 R&D

announcements made by all publicly biotechnology firms between 1998 and 2009. The information related to R&D announcements is primarily hand-collected from corporate websites. The methodology in the first research paper is the standard event study methodology (e.g. MacKinlay, 1997). Event studies using short event windows are often referred to as information content studies (Francis and Shipper, 1999). Stock exchange regulations require firms to disclose "price sensitive" information as soon as possible on their corporate website. Since R&D announcements in the biotechnology industry are mandatory, the corporate website is the most reliable source of information.

In the second research paper, equity issue data of 232 seasoned equity offerings (SEOs) made by European biotech firms is used. The data is collected from corporate websites, annual reports and the Thomson Reuters Knowledge Database. This study uses 561 R&D announcements from the first research paper. The methodology employed is a probit model, in which the probability of an equity issue is explained using firm- and market-specific variables.

The European biotechnology industry

The European biotech industry is considerably smaller than the US biotech industry in terms of number of firms, number of employees, products and market capitalization (Bains, 2006). In addition, the industry is relatively young, compared to its US counterpart. The Swedish company, Active Biotech, which went public in December 1986, is the oldest European biotechnology firm.[2] However, the number of European biotech firms has increased substantially over time. In 1998, the total number of European publicly listed biotech firms were 22, of which 12 were from the UK. The sector has grown during especially two IPO windows; in 2000 when 12 firms went public, and, between 2004 and 2006 when the sector grew from 47 to 73 firms. As of 2010, the sector consists of 76 active biotech firms, of which they are distributed per region as follows: Scandinavia- 18, United Kingdom 20, French 17, and, German 21[3]. These firms are listed on the following stock exchanges: Vienna Stock Exchange (Austria), Copenhagen Stock Exchange (Denmark), Helsinki Stock Exchange (Finland), Euronext Paris (France), Frankfurt Stock Exchange (Germany), Milano Stock Exchange (Italy), Euronext Amsterdam (the Netherlands), Oslo Stock Exchange (Norway),

[2] Active Biotech (or originally Active), was founded in 1983, and became a pure biotechnology company in 1997, when operations were to concentrate on biotechnology.
[3] Classification according to La Porta et al (1998).

OMX Stockholm (Sweden), Swiss Stock Exchange (Switzerland), and, London Stock Exchange/Alternative Investment Market (United Kingdom).

Bains (2006) argues that the cause of the relatively immature European biotech industry is because of low investment levels; the sector receives smaller amounts of funding, and less funding per company compared to US biotech firms. In contrast, Fazeli (2005) suggests that the cause of the less successful European biotech industry is not due to that there is not enough cash available that is needed to bring products to market, but rather due to fragmented equity market.

In the sample period 1998 to 2009, 57 firms went public raising a total of €2,512 million or €46.5 million per firm (not tabulated). The three largest IPOs were all made in 2000: Genmab raised €209.6, Actelion €165.6, and, Crucell €144.0 million, respectively. In total, 232 SEOs have raised equity capital worth €6,536 million[4]. Firms with Scandinavian-origin have raised most equity capital, totaling €2.00 billion in 65 equity issues (i.e. €30.81 million per issue). Firms with English-origin have made the largest number of equity issues; 86, with a total value of €1.77 billion (i.e. €20.56 million per issue). The largest amount per issue has been made by French-origin biotech firms: €47.96 million per issue. There is a substantial variation over time, both in terms of the number of issuing firms and the size of their equity issues. While the average size of gross issue proceeds has been €28.2 million, the lowest annual average is €6.9 million (1999) and the highest is €50.1 million (2007). Finally, the value of the equity proceeds also varies substantially and it is determined by both the number of issuing firms and the value of their issues. As a consequence the sum of the proceeds per firm is €18.4 million in 2007, €3.2 million in 2008, only to be followed by €15.7 million in 2009.

[4] A SEO is a new equity issue made by an already publicly listed firm.

Appendix 1. The drug development process

(i) Discovery research and pre-clinical research

The first stage in the drug development process is discovery research. The objective of this stage is to identify one or more active chemical or biological substances with the desired effect and drugable potential. In preclinical research, selected candidate drugs from discovery research are tested in animals. The primary goal is to determine whether the identified drug can be administered to humans. Discovery research and the pre-clinical phase usually take 3-5 years to complete (Active Biotech, Annual Report 2009). A company files an investigational new drug (IND) application with national regulatory authorities, to request permission to initiate testing of the drug on humans.[5]

(ii) Clinical phase I

In clinical phase I trials, the candidate drug is tested in a group of healthy volunteers (20 - 80). The purpose is to evaluate its safety and determine safe dosing ranges. Phase I usually takes 1 to 1.5 year(s) to complete and costs between €5.4 and €8.1 million. (Active Biotech, Annual Report 2009; Keegan, 2008) On average, only 10-20% of drugs at this phase reach the market (Bogdan and Villiger, 2008).

(iii) Clinical phase II

In clinical phase II trials, the drug is tested on patients suffering from the target disorder. The trials usually encompass 100 to 300 patients. Clinical phase II can take from 1 to 2 years and costs between €10.8 and €21.6 million to complete. (Active Biotech, Annual Report 2009; Keegan, 2008) About 30% of drugs at this stage reach the market (Bogdan and Villiger, 2008).

(iv) Clinical phase III

In clinical phase III trials, the drug is given to large groups of patients (1,000 – 3,000), and intends to confirm its safety, monitor potential side effects, and measure efficacy in relation to commonly used treatments (if any exist). Clinical phase III usually takes 2 to 4 years and costs between €27.1 and €54.1 million. (Active Biotech, Annual Report 2009; Keegan, 2008) After successful results, the company will submit an NDA ("New Drug Application") or BLA

[5] The IND includes detailed information on the structure of the trials the company intends to use for testing the drug.

("Biologics License Application") to a regulatory authority for regulatory review. Approximately 50-75% of drugs at this stage are approved (Bogdan and Villiger, 2008).

References

Aggarwal, S., 2007. What's fueling the biotech engine? Nature Biotechnology 25, 1097-1104.

Bains, W., 2006. What you give is what you get: Investment in European biotechnology. Journal of Commercial Biotechnology 12, 274-283.

Bogdan, B, Villiger, R., 2008. Valuation in life sciences. Heidelberg: Springer-Verlag.

Fazeli, S., 2005. The European biotech sector: Could it achieve more?. Journal of Commercial Biotechnology 12, 10-19.

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

Guo, L., Mech, T. S., 2000. Conditional event studies, anticipation, and asymmetric information: The case of seasoned equity issues and pre-issue information releases. Journal of Empirical Finance 7, 113-141.

Kaitin, K. I., 2003. Post-approval R&D raises total drug developments costs to $897 million. Tufts Center for the Study of Drug Development Impact Report 5(3).

Keegan, K, 2008. Biotechnology valuation: An introductory guide. West Sussex: John Wiley & Sons Ltd.

MacKinlay, C. A., 1997. Event studies in economics and finance. Journal of Economic Literature 35, 13-39.

McConomy, B., Xu, B., 2004. Value creation in the biotechnology industry. CMA Management, 29-31.

Miller, H. I., 2002. As biotech turns 20. Nature Review of Drug Discovery 1, 1007-1008.

Pisano, G. P., 2006. Science Business: The promise, the reality, and the future of biotech. Boston: Harvard Business School Press.

Robbins-Roth, C., 2001. From alchemy to IPO: The business of biotechnology. New York: Basic Books.

Schultz, P., 2003. Pseudo market timing and the long-run underperformance of IPOs. Journal of Finance 58, 483-517.

Tan, P. M-S., Lim, C. Y., 2007. The value relevance of accounting variables and analysts' forecasts: The case of biotechnology firms. Review of Accounting and Finance 6, 233-253.

Viswanathan, S., Wei, B., 2008. Endogenous events and long-run returns. Review of Financial Studies 21, 855-888.

Walsh, G., 2006. Biopharmaceutical benchmarks 2006. Nature Biotechnology 24, 769-776.

The Value Relevance of Research Progress in the European Biotechnology Industry

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Abstract

In this paper, the stock market's reaction to the progress of individual research projects is examined. The study is based on hand-collected data of all publicly listed companies in the European biotechnology industry from 1998–2009. The study shows that a stock market reacts more strongly to late-stage announcements than to early-stage announcements. These findings are consistent for both positive and negative R&D announcements. Furthermore, the study documents a large asymmetry in the stock market's reaction to positive and negative R&D announcements. The mean abnormal return to negative (positive) phase III clinical trials is −31.8% (7.5%). In addition, market reactions are explained using project- and firm-specific variables. The findings of this study raise two important issues. First, firms may be reluctant to disclose negative information because of the huge impact of adverse news announcements. Second, given the large information asymmetries in the biotech industry, managers may use the value-relevant R&D news announcements as an instrument to time new equity issues when information asymmetries (or adverse selection costs) are low.

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Keywords: Event study; Market efficiency; Value relevance; Non-financial information; R&D; Biotechnology

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1. Introduction

At any time, a stock price represents the aggregate expectations of investors on future cash flows, with an adjustment for risk. To estimate future cash flows and risk, investors use information that they deem to be value relevant (Holthausen and Watts, 2001; Barth et al., 2001). Accounting reflects the financial performance and position of a firm, and as long as the firm's future resembles the past, historical accounting information is associated with stock prices. Consequently, many studies have indicated that the book value of equity and net profit explains a majority of the cross-sectional variation in stock price (Collins et al., 1997; Beisland and Hamberg, 2010). Similarly, analysis of accounting information shows that many individual accounting items are value relevant (Amir and Lev, 1996; Hamberg and Beisland, 2010).

Clearly, historical accounting information is only value relevant when the future resembles the past; this is typically the case in mature industries where it is possible to capitalize resources as assets. Problems arise when a firm makes large investments that have to be expensed immediately. Because most investments are made in positive NPV projects, an immediate expenditure has two consequences. First, current performance measures are excessively low (often negative), even though one can expect that the more negative the current performance, the more positive future performance will be. Second, the measure of the current resources, equity, becomes excessively low because few investments are booked as assets. For these firms, accounting information will explain very little of the cross-sectional variation in stock price. The future does not resemble the past.

Instead of relying on accounting information, investors must use voluntary and mandatory disclosures of information about the status of the firm's investment projects. Empirical accounting research verifies that voluntary disclosures improve stock liquidity (Diamond and Verrecchia, 1994), reduce the cost of equity capital (Botosan, 1997) and increase information intermediation (Lang and Lundholm, 1996). However, because voluntary disclosures are subject to a self-selection bias, the association between market reactions and disclosure might be driven by firm performance rather than by disclosure per se (Healy and Palepu, 2001). In this setting, the biotechnology industry is studied as an industry in which investors make little use of mandatorily disclosed accounting information and in which voluntary disclosures are frequently verified by external regulatory authorities (Guo et al., 2004). These factors enable studies of market reactions to the disclosure of information while avoiding the self-selection

biases caused by personal (and often agency cost-based) incentives. Indeed, most of the disclosures are obligatory and unbiased. In addition, the non-discretionary nature of disclosures in this industry overcomes the common criticism of endogenous events in the event study literature (Schultz, 2003; Viswanathan and Wei, 2008).

This study provides three contributions to the accounting and finance literature. First, it documents how the market reacts in aggregate to the disclosure of non-discretionary information. It shows the extent to which different information is relevant to investors (in the sense that it influences security prices). This knowledge is important to investors who are evaluating firms within a given industry. For example, a firm with a single project in phase II has a considerably different risk profile than a firm with five projects in clinical trials, of which one is in phase II. Although these factors are important to investors, reliable measures of these differences are scarce in the literature (particularly for the European biotechnology industry).

Secondly, while numerous studies have used information from the US stock exchanges (Ely et al., 2003; McConomy and Xu, 2004), this study used a unique hand-collected dataset of all publicly listed firms in the European biotechnology industry from 1998–2009. It has been argued that the US biotechnology sector differs from the European biotechnology sector in terms of maturity, size and the availability of funding (Dedman et al., 2008). Hence, this study provides the largest analysis by far of the European biotechnology industry, covering 87 firms from eleven countries over thirteen years.

Thirdly, the study provides evidence of the differences in market reactions according to predictions. In particular, there are differences in stock price and in trading volume between projects in different phases, as well as between positive and negative outcomes. The study also documented how market reactions are explained, using project- and firm-specific variables.

This study shows that the stock market reacts more strongly to later-stage R&D announcements than to earlier-stage R&D announcements. These findings are consistent for both positive and negative R&D announcements. Furthermore, this study documents a large asymmetry in the stock market's reaction to positive and negative R&D announcements. The mean abnormal return to positive (negative) phase III clinical trials is 7.5% (−31.8%), and this result is robust with respect to abnormal trading volume. These findings raise two important issues. First, firms may be reluctant to disclose negative information because of the huge

impact of adverse news announcements. Second, given the large information asymmetries in the biotech industry, firms may use the R&D news as an instrument to access the capital markets when the information asymmetries are low.

The remainder of the paper is organized as follows. Section 2 contains a literature review and describes the hypotheses. Section 3 introduces the methodology, and section 4 explains the data sample. Section 5 presents the empirical results, and section 6 offers a conclusion.

2. Theory and research hypotheses

2.1 Value relevance of accounting and non-accounting information

It is known that value-relevant information changes stock prices because it causes investors to revise their expectations of the firms' future cash flows (Francis and Schipper, 1999). Accounting information, such as earnings and book value of equity, has generally been considered as value-relevant to investors (Easton and Harris, 1991; Francis and Schipper, 1999; Beisland and Hamberg, 2010). However, it has been questioned to what extent accounting information plays a role for firms in high-tech industries that invest heavily in intangible assets, such as R&D, that are less frequently capitalized. Current accounting practice requires firms to expense their significant value enhancing investments in internally developed intangible assets.[6] Consequently, assets do not fully reflect a company's valuable resources, and accounting items, such as earnings and book values of equity, are quite unrelated to market values (e.g. Amir and Lev, 1996). Historical accounting information is only value relevant if the future resembles the past, and it typically does so for firms in mature industries where it is possible to capitalize resources as assets. But, for firms in research-intensive industries accounting information is a poor indicator of firm value. Instead, McConomy and Xu (2004) suggest that for biotech firms, non-accounting information, such as clinical trials results and governmental approvals, are key drivers of value and better indicators of a firm's future earnings potential.[7]

[6] According to IAS 38 (IFRS), research costs should be expensed when they incur, while development costs can be capitalized if certain criteria are met. One such criteria is that future economic benefits can be are highly probable.

[7] McConomy and Xu (2004) find that the stock market reacts more strongly to R&D progress information than to earnings announcements, indicating that non-financial information is more value-relevant than financial information.

In the biotechnology industry, risk and uncertainty associated with R&D projects is especially high when compared to other industries (Guo et al., 2004). The high uncertainty is attributable to the complexity and novelty of the science, but also to the characteristics of drug development, which is a long and expensive process. On average, the costs of developing a drug exceed $800 million and it often takes more than 10 years before a drug candidate reaches the market (Kaitin, 2003). Drug development has two key features. First, it consists of different stages, which are linked to each other and where the movement from one stage to the next must be built on the success from the previous stage. Second, regulatory authorities closely monitor the drug development process and the movement from one stage to another must be approved by these regulatory authorities (such as the EMA in Europe and the FDA in the US).

The high uncertainty in drug development causes most firms to immediately expense R&D investments.[8] In addition, a majority of the firms in the biotech industry (especially in the European sector) are at an early stage in the corporate lifecycle. Most of the firms have no marketable products that can generate sales revenues; consequently, they report large losses. For these firms, the current earnings do not provide a good proxy for future earnings; i.e., the future does not resemble the past.

In summary, the value created from R&D is highly uncertain (Xu et al., 2007). Therefore, it is important to consider how investors respond to information that contains a substantial amount of uncertainty.

