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THREE ESSAYS ON R&D INVESTMENTS IN THE PHARMACEUTICAL INDUSTRY

Aoun Adam

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FACULTÉ DES HAUTES ÉTUDES COMMERCIALES

DÉPARTEMENT COMPTABILITÉ ET CONTRÔLE

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THÈSE DE DOCTORAT

présentée à la

Faculté des Hautes Études Commerciales
de l'Université de Lausanne

pour l'obtention du grade de
Docteur ès Sciences Économiques, mention « Management »

par

Adam AOUN

Directeur de thèse
Prof. Alain Schatt

Jury

Prof. Rafael Lalive, Président
Prof. Paul André, expert interne
Prof. Beatriz García Osma, experte externe
Prof. Laurent Frésard, expert externe

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I M P R I M A T U R

Sans se prononcer sur les opinions de l'auteur, la Faculté des Hautes Etudes Commerciales de l'Université de Lausanne autorise l'impression de la thèse de Monsieur Adam AOUN, titulaire d'un bachelor en administration économique et sociale de l'Université de Nice Sophia Antipolis et d'un master en comptabilité, contrôle, et finance de l'Université de Lausanne, en vue de l'obtention du grade de docteur ès Sciences économiques, mention management.

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Lausanne, le 8 décembre 2020

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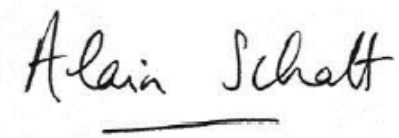

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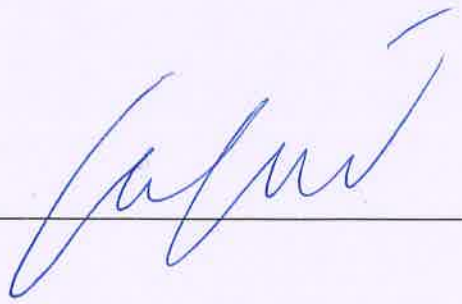
Signature:  Date: 30/11/2020

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Lausanne, the 1st of December 2020

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Introduction

A century ago, the famous economist Joseph Schumpeter suggested that innovation is a critical dimension of economic change. In line with this idea, we argue that innovation in the pharmaceutical industry is also a critical issue for human health and well-being (e.g., finding a cure for the COVID-19 should improve the well-being of many people across the world).

To develop new drugs, pharmaceutical firms invest important resources in research and development (R&D). For instance, in 2019, these investments amounted to $2.4 trillion around the world (R&D World, 2020)[1], which represents about 15% of their global sales (EFPIA, 2018).[2] R&D investments have two specific characteristics: a long-term horizon and a high risk. Indeed, it usually takes around 10 years to launch a new drug, and there is only a limited number of successful R&D projects (Buonansegna et al., 2014; Petrova, 2014; DiMasi et al., 2016).

From an academic point of view, these two key characteristics may lead to severe agency conflicts between managers and shareholders (Jensen and Meckling, 1976). Indeed, it is possible that managers underinvest in R&D, because they do not hold well-diversified portfolio, and they are usually relatively old. Thus, they may be more interested by short-term results and, therefore, cut R&D investments to avoid bad surprises when disclosing quarterly earnings (Graham et al., 2005; Shon and Yan, 2015).

[1] https://www.rdworldonline.com/global-rd-investments-unabated-in-spending-growth/
[2] European Federation of Pharmaceutical Industries and Associations (EFPIA). (2018). https://efpia.eu/publications/downloads/

In such context, a first key question arises: How can investors influence the R&D strategy of pharmaceutical firms, in order to create value in the long run?

The first chapter of the thesis tackles this issue, by analyzing the impact of corporate governance on R&D investments in pharmaceutical firms. More precisely, we investigate whether a R&D committee established at the board level influences the R&D strategy of pharmaceutical firms. Based on a sample of 157 U.S. and European firms, we find a positive association between the existence of a R&D committee and R&D intensity, the numbers of products in clinical trial development, approved drugs by the FDA, and acquisitions of pharmaceutical firms. Our staggered difference-in-differences supports the idea of a significant change in R&D strategy after the creation of such a committee. These findings hold after reweighting the treatment and control groups with entropy balancing. However, when comparing U.S. and European firms, we find that R&D committees only influence the R&D strategy of U.S. firms, which are often criticized for their short-termism. In European countries, where short-termism is less problematic, R&D committees have a merely symbolic value. Our results therefore suggest that R&D committees significantly influence the R&D strategy of pharmaceutical firms, and curb short-termism.

Given that many pharmaceutical firms form R&D alliances to access knowledge and to share the costs and risks associated with the development of new drugs, a second key question arises: Do investors really benefit from such strategy?

We tackle this issue in the second chapter of the thesis. More precisely, we investigate the expropriation risk (i.e., the risk of extraction of private benefits by large firms) faced by small firms that form an alliance with large firms. Our empirical analysis is based on a sample of 544 hand-collected announcements of successes

(good news) and failures (bad news) in clinical trials, during the period 2011-2017, and on two measures of market reaction (i.e., cumulative abnormal returns and abnormal trading volumes). We find a positive (negative) market reaction to good (bad) news in the latest stage of product development (i.e., Phase III), which is expected as uncertainty about future payoffs is much lower. Moreover, a stronger market reaction is found in the absence of a R&D alliance, which is also expected as all costs, benefits, and risks are borne by the large pharmaceutical firm alone. Finally, if an alliance exists, a larger market reaction is found for clinical trial announcements involving another large firm, in comparison to announcements involving small (non-listed) firms. Overall, the expropriation risk faced by small firms seems low from the investors' point of view, suggesting that these firms have enough bargaining power to protect themselves with effective contractual arrangements, but also that large firms may not extract private benefits, in order to protect their reputation and to attract other small allies in the future.

Finally, given that investors react to clinical trial disclosure by pharmaceutical firms, a last key question arises: Does this specific non-information influence the target prices computed by financial analysts?

We tackle this issue in the third chapter of the thesis. In line with the well-documented base-rate fallacy, which suggests that people tend to ignore the base-rate information (i.e., general information on the probability of success of clinical trials and its consequences on future cash flows in our case) in favor of the new and specific information (i.e., clinical trial disclosures in our case), we expect that analysts become more optimistic (pessimistic) after the disclosure of information concerning the latest (earliest) phase of drug development because the probability of success (failure) is

higher. Our empirical examination confirms that Phase III (Phase I) disclosures lead to more optimistic (pessimistic) target prices. Our findings hold after controlling for the probability of success of the drug portfolio, analyst following, the seasonality and the frequency of analyst reports, and the intensity of clinical trial disclosure. Finally, some differences exist between large and small firms, as optimistic target prices are issued by analysts after Phase III disclosures by large firms, but after Phase II disclosures by small firms. Overall, our findings suggest that analysts become more optimistic after the disclosure of specific non-financial information by pharmaceutical firms and, therefore, supports the existence of a base-rate fallacy among financial analysts.

Thus, this thesis provides three main results on the causes and consequences of R&D investments by pharmaceutical firms. First, R&D committees have a significant influence on R&D strategy. Second, investors of large pharmaceutical firms react more significantly to news regarding drug development (i.e., clinical trial disclosure) in the absence of an alliance, especially if the alliance involves a small firm. Third, analysts also react to clinical trial disclosure, by significantly modifying their target prices, suggesting that such specific non-financial information is an effective substitute for the "deficient" financial reports.

By investigating three different questions, with various databases and methodologies, we hope that our findings will be valuable for investors, managers, and board of directors of pharmaceutical firms, as well as for researchers interested by R&D investments and, more generally, by innovation in the pharmaceutical industry.

Chapter 1: Do R&D committees influence the R&D strategy?

1.1. Introduction

Investing in R&D is a key decision for firms evolving in the pharmaceutical industry. The European Federation of Pharmaceutical Industries and Associations (2018) highlights that this industry invests more in R&D than other R&D intensive industries, such as software and computer services or technology hardware and equipment. For investors, such investments are important as they lead to the development of new products that may increase future cash-flows and firm value (Eberhart et al., 2004; Wang et al., 2017; Zhang and Toffanin, 2018). This idea is supported by academic research showing a positive financial market reaction to announcements of additional R&D investments or other good news regarding the development of new drugs by pharmaceutical firms (Ely et al., 2003; Dedman et al., 2008; Szutowski, 2018).

However, some pharmaceutical firms invest less in R&D than others, which may notably be explained by the two key characteristics of R&D investments: high risk and long-term horizon. Managers, who do not have well-diversified portfolios and have a shorter time-horizon (Jensen and Meckling, 1976; O'Connor and Rafferty, 2012; Balsmeier et al., 2017) may limit R&D investments.[3] In this case, the board of directors plays a key role by proposing appropriate long-term compensation to a CEO (Cheng, 2004; Deutsch, 2007; Brown et al., 2008; Lim, 2015), and by advising and monitoring the CEO's efforts regarding R&D strategy (Adams et al., 2010).

[3] This argument derived from agency theory is challenged by behavioral economics. In particular, Hirshleifer et al. (2012) mention that overconfident CEOs may invest too many resources in R&D (i.e., overinvestment).

Previous literature has shown that the board of directors' effectiveness depends on its composition (Lu and Wang, 2015; Ghosh, 2016; Helmers et al., 2017; Faleye et al., 2018). To the best of our knowledge, however, no study has yet examined whether the organization of the board influences managers' decisions to invest in R&D. We fill this gap by investigating the impact of R&D committees on R&D strategy. Such committees have been established at the board level in many pharmaceutical firms over the two last decades.[4] They are mainly composed of board members with a scientific background (i.e., a medical or pharmaceutical education), and advise the board of directors on R&D projects and monitor R&D investments as well as the drug development process.[5]

We also examine whether the national context moderates the association between R&D committees and R&D strategy. Hillier et al. (2011), Shao et al. (2013), and Iturriaga and Lopez-Millan (2017) show that firms' R&D related decisions are driven by national context. In this paper, we are concerned by the long term orientation of a country (Hofstede et al., 2010), which is a trait of the national culture and which may significantly impact R&D strategy (Shao et al., 2013). In particular, public firms in the U.S. are often criticized for their short-termism (Drucker, 1986; Martin, 2015)[6], a view that is supported by some academic research (Graham et al., 2005; Chakravarty

[4] R&D committees are specific to the pharmaceutical industry. An exploratory analysis of other industries, via the *BoardEX* database, suggests that only 12 companies in various industries have implemented a similar committee at the board level during our period of interest.

[5] Table 2 describes the characteristics of R&D committee members and Appendix C provides some examples of R&D committee objectives.

[6] Even the United Nations indicate that short-termism is an issue for public firms: "*The short-term performance pressures on investors result in an excessive focus on quarterly earnings, with less attention paid to strategy, fundamentals and long-term value creation. Many companies respond to these pressures by reducing expenditures on research and development and foregoing investment opportunities with a positive long-term net present value.*" https://www.unglobalcompact.org/take-action/action/long-term.

and Grewal, 2011; Sampson and Shi, 2020). In Europe, short-termism seems less problematic. Thus, we compare U.S. and European firms to better understand whether R&D committees have a different impact in distinct national contexts.

Our empirical analysis is based on a sample of 157 pharmaceutical firms during the period 2010-2018. Our main findings are as follows. First, we show a positive association between the existence of a R&D committee and R&D intensity, the numbers of products in clinical trial development, approved drugs by the Food and Drug Administration (FDA), and acquisitions of pharmaceutical firms. Second, our staggered difference-in-differences supports the idea of a significant change in R&D strategy after the creation of such a committee. When compared to firms without a R&D committee (i.e., our control group), firms that have established a R&D committee (i.e., our treated group) invest more in R&D, have higher numbers of products in clinical trial development, have a higher number of approved drugs by the FDA, and make more acquisitions of other pharmaceutical firms. Third, our findings hold after reweighting the treatment and control groups with entropy balancing, which allows greater comparability of our two groups of firms (Hainmuller, 2012). Fourth, the comparison between U.S. and European firms shows that significant changes in R&D strategy only occur in U.S. pharmaceutical firms. In European firms, R&D committees merely have a symbolic value. Overall, we conclude that R&D committees have a real impact on R&D strategy in the U.S., a country which is characterized by a short-term orientation, but they have no significant impact in European pharmaceutical firms in which short-termism is less problematic.

By highlighting the importance of the board of directors' organization, our paper contributes to the literature on the effect of corporate governance on R&D strategy.

Our paper is the first to show that R&D committees established at the board level significantly impact R&D strategy in the pharmaceutical industry, after controlling for board composition (Deutsch, 2007; Osma, 2008; Dalziel et al., 2011; Yoo et al., 2015; Chen et al., 2016; Ghosh et al., 2016; Midavaine et al., 2016; Rossi et al., 2017; Balsmeier et al., 2017; Helmers et al., 2017; Jia, 2017; Chen et al., 2018; Faleye et al., 2018, Lu et al., 2018; Oh et al., 2018). In line with Hillier et al. (2011), Shao et al., (2013), and Iturriaga and Lopez-Millan (2017), we also show that the effectiveness of such a committee is sensitive to the institutional context. It has significant economic consequences in the U.S., a country characterized by (and criticized for) short-termism, but it has only a symbolic value in European countries that have a long term orientation. Overall, these findings should be of interest to investors.

The rest of the paper is organized as follows. Section 2 is dedicated to the literature review and the development of our hypotheses. Section 3 describes the research design and the sample. Section 4 presents our results. We conclude in the last section.

1.2. Literature review

1.2.1. The determinants of R&D strategy

Since R&D investments are risky (i.e., the probability of not finding a new drug is high), with a long term horizon (i.e., it takes about 10 years to launch a new drug), managers of pharmaceutical firms, who are generally more risk averse than shareholders, may limit such investments (Jensen and Meckling, 1976; O'Connor and Rafferty, 2012; Balsmeier et al., 2017). It has been argued that a reduction in R&D expenses helps disclose higher earnings, which may satisfy financial analysts in the short-run and lead

to higher CEO compensation (Cheng et al., 2004; Cao and Laksmana, 2010; Lim et al., 2015; Shon and Yan, 2015).

Prior literature has identified various mechanisms that lead managers to invest more resources in R&D. Some of these mechanisms are related to the institutional context such as shareholders' legal protection (Hillier et al., 2011), national culture (Shao et al., 2013), or tax regulations (Brown and Krull, 2008). Corporate governance also influences managers' decisions regarding R&D intensity. In particular, the board of directors can encourage managers to invest more in R&D.[7]

Dalziel et al. (2011) indicate that directors with Ivy League education and technical experience increase the R&D spending of the firm. Midavaine et al. (2016) show that education and gender diversity within the board lead firms to invest more in R&D, and that tenure diversity decreases R&D. Chen et al. (2016) find that female directors improve risk management related to R&D, as they reduce the positive association between R&D and future performance volatility. Board interlocks also have a positive impact on R&D intensity (Helmers et al., 2017). Oh et al. (2018) suggest a mimetic behavior for CEOs serving as directors on other boards. Lu and Wang (2018) argue that higher board independence enhances firm R&D. Faleye et al. (2018) indicate that having directors with industry expertise increases R&D investments. Finally, Chen et al. (2018) add to the gender diversity research and show that higher female board representation positively affects R&D effort. All previous papers are based on U.S. data.

The literature in other countries is less extensive but generally supports the results found in the U.S.. Osma (2008) analyses British firms and shows that having

[7] Appendix A provides a selected list of articles focusing on this issue.

higher board independence reduces the probability that firms will cut R&D. Schmid et al. (2014) argue that German family firms invest more in R&D than non-family firms. Yoo et al. (2015) investigate South-Korean firms and find that a higher presence of outside directors does not influence a firm's R&D policy. Ghosh et al. (2016) find that commercial-bank directors invest less in R&D in India. In Italy, the presence of women on boards decreases R&D intensity (Rossi et al., 2017). Finally, De Massis et al. (2018) study Chinese firms and suggest that a higher presence of family directors positively affects R&D investments.

Overall, the academic literature suggests that board composition influences R&D strategy. To the best of our knowledge, however, no study has yet investigated the impact of board organization, especially the role of R&D committees established at the board-level, on R&D strategy.[8]

1.2.2. R&D committees in the pharmaceutical industry

In the pharmaceutical industry, many firms have established R&D committees over the last decade. Such organization of the board is probably favored by the large financial resources invested in R&D as well as by the specific drug development process in this industry (Petrova, 2014; DiMasi et al., 2016). Bringing a new product to the market usually takes more than 10 years and costs about USD 2.5 billion (DiMasi et al., 2016).[9]

[INSERT FIGURE 1]

[8] The literature on board organization focuses on audit committees. It has notably been shown that the presence of such committees impacts financial reporting quality (Bédard and Gendron, 2010), but their impact is sensitive to the institutional context (Poretti et al., 2018).

[9] Figure 1 shows that the first step of new drug development consists in a pre-clinical phase, which usually takes between 3 to 6 years. Companies then start their clinical trials, which lead them to test the medicines on humans during three different phases. This second step is the most expensive, as pharmaceuticals have to tackle all the safety and secondary outcomes of the treatment related to the new drugs. Finally, when a firm succeeds in Phase III, the new drug must be approved by the competent market regulator (e.g., the FDA in the US).

A R&D committee established at the board-level may provide advice and improve the monitoring of R&D investments and the drug development process. Such a committee, which includes members sitting on the board of directors with a scientific background (i.e., a medical or pharmaceutical education), discusses strategic and operational issues related to R&D during additional meetings. Appendix C provides some examples of R&D committees' objectives described in the annual reports of pharmaceutical firms. They vary from generic (e.g., "Advise and monitor R&D" at 4SC) to more specific objectives (e.g., "Responsible for reviewing and monitoring R&D projects, programs, budgets and risk related to company's portfolio" at Qiagen).

One may therefore argue that a R&D committee impacts R&D strategy because the members sitting on such a committee have strong incentives (i.e., their reputation is on the line, and they receive a specific compensation) to improve R&D policy. However, one may also argue that such a committee only has a symbolic value, because the R&D committee does not necessarily reflect the point of view of the board of directors, which is the ultimate decision-maker regarding the R&D policy. In addition, members with different profiles and objectives may sit on the R&D committee, which may lead to some cognitive conflicts regarding R&D policy. Overall, these various arguments (pros and cons) lead us to formulate our first non-directional hypothesis:

H1: Ceteris paribus, the existence of a R&D committee does not influence R&D strategy.

We also focus on the influence of the national context on the association between a R&D committee and R&D intensity. Based on Hillier et al., (2011), Shao et al., (2013) and Iturriaga and Lopez-Millan (2017), we posit that the effectiveness of a R&D committee may be sensitive to a country's long term orientation, which is a key

national cultural trait (Hofstede et al., 2010). However, it is not clear in which context the R&D committee matters the most. On the one hand, it is possible that a complementary effect exists, meaning that R&D committees exert more influence on R&D strategy in countries with a long term orientation. On the other hand, it is also possible that a substitution effect exists, meaning that such a committee may curb short-term orientation. This issue is particularly relevant in the U.S., where public firms are often criticized for their short-termism (Drucker, 1986; Martin, 2015). Some academic research supports this idea (Graham et al., 2005; Chakravarty and Grewal, 2011; Sampson and Shi, 2020). In Europe, short-termism seems less problematic. Thus, we compare U.S. and European firms to better understand whether R&D committees have a different impact in distinct national contexts. Since the effect is not clear, we formulate the second hypothesis as follows:

H2: Ceteris paribus, the national context influences the association between a R&D committee and R&D strategy.

1.3. Research design

1.3.1. Sample

To select our sample, we started with all pharmaceutical and biotechnology firms listed on U.S. and European markets from 2010 to 2018. We focus on U.S. and European firms because they possess a very large market share of the global pharmaceutical market (EFPIA, 2018). We began in 2010 to avoid any specific effects of the global financial crisis. We dropped all firms that were not listed during the full period as well as companies without all necessary financial data in *Thomson Reuters*. We also dropped firms for which we were unable to verify the existence of a R&D committee in their annual reports. Our final balanced sample includes 157 firms over nine years,

representing 1,413 firm-year observations. The existence of a R&D committee and its composition (i.e., independence, gender, age, and scientific culture of the members), as well as the presence of a chief scientific officer in the top management team, were hand-collected in the annual reports of these firms.

Table 1 reports the sample distribution by country and by sub-groups. The three groups are based on the existence of a R&D committee. The first group includes 80 firms without a committee during the full period (NEVER; 51% of the sample). The second group includes 33 firms with a committee during the full period (ALWAYS; 21% of the sample). The last group includes 44 firms that created a committee between 2011 and 2018 (CREATION; 28% of the sample). When splitting our sample by national contexts, U.S. and European firms represent 65% and 35% of our sample, respectively. Table 1 also confirms that the U.S. is more short-term oriented (LTO=26) than European countries (LTO ranging between 51 and 83).

[INSERT TABLE 1]

1.3.2. Models

We start with a cross-sectional analysis of the association between the existence of a R&D committee and R&D strategy. Our first equation writes as follows:

$$R\&D_{i,t} = \alpha_0 + \alpha_1 RDC\_EXISTENCE_{i,t} + CONTROLS_{i,t} + \varepsilon_{i,t} \quad \text{(Eq. 1)}$$

RDC_EXISTENCE is equal to one if a firm has a R&D committee during the year, and zero otherwise. Our first hypothesis suggests that α1 is not different from zero, whereas our second hypothesis suggests this coefficient is different from zero in the two sub-samples of U.S. and European firms.

Table 2 shows the characteristics of the existing R&D committees for the full sample and for U.S. and European sub-samples. On average, such a committee includes

about 4 members (RDC_Size), which represents about 46% of all board members (RDC_Board); 89% of them are independent and 82% have a scientific background. Moreover, they are relatively elderly (about 62 years old), and only a small proportion (18%) of women (RDC_Gender) are present on R&D committees. When comparing the two sub-samples of U.S. and European firms, some significant differences appear regarding these characteristics.

[INSERT TABLE 2]

We also analyze the impact of the creation of a R&D committee on R&D strategy with a staggered difference-in-differences design. In this approach, we compare firms from groups CREATION (treatment group) and NEVER (control group). Our second equation is the following:

$$R\&D_{i,t} = \beta_0 + \beta_1 RDC\_CREATION_{i,t} + \beta_2 POST_{i,t} + \beta_3 RDC\_CREATION_{i,t}*POST_{i,t} + CONTROLS_{i,t} + \varepsilon_{i,t} \quad \text{(Eq. 2)}$$

RDC_CREATION is equal to one if a firm creates a R&D committee during the year, and zero otherwise. POST is equal to one for the years after the creation of a R&D committee, and zero otherwise. In this model, the variable of interest is RDC_CREATION*POST, which captures the marginal effect of R&D committee creation on R&D strategy. Our first hypothesis suggests that β3 is non-significant. Our second hypothesis suggests that this coefficient is different from zero in the two sub-samples of U.S. and European firms.

In all models, we include country and year fixed effects to control for year and country invariant and unobservable factors. The statistics are based on robust standard

errors clustered at the firm level (White, 1980; Petersen, 2009). Finally, we winsorize our variables at the 1st and 99th percentiles to minimize the effects of outliers.[10]

1.3.3. Dependent variables

Since no consensus exists in the literature regarding the appropriate measure of R&D strategy, we use six variables that capture various dimensions of that strategy. The first three variables concern R&D intensity: (1) natural logarithm of R&D expenses (RD_Log); (2) ratio of R&D expenses to total assets (RD_TA); (3) ratio of R&D expenses to sales (RD_Sales).[11] For the last variable, we observe that some firms have very low levels of sales. To avoid extreme values, we follow Zhang et al. (2018) and test our hypotheses on a subsample of firms whose R&D expenses are not larger than their sales. Three other variables concern: (4) the number of products in development (Products); (5) the number of products approved by the regulator (FDA); (6) the number of acquisitions of pharmaceutical firms (M&A).

Descriptive statistics from Panel A in Table 3 show that firms in our sample have average R&D expenses of $639.5 million, and average RD_TA and RD_Sales ratios of 23% and 25%, respectively. Their pipeline includes about 12 products, but only 1 drug is approved by the FDA, confirming the low probability of success of R&D projects (DiMasi, 2000). Finally, our sample firms acquire a pharmaceutical company every two years. Panel B shows that firms with a R&D committee (ALWAYS) have significantly larger R&D expenses than firms without such a committee (NEVER), as

[10] All variables are summarized in Appendix B. The variance inflation factors (VIF) for all our variables are inferior to 1.65, suggesting that multicollinearity is not an issue in our empirical analysis.

[11] Accounting treatment of R&D investments differs between US GAAP and IFRS, as the latter allows the capitalization of a portion of R&D investments, under specific circumstances (see IAS 38). Thus, we also summed the expensed and capitalized portion of R&D to measure R&D intensity. Our (untabulated) results are similar as the capitalized portion of R&D is small.

well as more products in their pipeline, more drugs approved by the FDA, and are involved in more acquisitions in the pharmaceutical industry. Finally, when compared to European firms, Panel C highlights greater RD_TA and RD_Sales ratios and more acquisitions in the group of U.S firms, but a lower number of products in the pipeline and drugs approved by the FDA.

[INSERT TABLE 3]

1.3.4. Control variables

We incorporate several control variables to capture other possible determinants of R&D intensity (Osma, 2008; Hillier et al., 2011; Shao et al., 2013; Chen et al., 2016; Balsmeier et al., 2017; Rossi et al., 2017; Chen et al., 2018; Lu and Wang, 2018). CSO is a dummy variable taking the value of one if a Chief Scientific Officer (CSO) is a member of the top management team, and zero otherwise. Family_Firm, is a dummy variable equal to one if the firm is classified as a family firm, and zero otherwise. CEO_Change is a dummy variable equal to one if the company changed its CEO during the year, and zero otherwise. CEO_Age is the age of the CEO. BoD_Independence is the proportion of independent directors to the total number of directors. BoD_Gender is the proportion of female directors to the total number of directors.

We also control for the financial characteristics of the firms. Market_Value represents the size of the company, measured as the natural logarithm of market capitalization. The market-to-book ratio (M_B) captures growth opportunities. Leverage is the ratio of total debt to total assets. ROA is the operating income divided by total assets. PPE_TA, which captures firms' investment capabilities, is calculated as the property, plant, and equipment to total assets. Finally, we include Listed_Years, equal to the number of years since the initial public offering.

1.4. Results

1.4.1. Existence of a R&D committee

We start with a cross-sectional analysis to capture the association between the existence of a R&D committee and our three measures of R&D intensity. Table 4 presents our findings for the full sample, as well as for the two sub-samples of U.S. firms (Sub-sample 1) and European firms (Sub-sample 2). Using the two sub-samples allows us to evaluate more precisely the effect of a R&D committee in countries that have a more (i.e., European countries) or less (i.e., U.S.) long term orientation.

[INSERT TABLE 4]

Table 4 shows a strong and positive impact of the existence of a R&D committee on our three measures of R&D intensity for the full sample. Firms with such a committee experience an increase of 6.7% and 7.1% in the ratios RD_TA and RD_Sales, respectively. However, the analysis of the two subsamples shows that our previous results hold only for U.S. firms, as we observe no significant association between the existence of a committee and R&D intensity in European firms. Our findings therefore suggest that R&D committees put more pressure on managers to increase R&D investments in countries with a short-term orientation, which supports the substitution effect.

Table 5 shows the results with the other variables capturing R&D strategy: (1) the number of products in development (Products); (2) the number of products approved by the regulator (FDA), and (3) the number of acquisitions (M&A).[12] We find a strong and positive association between the presence of a R&D committee and these

[12] We obtain the data on Products from *ClinicalTrials.gov*, on FDA from *FDA.gov,* and on M&A from *Thomson Reuters M&A (SDC)*.

three variables of R&D strategy for the full sample. Thus, firms having a R&D committee have more products in development, more drugs approved by the regulator, and are involved in more M&As (i.e., acquisition of other pharmaceutical firms). On average, companies with a R&D committee report an increase of 27.5% in the number of products in development (Products), an increase of 7.6% in the number of approved drugs by the regulator (FDA), and an increase of 11.6% in the number of acquisitions of pharmaceutical firms. Such an impact is significant given the competitive nature of the pharmaceutical industry, where producing a novel drug becomes more and more challenging (DiMasi, 2000; DiMasi et al., 2016). Again, the analysis of the two subsamples supports a significant association between R&D committee and R&D strategy in the U.S., but not in Europe.

[INSERT TABLE 5]

1.4.2. Creation of a R&D committee

Our second analysis helps to better capture the causal relation between the R&D committee and R&D strategy. We take advantage of the fact that some companies create such a committee during our period of interest and implement a staggered difference-in-differences design. More precisely, we use 44 sample firms that created a R&D committee between 2011 and 2018 as a treatment group (CREATION), and the 80 firms that did not have such a committee as a control group (NEVER). Our variable of interest in this approach is RDC_CREATION*POST, which captures the marginal effect of R&D committee creation on R&D intensity.[13]

In the first model of Table 6, we observe a significant and positive effect of the creation of a R&D committee on R&D intensity. This finding holds with our three

[13] In our empirical model, POST variable is absorbed by the year fixed effects. In the (untabulated) analysis, we ran our regressions without year fixed effects and our results hold.

measures of R&D intensity, and suggests that the creation of a R&D committee leads to an increase in R&D investments, representing 6.9% of the RD_TA ratio in comparison to firms that did not have a R&D committee. However, this effect is also sensitive to the national context. The findings with the two sub-samples support previous findings. The creation of R&D committees influences R&D intensity only in U.S. firms. In European firms, such a committee has a merely symbolic value.

[INSERT TABLE 6]

In Table 7, we replicate our difference-in-differences analysis with the other measures of R&D strategy. The findings for the full sample also suggest a strong and positive influence of the R&D committee on these measures. This is the case for Products and FDA, which suggests that firms creating a committee are more effective in terms of the number of products in development and the number of approved drugs by the regulator. It is also the case for M&As, suggesting that firms that create a R&D committee acquire more firms in the pharmaceutical industry. Finally, the results on the full sample hold again for the subsample of U.S firms, but not for the sample of European firms.

[INSERT TABLE 7]

1.4.3. Entropy balancing

Given that the characteristics of our treated and control groups are different in our difference-in-differences design, we also employ entropy balancing to adjust for the observable characteristics of companies with and without a R&D committee (Hainmuller, 2012). In firms without a R&D committee, the descriptive statistics in Panel B of Table 3 suggest a less frequent presence of CSO (CSO), less concentrated ownership (Family_Firm), older CEOs (CEO_Age), less independent boards

(BoD_Independence), and less gender-diverse boards (BoD_Gender). Additionally, firms are smaller (Market_Value), less profitable (ROA), younger (Listed_Years), and with lower market opportunities (M_B).

This matching procedure differs from propensity score matching (PSM), by not confining the analyses to subsamples of observations which could affect the estimates of the average treatment effect (Hainmuller, 2012; Shipman et al., 2017). However, entropy balancing requires identifying a set of continuous weights for each observation, such that the first, second, and third moments of the distributions of the treatment and control group will become indistinguishable. The weights generated by entropy balancing are employed in the weighted regressions.

Table 8 shows that this matching procedure yields similar results to those provided in Tables 4 and 6. We report a positive and significant association between R&D committee and our three measures of R&D intensity for the full sample. Thus, the coefficients remain significant after controlling for observable differences between the two groups. By analyzing the effect of the institutional context, the presence of a R&D committee is still positively and significantly associated with R&D intensity in the U.S., whereas such a committee still has a symbolic value in European countries, where long-term orientation is less problematic. Finally, the results in Table 9 for our three other measures of R&D strategy with entropy balancing are also in line with previous results.

[INSERT TABLE 8]

[INSERT TABLE 9]

1.4.4. Discussion of the results

Our various analyses suggest that the existence or the creation of a R&D committee has a positive impact on R&D strategy, as well as on the number of products in development, the number of drugs approved by the regulator, and the number of acquisitions announced by firms. Thus, our findings do not support our first hypothesis stating that there is no influence of R&D committees on R&D intensity. This hypothesis is based on the existence of some advantages and some limitations associated with such committees. It finally seems that real (and positive) economic consequences are associated with the existence of R&D committees.