2.2 Corporate disclosures

Corporate disclosures should reduce the information asymmetry between managers and investors. Firms may have incentives to make additional voluntary disclosures if they perceive that such disclosures will benefit the firm (Cerbioni and Parbonetti, 2007), but reducing information asymmetry via voluntary disclosures is a trade-off between benefits and the costs of disclosing information. Prior empirical research has shown that voluntary

[8] The project stage generally forms the basis for deciding whether the costs associated with development projects can be capitalized or not. For example, Amsterdam Molecular Therapeutics do not capitalize their clinical development expenditures until filing for market approval or until market approval is obtained, arguing that this is basically the first point when it becomes probable that future revenues can be generated (Annual Report, 2006). Thrombogenics capitalize development costs in clinical phase III, when they estimated that the chance of future success is high (Thrombogenics, Annual Report, 2009).

disclosures are associated with a lower cost of equity capital (Botosan, 1997), a higher stock liquidity (Diamond and Verrecchia, 1994), and an increase in the intermediation of information (Lang and Lundholm, 1996). In contrast, the costs of disclosures are related to benefiting competitors and increasing litigation exposure (Darrough and Stoughton, 1990). However, because voluntary disclosures are subject to a self-selection bias, the association between market reactions and disclosure might be driven by firm performance rather than disclosure per se (Healy and Palepu, 2001). In the biotechnology industry, most disclosures are mandatory and unbiased.[9] In addition, managers' incentives to disclose value-relevant product development information are also derived from investor demand (Guo et al, 2004; Cerbioni and Parbonetti, 2007).Regulatory authorities stipulate the requirements that must be met to advance a drug from one development stage to the next, and public firms have to disclose information (according to security laws) regarding decisions taken by regulatory authorities. These security laws limit the ability of firms to manage and time corporate disclosures.[10] The non-discretionary nature of disclosures in this industry allows for studies of the stock market's reaction to R&D news announcements. In addition, this environment overcomes the common criticism of the presence of endogenous events in the event study literature (Schultz, 2003; Viswanathan and Wei, 2008).

Disclosures on particular R&D projects might be value relevant, meaning that they resolve investors' uncertainty about a firm's ability to generate future revenues from particular R&D projects. As an R&D project progresses through the various stages, uncertainty is reduced and future expected cash flows become more certain. As a result, the stock market reacts more strongly to late-stage announcements (when uncertainty is comparatively low) compared to early-stage announcements (when uncertainty is higher). However, prior studies indicate inconsistent value relevance between stages during the drug development process.[11] For example, Ely et al. (2003) found that the stock market reacts to status updates related to clinical phase II, but not to phase III or to FDA submission announcements.[12] In contrast, McConomy and Xu (2004) and Dedman et al. (2008) proposed that the later stage

[9] For a review of disclosure issues for biotechnology and pharmaceutical firms, see Fisher (2002).
[10] Publicly-listed firms are subject to certain requirements about trading rules and regulations. Following general disclosure rules, firms have an obligation to disclose "price sensitive" information as soon as possible to the public.
[11] The stages in drug development are broadly classified as discovery, pre-clinical, clinical phase I, clinical phase II, clinical phase III, and regulatory review.
[12] Ely et al (2003) argue that during phase II, investors begin to ascribe significant value to a drug that is under development.

announcements (phase III and the final success) most value-relevant. The first hypothesis is the following:

H_1: Disclosures of late-stage (phase III) R&D announcements have a more profound effect on security pricing than disclosures of early-stage (phase I) R&D announcements.

If clinical trials exhibit negative results in any phase, the firm is required to terminate these trials (Xu et al., 2007). As a result, the certainty of a loss following negative results is absolutely sure.[13] In contrast, there is still a great deal of uncertainty remaining after positive clinical trial results. Even after a governmental approval, there is uncertainty related to market risk. Prior studies on pharmaceutical firms have shown that the stock market's reaction to positive and negative FDA decisions upon new drug approval (NDA) is asymmetrical (Sharma and Lacey, 2004; Torabzadeh et al., 1998). One problem is that voluntary disclosures of the clinical trial results of pharmaceutical firms suffer from potential self-selection bias, meaning that the results cannot be generalized to biotechnology firms.[14] Prior studies on biotech firms have only studied the stock market reaction to positive news, due to small sample sizes (Ely et al., 2003; Dedman et al., 2008).[15] Therefore, the second hypothesis is the following:

H_2: Disclosures of negative R&D announcements have a more profound effect on security pricing than disclosures of positive R&D announcements.

One key feature of the biotechnology industry is that firms disclose detailed information. Quite possibly, there is no other industry in which such detailed information about ongoing projects is disposed. Corporate disclosures of clinical trial results generally contain such

[13] However, firms can theoretically submit an application to regulatory authorities to start clinical trials on other indications.

[14] Even though the drug development process is essentially identical for biotechnology and pharmaceutical companies, the key difference is that pharmaceutical companies are generally much larger and hold a much more diversified project pipeline than biotech companies. Furthermore, pharmaceutical companies have revenue-generating products, and therefore, failures (and successes) of early-stage projects might be considered to be, relatively speaking, less value relevant information.

information as the type of compound, indication, therapy area, stage of development, number of patients, comments made by the CEO and/or medical director, et cetera. In addition, disclosures describe whether the primary endpoint of the study was met (such as safety, efficacy, or tolerability of the drug).[16] Hence, clinical trial results are subject to a good news-bad news ranking (Guo et al., 2004).

If the stock market responds differently to similar types of information, the results may be driven by key features of the sample. For example, a firm with a single project in phase II has a considerably different risk profile than a firm with five projects in clinical trials, of which one is phase II. Joos (2003) proposed that collecting a richer data set on the micro level might provide additional insight into the value creation process and how R&D contributes to the value of a biotech firm. Although it is important to investors, reliable measures of these factors are scarce in the literature. Thus, market reactions are explained using project- and firm-specific variables.

3. Methodology

This section describes the research methodologies used in the paper. First, the event study methodology that was employed to assess the stock market's reaction to R&D announcements is described. Second, the cross-sectional regression model that was used to investigate the link between project- and firm-specific variables, as well as stock market returns, is presented.

3.1 Event study

To investigate the stock market's reaction to R&D announcements, the standard methodology for a short run event study, as suggested by MacKinlay (1997) and Campbell et al. (1997), is followed. Abnormal returns are calculated as the difference between the actual and predicted returns. The predicted returns are estimated using a single-index market model with an

[15] McConomy and Xu (2004) found that phase III results (positive/negative) exhibits the strongest market reaction of the different stages, but do not comment on differences between market reactions between positive and negative news across phases.

[16] Stock exchange regulations not only require information disclosed by the company to be correct, relevant, clear, and not misleading, they also requires information to be comprehensive enough to provide adequate guidance to render possible assessment of the effect of the price of its securities.

estimation window of 180 days (day −200 to day −21). As a proxy for the market portfolio, the equal-weighted dividend- and split-adjusted stock return for all other firms that were included in the sample is used.[17] To eliminate the effect of confounding events and a possible dependence between abnormal returns, overlapping events were excluded (using a three-day period centered on the announcement date). Day 0 is designated as the day when the firm makes the R&D announcement.[18] If the information is disclosed during a weekend or any other time when the markets are closed, the next trading day becomes the event day. As in all event studies, there is an implicit assumption that markets are efficient (Fama, 1970).

As a check of robustness, the cumulative abnormal returns (CAR) for a three-day event window (from day −1 to day +1), a five-day event window (from day −2 to day +2), and a twelve-day event window (from day −2 to day +10) are calculated. The CAR is calculated by aggregating the abnormal returns across two dimensions (firms and time). In addition to Student's *t* test, the non-parametric Wilcoxon signed ranks test is used, which does not require that the population be normally distributed.

Trading volumes may provide a better measure of information content than do price reactions (Beaver, 1968; Bamber, 1986). While price reactions reflect an average revision in investor beliefs, trading volume reactions reflect idiosyncratic belief revisions (Karpoff, 1986; Kim and Verrecchia, 1991a and 1991b). Following Ajinkya and Jain (1989), abnormal volume is the difference between the actual and predicted trading volume. Equivalent to the estimation of predicted returns, the single-index market model with an estimation window of 180 days (day −200 to day −21) is used. A firm's actual volume is the number of shares traded on day *t* scaled to the total number of shares outstanding. The market proxy is the number of shares traded for all other firms (that were included in the sample), scaled by these firms' total number of shares outstanding.

[17] Biotech- (and pharmaceutical) stocks are non-cyclical. Hence, this study uses an industry index rather than a market index.

[18] Most US studies use the announcement dates in the *Wall Street Journal* as the event dates. Newspapers normally have one or two days of delay in their announcements. Business intelligence databases use newspapers as sources of information. Hence, relying on the dates from newspapers or databases might bias the event date. Therefore, as a check of robustness, different event windows are used, although the longer event windows tend to be noisier.

3.2 Hypothesis testing

Two tests are performed. First, the stock market's reaction (with respect to price and volume) to early-stage (phase I) and late-stage (phase III) R&D announcements is examined. Second, the stock market's reaction (with respect to price and volume) to positive and negative R&D announcements is investigated. To test for hypothesis 1 and hypothesis 2, pair-wise analysis of the differences in mean is used.

3.3 Cross-sectional regression

Following standard practice, a regression model is used to explain the cross-sectional variations in abnormal return (Kale et al., 2002), using firm- and project-specific information:

$$AR_i = \alpha_0 + \alpha_1 COMPLEXITY_i + \alpha_2 RISK\_SHARING_i + \alpha_3 INVESTMENT_i + \alpha_4 DIVERSIFICATION_i + \alpha_5 MTB_i + \sum_{j=1}^{3} \beta_j REGION_i + e_i$$

3.2.1 The dependent variable

The abnormal return on day zero is used as the dependent variable (McWilliams and Siegel, 1997). The regression is run for four models with the following dependent variables: (i) all R&D announcements (positive and negative), (ii) all positive R&D announcements, (iii) positive phase I announcements, and (iv) positive phase II announcements.[19]

3.2.2 Independent variables

Complexity

The therapy area of a project is a proxy for the complexity of the research project (*COMPLEXITY*). Projects within therapy areas that tend to have low success rates, such as the central nervous system, are expected to have a larger stock market reaction following positive news on clinical trials. Historical success rates per therapy area are based on DiMasi (2001).[20]

[19] The number of R&D announcements in the categories was restricted to test only these models.

[20] The success rates by DiMasi (2001) are based on pharmaceutical firms and may not directly apply to biotechnology firms. However, the success rates are not inflated by the R&D announcements in this sample. Hence, they are considered to be independent.

Risk-sharing

Biotech firms generally seek to collaborate with experienced partners in the costly late-stage clinical trials to share the risk.[21] A dummy variable (*RISK_SHARING*) is given a value of one when a project is developed with a partner; otherwise, it is zero.

Investment

The number of patients varies; not only between the different stages of drug development, but also between firms. The size of clinical trials (i.e., the number of patients included in the study) is a function of the size of the investment made by the firm and may provide investors with a more credible signal of the firms' belief in the project. The variable (*INVESTMENT*) is the logarithmic value of the number of patients.

Project diversification

A firm with many projects is less dependent on the success of each single project, compared to a firm with only one project. Project diversification (*DIVERSIFICATION*) is measured as the logarithmic market value of equity (measured as the average market value from day −21 to day −2, relative to the R&D announcement).

Other independent variables

Other control variables are market-to-book (*MTB*) and region dummies. Following La Porta et al. (1998), region dummies are included to control for the institutional characteristics between countries. The Anglo-Saxon region is used as a benchmark relative to the other three regions (Germanic, French, and Scandinavian).

[21] For example, Paion's business strategy is to partner clinical products after the first major value driving milestone (after phase II), in order to share the risk of later clinical development (Paion, Annual Report, 2008).

4. Data and sample selection

4.1 Sample selection

This study examines R&D announcements of 87 publicly listed European biotechnology firms between 1998 and 2009[22]. The sample is primarily identified from the Thomson Datastream database. Three restrictions to the sample are made. First, the company's primary quotation has to be at a European stock exchange. Second, only firms that are engaged in the development of drugs are included.[23] Third, to ensure a homogenous sample, pharmaceutical and generic companies are excluded. These restrictions reduce the number of firms from 431 to 87. These firms are listed on the following stock exchanges: Vienna Stock Exchange (Austria), Copenhagen Stock Exchange (Denmark), Helsinki Stock Exchange (Finland), Euronext Paris (France), Frankfurt Stock Exchange (Germany), Milano Stock Exchange (Italy), Euronext Amsterdam (the Netherlands), Oslo Stock Exchange (Norway), OMX Stockholm (Sweden), Swiss Stock Exchange (Switzerland), and London Stock Exchange/Alternative Investment Market (United Kingdom).

Financial and accounting information such as the dividend- and split-adjusted stock prices and trading volumes, as well as the number of shares outstanding and the book value of equity, are gathered from the Thomson Datastream.

4.2 R&D announcements

This study uses a complete sample of 1,089 R&D announcements made by all public biotechnology firms between 1998 and 2009.[24] The information related to R&D announcements is hand-collected from corporate websites.[25,26]

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[22] Ely et al. (2003) use a sample of 83 US biotech firms with no marketable products between 1988 and 1998. Dedman et al. (2008) use a sample of 22 UK firms, comprising a mixture of both biotechnology and pharmaceutical companies. The final sample consists of 151 positive announcements made between 1990 and 1998, of which 81 are made by three pharmaceutical firms.

[23] The biotechnology companies can be broadly classified to the fields of medical devices, diagnostics, information technology, tools and equipment, and drug development.

[24] Hence, survivorship bias is not considered as a problem.

[25] For some inactive firms, the announcement dates are collected using annual reports and the Factiva database.

[26] Joos (2003) argue that clinical trial results may also become available through alternative information sources, such as medical journals, conference abstracts and analyst meetings, and consequently, some news may suffer from potential biases. However, stock exchange regulations require public firms to have their own website on which "price-sensitive" information shall be made available as soon as possible after the information has been disclosed. According to these rules, firms are not allowed to provide price sensitive information at general meetings or analyst presentations without also disclosing the information elsewhere.

Clinical trial results are subject to a good news-bad news ranking (Guo et al., 2004). Stock exchange regulations not only require the information disclosed by a company to be correct, relevant, clear, and not misleading, they also require the information to be comprehensive enough to provide adequate guidance to assess the effect on the price of its securities. Firms must have a headline indicating the substance of the announcement and they must also clearly present the most important information at the beginning of the announcement. Hence, wording in the heading such as "positive results," "successful completion" or "primary endpoint was met" are classified as positive news. Similarly, press releases including adverse notifications such as "negative results," "failure" or "primary endpoint was not met" are coded as negative news. Examples of a positive and a negative R&D news announcement are given in Appendix 1. Description and classification of R&D announcements is illustrated in Table 1. The event date, stage of development, and firm- and project-specific information are also collected from the press releases.

Table 1. Description and classification of R&D announcements

Announcement category	*Stage*	*Number of announcements*
Initiation		8
Results (positive)	Pre-clinical	56
Results (negative)		15
Initiation		200
Results (positive)	Phase I	123
Results (negative)		36
Initiation		214
Results (positive)	Phase II	175
Results (negative)		55
Initiation		88
Results (positive)	Phase III	66
Results (negative)		35
Total		1,071

Note: This table reports different types of announcements related to different phases (or stages) of the R&D process. These announcements are classified to three main announcement categories: initiation, results (positive), and, results (negative). Four different phases are distinguished between, i.e. pre-clinical, phase I, phase II and phase III. The review stage is excluded due to few observations.

4.3 Descriptive statistics

Table 1 reports the distribution of positive and negative R&D announcements per stage. In total, there are 1,071 news announcements, of which 561 announcements are related to positive and negative R&D results. There are more positive R&D announcements than negative R&D announcements: 75% [420/(420+141)] of the R&D announcements are

positive. These findings are consistent with those of Dedman et al. (2008) and Ely et al. (2003), who also found that firms disclose relatively few negative announcements in relation to positive announcements. The cumulative success rate from pre-clinical to clinical phase III is 30%, which reflects the low success of drug development.[27,28] Interestingly, the main attrition occurs in late-stage, rather than in early-stage, as 35% of the projects fail in phase III, and only 23% fail in phase I.[29] The results contrast those in DiMasi (2001), where the main attrition of pharmaceutical companies occurred in phases I and II (87%). There are also more announcements of phase II than of phase I because firms often expand a candidate drug's number of indications during later clinical stages. Fewer announcements concern the initiation of projects at the pre-clinical stage, compared with the initiation of projects in the clinical stages.

Preclinical results are often published in scientific journals and companies only sporadically disclose this information in annual reports and company announcements (Joos, 2003). A firm has no reason to file an Investigational New Drug (IND) with regulatory authorities if they find that the drug has adverse effects in animal studies. As a result, an announcement related to this stage may suffer from a self-reporting bias problem. In summary, this study primarily focuses on the three stages of drug development: clinical phase I, phase II and phase III, and there is good reason to believe that disclosures during these stages constitute the most value relevant disclosures about the firms' projects.

5. Empirical results

5.1 Stock market reaction to R&D announcements

Table 2 presents the short-run stock price and volume reaction to R&D announcements related to the stages of drug development. The stock market reacts positively (negatively) to all positive (negative) R&D announcements on day zero.[30,31] The day zero mean abnormal return is 1.99% (−12.25%) for clinical phase I results, 6.37% (−15.78%) for clinical phase II

[27] The success rate is the probability that a project entering a phase reaches the next phase. Attrition, or failure, is equal to one minus the success rate.
[28] Not tabulated. [15/(56+15)]* [36/(123+36)]* [55/(175+55)]* [35/(66+35)] = 0.303
[29] [35/(66+35)]
[30] All of the reactions are statistically significant at the 1% level, but reactions to positive phase I announcements were significant at the 5% level.

results and 7.53% (−31.77%) for clinical phase III results. The strong stock market reaction to negative news announcements, especially to clinical phase III, suggests that they were largely unanticipated by investors. In the most extreme case, the market value decreased by 75% during one day on a single negative phase III news announcement (not tabulated).

Table 2. Mean abnormal returns ($\overline{AR}$), mean cumulative abnormal return ($\overline{CAR}$), mean abnormal volume ($\overline{AV}$), and, cumulative abnormal volume ($\overline{CAV}$) for R&D announcements

Stage of R&D process	Event	Abnormal return (%)			Abnormal volume (%)		
		n	$\overline{AR}_0$ (*t* value)	$\overline{CAR}_{-1,+1}$ (*t* value)	n	$\overline{AV}_0$ (*t* value)	$\overline{CAV}_{-1,+1}$ (*t* value)
Phase I	Initiation	200	1.55***	1.22*	190	0.30	0.37
			(3.07)	(1.77)		(1.47)	(1.28)
	Results (positive)	120	1.99***	1.68**	118	0.54***	0.73***
			(3.67)	(2.32)		(2.81)	(2.62)
	Results (negative)	34	-12.25***	-15.20***	32	3.00*	3.52*
			(-3.94)	(-5.04)		(1.93)	(-1.91)
Phase II	Initiation	202	1.23**	0.95*	180	0.23***	0.30**
			(2.46)	(1.71)		(3.16)	(1.99)
	Results (positive)	174	6.37***	7.13***	172	0.93***	1.66***
			(4.21)	(4.43)		(4.96)	(4.90)
	Results (negative)	55	-15.78***	-24.18***	54	2.58**	4.94***
			(-4.24)	(-4.25)		(2.01)	(2.67)
Phase III	Initiation	88	2.28	2.57	78	0.26	0.29
			(1.31)	(1.53)		(1.22)	(0.85)
	Results (positive)	66	7.53***	6.44***	65	0.90**	1.23***
			(8.02)	(4.45)		(2.55)	(2.83)
	Results (negative)	34	-31.77***	-38.80***	32	7.82***	11.55***
			(-4.45)	(-5.35)		(2.59)	(3.13)

Note: This table reports mean abnormal return and mean abnormal volume for day zero and for the event window (-1 to +1 day relative to the announcement day). Mean cumulative abnormal return is estimated as: $\overline{CAR}(t_1, t_2) = \sum_{t=t_1}^{t_2} \overline{AR}_t$. $\overline{AR}_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$. AR_{it} is calculated using estimates from the market model: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$. Mean cumulative abnormal volume is estimated as: $\overline{CAV}(t_1, t_2) = \sum_{t=t_1}^{t_2} \overline{AV}_t$. $\overline{AV}_t = \frac{1}{N}\sum_{i=1}^{N} AV_{it}$. AV_{it} is calculated using estimates from the market model: $AV_{it} = v_{it} - (\hat{\alpha}_i + \hat{\beta}_i v_{mt})$. The *t* values are based on robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

[31] Non-parametric tests confirm the results.

Column two of Table 2 documents the stock market's reaction over a three-day event window (days −1 to +1 relative to the announcement day). Positive R&D announcements are no different when using a one- or three-day event window. In contrast, negative R&D announcements exhibit a larger negative reaction when using the three-day event window. For example, the three-day cumulative abnormal return to negative phase II results is −24.18% (*t*-statistic −4.25), while the day zero mean abnormal return is −15.78% (*t*-statistic −4.24). If negative announcements are largely unanticipated, one would expect that the larger stock market reaction to negative news for the three-day event window occurs on day zero and on the following day, rather than before the event date.[32] Not tabulated data shows that the mean cumulative abnormal return prior to the event (i.e., day −10 to day −1) is −8.31% for negative phase I news announcements (*t*-statistic −3.02). However, the market's reactions to negative phase II and phase III news announcements are insignificant; hence, investors do not seem to anticipate negative phase II and III results.

Columns 3 and 4 of Table 2 present the results of the day zero mean abnormal volume and the three-day mean cumulative abnormal volume for R&D announcements, respectively. The stock market reacts to all positive (negative) R&D announcements on day zero. For example, the mean abnormal volume on day zero for negative phase III results is 7.82% (*t*-statistic 2.59) compared to 3.00% (*t*-statistic 1.93) for negative phase I results. The mean cumulative abnormal volume over the three-day window documents that the trading volume increases significantly for negative phase II and III results, compared to day zero (11.55% > 7.82%, and 4.94% > 2.58%, respectively). In contrast, the trading volumes (in regards to the positive and negative phase I results) only exhibit small differences between the one- and three-day event windows.

Table 2 also reports that the stock market reacts positively to news about the initiations of clinical phase I (1.55%, *t*-statistic 3.07) and clinical phase II (1.23%, *t*-statistic 2.46), but that there is no significant reaction to initiations of clinical phase III. There are two explanations for this result for clinical phase III. First, phase initiations are not always good news because firms may start a clinical trial for fewer indications than were being investigated in the prior stage (Joos, 2003). Second, following positive clinical phase II results, the initiation of clinical phase III trials is generally already assumed by investors.

[32] It is important to note that only events with no announcements that occurred simultaneously or during a three-day period centered on the event date are included in the sample, and, hence, the impact of other events should not explain the difference between the day-zero and the three-day event window.

To test for hypotheses 1 and 2, pair-wise analysis of differences in mean between early-stage (phase I) and late-stage (phase III) announcements are analyzed. The results are shown in Table 3. Panel A of Table 3 presents the pair-wise analyses of the differences in mean abnormal return for early-stage and late-stage R&D announcements, as well as for positive and negative R&D announcements. The difference between early-stage positive R&D announcements and late-stage positive R&D announcements is 5.54% and significant at the 1% level (*t*-statistic 5.14). Similarly, the difference between early-stage negative R&D announcements and late-stage negative R&D announcements is 19.52% (*t*-statistic 2.51). Hence, the pair-wise analysis supports H1 for both positive and negative R&D announcements.

Table 3. Hypothesis testing

Panel A. Abnormal return (%)

	Positive R&D news	**Negative R&D news**	**Difference**
Early-stage	1.99*** (3.67)	12.25*** (3.94)	10.26*** (4.52)
Late-stage	7.53*** (8.02)	31.77*** (4.45)	24.24*** (5.46)
Difference	5.54*** (5.14)	19.52** (2.51)	

Notes: This table reports pair-wise analysis of differences in mean abnormal return for early-stage and late-stage R&D announcements, and, for positive and negative R&D announcements. Negative R&D news are reported in absolute values. Reported *t*-values are the results of the Games-Howell pair-wise comparison test with unequal variances. ***, **, and *, denote one-tail 1%, 5% and 10% significance, respectively.

Panel B. Abnormal volume (%)

	Positive R&D news	**Negative R&D news**	**Difference**
Early-stage	0.54*** (2.81)	3.00* (1.93)	2.46 (1.57)
Late-stage	0.90** (2.55)	7.82*** (2.59)	6.92** (2.19)
Difference	0.46 (0.87)	4.82 (1.38)	

Notes: This table reports pair-wise analysis of differences in mean abnormal volume (%) for early-stage and late-stage R&D announcements, and, for positive and negative R&D announcements. Reported *t*-values are the results of the Games-Howell pair-wise comparison test with unequal variances. ***, **, and *, denote one-tail 1%, 5% and 10% significance, respectively.

Next, negative and positive R&D announcements and their impact on mean abnormal returns are compared. The results show that there is a statistically significant difference between positive and negative news both for early-stage (*t*-statistic 4.52) and late-stage (*t*-statistic 5.46) R&D announcements; these results support H2.

Panel B of Table 3 presents a pair-wise analysis of the differences in the mean abnormal volume for early-stage and late-stage R&D announcements, as well as for positive and negative R&D announcements. While a significant stock market reaction with respect to trading volume is observed on day zero, there is only a significant difference between positive and negative late-stage R&D announcements (6.92%, *t*-statistic 2.19). Thus, the volume tests offer no support for H1.

5.3 Robustness checks

5.3.1 Event windows

Table 4 presents the mean cumulative abnormal return (volume) for R&D announcements for two different event windows: days −2 to +2, and days −2 to +10, respectively. Overall, the results reveal that the price- and volume-reactions to phase II and phase III results are persistent over longer event windows, while only price-reactions to negative phase I results are persistent.

Table 4. Mean cumulative abnormal return ($\overline{CAR}$) and mean cumulative abnormal volume ($\overline{CAV}$) for R&D announcements

Stage of R&D process	Event	Abnormal return			Abnormal volume		
		n	$\overline{CAR}_{-2,+2}$ (*t* value)	$\overline{CAR}_{-2,+10}$ (*t* value)	n	$\overline{CAV}_{-2,+2}$ (*t* value)	$\overline{CAV}_{-2,+10}$ (*t* value)
Phase I	Initiation	200	1.47*	1.34	190	0.43	0.40
			(1.93)	(1.15)		(1.26)	(0.65)
	Results (positive)	120	1.33*	-1.28	118	0.75**	0.75
			(1.71)	(-0.93)		(2.42)	(1.37)
	Results (negative)	34	-17.25***	-19.31***	32	3.58*	2.73
			(-5.82)	(-3.91)		(1.84)	(1.31)
Phase II	Initiation	202	0.45	-0.41	180	0.38*	0.69
			(0.64)	(-0.31)		(1.70)	(1.19)
	Results (positive)	174	7.33***	6.43***	172	2.08***	3.18***
			(4.17)	(2.86)		(4.55)	(4.04)
	Results (negative)	55	-24.74***	-27.78***	54	6.33***	9.12***
			(-4.49)	(-3.88)		(3.08)	(3.49)
Phase III	Initiation	88	1.84	4.62	78	0.25	-0.20
			(0.95)	(1.46)		(0.64)	(-0.28)
	Results (positive)	66	5.34***	6.69*	65	1.53***	2.48***
			(2.94)	(1.68)		(2.69)	(3.58)
	Results (negative)	34	-38.60***	-38.55***	32	13.32***	14.63**
			(-5.73)	(-5.16)		(2.91)	(2.55)

Note: This table reports mean abnormal return and mean abnormal volume for two different event windows (-2 to +2 day, and -2 to +10 day relative to the announcement day, respectively). Mean cumulative abnormal return is estimated as: $\overline{CAR}(t_1, t_2) = \sum_{t=t_1}^{t_2} \overline{AR}_t$. $\overline{AR}_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$. AR_{it} is calculated using estimates from the market model: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$. Mean cumulative abnormal volume is estimated as: $\overline{CAV}(t_1, t_2) = \sum_{t=t_1}^{t_2} \overline{AV}_t$. $\overline{AV}_t = \frac{1}{N}\sum_{i=1}^{N} AV_{it}$. AV_{it} is calculated using estimates from the market model: $AV_{it} = v_{it} - (\hat{\alpha}_i + \hat{\beta}_i v_{mt})$. The *t* values are based on robust standard errors. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

5.3.2 Cross-sectional regression results

To examine the association between the magnitude of the abnormal returns on day zero and the project- and firm-specific variables, a cross-sectional regression model is used. Panel A of Table 5 presents summary statistics of the independent variables. The mean success rate (*COMPLEXITY*) per therapy area is 0.56. The average clinical trial (INVESTMENT) enrolls 176 patients (or health volunteers). 24.5% of the projects are developed in collaboration with

a partner (*RISK_SHARING*). However, there is a large variation in the size. The largest clinical trial involves 3,000 patients and the smallest has only 10 patients enrolled (not tabulated). The average market capitalization (*DIVERSIFICATION*) is €369 million. Most of the firms are quite small, though a few firms are substantially larger than the average (not tabulated). Panel B of Table 5 contains a pair-wide correlation matrix and documents a low correlation overall between the independent variables.

Table 5. Descriptive statistics

Panel A. Summary statistics

	Number of observations	*Mean*	*Q1*	*Median*	*Q3*	*St. dev*
COMPLEXITY	483	0.555	0.446	0.512	0.646	0.122
RISK_SHARING	483	0.245				
INVESTMENT	483	176.1	33	66	186	318.9
DIVERSIFICATION	483	369.2	87.0	155.0	312.0	713.0
MTB	483	2.145	0.697	1.047	2.017	3.153

Notes: This table reports descriptive statistics of the independent variables. COMPLEXITY, RISK_SHARING, and, INVESTMENT are project-specific variables. DIVERSIFICATION and MTB are firm-specific variables. COMPLEXITY is the historical success rate per therapy area. RISK_SHARING equals 1 if the project is developed in collaboration with a partner company, zero otherwise. INVESTMENT represents size of the clinical trial, i.e. the number of patients. DIVERSIFICATION is measured as the average market value of equity 20 days prior to the R&D news announcement (measured between day -24 to day -5). MTB represents market-to-book value of equity and is measured as the market value of equity divided by the book value of equity preceding the R&D announcement (scaled by the median market-to-book value).

Panel B. Correlation matrix

	COMPLEXITY	RISK_SHARING	INVESTMENT	DIVERSIFICATION	MTB
COMPLEXITY	1				
RISK_SHARING	0.117*	1			
INVESTMENT	-0.066	0.160**	1		
DIVERSIFICATION	-0.028	-0.026	0.071	1	
MTB	0.167	-0.038	0.075	0.310***	1

Notes: This table reports pair-wise correlations. ***, **, and *, denote two-tail 1%, 5% and 10% significance, respectively. The variables are detailed in Table 5, panel A.

Table 6 presents the results of the cross-sectional regression model. The dependent variables are the day zero abnormal returns for (i) all positive R&D announcements, (ii) positive phase I announcements, and (iii) positive phase II announcements. In general, these tests confirm our expectations. Model (i) documents negative and significant effects of *COMPLEXITY* (*t*-

statistic −2.00) and *DIVERSIFICATION* (*t*-statistic −2.21), as well as a positive and significant effect of *INVESTMENT* (*t*-statistic 1.99). In model (ii) and model (iii), positive R&D announcements of phase I and II are tested separately. Both models suggest that *COMPLEXITY*, *INVESTMENT* and *DIVERSIFICATION* are statistically significant.

Table 6. Cross-sectional regression model

$$AR_i = \alpha_0 + \alpha_1 COMPLEXITY_i + \alpha_2 RISK\_SHARING_i + \alpha_3 INVESTMENT_i + \alpha_4 DIVERSIFICATION_i + \alpha_5 MTB_i + \sum_{j=1}^{3} \beta_j REGION_i + e_i$$

	Predicted Sign	(i) All positive R&D announcements (n=360)	(ii) Positive phase I announcements (n=120)	(iii) Positive phase II announcements (n=174)
INTERCEPT		0.191*** (2.69)	0.186 (1.40)	0.216 (1.20)
COMPLEXITY	-	-0.158** (-2.00)	-0.264* (-1.68)	-0.150* (-1.66)
RISK_SHARING	-	0.031 (0.92)	0.013 (0.81)	0.089 (0.89)
INVESTMENT	+	0.039** (1.99)	0.055* (1.80)	0.047* (1.69)
DIVERSIFICATION	-	-0.050** (-2.21)	-0.025* (-1.82)	-0.089** (-2.45)
MTB	+/-	0.002 (0.41)	0.001 (0.51)	0.021 (1.18)
Dummies for regions	+/-	Yes	Yes	Yes

Notes: This table provides the estimates from the linear regressions. The sample consists of R&D announcements made by publicly listed European biotech firms during 1998-2009. The dependent variable is the day zero abnormal return for (i) all positive announcements, (ii) positive phase I announcements, and, (iii) positive phase II announcements. COMPLEXITY, RISK_SHARING, and, INVESTMENT are project-specific variables. DIVERSIFICATION and MTB are firm-specific variables. COMPLEXITY is the historical success rate per therapy area. RISK_SHARING equals 1 if the project is developed in collaboration with a partner company, zero otherwise. INVESTMENT represents size of the clinical trial and is measured as the log of number of patients recruited to the study. DIVERSIFICATION is measured as the log of average market value of equity 20 days prior to the R&D news announcement (measured between day -24 to day -5). MTB represents market-to-book value of equity and is measured as the market value of equity divided by the book value of equity preceding the R&D announcement (scaled by the median market-to-book value). All regressions contain robust standard errors.