However, we also find that a R&D committee only matters in the U.S., a country characterized by short-termism (Drucker, 1986; Graham et al., 2005; CFA Institute, 2006; Chakravarty and Grewal, 2011; Martin, 2015; Sampson and Shi, 2020). This result does not support our second hypothesis, especially the hypothesis of a substitution effect. In other words, R&D committees may curb short-termism, but do influence R&D strategy in countries with a long-term orientation (i.e., countries in which short-termism is less problematic).

We also note that one control variable is highly significant in our models: the presence of a chief scientific officer (CSO) in the top management team. In our cross-sectional analysis (Tables 4 and 5), we find a positive and significant effect in all cases (full sample, U.S. firms, and European firms). This result holds with our difference-in-differences design (Tables 6 and 7), for the entropy balancing approach (Tables 8 and 9). More work is therefore needed to understand when a CSO has a real impact on R&D strategy.

Finally, the two variables capturing the board's composition are not very significant in our various models, suggesting that the organization of the board matters more than the composition of the board for R&D policy. In other words, having a R&D committee composed of members with a scientific background matters more than having a board composed of independent members or women.

1.5. Conclusion

This paper investigates the impact of R&D committees established at the board level on the R&D strategy of 157 pharmaceutical companies. It is motivated by the importance of R&D investments in this industry, in which it takes several years to develop a new drug for which the risk of failure is high. These two characteristics (long-term horizon and high risk) may lead managers to limit R&D investments and, ultimately, to reduce shareholders value creation. Thus, it is interesting to better understand whether the organization of the board, especially the presence of a R&D committee, may impact managerial decisions to invest more resources in R&D.

Our main results suggest that firms with a R&D committee invest more in R&D. These are robust to several analyses (cross-sectional analysis, difference-in-differences design, and entropy balancing). We also find that firms with a R&D committee have a higher number of drugs in development, a higher number of approved drugs, and a higher number of acquisitions of pharmaceutical firms, confirming a positive impact of such a committee on firm innovation. However, our findings hold only for U.S. firms. Thus, this specific organization of the board has real economic consequences in a country characterized by short-termism, but it has a merely symbolic value in European countries that have a long-term orientation (Hofstede et al., 2010).

We acknowledge that our study has some limitations. In particular, we posit that our difference-in-differences design with entropy balancing is well-suited for the identification of a causal relation between the presence of a R&D committee and R&D strategy. Nonetheless, we acknowledge that other studies employing other approaches are needed to confirm a causal relationship. Second, our results suggest that the presence of a R&D committee at the board-level influences R&D strategy. However, this committee advises the board and has no decision power. Thus, additional research is needed to better understand under which circumstances a committee influences R&D strategy. With all these caveats in mind, we nevertheless hope that our research is valuable for investors and researchers.

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Figure 1. Research and development process

Pre-development	Development			Post-development
Drug discovery & Animal testing	Clinical trials			FDA review & Post-market monitoring
	Phase 1	Phase 2	Phase 3	
3-6 years	6-7 years			0.5-2 years

Note: This figure is adapted from Petrova (2014).

Table 1. Sample distribution

The groups of firms in Table 1 are determined as follows: (1) NEVER, 80 firms without a R&D committee during the full period; (2) ALWAYS, 33 firms with a R&D committee during the full period; and (3) CREATION, 44 firms that created a R&D committee between 2011 and 2018. LTO captures the long term orientation of the country, a key dimension of the national culture computed by Hofstede. (https://hi.hofstede-insights.com/national-culture).

Country	LTO	NEVER	ALWAYS	CREATION									*Total*
		Total	Total	2011	2012	2013	2014	2015	2016	2017	2018	Total	
Austria	60	1	0	0	0	0	0	0	0	0	0	0	*1*
Belgium	82	3	1	0	0	0	0	0	0	0	0	0	*4*
France	63	2	4	0	1	0	0	0	1	1	1	4	*10*
Germany	83	6	2	1	1	0	0	1	1	1	0	5	*13*
Italy	61	1	0	0	0	1	0	0	0	0	0	1	*2*
Netherlands	67	2	0	0	1	0	1	0	0	0	0	2	*4*
Switzerland	74	4	2	0	0	1	1	0	0	0	0	2	*8*
United Kingdom	51	9	1	0	0	1	1	0	1	0	0	3	*13*
Western Europe	-	*28*	*10*	*1*	*3*	*3*	*3*	*1*	*3*	*2*	*1*	*17*	*55*
United States	26	52	23	3	3	2	9	6	1	2	1	27	102
Total	-	*80 (51%)*	*33 (21%)*	*4*	*6*	*7*	*12*	*7*	*4*	*6*	*2*	*44 (28%)*	*157 (100%)*

Table 2. Description of R&D committees

The sample is described in Table 1 and a detailed description of the variables can be found in Appendix B. The statistical significance in the two last columns represents the results of two univariate tests between U.S. and European firms: Student test for difference in means and Mann-Whitney test for difference in medians.

	Full sample (N=511)		U.S. firms (N=341)		European firms (N=170)	
	Mean	Median	Mean	Median	Mean	Median
RDC_Size	4.14	4	4.09	4	4.23	4*
RDC_Board	0.46	0.43	0.47	0.43	0.45*	0.43**
RDC_Independence	0.89	1	0.91	1	0.83***	1
RDC_Gender	0.18	0.17	0.14	0	0.28***	0.25***
RDC_Age	61.81	62	62.89	63	59.66***	59.80***
RDC_Science	0.82	1	0.86	1	0.74***	0.75***

Table 3. Descriptive statistics

The sample includes 1,413 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018), except for RD_Sales (N=945). Variable definitions are provided in Appendix B. The statistical significance represents the results of two univariate tests (Student test for difference in means and Mann-Whitney test for difference in medians) between groups NEVER and ALWAYS in panel B, and between U.S. and Europe in panel C.

Panel A. Full sample

	Mean	SD	25%	Median	75%
A1. Variables of interest					
RD_Expense (million USD)	639.5	1,803	11.35	36.23	119.6
RD_TA	0.23	0.25	0.06	0.15	0.34
RD_Sales	0.25	0.25	0.07	0.16	0.34
Products	11.84	37.59	0	0	3
FDA	1.05	3.26	0	0	0
M&A	0.43	0.74	0	0	1
A2. Control variables					
CSO	55%				
Family_Firm	33%				
CEO_Change	10%				
CEO_Age	55.15	7.34	50	55	60
BoD_Independence	0.82	0.12	0.75	0.86	0.89
BoD_Gender	0.14	0.12	0	0.13	0.22
Market_Value (million USD)	14,236	41,348	118.8	512.4	2,673
M_B	1.93	96.91	1.86	3.21	6.10
Leverage	0.52	0.96	0.22	0.42	0.62
ROA	-0.20	0.60	-0.39	-0.08	0.08
PPE_TA	0.11	0.12	0.02	0.06	0.15
Listed_Years	18.90	10.63	11	17	24

Panel B. Comparison of the three groups of firms

	CREATION (N=396)		NEVER (N=720)		ALWAYS (N=297)	
	Mean	Median	Mean	Median	Mean	Median
B1. Variables of interest						
RD_Expense (million USD)	519.8	46.58	304.1	20.32	1,612***	120.2***
RD_TA	0.30	0.25	0.21	0.12	0.19	0.12
RD_Sales	0.30	0.16	0.25	0.14	0.23**	0.18**
Products	12.37	0	4.62	0	28.66***	3***
FDA	1.53	0	0.31	0	2.20***	0
M&A	0.41	0	0.21	0	0.85***	1***

B2. Control variables						
CSO	64%		39%		81%***	
Family_Firm	27%		43%		18%***	
CEO_Change	11%		9%		12%	
CEO_Age	54.73	55	54.70	54	56.80***	57
BoD_Independence	0.83	0.86	0.79	0.82	0.87***	0.89***
BoD_Gender	0.13	0.13	0.12	0.11	0.19***	0.20***
Market_Value (million USD)	11,026	365.0	7,030	349.5	35,983***	2,250***
M_B	-1.23	3.05	2.74	3.30	4.17***	3.21
Leverage	0.56	0.40	0.53	0.42	0.43	0.43
ROA	-0.37	-0.25	-0.18	-0.09	-0.05***	0.06***
PPE_TA	0.08	0.04	0.12	0.06	0.13	0.12***
Listed_Years	17.23	14	18.36	17	22.42***	20***

Panel C. Comparison of U.S. and European firms

	U.S. firms (N=918)		European firms (N=495)	
	Mean	Median	Mean	Median
C1. Variables of interest				
RD_Expense (million USD)	544.1	38.68	816.2**	31.96
RD_TA	0.29	0.22	0.14***	0.07***
RD_Sales	0.32	0.21	0.165***	0.10***
Products	9.10	0	16.93**	0
FDA	0.62	0	1.83**	0
M&A	0.50	0	0.39***	0
C2. Control variables				
CSO	57%		50%***	
Family_Firm	37%		26%***	
CEO_Change	11%		10%	
CEO_Age	56.10	56	53.39***	53
BoD_Independence	0.83	0.86	0.78***	0.80***
BoD_Gender	0.12	0.13	0.17***	0.18***
Market_Value (million USD)	12,930	393.5	16,657	834.5***
M_B	3.32	3.82	-0.65	2.62***
Leverage	0.55	0.41	0.47	0.42
ROA	-0.26	-0.18	-0.09***	0.05***
PPE_TA	0.10	0.05	0.14***	0.10***
Listed_Years	19.17	18	18.40	15***

Table 4. The association between the existence of a R&D committee and R&D intensity

The sample includes 1,413 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018), except for RD_Sales (N=945). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales
Constant	-2.189***	0.431***	0.165	-0.712	0.809***	0.459***	-4.540	-0.659*	-1.827***
	(0.422)	(0.085)	(0.106)	(0.551)	(0.132)	(0.177)	(2.769)	(0.366)	(0.620)
RDC_EXISTENCE	0.408***	0.067***	0.071***	0.529***	0.091***	0.092***	-0.000	0.006	0.004
	(0.061)	(0.013)	(0.018)	(0.069)	(0.017)	(0.030)	(0.007)	(0.011)	(0.024)
CSO	0.527***	0.076***	0.125***	0.342***	0.080***	0.126***	0.709***	0.052***	0.122***
	(0.058)	(0.011)	(0.016)	(0.074)	(0.016)	(0.024)	(0.099)	(0.011)	(0.022)
Family_Firm	-0.136**	0.013	-0.048**	-0.145**	0.030**	-0.039	-0.036	-0.005	-0.033
	(0.061)	(0.012)	(0.020)	(0.072)	(0.015)	(0.027)	(0.127)	(0.013)	(0.021)
CEO_Change	0.137	-0.025	-0.021	0.170	-0.024	-0.015	0.122	-0.014	-0.024
	(0.088)	(0.018)	(0.023)	(0.113)	(0.025)	(0.034)	(0.121)	(0.015)	(0.024)
CEO_Age	0.008**	-0.001	-0.001	0.007	-0.001	-0.001	0.023***	0.000	0.001
	(0.004)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.007)	(0.001)	(0.002)
BoD_Independence	0.935***	-0.090	0.128	0.822*	-0.152*	0.205	0.472	-0.099	0.082
	(0.306)	(0.060)	(0.083)	(0.429)	(0.091)	(0.136)	(0.437)	(0.065)	(0.122)
BoD_Gender	-0.748***	0.090*	-0.091	-0.315	0.113	-0.185*	-1.013**	0.048	-0.024
	(0.280)	(0.047)	(0.070)	(0.373)	(0.072)	(0.102)	(0.470)	(0.048)	(0.096)
Market_Value	0.778***	-0.025***	-0.010*	0.750***	-0.029***	-0.007	0.841***	-0.002	-0.017**
	(0.026)	(0.007)	(0.005)	(0.029)	(0.007)	(0.006)	(0.042)	(0.004)	(0.008)
M_B	-0.000	-0.000	-0.000	-0.000	-0.000*	0.000	-0.000	0.000**	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.234***	0.078***	0.041	0.233**	0.073***	0.040	0.134	0.066***	0.086
	(0.091)	(0.011)	(0.026)	(0.097)	(0.009)	(0.026)	(0.252)	(0.023)	(0.068)
ROA	-0.394*	-0.140**	-0.148**	-0.317	-0.108*	-0.138**	-0.947**	-0.394***	-0.352***
	(0.223)	(0.060)	(0.067)	(0.228)	(0.055)	(0.067)	(0.413)	(0.044)	(0.100)
PPE_TA	-0.098	-0.150***	-0.284***	-0.121	-0.210***	-0.190**	-0.149	0.004	-0.409***
	(0.305)	(0.043)	(0.064)	(0.398)	(0.056)	(0.085)	(0.450)	(0.046)	(0.095)
Listed_Years	0.011***	-0.002***	-0.006***	-0.002	-0.002***	-0.008***	0.030***	-0.001	-0.002**
	(0.003)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,413	1,413	945	918	918	522	495	495	423
Adj. R2	0.824	0.484	0.351	0.811	0.426	0.285	0.862	0.702	0.361

Table 5. The impact of R&D committee existence on other measures of R&D strategy

The sample includes 1,413 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	Products	FDA	M&A	Products	FDA	M&A	Products	FDA	M&A
Constant	-4.434***	-0.686***	-0.556**	-4.885***	-0.631***	-0.762***	-4.855***	-0.919***	-0.227
	(0.296)	(0.089)	(0.238)	(0.376)	(0.094)	(0.267)	(0.506)	(0.201)	(0.457)
RDC_EXISTENCE	0.275***	0.076***	0.116***	0.398***	0.081***	0.141***	0.029	0.059	0.077
	(0.057)	(0.019)	(0.045)	(0.066)	(0.019)	(0.049)	(0.096)	(0.039)	(0.090)
CSO	0.319***	0.023	0.025	0.141**	0.012	0.023	0.603***	0.008	-0.044
	(0.047)	(0.014)	(0.037)	(0.055)	(0.014)	(0.042)	(0.082)	(0.030)	(0.074)
Family_Firm	0.054	-0.007	0.032	0.179***	-0.006	0.009	-0.124	-0.002	0.105
	(0.048)	(0.012)	(0.037)	(0.058)	(0.012)	(0.041)	(0.102)	(0.032)	(0.075)
CEO_Change	0.084	-0.013	0.026	0.062	-0.001	0.126*	0.173	-0.034	-0.205*
	(0.075)	(0.025)	(0.060)	(0.093)	(0.026)	(0.070)	(0.106)	(0.049)	(0.110)
CEO_Age	0.006*	-0.001	0.001	0.007**	0.000	0.010***	0.004	-0.002	-0.018**
	(0.003)	(0.001)	(0.003)	(0.004)	(0.001)	(0.003)	(0.007)	(0.003)	(0.007)
BoD_Independence	0.405*	0.225***	-0.146	0.125	0.122	-0.086	0.527	0.284**	-0.112
	(0.226)	(0.066)	(0.176)	(0.317)	(0.080)	(0.224)	(0.339)	(0.115)	(0.261)
BoD_Gender	-0.393*	-0.042	-0.243	-0.319	0.012	0.151	0.045	-0.011	-0.677*
	(0.208)	(0.074)	(0.179)	(0.256)	(0.083)	(0.195)	(0.372)	(0.141)	(0.366)
Market_Value	0.363***	0.045***	0.089***	0.358***	0.036***	0.053***	0.403***	0.073***	0.162***
	(0.017)	(0.005)	(0.011)	(0.019)	(0.005)	(0.012)	(0.036)	(0.013)	(0.030)
M_B	-0.000	-0.000	0.000	-0.000	0.000	-0.000	-0.000**	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.128***	0.015***	0.013	0.119***	0.014***	0.009	0.121	-0.047	0.014
	(0.042)	(0.005)	(0.011)	(0.040)	(0.005)	(0.010)	(0.169)	(0.030)	(0.064)
ROA	-0.243**	-0.035***	-0.073***	-0.174**	-0.018**	-0.062***	-0.721**	-0.160**	-0.104
	(0.099)	(0.013)	(0.020)	(0.083)	(0.009)	(0.019)	(0.341)	(0.075)	(0.087)
PPE_TA	-1.174***	-0.124**	-0.734***	-0.353*	-0.069	-0.535***	-2.368***	-0.207*	-1.123***
	(0.200)	(0.053)	(0.127)	(0.213)	(0.051)	(0.144)	(0.348)	(0.105)	(0.224)
Listed_Years	0.033***	0.008***	0.004**	0.025***	0.005***	-0.001	0.039***	0.011***	0.007
	(0.003)	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)	(0.006)	(0.003)	(0.004)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,413	1,413	1,413	918	918	918	495	495	495
Adj. R2	0.651	0.319	0.179	0.617	0.242	0.084	0.744	0.396	0.309