In summary, three project-specific variables can explain the cross-sectional variation in positive R&D news: (1) when there is low probability of a success but a success occurs, the market reaction is large (*COMPLEXITY*); (2) the smaller and less diversified the firm is, the larger the market reaction (*DIVERSIFICATION*); and (3) the more capital that has been invested in the clinical trial, the larger the market reaction (*INVESTMENT*). The models do not lend support to the idea that *RISK_SHARING* could explain the cross-sectional variation in abnormal returns.

6. Conclusion

This paper investigates the stock market's reaction to disclosures of non-accounting information in the biotechnology industry. Interest in the value relevance of non-accounting information comes from the concern that accounting information is not particularly relevant in certain industries in which firms invest heavily in intangibles such as R&D. The biotechnology industry has two features that make studies of market reactions to the disclosure of non-accounting information of special interest. First, disclosures are generally mandatory (rather than voluntary), and hence, self-selection biases caused by personal incentives are less prominent. Second, the drug development process is heavily regulated and monitored by regulatory authorities. As a result, the non-discretionary nature of disclosures in this industry overcomes the common criticism of endogenous event in the event study literature.

The empirical study is based on a unique hand-collected dataset of all publicly-listed firms in the European biotech industry from 1998–2009. While prior studies have used data from the US stock exchanges, this study provides the largest analysis by far of the European biotech industry, covering 87 firms from 11 countries over 13 years. The study shows the extent to which different non-accounting information, such as positive and negative news announcements concerning R&D projects, are value relevant to investors and can influence security prices and trading volumes. The study provides evidence of differences in market reactions according to predictions. In particular, there are differences in stock price and trading volume differences between projects in different phases, as well as between positive and negative outcomes.

The findings highlight two important issues. First, the large stock market reaction to clinical trial events is of great concern to both investors and the management of biotech companies. Firm managers may be reluctant to disclose negative R&D news; this reluctance highlights the importance of stock exchange regulations and the disclosure of price-sensitive information. At the same time, the disclosure of information has to be credible and reliable to investors and other market participants. This is of crucial importance in an industry where capital markets provide the only funding alternative. Second, the firm's managers may use the value-relevant R&D news as an instrument to access the capital markets when information asymmetries are low.

While the biotechnology industry has certain characteristics, the identification of value-relevant non-accounting information could be assessed in other high-tech industries.

Appendix 1.

Example of a negative R&D news announcement:

Topline results of phase III study in acute ischemic stroke (DIAS-2) do not demonstrate difference between Desmoteplase and placebo

"Aachen (Germany), May 31st, 2007 – PAION AG (Frankfurt Stock Exchange, Prime Standard: PA8) and its US partner Forest Laboratories, Inc. (NYSE: FRX) today announced topline results of the DIAS-2 (Desmoteplase In Acute Ischemic Stroke) study with the compound Desmoteplase. The Phase III study was designed to investigate the improvement of clinical outcome in patients with acute ischemic stroke treated with Desmoteplase within 3 to 9 hours after onset of stroke symptoms as compared to placebo. The primary efficacy endpoint (difference between active treatment and placebo in percentage of composite responders as defined below) was not met. The blinded, randomized, placebo-controlled, dose-ranging trial was jointly conducted by PAION and Forest Laboratories, Inc., and enrolled a total of 186 patients in Europe, USA, Canada, Australia, Hong Kong and Singapore. Forest Laboratories, Inc., is the partner of PAION for Desmoteplase for North America and H. Lundbeck A/S for the rest of the world."[33]

Example of a positive R&D news announcement:

Ablynx reports positive phase I results for its anti-thrombotic nanobody®, ALX-0081

"GHENT, Belgium, 17 December 2007 - Ablynx [Euronext Brussels: ABLX], a pioneer in the discovery and development of Nanobodies®, a novel class of antibody-derived therapeutic proteins, today reported the final, positive results from a Phase I study of its lead development programme, ALX-0081. The results of the double-blind, placebo controlled study in 40 healthy male volunteers show that ALX-0081, an anti-thrombotic therapeutic, was safe and well tolerated at all doses tested, with no dose limiting toxicities or serious adverse events.

ALX-0081, generated through Ablynx's in-house discovery platform, is a novel "first-in-class" therapeutic Nanobody® targeting von Willebrand Factor (anti-vWF). It is being developed to reduce the risk of thrombosis in patients with acute coronary syndrome (ACS) and thrombotic thrombocytopenic purpura (TTP). Following these positive Phase I results, Ablynx will now progress ALX-0081 to a multi-dose study in 2008.

In the study, treatment with the Nanobody® did not result in detectable immunogenicity. The study suggests that ALX-0081 adopts at least the plasma half-life of the target, von Willebrand Factor. The expected anti-thrombotic activity was shown with a biomarker in all volunteers receiving at least 2 mg of ALX-0081, indicating the high potency of the drug. ALX-0081's pharmacological activity, based on a single injection, started at the lowest dose of 2 mg and reached a maximum duration of 12 hours at a dose of 12 mg.

[33] http://www.paion.de/en/newsroom-2007

Edwin Moses, CEO and Chairman said: "We are extremely pleased with these positive safety results and demonstration of the high potential potency of ALX-0081, our first Nanobody® in clinical development. In addition, ALX-0081 has been progressed from discovery to completion of Phase I in just over three years, demonstrating the speed at which our discovery platform can generate a novel therapeutic. Based on these positive data, we are looking forward to initiating our discussions with the regulatory authorities this year and embarking on our next clinical study in 2008 in order to progress programmes in acute coronary syndrome and TTP."[34]

[34] http://www.ablynx.com/newsroom/pressreleases_2007.php

Appendix 2. Mean abnormal return ($\overline{AR}$) for R&D announcements

	Phase I						Phase II						Phase III					
	Initiation (n=200)		Results (positive) (n=120)		Results (negative) (n=34)		Initiation (n=202)		Results (positive) (n=174)		Results (negative) (n=55)		Initiation (n=88)		Results (positive) (n=66)		Results (negative) (n=34)	
Day	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value	$\overline{AR}$ (%)	*t*-value
-10	**-0.47****	-2.05	0.03	0.08	-0.53	-0.54	0.34	0.95	0.11	0.33	1.12	1.43	0.15	0.49	-0.20	-0.31	-0.38	-0.52
-9	-0.03	-0.12	0.37	1.02	0.11	0.15	-0.50	-1.58	0.22	0.61	0.06	0.11	-0.18	-0.44	-5.15	-1.11	-0.14	-0.27
-8	-0.18	-0.79	-0.08	-0.21	-0.93	-0.60	0.35	0.77	0.00	0.01	-0.38	-1.06	0.52	1.28	-0.82	-0.88	0.34	0.43
-7	-0.19	-0.79	0.44	1.07	-2.97	-1.33	0.73	1.16	**0.57****	1.92	1.78	0.86	0.34	0.62	0.02	0.01	0.22	0.21
-6	-0.20	-0.69	-0.17	-0.53	0.14	0.15	-0.49	-1.25	-0.29	-0.70	2.62	0.93	0.26	0.60	2.12	0.93	0.22	0.21
-5	-0.16	-0.69	0.36	1.17	**-2.26*****	-2.90	-0.14	-0.45	-0.25	-1.05	1.38	1.08	0.10	0.22	-0.44	-0.62	**1.87****	1.98
-4	0.13	0.43	-0.47	-1.19	0.99	1.62	0.24	0.92	-0.06	-0.20	0.70	0.74	-0.26	-0.59	-0.66	-0.12	1.05	1.26
-3	0.36	1.20	-0.34	-0.92	-1.04	-1.46	0.02	0.07	1.01	1.50	-0.56	-1.35	-0.30	-0.65	-0.47	-0.19	-0.34	-0.46
-2	0.38	1.29	-0.28	-0.92	-0.42	-0.71	-0.35	-1.15	0.05	0.17	0.25	0.51	-0.36	-0.80	-0.83	-1.24	-0.68	-0.80
-1	-0.10	-0.35	-0.30	-0.91	**-1.40***	-1.82	-0.21	-0.56	-0.03	-0.08	0.81	0.64	0.24	0.75	-0.05	-0.06	0.41	0.77
0	**1.55*****	3.07	**1.99*****	3.67	**-12.25*****	-3.94	**1.23****	2.46	**6.37*****	4.21	**-15.78*****	-4.24	2.28	1.31	**7.53*****	8.02	**-31.77*****	-4.45
1	-0.24	-0.84	-0.02	-0.03	**-1.55****	-2.27	-0.08	-0.27	0.78	1.52	**-9.21****	-2.56	0.05	0.07	-1.04	-1.29	-7.43	-1.54
2	-0.13	-0.53	-0.07	-0.25	**-1.63***	-1.79	-0.15	-0.51	0.16	0.42	-0.81	-0.90	-0.37	-0.65	-0.27	-0.46	0.88	0.42
3	0.07	0.32	**-0.59****	-2.11	0.21	0.32	0.02	0.09	-0.41	-1.07	**-2.34*****	-3.27	0.64	0.75	0.22	0.17	-1.99	-1.35
4	-0.30	-1.09	-0.31	-1.07	-0.29	-0.37	-0.89	-1.34	-0.18	-0.47	-0.32	-0.51	0.24	0.40	0.00	0.00	1.54	1.39
5	0.42	1.17	-0.12	-0.40	0.37	0.34	-0.31	-1.25	-0.07	-0.15	-0.18	-0.35	0.16	0.41	0.80	0.50	-0.63	-1.22
6	0.11	0.45	-0.48	-1.16	-0.01	-0.01	0.24	0.69	-0.36	-1.45	0.00	-0.01	-0.09	-0.20	-1.89	-1.46	**2.48****	2.00
7	-0.15	-0.52	0.12	0.38	-1.58	-1.39	0.38	1.45	0.20	0.51	**2.33****	2.32	0.63	1.07	1.53	0.96	-1.19	-1.21
8	-0.04	-0.17	**-0.55***	-1.90	-1.24	-0.91	-0.03	-0.11	-0.31	-0.95	-1.11	-0.71	0.29	0.36	-1.56	-1.17	0.68	0.81
9	-0.11	-0.48	-0.45	-1.37	0.01	0.02	-0.15	-0.53	0.18	0.53	0.25	0.18	**1.73****	2.15	2.07	1.33	-0.25	-0.28
10	-0.13	-0.60	-0.21	-0.62	0.45	0.60	-0.11	-0.47	0.06	0.21	**-1.68****	-2.41	**-0.84*****	-3.07	0.18	0.13	-0.60	-0.63

Note: Mean abnormal return is estimated as: $\overline{AR}_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$. AR_{it} is calculated using estimates from the market model: $AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix 3. Mean abnormal volume ($\overline{AV}$) for R&D announcements

	Phase I						Phase II						Phase III					
	Initiation (n=190)		Results (positive) (n=118)		Results (negative) (n=32)		Initiation (n=180)		Results (positive) (n=172)		Results (negative) (n=54)		Initiation (n=78)		Results (positive) (n=65)		Results (negative) (n=32)	
Day	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value	$\overline{AV}$ (%)	*t*-value
-10	**-0.10***	-1.83	0.00	-0.01	**-0.28****	-2.33	-0.08	-1.48	0.06	1.13	0.04	0.39	-0.07	-1.58	0.02	0.32	-0.18	-0.60
-9	**-0.10*****	-2.95	0.04	0.64	**-0.13****	-1.97	**-0.08****	-2.01	0.06	0.71	0.01	0.11	0.01	0.16	-0.02	-0.63	1.06	0.70
-8	**-0.10*****	-2.73	0.00	0.09	-0.13	-1.37	**-0.09****	-2.46	0.06	0.92	0.05	0.52	-0.02	-0.41	0.01	0.16	0.10	0.14
-7	**-0.15*****	-3.25	-0.04	-1.61	0.81	1.04	**-0.12*****	-2.77	0.12	1.07	0.23	1.03	-0.03	-0.32	-0.01	-0.34	0.81	0.76
-6	-0.02	-0.24	**-0.06***	-1.78	0.16	0.67	-0.02	-0.55	0.12	0.88	0.31	1.42	-0.05	-0.59	0.06	1.18	0.00	-0.03
-5	**-0.09****	-2.43	**-0.06***	-1.66	0.01	0.14	-0.04	-0.75	0.07	1.17	0.29	0.83	-0.07	-1.31	0.00	0.05	-0.20	-0.52
-4	-0.07	-1.21	**-0.05***	-1.72	**-0.20*****	-2.91	-0.04	-0.62	**0.09***	1.79	0.19	0.97	**-0.10***	-1.73	0.33	1.18	-0.28	-0.84
-3	0.03	0.78	0.00	0.10	**-0.23*****	-3.01	-0.07	-1.34	**0.25***	1.94	0.12	1.37	-0.07	-1.34	0.45	1.45	0.18	0.50
-2	0.02	0.41	0.01	0.08	-0.11	-1.23	0.02	0.22	0.17	1.74	-0.01	-0.14	-0.05	-0.57	**0.14****	2.31	0.47	1.10
-1	-0.01	-0.18	0.00	-0.09	-0.13	-1.47	0.01	0.16	0.12	1.71	0.02	0.18	-0.07	-1.18	0.04	0.83	0.09	0.56
0	0.30	1.47	**0.54*****	2.81	**3.00***	1.93	**0.23*****	3.16	**0.93*****	4.96	**2.58****	2.01	0.26	1.22	**0.90****	2.55	**7.82*****	2.59
1	0.08	0.92	**0.19**	2.02	**0.65***	1.87	0.06	0.83	**0.61*****	4.48	**2.34*****	2.93	0.09	0.75	**0.29*****	3.33	**6.47****	2.18
2	0.04	0.64	0.02	0.38	0.17	1.10	0.06	0.99	**0.25*****	3.07	**1.40****	2.19	0.02	0.20	0.09	1.41	3.47	1.64
3	-0.01	-0.12	-0.01	-0.40	-0.18	-1.29	-0.04	-0.82	**0.17****	2.05	**0.51*****	2.69	-0.04	-0.54	0.03	1.01	1.18	1.63
4	-0.01	-0.15	0.10	0.75	0.01	0.06	-0.01	-0.20	**0.10****	2.07	**0.48****	2.53	0.00	0.00	**0.08***	1.80	0.81	1.58
5	0.08	1.08	**-0.06***	-1.80	-0.13	-1.17	-0.05	-1.23	**0.34****	2.27	**0.34****	2.48	0.05	0.50	0.09	1.44	0.48	1.02
6	0.03	0.42	0.00	-0.01	-0.07	-0.57	0.08	0.75	**0.16****	2.17	**0.39****	1.96	-0.09	-1.39	**0.17***	1.79	0.80	1.03
7	-0.06	-1.29	-0.01	-0.15	-0.15	-1.53	0.09	0.96	**0.11***	1.83	**0.35***	1.94	-0.05	-0.98	0.12	1.22	-0.03	-0.07
8	0.05	0.53	0.07	0.73	-0.04	-0.22	0.10	0.80	0.08	1.47	**0.29***	1.71	0.00	-0.02	0.20	1.52	2.76	1.03
9	**-0.09****	-2.38	-0.03	-0.98	**-0.18***	-1.81	0.03	0.40	0.05	0.92	**0.23***	1.65	**-0.14****	-2.32	0.06	1.22	1.03	0.92
10	-0.02	-0.40	**-0.05***	-1.95	-0.09	-1.05	0.10	0.75	0.08	1.45	0.20	1.50	**-0.18*****	-2.75	**0.10***	1.77	0.16	0.72

Note: Mean abnormal volume is estimated as: $\overline{AV}_t = \frac{1}{N}\sum_{i=1}^{N} AV_{it}$. AV_{it} is calculated using estimates from the market model: $AV_{it} = v_{it} - (\hat{\alpha}_i + \hat{\beta}_i v_{mt})$. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

References

Ajinkya, B. B., Jain, P. C., 1989. The behavior of daily stock market trading volume. Journal of Accounting and Economics 11, 331-359.

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

Bamber, L., 1986. The information content of annual earnings releases: A trading volume approach. Journal of Accounting Research 24, 40-56.

Barth, M. E., Beaver, W. H., Landsman, W. R., 2001. The relevance of the value relevance literature for financial standard setting: Another view. Journal of Accounting and Economics 31, 77-104.

Beaver, W. H., 1968. The information content of annual earnings announcements. Journal of Accounting Research 6, 67-92.

Beisland, L. A., Hamberg, M., 2010. Variations in value relevance. Working paper.

Botosan, C. A., 1997. Disclosure level and the cost of capital. The Accounting Review 72, 323-349.

Campbell, J. Y., Lo, A. W., MacKinlay, C. A., 1997. The econometrics of financial markets. Princeton: Princeton University Press.

Cerbioni, F., Parbonetti, A., 2007. Exploring the effects of corporate governance on intellectual capital disclosure: An analysis of European biotechnology companies. European Accounting Review 16, 791-826.

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

Darrough, M., Stoughton, N., 1990. Financial disclosure policy in an entry game. Journal of Accounting and Economics 12, 219-244.

Diamond, D., Verrecchia, R., 1991. Disclosure, liquidity, and the cost of capital. Journal of Finance 46, 1325-1359.

Dedman, E., Lin, S. W-J., Prakash, J. A., Chang, C-H., 2008. Voluntary disclosure and its impact on share prices: Evidence from the UK biotechnology sector. Journal of Accounting and Public Policy 27, 195-216.

DiMasi, J., 2001. Risks in new drug development: Approval success rates for investigational drugs. Clinical Pharmacology & Therapeutics 69, 297-307.

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

Ely, K., Simko, P. J., Thomas, L. G., 2003. The usefulness of biotechnology firms: Drug development status in the evaluation of research and development costs. Journal of Accounting, Auditing and Finance 18, 163-196.

Fama, E., 1970. Efficient capital markets: A review of theory and empirical work. Journal of Finance 25, 383-417.

Fisher, W. O., 2002. Key disclosure issues for life sciences companies: FDA product approval, clinical test results, and government inspections. Michigan Telecommunications and Technology Law Review 8, 115-193.

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

Guo, R-J., Lev, B., Zhou, N., 2004. Competitive costs of disclosure by biotech IPOs. Journal of Accounting Research 42, 319-355.

Hamberg, M., Beisland, L. A., 2010. Changed methods to account for goodwill – Did it really make a difference? Working paper

Healy, P. M., Palepu, K. J., 2001. Information asymmetry, corporate disclosure and the capital markets: A review of the empirical disclosure literature. Journal of Accounting and Economics 31, 405-440.

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

Joos, P., 2003. Discussion – The usefulness of biotechnology firms: Drug development status in the evaluation of research and development costs. Journal of Accounting, Auditing and Finance 18, 197-205.

Kaitin, K. I., 2003. Post-approval R&D raises total drug developments costs to $897 million. Tufts Center for the Study of Drug Development Impact Report 5(3).

Kale, P., Dyer, J., Singh, H., 2002. Allicance capability, stock market response, and long term alliance success: The role of the alliance function. Strategic Management Journal 23, 747-767.

Karpoff, J. M., 1986. A theory of trading volume. Journal of Finance 41, 1069-1087.

Kim, O., Verrecchia, R., 1991a. Market reaction to anticipated announcements. Journal of Financial Economics 30, 273-309.

Kim, O., Verrecchia, R., 1991b. Trading volume and price reactions to public announcements. Journal of Accounting Research 29, 302-321.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R. W., 1998. Law and finance. Journal of Political Economy 106, 1113-1155.

Lang, M., Lundholm, R., 1996. Corporate disclosure policy and analyst behavior. The Accounting Review 71, 467–493.

MacKinlay, C. A., 1997. Event studies in economics and finance. Journal of Economic Literature 35, 13-39.

McConomy, B., Xu, B., 2004. Value creation in the biotechnology industry. CMA Management, 29-31.

McWilliams, A., Siegel, D., 1997. Event studies in management research: Theoretical and empirical issues. Academy of Management Journal 40, 626-657.

Schultz, P., 2003. Pseudo market timing and the long-run underperformance of IPOs. Journal of Finance 58, 483-517.

Sharma, A., Lacey, N., 2004. Linking product development outcomes to market valuation of the firm: The case of the U.S. pharmaceutical industry. The Journal of Product Innovation Management 21, 297-308.

Torabzadeh, K., Woodruff, C., Sen, N., 1998. FDA decisions on new drug applications and the market value of pharmaceutical firms. American Business Review 16, 42-50.

Viswanathan, S., Wei, B., 2008. Endogenous events and long-run returns. Review of Financial Studies 21, 855-888.

Xu, B., Magnan, M., André, P., 2007. The stock market valuation of R&D information in biotech firms. Contemporary Accounting Research 24, 1291-1318.

Market Timing and Equity Financing Decisions

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Abstract

Market timing is a much-discussed topic in the capital structure literature. We study two views of equity market timing, mispricing and adverse selection costs, using a sample of 232 seasoned equity offerings (SEOs) made by publicly listed European biotech firms between 1998 and 2010. To a large extent, equity is issued to sustain operations, and the average survival time at the announcement date is less than 12 months. There is, however, support for both the mispricing and the adverse selection cost hypotheses. Biotech stocks perform significantly better in the months preceding the announcement of an equity issue. However, there is no sign that the issuing biotech firm yields an abnormal return in the same time period. Univariate analyses suggest that adverse selection costs influence the issue of new equity, as both positive and negative news announcements are associated with equity announcements. It seems as though the mispricing and adverse selection cost hypotheses have incremental effects. In particular, negative news announcements are followed by issues of new equity even though negative news carries no obvious investment need (and survival time is controlled for).

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Keywords: Market timing; Mispricing; Adverse selection; Equity financing; Seasoned equity offerings (SEOs); R&D; Biotechnology

1. Introduction

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Growing enterprises usually require external capital to fund their operations. Accessing capital markets is a balancing act that depends on both firm- and market-specific factors. Somewhat surprisingly, academic research is still puzzled by management's decisions over when and why to seek external equity financing. Over the years, two main theories have emerged: the mispricing and the adverse selection cost theories. According to the mispricing theory, managers seek external capital when it can easily get capital at favorable prices (Ritter, 1991; Loughran and Ritter, 1995; Baker and Wurgler, 2002). For the same reason, they will also repurchase shares when prices are excessively low (Ikenberry et al., 1995). The mispricing theory suggests that managers believe the firm is not always correctly priced and that managers, for their own sake, want to capitalize on the mispricing. In contrast, the adverse selection cost theory is built on a dynamic framework of the Myers and Majluf (1984) model, where time-varying asymmetric information plays a major role. The rationale goes that firms issue equity when adverse selection costs are low, that is, following credible information releases (Korajczyk et al., 1991). Consequently, the adverse selection cost theory suggests there are moments when it is more favorable for managers to issue equity without necessarily acting solely in their own interest.

Past empirical research has verified the importance of both theories; however, discriminating between them is cumbersome. For example, the adverse selection cost theory suggests that new equity is issued following the disclosure of credible information. However, an issue of new equity might be made after information has been disclosed because management believes that the firm's prospects are mispriced. In particular, information is usually discretionary, and both voluntary and mandatory disclosures can be manipulated by management. Observing equity issues following the release of accounting information (Korajczyk et al., 1991) is thus unlikely to be a clean test of the adverse selection cost hypothesis.

With these issues in mind, we study an industry, biotechnology, that has some attractive characteristics. Typically, biotech firms are in an early life-cycle stage with no commercial products and, hence, their investments cannot be internally funded. Because investments are mainly in (unrecognizable) intangible assets they cannot use debt financing either, and instead they regularly turn to the equity market. Therefore, a sample of biotech firms enables a study of equity market timing without having to think about alternative sources of external capital. Because biotech firms are in the early life-cycle stage, accounting information is a poor indicator of how research projects create value (Dedman et al., 2008; McConomy and Xu, 2004). However, indirectly, regulatory authorities, such as the European Medicinal Authority

(EMA) and the Food & Drug Administration (FDA), make independent assessments of the research projects. These assessments are known to be value relevant (Jeppsson, 2010) and cannot be manipulated by the biotech firm. Few industries are characterized by having so many value-relevant and non-discretionary disclosures as the biotech industry.

In this setting, we study market timing and assess the mispricing and adverse selection cost arguments. To avoid having the measure of mispricing affected by asymmetric information (between the biotech firm's management and shareholders) and manipulated information, we measure mispricing as the pre-issue stock return of other biotech firms. Firms are expected to issue new equity when market sentiments are strong, in other words, following general increases in stock prices. The adverse selection cost hypothesis is also tested using non-discretionary information, namely, regulatory authorities' assessment of the biotech firm's research projects. We expect firms to issue new equity when there is comparatively more information about their ability to create value.

The primary motive for seeking external financing is a need to sustain operations. Therefore, we expect market timing (either because of mispricing or adverse selection costs) to be incremental to the biotech firm's survival time.[35] The sample consists of 87 European biotech firms that have been publicly listed sometime between 1998 and 2010. In total, these firms have made 232 equity offerings as well as 561 public announcements concerning the development of their research projects.

The empirical data confirms that new equity, to a large extent, is issued to sustain operations; the average survival time at the announcement date is 12 months. However, in addition to the survival time, there is support for both the mispricing and the adverse selection cost hypotheses. Biotech stocks perform significantly better in the months before firms issue new equity, and they continue to do so in the months thereafter. There is, however, no sign that the issuing biotech firm yields an abnormal return in these time periods. Univariate analyses suggest that adverse selection costs influence the issue of new equity, as both positive and negative news announcements are associated with equity announcements. A comparison between mispricing and adverse selection cost shows that they, to some extent, have incremental effects. Negative news announcements are, surprisingly, followed by issues of

[35] An example of market timing is exemplified by the following paragraph from a press release on March 23, 2010, for the French biotech firm Transgene, which went public in 1998: "In light of its net cash position at December 31, 2009, of €64.7 million, the Company is able to determine the timing of the fund raising and its announcement when it deems the conditions most appropriate".

new equity, even though negative news carries no obvious investment need (and survival time is controlled for). We see this as clear support for the adverse selection cost hypothesis.

The remainder of the paper is outlined in the following way. Section two provides a theoretical framework, an overview of prior studies and a presentation of the two research hypotheses. Section three discusses methodological issues related to the study. Section four contains the empirical results and, finally, section five concludes.

2. Theory and research hypotheses

2.1 Market timing and capital structure

The capital structure decision has puzzled finance researchers for decades (Lintner, 1965; Myers, 1984), and two capital structure theories dominate research: the "static trade-off" and the "pecking-order" models. In the static trade-off model, firms have a target capital structure, determined by advantages and disadvantages of debt financing (Jensen and Meckling, 1976; Myers, 1977). Although agency costs are important in this setting, the capital structure decision depends on a rational analysis of relevant factors, and there is little room for managerial opportunism or for the timing of capital markets.

In the pecking-order model, firms follow a financing hierarchy, in which they finance their investments first with internal funds, then with external debt, and finally with equity as a last resort (Myers and Majluf, 1984; Myers, 1984). This model considers that agents make the decision, and that information is asymmetrically distributed between the firm's management and shareholders. In a similar vein, it has been suggested that a firm's capital structure is an effect of management's ability to seek external financing when accessible at a low cost (Baker and Wurgler, 2002). Two views on equity market timing have emerged: the mispricing and the adverse selection cost hypotheses.

2.2 The mispricing hypothesis

The standard finance model, in which rational investors make stock prices equal the present value of expected future cash flows, has considerable problems explaining many stock market events (Shiller, 2000; Baker and Wurgler, 2007). Empirical research has come across several factors, such as size and the book-to-market ratio, which seems to be associated with stock

returns without necessarily being measures of systematic risk. It is, therefore, not surprising that corporate finance decisions (e.g., initial public offerings, mergers, acquisitions and issues of equity and debt) are non-random. Just like investors, managers make use of capital markets as if they are predictable. The seemingly systematic variations in the association between stock price and fundamentals form the basis for the mispricing hypothesis of equity issuance.

There are many reasons for taking a privately owned firm public, including investment needs and public attention. However, a most important reason is that owners of the private firm believe they get a good price. Initial public offerings (IPOs) occur in cycles (Ibbotson and Jaffe, 1975; Ritter, 1984; Ibbotson et al., 1988, 1994) that seem to follow stock market sentiments; when prices are high, there are more IPOs (Pástor and Veronesi, 2005). In a similar vein, Alti, (2006) shows that market sentiments increase not only the number of IPOs but also their size and the proportion of the firm that is sold.

Research on mergers and acquisitions also reveal patterns, usually referred to as merger waves (Rhodes-Kropf et al., 2005; Harford, 2005; Martynova and Renneboog, 2008). While merger waves are more complicated to pinpoint – as dependent on prices of both acquiring and target firms and the method of payment – they stem from the idea of predictable stock prices. Harford (2005) explain merger waves as the outcome of market timing, where industries respond to shocks and reorganize through mergers and acquisitions, creating a clustering of merger activity, in which liquidity plays an important role.

A clustering of seasoned equity offerings (SEOs) in "hot issue" markets is well known in the finance literature (Hickman, 1953; Choe et al., 1993; Bayless and Chaplinsky, 1996). Starting with Taggart (1977), many studies also show how firms make more SEOs when market valuations are high relative to book values or historical market values. Survey evidence in Graham and Harvey (2001) reveals that market timing is a primary concern of corporate executives: CFOs admit that timing considerations influence financing decisions. In a very important study, Baker and Wurgler (2002) suggest that the capital structure is, by and large, a product of capital market timing. Several empirical studies have examined the stock market performance of firms conducting equity issues. For example, Loughran and Ritter (1995) find that firms issuing stock, either through IPOs or SEOs, experience low returns in subsequent years. In summary, there is ample evidence that firms take advantage of temporary mispricing in financial markets and thus issue equity when it is perceived as being be overvalued.

The market mispricing hypothesis suggests that managers issue new shares when market prices are high (Ritter, 1991; Loughran and Ritter, 1995), and repurchase shares when market prices are low (Ikenberry et al., 1995). There are two possible reasons for this behavior. One such reason is that managers have access to insider information and thus know better than investors what the firm's true performance is. Essentially, managers make use of asymmetrically distributed information. The second reason is that equity markets, in general, are "hot", in the sense that investors for the moment seem to be more optimistic about expected growth rates, profit margins, etc. This second reason is based on market sentiments, rather than asymmetric information, and it suggests that the firm's operating performance is unassociated with the decision to issue new equity (Alti, 2006). While the asymmetric information argument is interesting in itself, our first hypothesis is:

H_1: Firms issue new equity to a larger extent when equity market sentiments are strong.

2.3 The adverse selection cost hypothesis

Information asymmetries decrease when new value-relevant information is made public. Given that the disclosure of value relevant information varies between firms and over time, the level of asymmetrically distributed information also varies (Dierkens, 1991; Lucas and McDonald, 1990; Choe et al., 1993). Immediately following relevant news announcements, asymmetries are low, but the information advantage of management increases with time. Korajczyk et al. (1991, 1992) suggest that the perceived change in information asymmetry raise investments' adverse selection costs. There is thus a rational expectation that corporate financial decisions, such as issues of new equity, are influenced by information asymmetry and the release of new credible information. We refer to this as the adverse selection cost hypothesis of equity issuance, which suggests that firms issue equity when the market is comparatively better informed.

Empirical research tends to use mandated accounting information as a measure of credible value-relevant information. Korajzcyk et al. (1991; 1992) find that firms issue more equity following the disclosure of financial reports, when the asymmetry of information is small. In addition, the price drop at the announcement of a new equity issue increases with the time since credible information has been disclosed. All in all, they suggest that adverse selection

costs influence equity issuances negatively and that mandatorily reported accounting information reduces these costs.

Investors react to different types of information in the equity issuance setting. Korajczyk et al. (1991) find that accounting earnings have a significant effect on the market's reaction to the issuance of new equity. This is supported by Denis and Sarin (2001) who find earnings announcements from four quarters prior to the offer significantly associated with the market's reaction. Therefore, equity issues tend to follow informative earnings releases. Information of a more discretionary character seems less informative. Loderer and Mauer (1992) find that dividend announcements do not reduce valuation uncertainty. Lin et al. (2008) get similar price reactions, although dividends appear to be associated with volume reactions. Most non-accounting disclosures are discretionary and firms tend to make more such disclosures prior to issues of new equity (Cooper and Grinder, 1996; Lang and Lundholm, 2000). In summary, the association between disclosure and issuances of new equity supports the adverse selection cost hypothesis, and the association improves with the disclosed information's credibility.

Healy and Palepu (1990) document that firms perform better than usual when they issue new equity; however, after the issue, their profitability decreases (Loughran and Ritter, 1997). Quite the same, IPO firms are more profitable than similar firms already listed (Pagano et al., 1998) and more profitable than they are subsequent to the public listing (Jain and Kini, 1994; Mikkelson et al., 1997). The excess performance around the time of the issue of new equity can be a function of equity market timing, but a number of studies suggest that information disclosures are used opportunistically around the time of the SEO (Rangan, 1998; Shivakumar, 2000), and the IPO (Teoh et al., 1998a; Teoh et al., 1998b; Roosenboom et al., 2003). Although accounting information is informative and reduces adverse selection costs surrounding issuances of equity, it is still manipulable. Other type of announcements, such as information about major investments, product launches, and collaborations, are even more discretionary. When tests of the adverse selection cost hypothesis are based on discretionary information, it is impossible to avoid biases from manipulated information and thus mispricing issues.