Table 6. The impact of R&D committee creation on R&D intensity

The sample includes 1,116 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018), except for RD_Sales (N=675). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales
Constant	-1.971***	0.435***	-0.183	-0.472	0.797***	0.183	-3.103**	0.016	-0.077
	(0.481)	(0.098)	(0.129)	(0.615)	(0.146)	(0.193)	(1.444)	(0.104)	(0.200)
RDC_CREATION	0.339***	0.024	-0.067**	0.245**	0.019	-0.150***	0.124	-0.002	-0.036
	(0.098)	(0.022)	(0.028)	(0.124)	(0.031)	(0.051)	(0.332)	(0.037)	(0.046)
RDC_CREATION*POST	0.319***	0.069***	0.073***	0.311***	0.078***	0.130***	0.021	0.009	-0.057
	(0.094)	(0.021)	(0.028)	(0.108)	(0.026)	(0.050)	(0.242)	(0.030)	(0.044)
CSO	0.528***	0.077***	0.164***	0.343***	0.082***	0.198***	0.727***	0.055**	0.138***
	(0.074)	(0.014)	(0.019)	(0.100)	(0.021)	(0.030)	(0.204)	(0.026)	(0.038)
Family_Firm	-0.161**	-0.000	-0.082***	-0.179**	0.015	-0.079**	0.113	0.004	-0.021
	(0.069)	(0.013)	(0.022)	(0.083)	(0.017)	(0.031)	(0.283)	(0.030)	(0.046)
CEO_Change	0.082	-0.027	-0.007	0.116	-0.026	0.020	0.013	-0.020	-0.032
	(0.112)	(0.023)	(0.030)	(0.150)	(0.033)	(0.049)	(0.133)	(0.022)	(0.027)
CEO_Age	0.005	-0.002*	0.001	0.006	-0.002*	-0.000	0.017	0.000	0.000
	(0.004)	(0.001)	(0.001)	(0.005)	(0.001)	(0.002)	(0.013)	(0.002)	(0.003)
BoD_Independence	0.775**	-0.084	0.329***	0.857*	-0.104	0.286*	0.496	-0.085	0.354**
	(0.345)	(0.068)	(0.102)	(0.471)	(0.103)	(0.159)	(0.829)	(0.098)	(0.173)
BoD_Gender	-0.967***	0.051	-0.262***	-0.434	0.067	-0.440***	-1.411	0.067	-0.183
	(0.328)	(0.054)	(0.075)	(0.462)	(0.088)	(0.110)	(0.945)	(0.072)	(0.128)
Market_Value	0.786***	-0.024***	-0.000	0.739***	-0.028***	0.011	0.822***	0.001	-0.027*
	(0.030)	(0.007)	(0.006)	(0.034)	(0.007)	(0.007)	(0.086)	(0.009)	(0.015)
M_B	-0.000	-0.000	-0.000	-0.000	-0.000**	-0.000	-0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.232**	0.078***	0.037	0.231**	0.074***	0.032	0.002	0.059*	0.163**
	(0.091)	(0.010)	(0.024)	(0.098)	(0.009)	(0.023)	(0.364)	(0.034)	(0.073)
ROA	-0.378	-0.126**	-0.128**	-0.293	-0.101*	-0.113*	-1.478***	-0.437***	-0.285**
	(0.245)	(0.062)	(0.062)	(0.238)	(0.057)	(0.061)	(0.311)	(0.059)	(0.131)
PPE_TA	-0.154	-0.151***	-0.277***	-0.570	-0.279***	-0.257**	0.304	0.087	-0.306*
	(0.390)	(0.054)	(0.077)	(0.474)	(0.069)	(0.103)	(1.566)	(0.091)	(0.166)
Listed_Years	0.010**	-0.002***	-0.006***	-0.007	-0.003***	-0.006***	0.045***	-0.001	-0.001
	(0.004)	(0.001)	(0.001)	(0.005)	(0.001)	(0.002)	(0.016)	(0.002)	(0.003)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,116	1,116	675	711	711	387	405	405	288
Adj. R2	0.759	0.457	0.396	0.685	0.392	0.342	0.855	0.674	0.431

Table 7. The impact of R&D committee creation on other measures of R&D strategy

The sample includes 1,116 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	Products	FDA	M&A	Products	FDA	M&A	Products	FDA	M&A
Constant	-4.954***	-1.277***	-0.443**	-5.743***	-0.666***	-0.204	-3.796***	-0.224***	1.829
	(0.372)	(0.168)	(0.138)	(0.396)	(0.203)	(0.490)	(0.399)	(0.069)	(1.556)
RDC_CREATION	0.238***	0.168***	0.639***	0.147	0.165***	0.379***	0.005	-0.012	0.092
	(0.059)	(0.038)	(0.041)	(0.130)	(0.056)	(0.120)	(0.088)	(0.012)	(0.378)
RDC_CREATION*POST	0.306***	0.228***	0.632***	0.328**	0.156***	0.392***	0.056	0.013	0.247
	(0.057)	(0.041)	(0.034)	(0.138)	(0.049)	(0.123)	(0.073)	(0.020)	(0.397)
CSO	0.344***	0.058**	-0.045	0.762***	0.002	-0.082	0.035	-0.010	0.672**
	(0.025)	(0.026)	(0.030)	(0.060)	(0.034)	(0.087)	(0.062)	(0.013)	(0.259)
Family_Firm	0.050	0.041*	0.108***	0.106	0.016	0.035	0.116*	0.003	-0.037
	(0.037)	(0.024)	(0.029)	(0.100)	(0.035)	(0.101)	(0.065)	(0.012)	(0.302)
CEO_Change	0.018	0.002	0.055	0.024	-0.039	-0.135	-0.003	-0.024**	0.043
	(0.081)	(0.044)	(0.046)	(0.203)	(0.055)	(0.103)	(0.101)	(0.012)	(0.221)
CEO_Age	-0.003	-0.004***	0.001	-0.019**	-0.004	-0.017**	0.008**	0.000	-0.020
	(0.004)	(0.002)	(0.002)	(0.008)	(0.003)	(0.007)	(0.003)	(0.001)	(0.013)
BoD_Independence	0.591	0.246**	-0.559***	0.879**	0.209	-0.512	0.147	0.120*	-1.609
	(0.329)	(0.112)	(0.158)	(0.301)	(0.131)	(0.317)	(0.298)	(0.067)	(1.272)
BoD_Gender	-0.346	0.061	0.003	-0.388	-0.123	-0.402	-0.090	0.132*	-1.404
	(0.215)	(0.135)	(0.086)	(0.525)	(0.123)	(0.305)	(0.270)	(0.073)	(1.063)
Market_Value	0.402***	0.086***	0.100***	0.454***	0.055***	0.188***	0.292***	0.010**	0.174**
	(0.022)	(0.008)	(0.015)	(0.046)	(0.014)	(0.042)	(0.024)	(0.004)	(0.085)
M_B	-0.000	-0.000	0.000**	-0.000*	-0.000	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.128**	0.025**	0.007	-0.062	-0.073**	-0.015	0.099***	0.006**	0.065
	(0.048)	(0.011)	(0.005)	(0.215)	(0.030)	(0.064)	(0.034)	(0.002)	(0.086)
ROA	-0.226	-0.027	-0.008	-1.409***	-0.176***	-0.073	-0.128*	-0.005	-0.345
	(0.137)	(0.019)	(0.019)	(0.250)	(0.049)	(0.107)	(0.071)	(0.004)	(0.228)
PPE_TA	-1.112***	0.008	-0.294**	-1.128**	0.111	-0.818***	-0.776***	-0.081**	0.113
	(0.207)	(0.103)	(0.096)	(0.414)	(0.104)	(0.254)	(0.217)	(0.038)	(1.576)
Listed_Years	0.043***	0.016***	0.004***	0.085***	0.013***	-0.004	0.008**	-0.000	0.006
	(0.002)	(0.002)	(0.001)	(0.005)	(0.003)	(0.007)	(0.003)	(0.001)	(0.019)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,116	1,116	1,116	711	711	711	405	405	405
Adj. R2	0.584	0.470	0.348	0.794	0.424	0.364	0.373	0.042	0.051

Table 8. The impact of the creation of a R&D committee on R&D intensity with entropy balancing

The sample includes 1,116 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018), except for RD_Sales (N=675). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales	RD_Log	RD_TA	RD_Sales
Constant	-0.513	0.575***	-0.195	0.943	0.944***	0.027	-0.961	-0.112	0.328
	(0.533)	(0.133)	(0.144)	(0.586)	(0.146)	(0.184)	(0.888)	(0.124)	(0.257)
RDC_CREATION	0.268***	0.018	-0.091***	0.043	-0.004	-0.165***	-0.047	0.003	-0.029
	(0.097)	(0.023)	(0.032)	(0.109)	(0.032)	(0.057)	(0.150)	(0.024)	(0.024)
RDC_CREATION*POST	0.420***	0.094***	0.070**	0.386***	0.109***	0.103**	-0.074	0.007	-0.031
	(0.078)	(0.020)	(0.027)	(0.086)	(0.027)	(0.051)	(0.128)	(0.023)	(0.025)
CSO	0.533***	0.049***	0.144***	0.199**	0.038	0.164***	0.801***	0.037**	0.098***
	(0.071)	(0.018)	(0.021)	(0.084)	(0.026)	(0.033)	(0.123)	(0.017)	(0.026)
Family_Firm	-0.120	0.026	-0.087***	-0.141	0.046*	-0.042	0.483***	0.025	-0.081***
	(0.076)	(0.022)	(0.023)	(0.092)	(0.028)	(0.033)	(0.156)	(0.020)	(0.029)
CEO_Change	0.154	-0.049	-0.016	0.163	-0.066	-0.008	-0.130	-0.032	-0.072***
	(0.108)	(0.030)	(0.031)	(0.144)	(0.042)	(0.046)	(0.123)	(0.024)	(0.025)
CEO_Age	0.001	-0.001	0.001	0.015***	0.001	0.002	-0.009	-0.001	-0.006***
	(0.004)	(0.001)	(0.001)	(0.005)	(0.001)	(0.002)	(0.008)	(0.001)	(0.002)
BoD_Independence	-0.131	-0.136	0.321**	-0.155	-0.220*	0.260	-0.370	-0.090	0.300
	(0.432)	(0.115)	(0.142)	(0.550)	(0.120)	(0.181)	(0.589)	(0.137)	(0.189)
BoD_Gender	-0.684*	0.125	-0.368***	-0.302	0.177	-0.548***	-1.031*	0.220**	-0.149
	(0.372)	(0.086)	(0.093)	(0.431)	(0.124)	(0.143)	(0.601)	(0.103)	(0.127)
Market_Value	0.735***	-0.036***	0.005	0.670***	-0.043***	0.019**	0.872***	0.020***	-0.018
	(0.022)	(0.007)	(0.007)	(0.024)	(0.008)	(0.008)	(0.039)	(0.007)	(0.011)
M_B	-0.000	-0.000	-0.000	-0.000	-0.000***	-0.000	-0.000***	0.000	-0.000**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.234***	0.079***	-0.021	0.307***	0.076***	-0.033	-0.387***	0.016	0.087
	(0.090)	(0.019)	(0.044)	(0.095)	(0.014)	(0.048)	(0.075)	(0.021)	(0.069)
ROA	0.115	-0.019	-0.203***	0.151**	-0.014	-0.207***	-1.579***	-0.531***	-0.306**
	(0.089)	(0.040)	(0.060)	(0.065)	(0.032)	(0.066)	(0.159)	(0.062)	(0.118)
PPE_TA	-0.413	-0.161***	-0.356***	-0.367	-0.166**	-0.247*	-1.129	0.099	-0.338***
	(0.375)	(0.056)	(0.095)	(0.364)	(0.075)	(0.131)	(0.780)	(0.085)	(0.110)
Listed_Years	0.018***	-0.001	-0.006***	-0.008*	-0.002**	-0.007***	0.048***	-0.002*	-0.002
	(0.004)	(0.001)	(0.001)	(0.005)	(0.001)	(0.002)	(0.008)	(0.001)	(0.002)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,116	1,116	675	711	711	387	405	405	288
Adj. R2	0.838	0.415	0.527	0.771	0.312	0.404	0.934	0.858	0.588

Table 9. The impact of the creation of a R&D committee on other measures of R&D strategy with entropy balancing

The sample includes 1,116 observations (balanced sample of 157 pharmaceutical firms over the years 2010-2018). A detailed description of the variables can be found in Appendix B. T-statistics based on robust standard errors clustered at the firm-level are presented in parentheses. ***, ** and * denote 99%, 95% and 90% levels of confidence.

	Full sample			U.S. firms			European firms		
	Products	FDA	M&A	Products	FDA	M&A	Products	FDA	M&A
Constant	-4.525***	-1.455***	0.183	-4.951***	-1.716***	-1.211***	-5.283***	-1.102***	0.999
	(0.462)	(0.255)	(0.425)	(0.623)	(0.457)	(0.430)	(0.638)	(0.256)	(0.703)
RDC_CREATION	0.153	0.412***	0.557***	-0.058	0.548***	0.812***	0.078	0.044	0.282
	(0.107)	(0.068)	(0.088)	(0.141)	(0.110)	(0.078)	(0.128)	(0.038)	(0.200)
RDC_CREATION*POST	0.286***	0.346***	0.583***	0.288***	0.626***	0.745***	0.022	-0.011	0.311*
	(0.076)	(0.046)	(0.062)	(0.094)	(0.094)	(0.051)	(0.140)	(0.040)	(0.176)
CSO	0.426***	0.139***	-0.036	0.056	0.166**	-0.027	0.816***	-0.029	-0.130
	(0.070)	(0.041)	(0.070)	(0.089)	(0.072)	(0.065)	(0.100)	(0.039)	(0.139)
Family_Firm	0.416***	0.070*	0.043	0.506***	0.150	0.135*	0.250**	0.072	-0.025
	(0.080)	(0.040)	(0.071)	(0.107)	(0.092)	(0.073)	(0.112)	(0.047)	(0.183)
CEO_Change	-0.035	-0.015	0.033	-0.064	-0.017	0.198***	-0.065	0.027	-0.281*
	(0.105)	(0.060)	(0.079)	(0.146)	(0.106)	(0.072)	(0.109)	(0.051)	(0.154)
CEO_Age	-0.001	-0.012***	-0.006	0.010*	-0.017***	0.010***	-0.012	0.004*	-0.039***
	(0.005)	(0.003)	(0.005)	(0.006)	(0.005)	(0.003)	(0.008)	(0.002)	(0.012)
BoD_Independence	0.500	0.401**	-0.817***	0.012	0.183	-0.105	0.350	0.209	-0.648
	(0.402)	(0.191)	(0.295)	(0.534)	(0.340)	(0.224)	(0.529)	(0.209)	(0.459)
BoD_Gender	0.270	0.451	-0.192	0.503	-1.191***	0.419**	0.949**	0.706***	-0.797*
	(0.276)	(0.328)	(0.212)	(0.341)	(0.286)	(0.195)	(0.387)	(0.185)	(0.453)
Market_Value	0.382***	0.089***	0.096***	0.349***	0.125***	0.055***	0.508***	0.049***	0.196***
	(0.022)	(0.010)	(0.017)	(0.028)	(0.028)	(0.016)	(0.033)	(0.012)	(0.056)
M_B	-0.000**	0.000	0.000**	-0.000	-0.000	-0.000	-0.000***	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.167*	0.106**	-0.008	0.191*	-0.153	0.031	0.102	0.114***	-0.031
	(0.096)	(0.043)	(0.023)	(0.116)	(0.099)	(0.030)	(0.132)	(0.041)	(0.096)
ROA	-0.043	0.014	-0.024*	-0.010	-0.507***	-0.007	-1.287***	0.015	0.045
	(0.056)	(0.014)	(0.014)	(0.034)	(0.137)	(0.017)	(0.228)	(0.012)	(0.180)
PPE_TA	-1.731***	-0.197	-0.330	-1.657***	0.597*	-0.257	-1.521***	-0.679***	-1.110***
	(0.276)	(0.167)	(0.217)	(0.334)	(0.328)	(0.218)	(0.447)	(0.155)	(0.413)
Listed_Years	0.043***	0.022***	0.008***	0.029***	0.040***	0.011***	0.034***	-0.002	-0.004
	(0.004)	(0.003)	(0.003)	(0.005)	(0.007)	(0.003)	(0.007)	(0.002)	(0.011)
Country and Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,116	1,116	1,116	711	711	711	405	405	405
Adj. R2	0.797	0.684	0.364	0.602	0.341	0.383	0.917	0.825	0.472

Appendix A. Articles about the effect of Corporate Governance on R&D

Panel A. List of articles

Panel A1. Single country studies	
1	Li, M. (2019). Diversity of Board Interlocks and the Impact on Technological Exploration: A Longitudinal Study. Journal of Product Innovation and Management, 36(4), 490-512.
2	Brav, A., Jiang, W., Ma, S., Tian, X. (2018). How does hedge fund activism reshape corporate innovation? Journal of Financial Economics, 130, 237-264.
3	Chen, J., Leung, W.S., Evans, K.P. (2018). Female board representation, corporate innovation and firm performance. Journal of Empirical Finance, 48, 236-254.
4	Cummings, T., and Knott, A.M. (2018). Outside CEOs and innovation. Strategic Management Journal, 39, 2095-2119.
5	Faleye, O., Hoitash, R., Hoitash, U. (2018). Industry expertise on corporate boards. Review of Quantiative Finance and Accounting, 50, 441-479.
6	Harjoto, M.A., Laksmana, I., Yang, Y. (2018). Board diversity and corporate investment oversight. Journal of Business Research, 90, 40-47.
7	Lu, J., and Wang, W. (2018). Board independence and corporate investments. Review of Financial Economics, 24, 52-64
8	Oh, W.Y., Barker, V.L. (2018). Not All Ties Are Equal: CEO Outside Directorships and Strategic Imitation in R&D Investment. Journal of Management, 44(4), 1312-1337.
9	Shaikh, I.A., O'Brien, J.P., Peters, L. (2018). Inside directors and the underinvestment of financial slack towards R&D intensity in high-technology firms. Journal of Business Research, 82, 192-201.
10	Shaikh, I.A., Peters, L. (2018). The value of board monitoring in promoting R&D: A test of agency-theory in the US context. Journal of Management and Governance, 22, 339-363.
11	Balsmeier, B., Fleming, L., Manso, G. (2017). Independent boards and innovation. Journal of Financial Economics, 123, 536-557.
12	Bravo, F., and Reguera-Alvarado, N. (2017). The effect of board of directors on R&D intensity: board tenure and multiple directorships. R&D Management, 47(5), 701-714.
13	Helmers, C., Patnam, M., Rau, R. (2017). Do board interlocks increase innovation? Evidence from a corporate governance reform in India. Journal of Banking and Finance, 80, 51-70.
14	Jia, N. (2017). Should Directors Have Term Limits? - Evidence from Corporate Innovation. European Accounting Review, 26(4), 755-785.
15	Medcof, J.W., and Lee, T. (2017). The effects of the chief technology officer and firm and industry R&D intensity on organizational performance. R&D Management, 47(5), 767-781.
16	Chen, S., Ni, X., Tong, J.Y. (2016). Gender Diversity in the Boardroom and Risk Management: A Case of R&D Investment. Journal of Business Ethics, 136, 599-621.
17	Guldiken, O., and Darendeli, I.S. (2016). Too much of a good thing: Board monitoring and R&D investments. Journal of Business Research, 69, 2931-2938.
18	Midavaine, J., Dolfsma, W., Aalbers, R. (2016). Board diversity and R&D Investment, Management Decision, 54(3), 558-569.
19	Zona, F. (2016). Agency models in different stages of CEO tenure: The effects of stock options and board independence on R&D investment. Research Policy, 45, 560-575.
20	Lim, E.N.K. (2015). The role of reference point in CEO restricted stock and its impact on R&D intensity in high-technology firms. Strategic Management Journal, 36, 872-889.
21	Anderson, R.C., Duru, A., Reeb, D.M. (2012). Investment policy in family controlled firms. Journal of Banking & Finance, 36, 1744-1758.
22	Block, J.H. (2012). R&D investments in family and founder firms: An agency perspective. Journal of Business Venturing,27, 248-265.
23	Dalziel, T., Gentry, R.J., Bowerman, M. (2011). An Integrated Agency-Resource Dependence View of the Influence of Directors' Human and Relational Capital on Firms' R&D Spending. Journal of Management Studies, 48(6), 1217-1242.
24	Osma, C.G. (2008). Board Independence and Real Earnings Management: The Case of R&D Expenditure. Corporate Governance: An International Review, 16(2), 116-131.
25	Deutsch, Y. (2007). The Influence of Outside Directors' Stock-Option Compensation on Firms' R&D. Corporate Governance: An International Review, 15(5), 816-827.
Panel A2. Cross-country studies	
26	Zavertiaeva, M.A., Lopez-Iturriaga, F.J., Kuminova, E.V. (2018). Better innovators or more innovators? Managerial overconfidence and corporate R&D. Managerial and Decision Economics, 39, 447-461.
27	Honore, F., Munari, F., Pottelsberghe de la Potterie, B.V. (2015). Corporate governance practices and companies' R&D intensity: Evidence from European countries. Research Policy, 44, 533-543.
28	Shao, L., Kwok, C.C.Y., Zhang, R. (2013) National culture and corporate investment. Journal of International Business Studies, 44, 745-763.
29	Hillier, D., Pindado, J., Queiroz, V., Torre, C. (2011). The impact of country-level corporate governance on research and development. Journal of International Business Studies, 42(1), 76-98.
30	Munari, F., Oriani, R., Sobrero, M. (2010). The effects of owner identity and external governance systems on R&D investments: A study on Western European firms. Research Policy, 39, 1093-1104.

Panel B. Categorization of the literature

Variables	Articles
Panel B1. Countries	
US	1;2;3;4;5;6;7;8;9;10;11;12;13;14;15;16;17;18;19;20;21;22;23;25
EU	24;27;30
World	28;29
Panel B2. R&D measure	
R&D/Sales	5;9;12;15;16;17;19;20;22;26;27;30
R&D/TA	10;14;22;28
R&D expenses	3;7;13;18;23;29
R&D/Employees	25
R&D/Investments	21
Patent/Citations	2;7;11;13
Other R&D measure	1;4;6;8;24
Panel B3. Corporate Governance measure	
Board composition	
Board size	5;16
Board independence	5;11;16;24
Gender diversity	3;6;16;18
Age diversity	5;6;12;14;18;23;26
Tenure diversity	5;6;8;18;23
Industrial/Experience diversity	1;5;6;18;23
Education	18;23
Busy	5;13
Outside directors	7;9;10;23;25
Executive management	
CEO compensation	19
CEO directorship	8;21
CEO tenure	8;14;19;
CEO duality	10;12;14;16;19;20
CEO outside	4;8;21
CEO ownership	14;21
CEO overconfidence	26
CEO experience	26
CEO age	26
CTO	15
Other focus	
Director compensation	17;25
Director ownership	5;14
Ownership structure	21;22;30
Investor protection	29
Corporate governance index	29
Other measures	2;27;28

Appendix B. Variable definitions

Variable	Definition
PANEL A. Dependent variables	
RD_Log	Natural logarithm of R&D expenses.
RD_TA	R&D expenses to total assets.
RD_Sales	R&D expenses to sales.
Products	Number of products in clinical trial development.
FDA	Number of products approved by the regulator.
M&A	Number of acquisitions made.
PANEL B. Independent variables of interest	
RDC_EXISTENCE	Dummy variable equal to 1 if the company has a R&D committee in year t, and 0 otherwise.
RDC_CREATION	Dummy variable equal to 1 if the company created a R&D committee during the period of interest, and 0 otherwise.
POST	Dummy variable equal to 1 for the year of R&D committee creation and subsequent years, and 0 for previous years.
RDC_Size	Number of directors on the R&D committee.
RDC_Board	The ratio of number of directors on the R&D committee to number of directors on the board of directors.
RDC_Independence	Number of independent directors to total number of directors in the R&D committee.
RDC_Gender	Number of female directors to total number of directors in the R&D committee.
RDC_Age	Average age of directors in the R&D committee.
RDC_Science	Directors with scientific background (i.e., the director has a diploma in a scientific field related to the pharmaceutical industry) to total number of directors in the R&D committee.
PANEL C. Control variables	
CSO	Dummy variable equal to 1 if the company has a Chief Scientific or a R&D officer in the Top Management Team, and 0 otherwise.
Family_Firm	Dummy variable equal to 1 if the company is classified as a family firm, and 0 otherwise.
CEO_Change	Dummy variable equal to 1 if the company changed its CEO during the year, and 0 otherwise.
CEO_Age	Current age of the CEO.
BoD_Independence	Number of independent directors in BoD to total number of directors in BoD.
BoD_Gender	Number of female directors in BoD to total number of directors in BoD.
Market_Value	Natural logarithm of firm's market capitalization.
M_B	Market-to-book ratio, measured as the ratio of market capitalization to total common equity.
Leverage	Total debt to total assets.
ROA	Operating income to total assets.
PPE_TA	The ratio of net property, plant and equipment to total assets.
Listed_Years	The number of years since the company IPO.

Appendix C. Examples of R&D committees' objectives

Company	Reasons
4SC	Advise and monitor R&D.
Acorda Therapeutics	Oversees development opportunities regarding new or development products.
Advaxis	Provide advice on product scientific and development matters.
Allergan	Assist the Board with requirements related to product safety and quality, environmental, health and safety issues.
Alnylam	Review scientific and R&D strategy, R&D programs, scientific research, discoveries and commercial developments.
Array Biopharma	Oversee company's clinical development activities and decisions, and review company clinical development programs.
Assembly Biosciences	Oversee R&D activities and advise on strategic and tactical matters.
Bayer	Focus on innovation strategy and management of R&D projects.
Biofrontera	Deal with key issues related to product development.
Biomarin	Monitor strategy, direction, and effectiveness of R&D organization, including the review of matter related to scientific technology.
Caladrius Biosciences	Review the science, clinical and regulatory strategy and underlying company R&D strategy.
Catalyst	Assess R&D activities, initiatives, strategies and reporting emerging issues.
Curis	Evaluate the quality and direction of R&D programs and review R&D pipeline.
GlaxoSmithKline	Look at science, pipeline and R&D capital allocation.
Newron Pharmaceuticals	Review and evaluate internal R&D projects, R&D strategies and report scientific trends to the Board.
Novartis	Oversee R&D strategy, and evaluate the effectiveness and competitiveness of R&D organization.
Novo Nordisk	Assist the Board with oversight of R&D strategy, the pipeline and other related tasks.
Qiagen	Review and monitor R&D projects, programs, budgets and risk related to company's portfolio.
Valneva	Provide opinions regarding projects in research or under development, and assistance for evaluating and overseeing company's R&D strategy.
Vifor Pharma AG	Advise in matters of R&D strategy, innovation process, innovation pipeline.

Chapter 2: Do large pharmaceutical firms benefit from R&D alliances with small firms?

2.1. Introduction

Strategic alliances can take many forms, ranging from simple agreements with no equity ties to formal arrangements involving equity ownership and shared managerial control over joint activities. They have been frequent in the pharmaceutical industry over the last decades, which is not surprising as the drug development process is risky (i.e., the probability of not finding a new drug is high), takes a lot of time (i.e., the average duration is about 10 years), and is very expensive (DiMasi et al.,1991; Hagedoorn, 1993; Xu, 2006; Petrova, 2014). In such a context, alliances are motivated by firms' willingness to share the costs and risks associated with the development of new drugs, as well as by the access to specific knowledge (Hagedoorn, 1993; Chan et al., 1997; Das et al., 1998; Anand and Khanna, 2003; Xu et al., 2006; Higgins, 2007; Contractor and Reuer, 2014; Heil and Bornemann, 2018).

In this industry, alliances often involve a large and a small firm. Small firms usually lack financial resources, especially if they are not listed on the stock market, as well as experience to develop new drugs (Cullen and Dibner, 1993; Gomes-Casseres, 1997; Audretsch and Feldman, 2003), while large firms are motivated by the access to specific knowledge (Das et al., 1998). Prior research, however, has mentioned a "swimming with sharks" dilemma (Katila et al., 2008; Diestre et al., 2013), also known as the "hold-up" problem (Holmström and Roberts, 1998), which means that small firms expect some benefits from the alliance, but they must also face an expropriation risk as large pharmaceutical firms may try to extract private benefits.

Our paper contributes to this scant stream of research by investigating whether the existence of a R&D alliance impacts the market reaction to clinical trial announcements by large pharmaceutical firms, and whether that market reaction differs for alliances with large and with small firms. If large firms are able to extract private benefits in alliances with small firms (i.e., materialization of the "hold-up"), then a more positive market reaction is expected for new announcements about the development of new drugs. However, two key arguments suggest that this expropriation risk may be low or non-existent. First, (rational) small firms aware of such risk should use their bargaining power, which comes from the detention of specific knowledge or technological know-how (Das et al., 1998), to protect themselves with effective contractual arrangements (Higgins et al., 2007). Second, large firms should avoid the extraction of private benefits to protect their reputation in order to attract other small firms detaining specific knowledge in the future. Thus, the market reaction may not be very large for announcements made by large pharmaceutical firms involved in an alliance with a small firm as the latter may capture a large part of the benefits generated by the alliance (Das et al., 1998).

Our empirical examination is based on a sample of 544 hand-collected announcements of clinical trials by twelve large pharmaceutical firms over the period 2011-2017. We split this sample into good news (successes) and bad news (failures) at the various stages of drug development (clinical trials in Phase I, II, and III). Moreover, we distinguish announcements based on the existence of an alliance or not, and on the presence of a small or a large partner in the case of an alliance. We capture the market reaction with cumulative abnormal returns and abnormal trading volumes as these measures are not correlated. Indeed, Bamber et al. (2011) suggest that firms'

announcements may not change market expectations as a whole (i.e., no abnormal return), even if investors revise their expectations (i.e., significant trading), which may ultimately reflect an absence of market consensus.

Our main empirical results are as follows. First, in line with our expectations, we find a positive market reaction to announcements of successes in clinical trials, and a negative reaction for failures. However, a significant (positive or negative) reaction is only detected for later stages of drug development (i.e., Phase III). This result suggests that announcements of drug development in the earliest stage (Phase I) are not relevant for investors because uncertainty is still too great regarding future outcomes. Second, the market reaction is sensitive to the existence of an alliance. The market value (i.e., cumulative abnormal returns over a 3-day window) increases more in the case of success in Phase III, and decreases more in the case of failure in Phase III, when a large pharmaceutical firm develops the new drug alone. This finding is expected as all costs, benefits and risks are then borne by the large pharmaceutical firm. Third, a difference exists for alliances with large firms and with small firms. The market reaction is systematically negative for alliances with small firms, suggesting that large pharmaceutical firms do not extract private benefits in R&D alliances with small firms.