Studying firms in the biotechnology sector is particularly interesting given the problems highlighted above. Biotech firms are in early life-cycle stages, and, with their future performance being considerably uncertain, the adverse selection cost problems are likely to be substantial. Because biotech firms tend to be unprofitable and are unable to capitalize their

investments as assets, accounting information is less value relevant (Dedman et al., 2008; McConomy and Xu, 2004). However, regulatory authorities have to assess biotech firms' investment projects whenever they are in critical stages; therefore, there are credible non-discretionary evaluations of the value-creation process. Disclosure of how clinical trials progress is known to impact share prices and volumes (Jeppsson, 2010). On the basis of the above-mentioned discussion, we expect the following:

H_2: Firms issue new equity to a larger extent after they have released disclosures of R&D.

3. Methodology

3.1 Research design

The study is based on firms operating in the biotechnology industry, as it offers unique opportunities to study the decision to issue new equity. Biotech firms invest heavily on a continuous basis, but they can rarely fund these investments internally. Consequently, they regularly turn to the equity market for new capital.

Two issues make the biotech setting interesting. First, investors are unable to use accounting information in any meaningful way when assessing the biotech firm's future prospects. If a loss is indicative of future performance, then the firm has no value (Hayn, 1995; Beisland and Hamberg, 2010). In this case, investments are expensed immediately and, hence, both the income statement and the balance sheet contain little information useful to forecast future cash flows. Investors are, therefore, fully dependent on other type of information.

Second, biotech firms differ from other research-intensive firms in the sense that the development process is closely monitored by regulatory authorities with considerable experience of how to evaluate drugs on issues such as efficacy and safety. The biotech firm usually cooperates with regulatory authorities in early phases of research as a failure to comply with recommendations might ultimately prolong the development process, inhibit a future drug approval, and even lead to private lawsuits and enforcement actions by agencies such as the Securities and Exchange Commission (SEC).

Although accounting information has a low association to the value of biotech firms (Dedman et al., 2008; McConomy and Xu, 2004), investors can rely on information that is verified by

regulatory authorities acting independently. A candidate drug's progress in clinical trials is a strong signal to investors that the firm creates value (e.g., Jeppsson, 2010).

3.2 Measures

Our main interest is in identifying factors that affect the decision to make an equity offer. In this section we discuss the dependent (i.e., the equity announcement) and independent variables.

The equity announcement

Because biotech firms invest substantial amounts in research projects and tend to have few projects with positive operating cash flows, they need to issue new equity on a regular basis. From an economic perspective, the main motive for issuing new equity is that projects with a positive net present value exist and need to be funded. Therefore, when future investment cash flows cannot be covered by existing funds, the firm seeks external funding to sustain its survival.[36] A negative aspect of issuing new equity is that pre-issue shareholders have to split the value of future cash flows with others. Pre-issue shareholders lose rights to future cash flows unless they subscribe for their part of the new issue.

If a new issue of equity is used to finance previously unconsidered operating activities, the market's reactions to the new issue of equity might be positive. However, if the capital is used to finance ongoing activities, there will be a price drop following the announcement of a new issue. Although we make no distinction between different forms of equity issuances in the empirical study, we acknowledge that there are some notable differences between them. An important aspect of how to design a seasoned equity offering (SEO) is the uncertainty of the equity issue situation. A public offer typically offers the most uncertainty, whereas a rights

[36] There might be other options available for the biotech firm. One option is to cancel, or delay, investments. A considerable portion of the biotech firm's resources consist of human capital, and while a temporary reduction of personnel expenses reduces overall costs, it is in reality difficult not to make it a permanent reduction. From a strategic point of view, it might be undesirable and an absolute last resort. Another option is to sell valuable resources, should there be any, to another biotech firm. This alternative has two drawbacks; resources are often difficult to disentangle, and, if so, they often carry a lower value when disentangled. In addition, the choice to sell assets only exists if there is excess cash in the biotech industry and this tends to be positively correlated with market sentiments. In other words, it might be just as difficult to sell assets as it is to issue new equity. A final option is to enter a partnership with another firm on a candidate drug and thereby achieve an upfront cash payment.

offer (directed towards all shareholders or a few shareholders) removes some of the uncertainty. Another way to reduce uncertainty is to have an underwriter in the form of a large pre-issue shareholder or financial intermediaries.

We do not study the point in time when the subscription period starts or when the firm receives the proceeds of the equity. Instead, a dummy variable (*ISSUE*) takes the value 1 when the firm-quarter contains a public news announcement with details on a coming issue of new equity; otherwise, it takes the value 0. We use corporate websites, annual reports and the Thomson Reuters Knowledge Database to identify equity announcement dates.

Survival time

Financial distress has a well-known effect on capital structure decisions (Miller and Modigliani, 1966), and analyses of the decision to issue equity often employ the level of debt as a proxy of it (e.g., Mackie-Mason, 1990). Biotech firms tend not to hold debt, but given that their cash flows are almost always negative (large continuous investments and little revenue) costs associated with financial distress are captured using the firm's expected "survival time"; the time that the firm can sustain its operations without seeking additional financing or cutting back on its research activities (Lerner et al., 2003).

Following Lerner et al. (2003) survival time (*SURVIVAL_TIME*) is measured for each quarter as the firm's beginning-of-period cash balance scaled by net income. Net income is used as a proxy for cash flows because biotech firms tend to expense most investments immediately and, in addition, these firms rarely gain revenue from continuous operations. In the regression models, we use the inverse of the firms' survival time. There is no association between positive earnings and survival time (i.e., when earnings are positive, the survival time is infinite); therefore, the measure is set to zero for profitable firms (Lerner et al., 2003). In summary, because shorter survival time increases the probability of encountering financial distress costs, we expect the probability of issuing new equity to decrease with survival time.

Mispricing

We expect a biotech firm to hasten the issue of new equity should its management perceive that the equity market is overpriced. Biotech firms expense most of their investments

immediately, the market-to-book ratio to be likely to be a biased measure of overpricing.[37] Instead, we use historic stock returns as indicators of positive market sentiments and mispricing (Taggart, 1977; Baker and Wurgler, 2007; DeAngelo et al., 2010). The bulk of the analysis is made on quarterly data; consequently, for each firm in the sample, we use the following measures:

Absolute firm stock return: the dividend- and split-adjusted stock return in the 120 trading days (approximately 6 months) before and after the middle of each quarter.

Index stock return: the equal-weighted dividend- and split-adjusted stock return of all other biotech firms (included in the sample) in the 120 trading days before and after the middle of each quarter.

Abnormal stock return: the difference between the absolute and index stock returns. We assume unsystematic risk is similar across the industry (DeAngelo et al., 2010).

For firms that issue new equity, we use the same measurement procedure for the 120 trading days before and after the equity issue announcement date. To avoid effects stemming from asymmetric and, possibly, manipulated information, we use the index stock return (*PRE_INDEX_RET* and *POST_INDEX_RET*) in regression analyses. If management decides to take advantage of a perceived mispricing at the industry level it does so without using private information. It is quite likely that the absolute stock return is positively correlated with the index stock return. For robustness reasons, we also include the abnormal stock return in some of the analyses (*PRE_FIRM_RET* and *POST_FIRM_RET*).

In the empirical analysis, we test for differences in index (and abnormal) stock returns between equity announcement dates and those firm-quarters when there is no announcement of an issue of new equity. We expect *PRE_INDEX_RET* to be positively associated with the decision to issue new equity. We do not have any *a priori* expectation concerning *POST_INDEX_RET*, as it depends on the length of and the announcement time in a "hot issue" period. We do not have any expectations concerning the association between the decision to issue new equity and *PRE_FIRM_RET* and *POST_FIRM_RET*.

[37] Indeed, all measures involving accounting information are likely to suffer from biases.

Adverse selection costs

We expect the issue of new equity to be positively associated with announcements of the progress of the biotech firm's candidate drugs in clinical trial. Credible announcements of the status of research projects reduce adverse selection costs, and, as a result, managers make use of investors' better understanding of the firm's prospects and issue equity shortly after public news announcements about their R&D projects. We measure the number of news announcements made in the 90 days[38] before (/after) the middle of each quarter. For robustness reasons, we complement equal-weighted measures with phase-weight measures. It is not possible, *a priori*, to determine whether one is better than the other; rather, we prefer the simplicity of equal-weighted measures. We also distinguish between positive and negative news announcements. Both provide information to investors that reduces adverse selection costs, but their propensity to do so, as well as their association to other variables might differ.

Equal-weight positive outcome announcements: the sum of announcements with a positive outcome, in which research phases are equally weighted.

Equal-weight negative outcome announcements: the sum of announcements with a negative outcome, in which research phases are equally weighted.

Phase-weight positive outcome announcements: the sum of announcements with a positive outcome, in which research phases are phase weighted (i.e., phase I equals 1, phase II equals 2 and phase III equals 3).

Phase-weight negative outcome announcements: the sum of announcements with a negative outcome, in which research phases are phase weighted (i.e., phase I equals 1, phase II equals 2 and phase III equals 3).

For firms that issue new equity, we use the same measurement procedure for the 90 days before and after the equity issue announcement date. Equally weighted positive and negative outcome announcements (*R&D_NEWS_POS* and *R&D_NEWS_NEG*) are used in the regression analyses, where we test for differences in the equally weighted positive and negative outcome announcements between equity announcement dates and those firm-quarters when there is no announcement of an issue of new equity. According to the adverse

[38] Because regulatory authorities meet irregularly, their decisions (i.e., the biotech firms' news announcements) are clustered over time. As clustering mainly occurs within quarters and not between them, using 90 days removes a bias that otherwise would come should equity issues also be clustered over time (if, for example, quarterly reports are used to mitigate adverse selection costs).

selection cost hypothesis it is expected that both *R&D_NEWS_POS* and *R&D_NEWS_NEG* are positively associated with the decision to issue new equity. Because the announcement of positive news often implies that new investments need to be made, we assume that *R&D_NEWS_NEG* is a somewhat stronger confirmation of the hypothesis.

Control variables

To ensure that results are not driven by omitted correlated variables, we include a number of control variables: intangible intensity (*INT_INT*), investor understanding (*AGE*), firm size (*SIZE*), and growth opportunities (*MKTBOOK*). In addition, we also control for differences in market efficiency and institutional setting by employing region dummies. These variables are briefly discussed underneath.

As of January 2005, all firms in our sample apply International Financial Reporting Standards (IFRS). In our study, the most important accounting standard is IAS 38, which deals with intangible assets including investments in R&D. IAS 38 states that no intangible asset arising from research shall be recognized (IAS 38: 54), and it defines criteria that have to be met if development expenditure are to be recognized. These criteria include technical feasibility and the ability to prove that future economic benefits are probable. In most cases these criteria inhibit biotech firms from capitalizing their investment, and if they do capitalize, the capitalized investment is likely to represent only a small portion of total investments. In other words, they are expensed immediately. Prior to 2005, firms in our sample employed local accounting standards, which vary substantially on many accounts. To control for variations in the capitalization of intangibles, we measure the level of intangible intensity in the form of total intangible assets scaled by total assets (*INT_INT*).

Most shareholders are outsiders and rely on public information alone. They have to rely on information given to them by management and on insider owners acting in the interest of all shareholders. The extent to which the biotech firm has been publicly listed and thus upholds a track record is likely to be an indicator of how well investors know the firm. We measure this as the number of months that the firm has been publicly listed (*AGE*). A firm's size (*SIZE*) and market-to-book ratio (*MKTBOOK*) are used to control for several concerns, including risk and growth opportunities. Often, a larger firm is less dependent on individual news

announcements; therefore, *SIZE* also reduces scaling problems associated with news announcements.

Market efficiency and the level of shareholder protection are known to vary across institutional settings. To mitigate this problem, we use dummies for the four regions specified by La Porta et al. (1998); Anglo-Saxon, Germanic, French and Scandinavian legal origins. We use the Anglo-Saxon legal system as the reference.

3.3 Research model and data

We use a probit regression model and differentiate, on a quarterly basis, between firms that have issued an announcement declaring that they issue new equity and all other firms (our tests are thus based on all firm-quarters in the sample). We expect both mispricing (*PRE_INDEX_RET* and *POST_INDEX_RET*) and adverse selection costs (*R&D_NEWS_POS* and *R&D_NEWS_NEG*) to have incremental effects beyond those of survival time (*SURVIVAL_TIME*) and other control variables.

ISSUE(0,1) = SURVIVAL_TIME + PRE_INDEX_RET + POST_INDEX_RET + R&D_NEWS_POS + R&D_NEWS_NEG + CONTROLS.

Equity issue data

The total sample (issuers and non-issuers) consists of 87 European biotech firms that have been publicly listed some time during 1998 and 2010.[39] For firms that are cross-listed, we use share price information from the stock market in the country in which the firm is domiciled. In total, these firms make 232 seasoned equity offerings[40] (SEOs). Table 1 presents descriptive statistics of the SEOs. In Panel A, SEOs are sorted by year and by region following La Porta et al. (1998).

[39] The studied firms are listed in 14 countries across Europe.

[40] Firms can issue new shares (i.e., primary shares), or they can sell existing shares held by insiders or stockholders (i.e., secondary shares). We only consider SEOs in which the firm received cash because only the issuance of primary shares leads to a capital inflow to the firm, which can be used to finance investments. Similarly, we do not include SEOs, in which a firm has made standby equity distribution agreements (SEDA) or committed equity financing facility (CEFF). We exclude IPOs because we have no historical stock market data. The sample firms primary raise funds to finance existing and new drug development projects. Some firms also mention that they raise capital to broaden the institutional ownership base and to provide the firm with a better position when negotiating new collaboration agreements.

Table 1. Descriptive statistics

Panel A. Seasoned equity offerings (SEOs) across regions

	English			German			French			Scandinavia			Total		
	Firms	Issues	Value	Firms	Issues	Value	Firms	Issues	Value	Firms	Issues	Value	Firms	Issues	Value
1998	12	6	48.3	2	0	0	2	0	0	6	2	78.7	22	8	127.0
1999	13	5	37.5	4	0	0	3	0	0	6	1	3.7	26	6	41.1
2000	15	11	431.1	8	0	0	4	1	63.1	11	2	61.3	38	14	555.5
2001	15	2	62.1	9	1	34.2	4	0	0	12	3	31.2	40	6	127.6
2002	15	2	56.1	10	0	0	4	0	0	12	2	23.2	41	4	79.2
2003	16	7	130.0	11	2	33.7	4	1	4.0	12	4	66.5	43	14	234.2
2004	20	3	41.1	11	5	150.7	4	3	57.9	12	5	149.7	47	16	399.5
2005	24	8	266.7	17	5	107.7	7	4	110.6	15	8	217.7	63	25	702.7
2006	25	14	246.4	20	9	220.0	11	7	216.9	17	8	271.8	73	38	955.1
2007	24	6	112.8	21	11	496.0	16	4	277.1	18	8	567.7	79	29	1453.6
2008	24	7	116.3	20	5	86.9	17	0	0	18	5	51.4	79	17	254.6
2009	20	12	181.7	21	8	126.8	17	7	495.0	18	12	392.0	76	39	1195.5
2010	20	3	38.1	21	5	70.4	17	3	214.0	18	5	87.9	76	16	410.3
Total		86	1768.2		51	1326.4		30	1438.7		65	2002.6		232	6536.0

Note: All values displayed in the table are denominated in million Euros. Regions by origin follow the classification by La Porta et al (1998).

In total, the 232 SEOs raised equity capital worth €6.536 billion. Firms of Scandinavian origin have raised the most equity capital, totaling €2.00 billion in 65 equity issues (i.e., €30.81 million per issue). Firms of English origin have made the largest number of equity issues, 86, with a total value of €1.77 billion (i.e., €20.56 million per issue). The largest amount per issue has been made by biotech firms of French origin: €47.96 million per issue. These differences could be an indication of systematic variations between the different regions.

Table 1. Descriptive statistics

Panel B. Issue size per year

	Issue size (MEUR)									
Year	*Sum*	*Listed firms*	*n*	*Sum / firms*	*n / firms*	*Sum / n Mean*	*Median*	*Min*	*Max*	*St. dev.*
1998	127.0	22	8	5.8	0.364	15.9	10.7	0.4	46.7	15.7
1999	41.1	26	6	1.6	0.231	6.9	6.1	2.8	14.5	4.2
2000	555.5	38	14	14.6	0.368	39.7	17.4	0.5	251.1	63.7
2001	127.6	40	6	3.2	0.150	21.3	14.0	3.1	57.2	20.9
2002	79.2	41	4	1.9	0.096	19.8	16.3	8.0	38.6	13.2
2003	234.2	43	14	5.4	0.326	16.7	17.1	1.0	31.8	9.9
2004	399.5	47	16	8.5	0.340	25.0	17.8	6.0	87.2	20.8
2005	702.7	63	25	11.2	0.397	28.1	17.4	2.2	84.9	21.7
2006	955.1	73	38	13.1	0.521	25.1	17.2	1.1	98.5	22.4
2007	1453.6	79	29	18.4	0.367	50.1	32.1	2.5	272.8	62.3
2008	254.6	79	17	3.2	0.215	15.0	12.2	1.0	54.1	13.2
2009	1195.5	76	39	15.7	0.513	30.7	16.9	0.2	301.8	53.0
2010	410.3	76	16	5.4	0.211	25.6	13.4	1.2	152.0	37.6
	6536.0	87	232	75.1	2.667	28.2				

Notes: All values displayed in the table are denominated in million Euros.

Panel B of Table 1 reports descriptive statistics for the number and size of equity issues per year. The number of European biotech firms has increased substantially over time, as has the number of new equity issues. There is, however, a substantial variation over time, both in terms of the number of issuing firms and the size of their equity issues. Whereas the average size of gross issue proceeds has been €28.2 million, the lowest annual average is €6.9 million (1999), and the highest is €50.1 million (2007). Interestingly, the number of firms making an issue of new equity does not dip/peak in the same years; 1999 is quite an average year, and in the years 2006 and 2009, more than half of the biotech firms issue new equity (in 2007, 37% of the firms issue new equity). Finally, the value of the equity proceeds also varies substantially and is determined by both the number of issuing firms and the value of their

issues. As a consequence, the sum of the proceeds per firm is €18.4 million in 2007, €3.2 million in 2008, only to be followed by €15.7 million in 2009.

R&D announcements

The study is based on 87 firms that issued new equity in the years 1998 to 2010. In total, these firms have made 561 public announcements on clinical trial results. These announcements are classified on a good news-bad news ranking as suggested by Guo et al. (2004). The details of this classification are discussed in Jeppsson (2010). There are some discretionary elements in the disclosure of news announcements concerning, in particular, research projects in their early stages. Before initiation, regulatory authorities approve the design of a study, including primary and secondary endpoints, but they often do not scrutinize the clinical results before the biotech firm initiates the next phase. Opportunistic interpretations of results would, however, lead to serious discontent from both investors and regulatory authorities. Table 2 reports the distribution of positive and negative R&D announcements related to different stages. There are more news announcements concerning phase II projects than there are concerning phase I projects (and more news announcements concerning phase I projects than pre-clinical projects), and the main reason is that advancing a study often means that the biotech firm has to design multiple studies with different endpoints (e.g., separate safety and efficacy studies). Positive news announcements are more common than negative news announcements. Failure rates are the highest, at 35%, for phase III projects [35 / (66+35)], but the overall failure rate is 70%.[41]

Table 2. Description and classification of R&D announcements

Announcement category	*Phase*	*Number of announcements*
Results (positive)	Pre-clinical	56
Results (negative)		15
Results (positive)	Phase I	123
Results (negative)		36
Results (positive)	Phase II	175
Results (negative)		55
Results (positive)	Phase III	66
Results (negative)		35
Total		561

Note: This table reports different types of announcements related to different phases (or stages) of the R&D process.

[41] Not tabulated. [15/(56+15)]* [36/(123+36)]* [55/(175+55)]* [35/(66+35)] = 0.303

4. Empirical results

4.1 Market timing of new equity issues

Mean-comparison test of the mispricing hypothesis

The mispricing version of equity market timing is tested using two measures of mispricing. The primary measure is mispricing at the market level (measured in the form of *PRE_INDEX_RET*), and the other is based on mispricing at the firm level (measured in the form of *PRE_FIRM_RET*). The first measure considers all other biotech firms included in our sample prior to/ after the issue of new equity. We expect firms to issue new equity when there are positive market sentiments, and the market-wide measure is a stronger indication of timing than the firm-specific measure. Table 3 tabulates a mean-comparison analysis of market sentiments around the issue of equity. The means for the 206 issuers and 1,642 non-issuers are reported separately and *t*-statistics for differences across these groups are presented.[42]

Issuers of equity have a higher absolute stock return prior to an equity issue than non-issuing firms. This is consistent with Lucas and McDonald (1990) and Guo and Mech (2000), who show that firms tend to issue equity following large stock price run-ups. The *t*-statistics of the abnormal stock return indicate that there is no difference in means between issuers and non-issuers prior to an equity issue ($p > 0.10$). However, consistent with expectations, the *t*-statistics of the equal-weight index return show that firms issue equity following a stock price run-up of all other biotech firms in the sample ($p < 0.000$). We also observe that the post index return (*POST_INDEX_RET*) is positive and significant ($p < 0.000$), indicating that the timing of new equity issues occurs in the middle of a financing window.

[42] The reason for showing less than 232 issues of new equity in Table 3 is that some issues were made less than 120 trading days after the firm's public listing. Therefore, the abnormal stock return cannot be calculated. For the same reason, in the multiple regressions in Table 6, there are slightly fewer observations in those quarters when PRE_FIRM_RET is used as an explanatory variable. These differences in sample size have no material effects on the empirical results. To have a representative sample, we use samples that are as large as possible.

Table 3. Market sentiments around the issue of equity

		6 months before issue		6 months after issue	
	Number	*Mean*	*Difference*	*Mean*	*Difference*
Absolute firm stock return					
Issuers of equity	206	-0.0413	**0.0896****	-0.0458	**0.0591**
Non-issuers of equity	1642	-0.1309	(0.028)	-0.1049	(0.149)
Equal-weight index return					
Issuers of equity	206	-0.0898	**0.1090*****	-0.0179	**0.0899*****
Non-issuers of equity	1642	-0.1988	(0.000)	-0.1077	(0.000)
Abnormal stock return					
Issuers of equity	206	0.0485	**-0.0195**	-0.0279	**-0.0308**
Non-issuers of equity	1642	0.0680	(0.556)	0.0028	(0.414)

Notes: This table reports mean-comparison test results of market sentiments before and after the issue of equity. We use three measures (a) absolute firm stock return, (b) equal-weight index return, and, (c) abnormal stock return. We measure the stock returns in three ways (a) as the dividend- and split-adjusted stock return of the firm in the 120 trading days prior to/ after the issue of new equity (b) as the dividend- and split-adjusted stock return of all other biotech firms (included in our sample) in the 120 trading days prior to/ after the issue of new equity (c) as the difference between the dividend- and split-adjusted stock return of the firm in the 120 trading days prior to/ after the issue of new equity and the dividend- and split-adjusted stock return of all other biotech firms (included in our sample) in the 120 trading days prior to/ after the issue of new equity. Similar to DeAngelo et al (2010), we do not risk-adjust for firm-specific risk. The latter two measures refer to our measure of mispricing. Equal-weight index return refers to the managers' perception of mispricing on market level, while abnormal stock return refers to the managers' perception of mispricing on firm level. Reported p-values are the results of *t* test used to examine if there is a significant difference in the mean of the two samples (sample of equity issues and sample of no equity issues). Significance assessed using Games-Howell test, which does not assume balance samples or equality of variance. ***, **, and *, denote two-tail 1%, 5% and 10% significance, respectively.

Mean-comparison test of the adverse selection cost hypothesis

Table 4 presents descriptive statistics regarding news announcements around the time of the issue of new equity. We measure the number of announcements made in the 90 calendar days preceding/following an announcement of a new share issue and test for differences between issuers (232 firm-quarter observations) and non-issuers (1989 firm-quarter observations). Table 4 contains results using positive, negative and combined measures of equal-weight announcements. For robustness reasons, we also employ phase-weight measures. The data suggests that biotech firms issue equity following the issuance of both positive and negative news announcements. Although positive announcements implicitly lead to higher capital requirement in order to initiate the next phase, i.e., firms need to make substantial investments to continue with their drug development, negative announcements do not. Ceteris paribus, the results provide support for the adverse selection cost hypothesis of equity market timing. As expected, there is no significant difference in news announcements subsequent of the issue of new equity.

Table 4. Announcements around the issue of equity

		90 days before issue		90 days after issue	
	Number	*Mean*	*Difference*	*Mean*	*Difference*
Panel A – Equal-weighted measures					
Positive outcome announcements					
Issuers of equity	232	0.2457	**0.0923*** **	0.1509	0.0030
Non-issuers of equity	1989	0.1533	(0.010)	0.1478	(0.921)
Negative outcome announcements					
Issuers of equity	232	0.1164	**0.0661*** **	0.0302	-0.0191
Non-issuers of equity	1989	0.0503	(0.002)	0.0493	(0.252)
Positive and negative announcements					
Issuers of equity	232	0.3621	**0.1584*** **	0.1810	-0.0160
Non-issuers of equity	1989	0.2036	(0.000)	0.1971	(0.653)
Panel B – Phase-weighted measures					
Positive outcome announcements					
Issuers of equity	232	0.4612	**0.1716** **	0.3103	0.0288
Non-issuers of equity	1989	0.2896	(0.015)	0.2815	(0.650)
Negative outcome announcements					
Issuers of equity	232	0.2112	**0.1041** **	0.0647	-0.0409
Non-issuers of equity	1989	0.1071	(0.029)	0.1056	(0.283)
Positive and negative announcements					
Issuers of equity	232	0.6724	**0.2757*** **	0.3750	-0.0121
Non-issuers of equity	1989	0.3967	(0.003)	0.3871	(0.875)

Notes: Reported p-values are the results of *t* test used to examine if there is a significant difference in the mean of the two samples (sample of equity issues and sample of no equity issues). Equally weighted positive (negative) outcome announcements is defined as the sum of announcements with a positive (negative) outcome, in which research phases are equally weighted. Phase-weight positive (negative) outcome announcements is the sum of announcements with a positive (negative) outcome, in which research phases are phase-weighted (i.e., phase I equals 1, phase II equals 2 and phase III equals 3). ***, **, and *, denote two-tail 1%, 5% and 10% significance, respectively.

4.2 Determinants of the decision to issue new equity

In this section, we examine whether the probability that biotech firms issue new equity is positively related to the survival time and the market-timing measures, mispricing and adverse selection costs. Similar to Loughran and Ritter (1995, 1997) and DeAngelo et al et al. (2010), mispricing is measured using stock returns (*PRE_FIRM_RET* and *PRE_INDEX_RET*). Conversely, we follow Korajczyk et al. (1991) and Guo and Mech (2000) to study the probability of equity issues to adverse selection costs. However, positive and negative R&D announcements (*R&D_NEWS_POS* and *R&D_NEWS_NEG*) are used, rather than earnings and dividend announcements, as our proxy for adverse selection. Market

timing is expected to have incremental effects beyond those of survival time (*SURVIVAL_TIME*). Panel A of Table 5 shows descriptive statistics for the regression analysis.

Table 5. Descriptive statistics - Market timing when issuing new equity

Panel A. Summary statistics

	Number of observations	*Mean*	*Q1*	*Median*	*Q3*	*St. dev*
ISSUE	1542	0.117				0.322
SURVIVAL_TIME	1542	0.256	0.077	0.155	0.291	0.443
PRE_FIRM_RET	1471	0.069	-0.198	0.051	0.350	0.461
PRE_INDEX_RET	1542	-0.170	-0.512	-0.016	0.092	0.385
POST_INDEX_RET	1498	-0.099	-0.376	-0.031	0.094	0.278
R&D_NEWS_POS	1542	0.200				0.524
R&D_NEWS_NEG	1542	0.070				0.353
AGE	1542	6.033	2.736	5.250	8.586	4.233
SIZE	1542	2.038	1.711	2.028	2.378	0.544
MKTBOOK	1542	7.301	1.740	2.970	5.27	24.976

Notes: This table reports descriptive statistics of the dependent and independent variables. The dependent variable (ISSUE) equals 1 when the firm quarter contains an announcement of an issue of new equity, otherwise 0. SURVIVAL_TIME (measured on a quarterly basis) is computed as the inverse of the ratio of the sum of the company's cash and short-term investments at the end of the previous quarter divided by the absolute value of the net income in the previous firm quarter. Firms that are profitable, or operate on a breakeven basis, are considered to have an infinite survival time, and hence, the inverse is zero. PRE_FIRM_RET, PRE_INDEX_RET, and, POST_INDEX_RET are measures of mispricing. PRE_FIRM_RET denotes abnormal stock return of the firm during the 120 trading days prior to an equity issue announcement. PRE_INDEX_RET denotes the stock return of all other biotech firms included in the sample in the 120 trading days prior to the issue of new equity. POST_INDEX_RET denotes the stock return of all other biotech firms included in the sample in the 120 trading days after the issue of new equity. R&D_NEWS_POS and R&D_NEWS_NEG are measures related to adverse selection cost. R&D_NEWS_POS (R&D_NEWS_NEG) is equally weighted positive (negative) outcome announcements and is defined as the sum of announcements with a positive (negative) outcome during the prior 90 trading days to the issue of new equity, in which research phases are equally weighted. AGE, SIZE, MKTBOOK, are control variables. AGE represents the number of months the firm has been publicly listed. SIZE represents firm size and is measured as the log of market value of equity. MKTBOOK represents market-to-book value of equity and is measured as the market value of equity divided by the book value of equity at the end of the previous quarter preceding the equity issue announcement. MKTBOOK is winsorized by three standard deviations.

The average survival time is 11.7 months, which means that firms can sustain operations for a little less than one year before the cash balance falls to zero.[43] *PRE_INDEX_RET* has a negative median value, which indicates that more than 50% of the firm-quarters contain negative returns for the average biotech firm. The mean public firm age is 6 years, indicating

[43] Survival time (*SURVIVAL_TIME*) is computed as the inverse of the ratio of the sum of the company's cash and short-term investments at the end of the previous quarter divided by the absolute value of the net income in the previous firm quarter. A survival time of 0.256 is then equal to 3.9 firm quarters, or 11.7 firm months.

that biotech firms tend to be quite young. Finally, the standard deviation for the MKTBOOK variable is exceptionally high, even though it has been winsorized at three standard deviations. Panel B of Table 5 depicts the correlation between dependent and independent variables. We note, in particular, that the equity issue decision is positively associated with survival time, the prior index return, the post index return, negative R&D news and the biotech firm's age.

Table 5. Descriptive statistics - Market timing when issuing new equity

Panel B. Correlation matrix

	ISSUE	SURVIVAL_ TIME	PRE_FIRM_RET	PRE_INDEX_RET	POST_INDEX_RET	R&D_NEWS_POS	R&D_NEWS_NEG	AGE	SIZE	MKTBOOK
ISSUE	1									
SURVIVAL_TIME	0.117***	1								
PRE_FIRM_RET	-0.016	-0.144***	1							
PRE_INDEX_RET	0.072***	-0.040	-0.280***	1						
POST_INDEX_RET	0.082***	-0.009	0.033	-0.032	1					
R&D_NEWS_POS	0.023	-0.021	0.040	-0.056**	0.042	1				
R&D_NEWS_NEG	0.059**	-0.007	-0.031	-0.020	0.038	0.142***	1			
AGE	0.075***	0.085***	0.027	0.032	0.054**	0.093***	0.024	1		
SIZE	-0.001	-0.254***	0.241***	0.149***	-0.067***	0.115***	0.028	0.109***	1	
MKTBOOK	0.014	0.091***	-0.001	-0.001	-0.058**	-0.011	0.005	0.103***	0.046*	1

Notes: The variables are detailed in Table 5, panel A. ***, **, and *, denote two-tail 1%, 5% and 10% significance, respectively.

Table 6 presents the results from the probit regressions.[44] The coefficient of survival time (*SURVIVAL_TIME*) is positive and significant at the 1% level in all models, indicating that biotech firms are more likely to issue equity when they have a near-term need of cash. The marginal effect indicates that an increase of one unit in survival time increases the probability of an equity issue by 9%. In model 2, the abnormal firm return is insignificant, which indicates that the biotech firm manager does not time equity issues when she believes that the firm is overvalued relative to other biotech firms. In models 3 and 4, we find support for H1, which states that biotech firms tend to issue new equity to a larger extent when market

[44] All analyses presented in Table 5 have also been performed on sub-samples containing rights offerings and private placements. Because many of these are intertwined, there are 43 rights offerings and 112 private placements found. The coefficients have the same sign in these two sub-samples, but the limited number of rights offerings removes most power from the statistical tests. In the private placement sample, SURVIVAL_TIME, PRE_INDEX_RET, POST_INDEX_RET and R&D_NEWS_NEG are all significant at the 1% level.

sentiments are strong. Independent of the issuing firms' performance, the coefficient on prior index return (*PRE_INDEX_RET*), measured using the equally weighted average of other biotech firms' stock returns, is positive (*z*-statistic = 3.05) and indicates a marginal probability of 6.4%.