Overall, our findings suggest that R&D alliances with small firms have no favorable impact on the value of large pharmaceutical firms announcing the results of clinical trials. This result supports the idea that the expropriation risk is not that important, possibly because large firms care about their reputation (i.e., they want to attract other innovative firms in the future), or because small firms use their bargaining

power to protect themselves through effective contractual arrangements (Higgins et al., 2007).

Our study therefore contributes to the literature on market reactions to announcements of alliances, which usually shows a positive reaction and suggests that investors expect various benefits from an alliance, in terms of cost reduction, risk sharing, revenue growth or access to knowledge (Hagedoorn, 1993; Chan et al., 1997; Das et al., 1998; Anand and Khanna, 2003; Xu et al., 2006; Higgins, 2007; Contractor and Reuer, 2014; Heil and Bornemann, 2018). However, the existing studies usually focus on the initial market expectations, which are formed in a context of high uncertainty regarding the outcomes of the alliance, and do not consider subsequent revisions of expectations by investors when uncertainty decreases. Our study shows that the market reaction becomes significant at the very end of the R&D process, when uncertainty about future payoffs is reduced. Moreover, investor reaction for large firms is greater when the alliance involves another large firm, when compared to alliances with small firms, suggesting that small firms do not "swim with sharks" (Katila et al., 2008; Diestre et al., 2013). We also add to the literature on market reaction during the various stages of R&D in the pharmaceutical industry (Ely et al., 2003; Girotra et al., 2007; Dedman et al., 2008), which has not yet investigated whether the results are sensitive to the existence of an alliance. Our paper is the first to show that the market reaction to clinical trial announcements depends on the existence of an alliance.

The rest of the paper is organized as follows. Section 2 is dedicated to the literature review and to the development of our hypotheses. Section 3 describes the research design and the sample. Section 4 presents our results. We conclude in the last section.

2.2. Prior literature and hypotheses

2.2.1. Market reaction to clinical trial disclosure

The R&D process is highly standardized in the pharmaceutical industry (DiMasi et al., 1991; Petrova, 2014). As shown in Figure 1, drug development starts with a phase of pre-development including animal testing followed by a phase of development, which consists of three clinical trials on humans. During the final phase of clinical trials (Phase III), the new drug is tested on a large number of patients. Finally, after approval from the regulator, the R&D process ends with a post-development phase including post-market monitoring.

[INSERT FIGURE 1]

Since a new drug advances into the next phase only if it successfully passes the previous phase, uncertainty about future payoffs decreases as it moves through the different stages of clinical trials (Ely et al., 2003; Girotra, 2007). Thus, this specific environment creates a unique opportunity to better understand whether a decrease in uncertainty affects the market value of firms. Several papers have already shown that clinical trial announcements matter for investors (Ely et al., 2003; Qiao, 2006; Girotra et al., 2007; Dedman et al., 2008; Szutowski, 2018), but they do not investigate the impact of an alliance, especially between large firms and small firms.

Ely et al. (2003) focus on the various stages of product development for 243 biotechnology observations during the period 1988-1998 and find a significant and non-reverting market response for announcements of clinical trials in Phase II. They conclude that Phase II is the initial point at which investors have sufficient confidence that a new drug has reached a minimum potential for success, which leads to an increase in firm market value. Girotra et al. (2007) investigate 132 failures in Phase III, announced by pharmaceutical firms during the period 1994-2004. The market

reaction to such announcements is negative and economically important, amounting to $405 million. However, the impact of the failure is smaller when the firm is developing other projects for the same market as the failed project. For their sample of 151 non-contaminated announcements in the UK during the period 1990-1998, Dedman et al. (2008) find that drug development announcements have a greater impact on the market value than earnings announcements. They also note that firms announce more good news than bad news, and more news on the latest stage than on the earliest stage. This pattern of disclosure, and the subsequent market reactions, varies between larger firms and their smaller counterparts. Finally, Szutowski (2018) investigates 407 announcements by European biotechnology and pharmaceutical firms, for the period 2001-2016. The market reaction is sensitive to the stage of development as the stock returns are higher when the level of advancement is low, but smaller when the production of a new drug starts. Overall, these papers show that investors revise their expectations when uncertainty decreases (i.e., the probability of launching a new drug increases).

To the extent that investors are able to better predict future cash-flows when uncertainty is lower, we expect a more positive (negative) market reaction when a firm announces a success (failure) during the latest stage of drug development. Thus, we formulate our first hypothesis as follows:

H1: The market reaction is larger for announcements of the latest stage of clinical trials (i.e., Phase III) by a large pharmaceutical firm than for the earliest stage of clinical trials (Phase I).

2.2.2. Market reaction to announcements of alliances

Prior research has also focused on the market reaction to announcements of alliances. Investors often react positively when new alliances are announced (Chan et al., 1997; Das et al., 1998; Wu and Wei, 1998; Anand and Khanna, 2000; Qiao, 2006; Xu et al., 2006; Higgins et al., 2007).

Chan et al. (1997) study 345 alliances for the period 1983-1992 and find a positive market reaction for both partners, as well as for horizontal (i.e., alliances that involve partner firms in the same industry) and non-horizontal alliances. However, the market reaction is stronger when horizontal alliances involve the transfer and/or pooling of technical knowledge, in comparison to marketing alliances. Das et al. (1998) investigate 119 alliances during the period 1987-1991. They show a larger market reaction for technological alliances (i.e., activities such as R&D, engineering, and manufacturing, which often involve the production and sharing of knowledge) than for marketing alliances (i.e., activities such as sales, distribution, and customer service). Moreover, smaller partners appear to benefit the most from technological alliances, as larger firms capture less of the gain. Wu and Wei (1998) analyze 105 R&D alliances for the period 1985-1992 and show a positive market reaction, but intra-industry R&D cooperation leads to higher market reactions than inter-industry cooperation. Anand and Khanna (2000) investigate 870 joint ventures and 11,006 licensing agreements for the period 1990-1993, and find large learning effects in managing joint ventures but not for licensing contracts. However, the effects on market value are larger for research joint ventures, when compared to marketing joint ventures.

Qiao (2006), Xu et al. (2006), and Higgins et al. (2007) also consider R&D alliances, but only in the pharmaceutical industry. Qiao (2006) examines 611

announcements made by 103 biotechnology firms for the period 1983-1993. The market reaction is positive, but the five types of news included in their sample, including announcements of strategic alliances or research joint ventures formed by biotech firms, yield the same results. Based on a sample of 690 R&D alliances for the period 1998-2004, Xu et al. (2006) show that the market reaction is sensitive to the type of the alliance (i.e., R&D, marketing, and manufacturing), as well as of the announcer's size. Small firms benefit more from such alliances than large firms. Higgins et al. (2007) investigate the stock market response to the announcement of 165 alliances during the period 1993-2000, between research intensive biotechnology firms and large pharmaceutical firms. The market reaction is positive, but stronger when pharmaceutical firms enter into alliances where products are in earlier stages of development. The negative impact of an alliance during the later stages of development may signal a weakness in the research pipeline.

Overall, the previous results support the idea that various benefits are expected by investors when an alliance is announced, especially in terms of revenue growth, cost reduction, risk sharing, and access to knowledge (Hagedoorn, 1993; Chan et al., 1997; Das et al., 1998; Anand and Khanna, 2003; Contractor and Reuer, 2014; Heil and Bornemann, 2018). However, while instructive, previous studies only consider the market reaction at the announcement of new alliances, when the outcome of the alliances is highly uncertain. Since investors revise their expectations during the R&D process, it is possible that the previous findings change when uncertainty about future payoffs decreases. In fact, we expect a much lower market reaction when a large firm involved in an alliance announces the results of clinical trials in Phase III as it has to

share the future cash-flows generated by a new drug (in case of success) or the costs of the project (in case of failure). Thus, we formulate our second hypothesis as follows:

H2: The market reaction is lower for announcements of the latest stages of clinical trials (i.e., Phase III) when a large pharmaceutical firm is involved in a R&D alliance.

Finally, our last hypothesis concerns the size of the partner when a large pharmaceutical firm forms an alliance. It has been argued that large firms are eager to collaborate with small and innovative firms to access their specific knowledge (Das et al., 1998; Rothaermel and Deeds, 2004). Small firms are interested in alliances with large pharmaceutical firms because they lack financial resources and experience (Audtretsch and Feldman, 2004), which are essential to transform their specific knowledge into viable drugs (Rothaermel and Deeds, 2004; Diestre and Rajagopalan, 2012). However, small firms face the risk that large firms extract abnormal benefits from the alliance (Higgins, 2007; Katila et al., 2008; Diestre and Rajagopalan, 2012). This "hold-up" problem (Holmström and Roberts, 1998) means that alliances with small firms may be more beneficial for the large firms than alliances between two large firms.

One may argue, however, that the risk of "swimming with sharks" is low for two main reasons. First, small firms can protect their own interests against the opportunistic behavior of large firms with some effective contractual arrangements (Higgins et al., 2007; Katila et al., 2008; Diestre and Rajagopalan, 2012). This is likely as small firms detain the specific knowledge, or the technological know-how, which gives them a significant bargaining power (Das et al., 1998). Second, large pharmaceutical firms care about their reputation (i.e., being a "good ally") in order to attract innovative firms in the future. Therefore, they have no strong incentives to

extract abnormal benefits. Based on the previous arguments, we formulate the following hypothesis:

H3: The market reaction is lower for announcements of the latest stage of clinical trials (Phase III) when a large firm is involved in a R&D alliance with a small partner than when another large firm is involved in the alliance.

2.3. Research design

2.3.1. Sample and data

To test our hypotheses, we focus on clinical trial announcements made by the twelve largest pharmaceutical firms in terms of assets, revenue, and R&D investment. Appendix A provides the names of these firms, as well as key financial information extracted from *ThomsonReuters* for the year 2017. The clinical trials announcements for the period 2011-2017 were hand-collected from *Lexis/Nexis* and *ThomsonReuters*, and consist of successes and failures in Phase I, II, and III. We follow Das et al. (1998) and Dedman et al. (2008) by excluding contaminated announcements (e.g., several clinical trials, earnings or dividend announcements, etc.), which occurred within five calendar days before or after clinical trial announcements. Thus, we focus on the market reaction to non-contaminated news, which leads to a final sample of 544 clinical trial announcements. Some examples of announcements are provided in Appendix B.

Table 1 describes our sample. We observe more announcements for successful clinical trials than for failures, as well as more announcements for Phase III than for Phase I. This sample distribution supports the findings of Dedman et al. (2008): firms announce significantly more good news than bad news and more news regarding later stages of drug development. Finally, 128 announcements involve another firm, knowing

that alliances with small partners (101) are more prevalent than alliances with large partners (27).

[INSERT TABLE 1]

2.3.2. Models

To capture the market reaction to clinical trials, we implement an event study. Such an approach allows us to capture the changes in investors' expectations (or market reaction) when the clinical trials are announced. The main model writes as follows:

$$CAR_{i,t}\ (or\ AVOL_{i,t}) = \beta_0 + \beta_1 Phase\_II_{i,t} + \beta_2 Phase\_III_{i,t} + \beta_3 Alliance_{i,t}$$

$$+ \beta_4 Phase\_II{*}Alliance_{i,t} + \beta_5 Phase\_III{*}Alliance_{i,t} + CONTROLS + \varepsilon_{i,t}$$

(Eq. 1)

To capture the market reaction to clinical trial announcements, we use two variables: *CAR* and *AVOL*. The cumulative abnormal returns *(CAR)* over three days is frequently used in the literature (Chan et al., 1997; Das et al., 1998; Qiao, 2006; Girotra et al., 2007; Dedman et al., 2008). The event window goes from one day before (t-1) to one day after (t+1) the announcement. To obtain CAR, we compute the expected returns with the market model, with an estimation period starting 120 days and ending 10 days before the event date. Given that market reaction could be sensitive to the choice of the event window, we also use other windows in additional analyses. Table 2 reports the descriptive statistics and shows a mean value of 0.35% for *CAR*.

We also capture market reaction with the abnormal trading volume (*AVOL*), because it has been documented that abnormal returns and abnormal volumes are not perfectly correlated. Indeed, Bamber et al. (2011) suggest that firm announcements may not change market expectations as a whole (i.e., no abnormal return), even if investors revise their expectations (i.e., significant trading), which may ultimately reflect an absence of market consensus. We follow Garfinkel and Sokobin (2006) and

compute $AVOL$ as the difference between announcement period trading and market trading, and adjust our measure for the liquidity of the firm's trading volume before the announcement of a clinical trial:

$$AVOL_{i,t} = \left\{ \frac{\sum_{-1}^{+1} \left[\left(\frac{\text{Vol}_{i,t}}{\text{Shrs}_{i,t}} \right)_{firm} - \left(\frac{\text{Vol}_{t}}{\text{Shrs}_{t}} \right)_{mkt} \right]}{3} \right\} - \left\{ \frac{\sum_{-120}^{-10} \left[\left(\frac{\text{Vol}_{i,t}}{\text{Shrs}_{i,t}} \right)_{firm} - \left(\frac{\text{Vol}_{t}}{\text{Shrs}_{t}} \right)_{mkt} \right]}{111} \right\}$$

with $VOL_{i,t}$ being the firm volume on day t, and $SHRS_{i,t}$ is the firm outstanding shares. Table 2 shows a mean value of 1.65% for $AVOL$.

[INSERT TABLE 2]

Our main independent variables of interest are Phase_II, Phase_III, Alliance, and Small partner. These four variables are dummy variables, taking the value 1 if the announcement refers to Phase II or Phase III, or if two firms are involved in the drug development (Alliance), or if a large pharmaceutical firm is allied with a small firm (Small partner), and 0 otherwise.

To support our first hypothesis (H1) regarding a greater market reaction for clinical trials in the latest stage of development, we expect β_2 to be positive. For our second hypothesis (H2), we expect β_5 to be negative, reflecting a lower market reaction when a large firm is involved in an alliance and the clinical trials announcements concern the latest stage of development.

To test our last hypothesis (H3), we adapt our main model and test it on the sub-sample of firms that form R&D alliances. This model writes as follows:

$$CAR_{i,t} \text{ (or } AVOL_{i,t}) = \lambda_0 + \lambda_1 Phase\_II_{i,t} + \lambda_2 Phase\_III_{i,t} + \lambda_3 Small\ partner_{i,t} + \lambda_4 Phase\_II{*}Small\ partner_{i,t} + \lambda_5 Phase\_III{*}Small\ partner_{i,t} + CONTROLS + \varepsilon_{i,t} \quad \text{(Eq.2)}$$

To support H3, we expect the coefficient λ_5 to be negative, suggesting that the market reaction to Phase III announcements is smaller for alliances between a large and a small firm than between two large pharmaceutical firms. Such results would reflect the significant bargaining power of small firms that detain the specific knowledge (Das et al., 1998), which allows these firms to better protect themselves against a "hold-up" through effective contractual arrangements (Higgins, 2007).

2.3.3. Control variables

Following prior literature discussed in sections 2.1. and 2.2., we include several control variables. *Size* is the size of the company, measured with the natural logarithm of market capitalization. *R&D_Intensity* is defined as R&D expenses to sales.[14] *M_B* captures growth opportunities of the firm and is equal to the market capitalization divided by the book value of equity. *Leverage* measures the level of debt and is computed as total debt to total assets. We also control for unobservable factors by including year fixed-effects and firm fixed-effects. Finally, our statistics are based on robust standard errors clustered at the firm level (White, 1980; Petersen, 2009).

We note that the firm fixed-effects capture non-observable characteristics of the twelve large pharmaceutical firms of our sample. In particular, they measure their willingness to develop alliances and to avoid (or favor) the extraction of private benefits, as well as their experience with alliances.

[14] To the extent that our sample includes twelve large pharmaceutical firms, we can use this measure of R&D intensity without any concerns of extreme values (Zhang et al., 2018).