Table 6. Market timing when issuing new equity

$$Prob(equity\ issue_i) = \alpha_0 + \alpha_1 SURVIVAL\_TIME_I + \alpha_2 PRE\_FIRM\_RET_I + \alpha_3 PRE\_INDEX\_RET_I + \alpha_4 POST\_INDEX\_RET_i + \alpha_5 R\&D\_NEWS\_POS_i + \alpha_6 R\&D\_NEWS\_NEG_i + \alpha_7 AGE_i + \alpha_8 SIZE_i + \alpha_9 MKTBOOK_i + \sum_{j=1}^{3} \beta_j REGION_{j,i}$$

	Predicted Sign	(1)	(2)	(3)	(4)	(5)
INTERCEPT		-1.702*** (-9.05)	-1.659*** (-8.58)	-1.580*** (-8.33)	-1.487*** (-7.45)	-1.642*** (-8.56)
SURVIVAL_TIME	+	0.471 [0.090]*** (3.88)	0.452 [0.088]*** (3.87)	0.474 [0.089]*** (3.67)	0.466 [0.090]*** (3.77)	0.642 [0.117]*** (5.81)
PRE_FIRM_RET	+		-0.007 [-0.001] (-0.07)		0.104 [0.020] (0.99)	
PRE_INDEX_RET	+			0.342 [0.064]*** (3.05)	0.389 [0.075]*** (3.21)	0.432 [0.079]*** (3.82)
POST_INDEX_RET	-					0.591 [0.108]*** (3.62)
R&D_NEWS_POS	+				0.044 [0.009] (0.51)	0.026 [0.005] (0.31)
R&D_NEWS_NEG	+				0.200 [0.038]** (2.08)	0.195 [0.036]** (2.08)
AGE	+/-	0.023 [0.004]** (2.22)	0.019 [0.004]* (1.81)	0.023 [0.004]** (2.28)	0.019 [0.004]* (1.72)	0.018 [0.003]* (1.71)
SIZE	+/-	0.095 [0.018] (1.12)	0.090 [0.018] (1.03)	0.050 [0.009] (0.59)	0.013 [0.002] (0.14)	0.092 [0.017] (1.03)
MKTBOOK	+/-	-0.001 [-0.000] (-0.34)	-0.001 [-0.000] (-0.43)	-0.001 [-0.000] (-0.28)	-0.001 [-0.000] (-0.33)	-0.000 [-0.001] (-0.17)
Dummies for regions	+/-	Yes	Yes	Yes	Yes	Yes
Observations		1542	1471	1542	1471	1498
Pseudo R^2		0.0363	0.0330	0.0443	0.0456	0.0609

Notes: This table provides the estimates from the probit regressions. The sample consists of all seasoned equity offerings (SEOs) of all publicly listed European biotech firms during 1998-2010. The dependent variable equals 1 when the firm quarter contains an announcement of an issue of new equity, otherwise 0. Coefficients are reported with z statistics in parentheses. SURVIVAL_TIME (measured on a quarterly basis) is computed as the inverse of the ratio of the sum of the company's cash and short-term investments at the end of the previous quarter divided by the absolute value of the net income in the previous firm quarter. Firms that are profitable, or operate on a breakeven basis, are considered to have an infinite survival time, and hence, the inverse is zero. PRE_FIRM_RET, PRE_INDEX_RET, and, POST_INDEX_RET are measures of mispricing. PRE_FIRM_RET denotes abnormal stock return of the firm during the 120 trading days prior to an equity issue announcement.

PRE_INDEX_RET denotes the stock return of all other biotech firms included in the sample in the 120 trading days prior to the issue of new equity. POST_INDEX_RET denotes the stock return of all other biotech firms included in the sample in the 120 trading days after the issue of new equity. R&D_NEWS_POS and R&D_NEWS_NEG are measures related to adverse selection cost. R&D_NEWS_POS (R&D_NEWS_NEG) is equally weighted positive (negative) outcome announcements and is defined as the sum of announcements with a positive (negative) outcome during the prior 90 trading days to the issue of new equity, in which research phases are equally weighted. AGE, SIZE, MKTBOOK, and, region-dummies are control variables. AGE represents the number of months the firm has been publicly listed. SIZE represents firm size and is measured as the log of market value of equity. MKTBOOK represents market-to-book value of equity and is measured as the market value of equity divided by the book value of equity at the end of the previous quarter preceding the equity issue announcement. MKTBOOK is winsorized by three standard deviations. We include region dummies as defined by La Porta et al (1998), which equal one if the firm is of French-, German-, or Scandinavian origin, otherwise zero (English-origin). We also control for risk (BETA) and intangible intensity (INT_INT). These measures are insignificant. However, we exclude them from the above regression due to a reduction in sample size due to missing data. We report coefficient estimates, marginal effects (within angle brackets), and, *z*-statistics for marginal effects (within brackets). All regressions contain robust standard errors.

In models 4 and 5, we find support for the hypothesis (H2) that managers are more likely to issue equity when asymmetric information (or adverse selection costs) is relatively low. The coefficient of positive R&D news announcements (*R&D_NEWS_POS*) is positive, but insignificant. This is contrary to expectations because positive R&D announcements carries an investment need. However, the coefficient of negative R&D news announcement (*R&D_NEWS_NEG*) is positive (*z*-statistic = 2.07), supporting the adverse selection cost hypothesis. An increase of one unit in negative R&D news (*R&D_NEWS_NEG*) increases the probability of an equity issuance by 3.8%. In model 5, the coefficient of the post index return (*POST_INDEX_RET*) is positive and significant. This indicates that biotech firms make new share issues well before the end of a period with positive market sentiments.

In untabulated tests, we follow Ai and Norton (2003) and interact survival time with prior index return and negative R&D news announcements. Although both the survival time and prior index return are statistically significant at 1% level, their interaction term is insignificant (*z*-statistic = 0.27). In contrast, the interaction term between survival time and negative R&D news is positive and significant (*z*-statistic = 2.00). This implies that when firms running out of cash release negative R&D news, they are particularly likely to issue new equity.

5. Conclusions

When regulatory authorities, such as the FDA and the EMA, publicly announce the progress of research projects, they provide highly relevant information to investors analyzing biotech firms (Jeppsson, 2010). However, investors receive not only relevant information about

future cash flows but also exceptionally credible news announcements. Past studies of market timing in relation to actions such as earnings announcements are biased in the case that managers deliberately disclose information that is at their advantage. In comparison with previous studies on the mispricing theory and particularly those on the adverse selection cost theory, our measures are essentially unaffected by managerial discretion.

The empirical study is based on 87 biotech firms listed across Europe in the years 1998 through 2009. In total, these firms offered 232 issues of new equity and 561 publicly disclosed announcements about the progress of their research projects. We find strong support for both the mispricing and adverse selection cost theories. They are highly significant explanatory factors on a stand-alone basis, but, interestingly, they also contain some incremental explanatory power. New equity is issued to a considerably greater extent when market sentiments in the biotech industry are strong. It is notable that a firm's abnormal return is unassociated with the equity announcement. This suggests either that there is no opportunistic disclosure of firm-specific information or that it has had no effect on pricing. We also note that market sentiments in the biotech industry continue to be strong following the equity announcement and thus that many of the issues of new equity are made in the middle of quite extensive time periods when market sentiments are positive.

The adverse selection cost theory suggests that rational managers decide to issue new equity when there is relatively little asymmetric information between shareholders and management. Mean-comparison tests suggest that news of both positive and negative character is associated with issues of new equity. However, in the multivariate tests positive news announcements have no incremental positive effect on equity issues. This is quite surprising, given that positive news not only contains credible signals of the biotech firm having value-creating projects but also tends to force biotech firms to increase their investment rate. Announcements of negative news do not necessarily carry these side effects; we thus see their positive significant association with the issuance of equity as solid support for the adverse selection hypothesis.

It needs to be mentioned that, overall, a firm's survival time is the best indicator of a new equity issue. On average, firms that issue new equity can sustain their ongoing operations less than a year.

The biotech industry is, arguably, different from other industries in the sense that firms usually operate with large negative free cash flows and have no other choice but to regularly

ask investors for (equity) financing of their research projects. From an investor perspective, there is considerable asymmetric information and, given the inherent risk of the industry, a search for credible signals of a biotech firm's prospects seems to be a clear-cut requirement before buying into an issue of new shares. Although an investor's search for credible signals is particularly important in this setting, we are convinced that it is not unique to the biotech industry. In other words, our findings lend support for studying market timing not only from the point of view that managers want to capitalize on mispricing but also from the point of view that they rationally go to equity markets when there is a chance that investors will understand the firm's prospects better. In the last decade, a vast amount of empirical support has been given to the idea that market timing is about opportunistic managers trying to capitalize on moments when markets are mispriced. The adverse selection cost theory seems to be, if not an equally important factor, at least a less-than-marginal factor to be considered when understanding firms' decisions to finance their ventures.

References

Ai, C., Norton, E. C., 2003. Interaction terms in logit and probit models. Economics Letters 80, 123-129.

Alti, A., 2006. How persistent is the impact of market timing on capital structure? Journal of Finance 61, 1681-1710.

Baker, M., Wurgler, J., 2002. Market timing and capital structure. Journal of Finance 57, 1-32.

Baker, M., Wurgler, J., 2007. Investor sentiment in the stock market. Journal of Economic Perspectives 21, 129-151.

Bayless, M., Chaplinsky, S., 1996. Is there a window of opportunity for seasoned equity issuance? Journal of Finance 51, 253-278.

Beisland, L. A., Hamberg, M., 2010. Variations in value relevance. Working paper.

Choe, H., Masulis, R., Nanda, V., 1993. Common stock offerings across the business cycle: Theory and evidence. Journal of Empirical Finance 1, 3-31.

Cooper, D. W., Grinder, B., 1996. Voluntary information disclosure during periods of stock price vulnerability. Journal of Business Finance and Accounting 23, 461-472.

DeAngelo, H., DeAngelo, L., Stulz, R. M., 2010. Seasoned equity offerings, market timing, and the corporate lifecycle. Journal of Financial Economics 95, 275-295.

Dedman, E., Lin, S. W-J., Prakash, A., Chang, C-H., 2008. Voluntary disclosure and its impact on share prices: Evidence from the UK biotechnology sector. Journal of Accounting and Public Policy 27, 195-216.

Denis, D. J., Sarin, A., 2001. Is the market surprised by poor earnings realizations following seasoned equity offerings. Journal of Financial and Quantitative Analysis 30, 169-193.

Dierkens, N., 1991. Information asymmetry and equity issues. Journal of Financial and Quantitative Analysis 26, 181-199.

Graham, J. R., Harvey, C. R., 2001. Theory and practice of corporate finance: Evidence from the field. Journal of Financial Economics 60, 187-243.

Guo, R-J., Lev, B., Zhou, N., 2004. Competitive costs of disclosure by biotech IPOs. Journal of Accounting Research 42, 319-355.

Guo, L., Mech, T. S., 2000. Conditional event studies, anticipation, and asymmetric information: The case of seasoned equity issues and pre-issue information releases. Journal of Empirical Finance 7, 113-141.

Harford, J., 2005. What drives merger waves? Journal of Financial Economics 77, 529-560.

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

Healy, P. M., Palepu, K. G., 1990. Earnings and risk changes surrounding primary stock offers. Journal of Accounting Research 28, 25-48.

Hickman, B., 1953. The volume of corporate bond financing. New York: National Bureau of Economic Research..

Ibbotson, R. G., Jaffe, J. F., 1975. "Hot issue" markets. Journal of Finance 30, 1027-1042.

Ibbotson, R. G., Sindelar, J. L., Ritter, J. R., 1988. Initial public offerings. Journal of Applied Corporate Finance 1, 37-45.

Ibbotson, R. G., Sindelar, J. L., Ritter, J. R., 1994. The market's problems with the pricing of initial public offerings. Journal of Applied Corporate Finance 7, 66-74.

Ikenberry, D., Lakonishok, J., Vermaelen, T., 1995. Market underreaction to open market share repurchases. Journal of Financial Economics 39, 181-208.

Jain, B. A., Kini, O., 1994. The post-issue operating performance of IPO firms. Journal of Finance 49, 1699-1726.

Jeppsson, H., 2010. The value relevance of research progress in the European biotechnology industry. Working paper.

Jensen, M. C., Meckling, W., 1976. Theory of the firm: Managerial behavior, agency costs and capital structure. Journal of Financial Economics 3, 305-360.

Korajczyk, R. A., Lucas, D. J., McDonald, R. L., 1991. The effect of information releases on the pricing and timing of equity issues. The Review of Financial Studies 4, 685-708.

Korajczyk, R. A., Lucas, D. J., McDonald, R. L., 1992. Equity issues with time-varying asymmetric information. Journal of Financial and Quantitative Analysis 27, 397-417.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R. W., 1998. Law and Finance. Journal of Political Economy 106, 1113-1155.

Lang, M. H., Lundholm, R. J., 2000. Voluntary disclosure and equity offerings: Reducing information asymmetry of hyping the stock? Contemporary Accounting Research 17, 623-662.

Lerner, J., Shane, H., Tsai, A., 2003. Do equity financing cycles matter? Evidence from biotechnology alliances. Journal of Financial Economics 67, 411-446.

Lin, Y-M., You, S-J., Lin, F-J., 2008. The effects of pre-issue information releases on seasoned equity offerings. Journal of Business Finance & Accounting 35, 1138-1163.

Lintner, J., 1965. The valuation of risk assets and the selection of risky investments in stock portfolios and capital budgets. The Review of Economics and Statistics 47, 13-37.

Loderer, C. F., Mauer, D. C., 1992. Corporate dividends and seasoned equity issues: An empirical investigation. Journal of Finance 47, 201-225.

Loughran, T., Ritter, J., 1995. The new issues puzzle. Journal of Finance 50, 23-51.

Loughran, T., Ritter, J., 1997. The operating performance of firms conducting seasoned equity offerings. Journal of Finance 52, 1823-1850.

Lucas, D., McDonald, R., 1990. Equity issues and stock price dynamics. Journal of Finance 45, 1019-1043.

Mackie-Mason, J. K., 1990. Do taxes affect corporate financing decisions? Journal of Finance 45, 1471-1493.

Martynova, M., Renneboog, L., 2008. A century of corporate takeovers: What have we learned and where do we stand? Journal of Banking and Finance 32, 1723-1742.

McConomy, B., Xu, B., 2004. Value creation in the biotechnology industry. CMA Management, 29-31.

Mikkelson, W. H., Partch, M. M., Shah, K., 1997. Ownership and operating performance of companies that go public. Journal of Financial Economics 44, 281-307.

Miller, M., Modigliani, F., 1966. Some estimates of the cost of capital to the utility industry, 1954-7. American Economic Review 56, 333-391.

Myers, S. C., 1977. Determinants of corporate borrowing. Journal of Financial Economics 5, 147-175.

Myers, S. C., 1984. The capital structure puzzle. Journal of Finance 39, 575-592.

Myers, S. C., Majluf, N. S., 1984. Corporate financing and investment decisions when firms have information that investors do not have. Journal of Financial Economics 13, 187-221.

Pagano, M., Panetta, F., Zingales, L., 1998. Why do companies go public? An empirical analysis. Journal of Finance 53, 27-64.

Pástor, L., Veronesi, P., 2005. Rational IPO waves. Journal of Finance 60, 1713-1757.

Rangan, S., 1998. Earnings management and the performance of seasoned equity offerings. Journal of Financial Economics 50, 101-122.

Rhodes-Kropf, M., Robinson, D., Viswanathan, S., 2005. Valuation waves and merger activity: The empirical evidence. Journal of Financial Economics 77, 561-603.

Ritter, J., 1984. The “hot issue” market of 1980. Journal of Business 57, 215-240.

Ritter, J., 1991. The long-run performance of initial purchase offerings. Journal of Finance 46, 3-27.

Roosenboom, P., van der Goot, T., Mertens, G., 2003. Earnings management and initial public offerings: Evidence from the Netherlands. International Journal of Accounting 38, 243-266.

Shiller, R. J., 2000. Irrational exuberance. Princeton: Princeton University Press.

Shivakumar, L., 2000. Do firms mislead investors by overstating before seasoned equity offerings? Journal of Accounting and Economics 29, 339-371.

Taggart, R. A., 1977. A model of corporate financing decisions. Journal of Finance 32, 1467-1484.

Teoh, S. H., Wong, T. J., Rao, G. R., 1998a. Are accruals during initial public offerings opportunistic? Review of Accounting Studies 3, 175-208.

Teoh, S. H., Welch, I., Wong, T. J., 1998b. Earnings management and the long-run market performance of initial public offerings. Journal of Finance 53, 1935-1974.