2.4. Results

2.4.1. Description of the market reaction to clinical trial announcements

Table 3 shows the market reaction by type of announcement for our two measures of market reaction. The mean *CAR* (*AVOL*) is 0.51% (1.72%) for *Success* and -0.43% (-0.30%) for *Failures*. When we split these two samples into trials in *Phase_II* and *Phase_III*, we find no significant differences for successes, but significant differences appear for failures between *Phase_II* and *Phase_III*. When we split the sample into clinical trials involving two firms (i.e., *Alliance* = 1) or just a large firm, we find a smaller market reaction when the large firm is involved in an alliance, which is in line with our second hypothesis (H2). Finally, as expected (H3), the market reaction is larger (and significant) only when the partner is another large firm. For alliances with small firms, no significant reaction is found.

[INSERT TABLE 3]

2.4.2. Results for market reaction captured with CAR

Table 4 reports our findings with cumulative abnormal returns (*CAR*) as a proxy of market reaction for successful clinical trial announcements. In Model 1, the market reaction is positive and significant when a large pharmaceutical firm announces success in *Phase_II* or in *Phase_III*. The abnormal market returns vary between 2% and 2.6% over the three-day window (columns 1 to 3), providing support for our hypothesis H1. However, *CAR* decreases (columns 2 and 3) when the clinical trials involve another firm (*Alliance*), which supports our hypothesis H2. Investors perceive less positively good news in the case of alliances, probably because large firms have to share future cash-flows with an ally.

[INSERT TABLE 4]

Since the regressions in Model 1 provide average results, we further analyze two sub-samples in Models 2 and 3. Based on firms not involved in an alliance, Model 2 supports our previous results, as the coefficient is positive and significant for the latest stage of drug development (*Phase_III*). Thus, investors positively perceive clinical trials developed alone by a large pharmaceutical firm. However, Model 3 shows non-significant coefficients of the variables *Phase_II* and *Phase_III*, but a negative coefficient for *Small partner*, as well as the interaction variable *Phase_III*Small partner*. Thus, the market reacts negatively when a large firm collaborates with a small firm, especially for a success in *Phase_III*, which does not support our third hypothesis (H3).

Table 5 provides our results on *CAR* for announcements of failures in clinical trials. Model 1 shows a negative and significant market reaction for failures in the last stage of drug development (*Phase_III*), but no significant result is found for *Phase_II*. This finding supports our hypothesis H1 of a greater market reaction during later stages of development. The abnormal decrease of the stock price of about -1% suggests a weaker market reaction for failures than for successes in clinical trials. The coefficient of the variable *Alliance* is still negative and significant, implying that the market reacts more negatively to announcements by firms involved in an alliance, which supports hypothesis H2. Model 2 confirms our findings. Finally, we do not provide results for Model 3 because the sample size is too small (17 announcements of failures in the case of an alliance). Hypothesis H3 can therefore not be tested in this setting.

[INSERT TABLE 5]

2.4.3. Results for market reaction captured with AVOL

Table 6 shows the results for successful clinical trial announcements when the market reaction is captured by the abnormal trading volume (*AVOL*). We find similar findings for Model 1 with abnormal trading volume as with cumulative abnormal returns. The market reaction is positive and significant for *Phase_II* and *Phase_III* in columns 1 to 3, but negative when the announcement involves an ally (*Alliance*). The interaction variables *Phase_II*Alliance* and *Phase_III*Alliance* are still not significant.

[INSERT TABLE 6]

When splitting the sample, we observe a significant increase in trading volume in Model 2, when a large pharmaceutical firm is not involved in an alliance. If the announcement involves an alliance of two firms (Model 3), no significant abnormal trading volume is detected. Finally, column 6 indicates that investors react negatively when a firm collaborates with a small partner, which supports our two hypotheses regarding the later stages of development (H1) and the alliance (H2), but not our last hypothesis regarding the size of the partner (H3).

Finally, Table 7 presents our findings for the announcements of failures. Again, the results with this second measure of market reaction are in line with those found with cumulative abnormal returns. The market reacts negatively when the failure involves clinical trials in *Phase_III* in Model 1. Finally, the coefficient of the variable *Alliance* is negative and significant in columns 2 and 3, suggesting a lower market reaction when firms collaborate.

[INSERT TABLE 7]

2.4.4. Sensitivity tests

We perform two additional analyses to test the robustness of our findings. The first one tackles the issue of opportunistic announcements of clinical trials. It is likely that pharmaceutical firms may strategically disclose some news (i.e., the timing and the nature of clinical trial announcement) to influence investors.

To investigate this issue, we analyze the distribution of clinical trial announcements during the year. Figure 2 shows that good news (i.e., successes in clinical trials) are more frequent in June, September, and December. These peaks coincide with the quarterly financial disclosures. However, there is no peak for bad news (i.e., failures in clinical trials). If investors are aware of these facts, which is probable (Li et al., 2020), our results may be biased.

[INSERT FIGURE 2]

To better control for the strategic clinical trial announcements, we add month fixed-effects in our models. If there is a more important market reaction during specific months (i.e., the peaks in Figure 2), these variables should capture some of the previously observed statistical power. The (untabulated) results support all our previous findings.

Our second sensitivity analysis consists of computing CAR and $AVOL$ on a different event window. We thus set the window from the event day (t=0) to two days after the event day (t + 2), and find (in untabulated tables) that our main results still hold. Thus, our sensitivity tests confirm and reinforce our main findings.

2.5. Conclusion

This paper investigates whether the existence of a R&D alliance impacts the market reaction to clinical trial announcements by twelve large pharmaceutical firms, and

whether that market reaction differs for alliances with large and with small firms. Based on a sample of 544 hand-collected announcements of successes (good news) and failures (bad news) in clinical trials during the period 2011-2017, we find a larger investors' reaction in the absence of an alliance. Moreover, in the case of an alliance, the market reaction is larger when the partner is another large firm than when the partner is a small (non-listed) firm. These results hold with our two measures of market reaction (i.e., cumulative abnormal returns and abnormal trading volumes), suggesting the existence of a market consensus regarding the impact of such announcements (Bamber et al., 2011).

Thus, the risk of expropriation faced by small firms is not reflected in the market's reaction to clinical trial announcements by large pharmaceutical firms. We posit that this finding is due to the specific nature of alliances with small (non-listed) firms, which have an important bargaining power as they detain specific knowledge (i.e., the key ideas allowing the development of new drugs) and protect themselves by effective contractual arrangements to limit the expropriation risk (Das et al., 1998; Higgins et al., 2007), also known as the "hold-up" problem (Holmström and Roberts, 1998). In other words, it seems that large firms are not perceived as "sharks" by investors (Katila et al., 2008; Diestre and Rajagopalan, 2012), which also supports the idea that large firms try to protect their reputation, by not extracting private benefits from the alliance, in order to attract other innovative (small) firms in the future.

Our study is not without limitations, as it is based on R&D alliances formed by a limited number of large pharmaceutical firms. Future research should investigate announcements made by other pharmaceutical firms to better understand under which circumstances the "swimming with sharks" problem is perceived by investors.

Moreover, we were not able to collect proprietary data about the contractual arrangements between the two allies. Such additional information could be useful to better understand the market reaction.

Without these caveats in mind, we nevertheless hope that our study will be interesting for managers and boards of directors that decide to develop alliances, as well as for researchers who are interested in the specific benefits, costs and risks associated with strategic alliances.

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Figure 1. Research and development process

Pre-development	Development			Post-development
Drug discovery & Animal testing	Clinical trials			FDA review & Post-market monitoring
	Phase 1	Phase 2	Phase 3	
3-6 years	6-7 years			0.5-2 years

Note: This figure is adapted from Petrova (2014).

Figure 2. Distribution of the drug development news over the year

Figure 2 shows the monthly distribution of our 544 clinical trial announcements by twelve large pharmaceutical firms during the period 2011-2017. We split announcements into announcements of success in clinical trials (1) and failure in clinical trials (2).

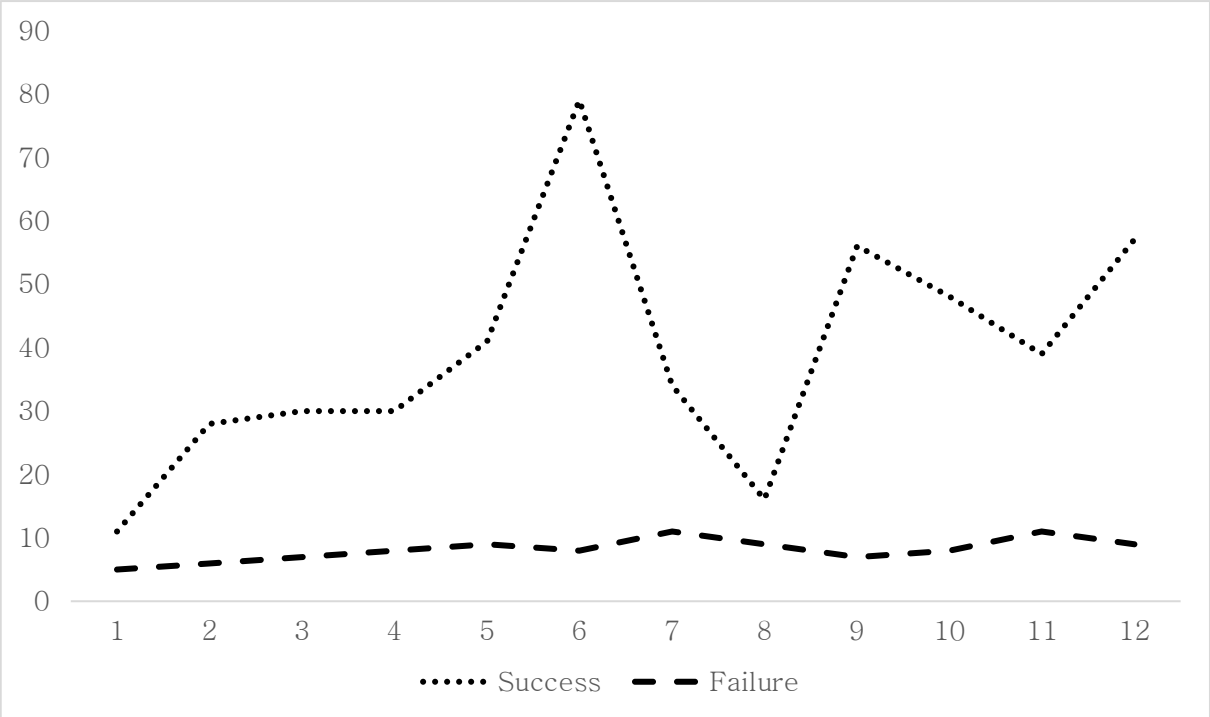

Table 1. Description of the sample

The sample includes 544 clinical trial announcements by twelve large pharmaceutical firms during the period 2011-2017. Table 1 distinguishes: (1) *Success*, announcement of successful clinical trial; (2) *Failure*, announcement of failure in clinical trial; (3) *Alliance*, announcement of a clinical trial with another firm; (4) *No alliance*, announcement of an individually developed clinical trial; (5) *Large partners*, in case of *Alliance*, the collaborating partner is a large pharmaceutical firm; and (6) *Small partners*, in case of *Alliance*, the collaborating partner is a small firm.

		Success	Failure	Total
Phase I	Total	25	1	26
	1. No alliance	16	1	17
	2. Alliance	9	0	9
	2.1. Large partners	2	0	2
	2.2. Small partners	7	0	7
Phase II	Total	90	12	102
	1. No alliance	75	9	84
	2. Alliance	15	3	18
	2.1. Large partners	1	0	1
	2.2. Small partners	14	3	17
Phase III	Total	336	80	416
	1. No alliance	249	66	315
	2. Alliance	87	14	101
	2.1. Large partners	22	2	24
	2.2. Small partners	65	12	77
TOTAL	**Total**	**451**	**93**	**544**
	1. No alliance	340	76	416
	2. Alliance	111	17	128
	2.1. Large partners	25	2	27
	2.2. Small partners	86	15	101

Table 2. Descriptive statistics

The sample includes 544 clinical trial announcements by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C.

	Mean	SD	25%	Median	75%
Panel A. Dependent variables					
CAR	0.35%	4.34%	0.31%	0.52%	0.97%
AVOL	1.65%	7.48%	0.16%	0.27%	3.45%
Panel B. Control variables					
Size (million USD)	118693	65239	65450	97812	163900
RD_Expense (million USD)	5778	2404	3574	5156	8118
R&D_Intensity	17.26%	6.33%	13.41%	16.03%	18.93%
M_B	5.92	8.63	2.43	3.29	6.01
Leverage	57.88%	14.63%	46.49%	57.50%	65.79%

Table 3. Market reaction by sub-samples

The sample includes 544 clinical trial announcements by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C. The statistical significance represents the results of two univariate tests between clinical trials in *Phase_II* and *Phase_III*, between *Alliance* and *No alliance*, and between *Small partner* and *Large partner*, per groups *Success* and *Failure*. *** and ** denote 99% and 95% levels of confidence for the Student test (for difference in means) and Mann-Whitney test (for difference in medians).

	Success			Failure		
	N	Mean	Median	N	Mean	Median
Panel A. Cumulative abnormal returns (CAR)						
Full sample	451	0.51%	0.72%	93	-0.43%	-0.45%
Phase_II	90	0.51%	0.64%	12	-0.31%	-0.17%
Phase_III	336	0.53%	0.65%	80	-0.59%***	-0.51%***
Alliance	111	0.48%	0.50%	17	-0.34%	-0.28%
No alliance	340	0.60%***	0.77%***	76	-0.56%***	-0.60%***
Small partner	86	-0.06%	-0.01%	2	-0.01%	-0.01%
Large partner	25	0.74%***	1.05%***	15	-0.50%***	-0.47%***
Panel B. Abnormal trading volumes (AVOL)						
Full sample	451	1.72%	0.87%	93	-0.30%	-0.12%
Phase_II	90	1.74%	0.75%	12	-0.19%	-0.04%
Phase_III	336	1.81%	0.94%**	80	-0.48%***	-0.21%***
Alliance	111	1.12%	0.41%	17	-0.15%	0.06%
No alliance	340	1.54%***	0.63%***	76	-0.37%***	0.18%***
Small partner	86	-1.21%	-0.34%	2	-1.47%	-1.47%
Large partner	25	0.73%***	0.12%***	15	-0.58%***	-0.31%***

Table 4. Analysis of CAR in case of successful clinical trials

The sample includes 451 announcements of success in clinical trials by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C; t-statistics based on robust standard error clustered at the firm-level are presented in parentheses; *** and ** denote 99% and 95% levels of confidence.

	Model 1: Full sample			Model 2: No Collaboration	Model 3: Collaboration	
	1	2	3	4	5	6
Constant	0.103	0.104	0.013	0.158	0.061	0.167
	(0.114)	(0.079)	(0.026)	(0.114)	(0.269)	(0.274)
Phase_II	0.025***	0.025***	0.020***	0.020***	0.008	0.015
	(0.003)	(0.005)	(0.003)	(0.003)	(0.008)	(0.011)
Phase_III	0.026***	0.026***	0.022***	0.022***	0.004	0.007
	(0.003)	(0.005)	(0.004)	(0.004)	(0.005)	(0.006)
Alliance		-0.052**	-0.023***			
		(0.017)	(0.005)			
Phase_II*Alliance			-0.008			
			(0.010)			
Phase_III*Alliance			-0.004			
			(0.003)			
Small partner						-0.031***
						(0.007)
Phase_II*Small partner						-0.025
						(0.022)
Phase_III*Small partner						-0.019**
						(0.007)
Size	-0.010	-0.010	-0.002	-0.015	-0.005	0.008
	(0.010)	(0.007)	(0.002)	(0.010)	(0.024)	(0.024)
R&D_Intensity	-0.073	-0.075	-0.005	-0.005	-0.154	0.279**
	(0.064)	(0.076)	(0.011)	(0.073)	(0.147)	(0.126)
M_B	-0.000***	-0.000	0.000	-0.000***	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.018	0.018	-0.007*	0.010	0.039	0.039
	(0.014)	(0.021)	(0.004)	(0.011)	(0.063)	(0.039)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Observations	451	451	451	340	111	111
Adj. R2	0.073	0.075	0.084	0.068	0.180	0.261

Table 5. Analysis of CAR in case of failure in clinical trials

The sample includes 93 announcements of failure in clinical trials by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C; t-statistics based on robust standard error clustered at the firm-level are presented in parentheses; *** and ** denote 99% and 95% levels of confidence.

	Model 1: Full sample			Model 2: No collaboration
	1	2	3	4
Constant	0.087	0.052	0.064**	-0.015
	(0.194)	(0.079)	(0.024)	(0.213)
Phase_II	0.001	-0.002	0.000	0.006
	(0.008)	(0.002)	(0.005)	(0.010)
Phase_III	-0.008***	-0.008***	-0.003**	-0.008**
	(0.002)	(0.002)	(0.001)	(0.003)
Alliance		-0.006**	-0.011**	
		(0.002)	(0.004)	
Phase_II*Alliance			0.000	
			(0.000)	
Phase_III*Alliance			-0.001	
			(0.005)	
Size	-0.009	-0.004	-0.004**	-0.000
	(0.018)	(0.007)	(0.002)	(0.020)
R&D_Intensity	0.110	-0.063	-0.028***	0.090
	(0.093)	(0.036)	(0.008)	(0.131)
M_B	-0.000	-0.000*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Leverage	0.014	0.015	-0.014*	0.011
	(0.036)	(0.012)	(0.007)	(0.046)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Observations	93	93	93	76
Adj. R2	0.225	0.225	0.228	0.217

Table 6. Analysis of AVOL in case of successful clinical trials

The sample includes 451 announcements of success in clinical trials by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C; t-statistics based on robust standard error clustered at the firm-level are presented in parentheses; *** and ** denote 99% and 95% levels of confidence.

	Model 1: Full sample			Model 2: No collaboration	Model 3: Collaboration	
	1	2	3	4	5	6
Constant	0.065	0.076	0.079	0.074	-0.170	-1.601
	(0.501)	(0.130)	(0.520)	(0.197)	(0.287)	(1.013)
Phase_II	0.050**	0.051**	0.052**	0.042	0.042	0.049
	(0.018)	(0.024)	(0.017)	(0.027)	(0.040)	(0.028)
Phase_III	0.069***	0.071***	0.070***	0.065**	0.009	0.115*
	(0.021)	(0.024)	(0.021)	(0.028)	(0.028)	(0.061)
Alliance		-0.001**	-0.065**			
		(0.000)	(0.027)			
Phase_II*Alliance			-0.019			
			(0.022)			
Phase_III*Alliance			-0.035			
			(0.023)			
Small partner						-0.214**
						(0.097)
Phase_II*Small partner						-0.067*
						(0.035)
Phase_III*Small partner						-0.109***
						(0.041)
Size	-0.020	-0.021**	-0.022	-0.023	0.028*	0.143
	(0.035)	(0.010)	(0.036)	(0.014)	(0.016)	(0.089)
R&D_Intensity	0.016	0.014	0.015	0.164	0.190	0.452*
	(0.212)	(0.119)	(0.214)	(0.169)	(0.213)	(0.251)
M_B	-0.002	-0.002***	-0.002	-0.003**	0.002	0.004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
Leverage	0.233	0.232***	0.232	0.254***	-0.420	-0.345
	(0.180)	(0.058)	(0.184)	(0.071)	(0.264)	(0.215)
Year FE	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Observations	451	451	451	340	111	111
Adj. R2	0.095	0.096	0.103	0.116	0.315	0.588

Table 7. Analysis of AVOL in case of failure in clinical trials

The sample includes 93 announcements of failure in clinical trials by twelve large pharmaceutical firms during the period 2011-2017. A detailed description of the variables can be found in Appendix C; t-statistics based on robust standard error clustered at the firm-level are presented in parentheses; *** and ** denote 99% and 95% levels of confidence.

	Model 1: Full sample			Model 2: No collaboration
	1	2	3	4
Constant	1.099	0.052	0.799	1.104
	(1.374)	(0.079)	(0.477)	(1.403)
Phase_II	-0.061	-0.002	-0.071*	-0.065*
	(0.062)	(0.002)	(0.037)	(0.033)
Phase_III	-0.056**	-0.008***	-0.124***	-0.060***
	(0.023)	(0.002)	(0.029)	(0.015)
Alliance		-0.006**	-0.120**	
		(0.002)	(0.039)	
Phase_II*Alliance			0.000	
			(0.000)	
Phase_III*Alliance			-0.071	
			(0.049)	
Size	-0.109	-0.004	-0.052	-0.107
	(0.132)	(0.007)	(0.037)	(0.133)
R&D_Intensity	0.779	-0.063	0.003	0.374
	(0.725)	(0.036)	(0.145)	(0.515)
M_B	0.003**	-0.000*	-0.003**	-0.001
	(0.001)	(0.000)	(0.001)	(0.001)
Leverage	0.297	0.015	-0.273	0.388
	(0.327)	(0.012)	(0.174)	(0.428)
Year FE	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Observations	93	93	93	76
Adj. R2	0.434	0.225	0.269	0.469

Appendix A. List of large sample firms

All financial data are expressed in billions of USD for the year 2017.

Name	Country	Total Assets	Sales	R&D
AstraZeneca	U.K.	45,26	17,25	4,16
Bayer	Germany	70,17	35,02	4,50
Bristol Myers	U.S.	31,94	20,78	4,82
Celgene	U.S.	30,14	13,00	5,92
Eli Lilly & Company	U.S.	44,98	22,87	5,28
Glaxosmithkline	U.K.	52,59	30,19	3,86
Johnson & Johnson	U.S.	150,20	76,45	10,56
Merck & Company	U.S.	87,87	40,12	9,71
Novartis	Switzerland	121,60	49,16	8,15
Pfizer	U.S.	169,90	52,55	7,66
Roche Holding	Switzerland	73,10	53,30	10,39
Sanofi	France	95,54	36,20	5,45

Appendix B. Examples of announcements of clinical trials

Journal	Announcement	Phase	Result	Alliance
02.02.2015 (Theflyonthewall.com)	AstraZeneca's 161-patient Phase 2b clinical trial evaluating tenapanor in hyperphosphatemic patients with chronic kidney disease on hemodialysis met its primary endpoint by demonstrating a statistically significant dose-related decrease in serum phosphate levels for tenapanor-treated patients compared to patients receiving placebo.	Phase_II	Success	No
23.08.2012 (RTT News)	Bristol-Myers Squibb said on Thursday that it has discontinued development of BMS-986094, a nucleotide polymerase inhibitor that was in Phase II development for the treatment of hepatitis C. The company had suspended the Phase II study on August 1, after an initial case of heart failure which subsequently resulted in death. Nine patients have been hospitalized to date.	Phase_II	Failure	No
05.12.2013 (The Pharma Letter)	Results of a 24-week Phase IIIb clinical study showed that French drug major Sanofi's diabetes drug Lyxumia (lixisenatide) met the primary endpoint of non-inferiority in blood sugar lowering (HbA1c) when administered either before breakfast or the main meal of the day. These results indicate that lixisenatide can effectively lower blood sugar at either time of administration.	Phase_III	Success	No
07.08.2013 (RTT News)	Novartis announced that results of the study of Afinitor in advanced liver cancer failed to meet primary endpoint of overall survival. The global Phase III study showed that Afinitor did not extend overall survival compared to placebo in patients with locally advanced or metastatic hepatocellular carcinoma after progression on or intolerance to sorafenib.	Phase_III	Failure	No
10.11.2011 (PR Newswire)	Sanofi and Regeneron Pharmaceuticals today announced positive preliminary results from the Phase 2 study program in which patients with elevated low-density lipoprotein cholesterol (LDL-C) were treated with.	Phase_II	Success	Yes
08.04.2016 (PR Newswire)	Eli Lilly and AstraZeneca today announced that Amaranth, a study of AZD3293, an oral beta secretase cleaving enzyme inhibitor currently in development as a potential treatment for early Alzheimer's disease, will continue to Phase 3 after successful Phase 2 trial.	Phase _II	Success	Yes

08.08.2014 (FierceBiotech)	GlaxoSmithKline and Galapagos has again scaled back its expectations for an anti-inflammatory treatment, calling off any plans for late-stage study after a Phase II miscue dulled its potential. The drug, GSK2586184, is a JAK1 inhibitor developed under a long-running partnership between the two companies, designed to treat lupus, ulcerative colitis and psoriasis. GSK is pulling the plug on the whole anti-inflammatory project, saying the treatment's overall risk-benefit profile left it wanting after GSK2586184 performed poorly on a drug-interaction study with statins.	Phase_II	Failure	Yes
03.08.2011 (Reuters News)	Danish biopharma ALK Abello said its ragweed allergy drug showed good results in Phase III clinical trials conducted by its U.S.-based partner Merck.	Phase_III	Success	Yes
08.12.2011 (Theflyonthewall.com)	Bristol-Myers Squibb and AstraZeneca announced positive results from a Phase 3 clinical study which showed that reductions in blood sugar levels, or glycosylated hemoglobin levels, or HbA1c, seen at 24 weeks with the investigational compound dapagliflozin added to existing glimepiride, or sulphonylurea, therapy, compared to placebo added to glimepiride, were maintained at 48 weeks in adults with type 2 diabetes.	Phase_III	Success	Yes
27.06.2014 (Reuters News)	GlaxoSmithKline and Genmab A/S announced today that the Phase III study of ofatumumab versus physicians' choice in patients with bulky fludarabine-refractory chronic lymphocytic leukaemia did not meet its primary endpoint of progression free survival.	Phase_III	Failure	Yes
02.02.2011 (Theflyonthewall.com)	Eli Lilly and Bristol-Myers Squibb announced that they have stopped enrollment in one of their two global Phase III studies evaluating necitumumab, an investigational anti-cancer agent. The decision to stop enrollment followed an independent Data Monitoring Committee (DMC) recommendation that no new or recently enrolled patients continue treatment in the trial because of safety concerns related to thromboembolism (blood clots) in the experimental arm of the study.	Phas_III	Failure	Yes

Appendix C. Variable definitions

Variables	Description
PANEL A. Dependent variables	
CAR	Cumulative abnormal 3-day return, centered on the earnings announcement date, and computed by market model.
AVOL	Abnormal volume is measured as the difference between firm announcement period trading and the market trading.
PANEL B. Independent variables of interest	
Phase_II	Dummy variable equal to 1 if the news relate to the Phase II of clinical development, and 0 otherwise.
Phase_III	Dummy variable equal to 1 if the news relate to the Phase III of clinical development, and 0 otherwise.
Alliance	Dummy variable equal to 1 if the news relate to the product that is developed with another company, and 0 otherwise.
Small partner	Dummy variable equal to 1 if the collaboration news relate to the product that is developed with a small company, and 0 otherwise.
PANEL C. Control variables	
Size	Natural logarithm of the firm's market capitalization.
R&D_Intensity	R&D expenditures scaled by sales.
M_B	Market-to-book ratio, measured as the ratio of market capitalization to total common equity.
Leverage	Total debt to total assets.

Appendix D. Correlation matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Phase_I	1.000								
(2) Phase_II	-0.111*	1.000							
	(0.001)								
(3) Phase_III	-0.410*	-0.005	1.000						
	(0.000)	(0.889)							
(4) Alliance	0.095*	-0.080	0.002	1.000					
	(0.007)	(0.021)	(0.950)						
(5) Small partner	-0.025	-0.140	0.129	(.)	1.000				
	(0.746)	(0.063)	(0.088)						
(6) Size	-0.073	-0.003	0.009	-0.123*	-0.010	1.000			
	(0.035)	(0.934)	(0.804)	(0.000)	(0.896)				
(7) R&D_Intensity	0.082	-0.053	-0.030	-0.048	0.334*	-0.143	1.000		
	(0.018)	(0.131)	(0.396)	(0.173)	(0.000)	(0.472)			
(8) M_B	0.121*	-0.011	-0.025	-0.030	0.121	-0.057	0.100*	1.000	
	(0.001)	(0.757)	(0.474)	(0.387)	(0.110)	(0.319)	(0.004)		
(9) Leverage	0.067	0.026	-0.051	-0.081	0.057	-0.195	0.097	0.617*	1.000
	(0.055)	(0.458)	(0.141)	(0.020)	(0.449)	(0.628)	(0.524)	(0.000)	

**** p<0.01, ** p<0.05, * p<0.1*

Chapter 3: Does clinical trial disclosure influence analyst optimism?

3.1. Introduction

Financial analysts issue target prices that help investors to make better investment decisions (Bradshaw, 2002; Asquith et al., 2005; Ramnath et al., 2008). However, academic research has shown that target prices are usually optimistic (i.e., target prices are higher than the future price) in a large majority of cases (Bilinski et al., 2013; Bradshaw et al., 2013). Such a finding could be attributed to analysts' incentives and conflicts of interest (Mehran and Stulz, 2007; Chan et al., 2018; Lourie, 2019), to improper implementation of valuation methods (Gleason et al., 2013; Green et al., 2016), or to behavioral biases (Cen et al., 2013; Roger et al., 2018). Our paper contributes to the latter by investigating whether clinical trial disclosure (i.e., new and specific non-financial information) influences analyst optimism in the pharmaceutical industry.

This paper is based on four key ideas. First, financial analysts face serious difficulties to value pharmaceutical firms that invest large financial resources in R&D.[15] Given that financial reports provide very little information about such investments (i.e., accounting standards require firms to recognize R&D expenses without any specific notes), investors face great uncertainty regarding the future payoffs of R&D projects. Thus, there is a significant risk that the actual stock prices do not reflect the fundamental value of pharmaceutical firms (Barth et al., 2001; Barron et al., 2002; Amir

[15] The European Federation of Pharmaceutical Industries and Associations (2018) highlights that pharmaceutical firms invest more in R&D than firms from other R&D intensive industries, such as software and computer services or technology hardware and equipment (https://efpia.eu/publications/downloads/).

et al., 2003). To reduce that risk of mispricing, analysts must therefore collect and analyze additional information to that provided by financial reports.

Second, analysts cannot easily obtain private information (i.e., earnings or cash flow forecasts) from managers who try to limit the proprietary costs and litigation risk (Guo et al., 2004; Jones, 2007; Simpson, 2010). That risk has increased after the adoption of new regulations (i.e., Reg. FD in the U.S. and MAD in Europe) prohibiting managers from revealing their private information to financial analysts (Mehran and Stulz, 2007; Dubois et al., 2014). Thus, analysts must consider other sources of information, but they face two problems. Gathering information is a costly activity, and analysts seek to optimize their efforts and their financial resources. In addition, some of the information collected may be unreliable because it is not certified by third parties (Dye, 2001).

Third, the R&D process is highly standardized in the pharmaceutical industry. Companies have to go through three phases of drug development and information about these phases is publicly available on the *ClinicalTrials.gov* website. From a financial point of view, uncertainty about future payoffs decreases when a firm moves from Phase I to Phase II to Phase III.[16] If financial analysts have sufficient expertise to understand this specific non-financial information, they should use it to assess the value of pharmaceutical firms.[17]

[16] Phase III of clinical trials is the last phase before drug approval by the regulator. Appendix A and B provide more detail on the drug development process in the pharmaceutical industry.
[17] Anecdotal evidence suggests that analysts use such non-costly non-financial information to value pharmaceutical firms. For instance, a report issued by Barclays indicates: "*A 'minor hit' from the suspended recruitment of AstraZeneca's Phase III trial of durvalumab/AZD9291 trial in non-small-cell lung cancer. An update on* **clinicaltrials.gov** *shows recruitment has been suspended in the trial after a signal of increased incident of interstitial lung disease was seen in the Phase Ib trial.*"

Fourth, psychology and behavioral economics have documented a based-rate fallacy, which is a tendency to ignore base-rate information (i.e., general information on the probability of success of clinical trials and its consequences on future cash flows in our case), and to focus on new and specific information (i.e., clinical trial disclosures in our case), rather than correctly integrating the two (Tversky and Kahneman, 1974; Bar-Hillel, 1980).[18] Thus, analysts may overestimate the probability of success of clinical trials in Phase III, which is higher (in general) than that in Phase I and II, and overestimate the probability of failure in the case of clinical trials in Phase I, which is higher (in general) than that in Phase II and Phase III.[19] In other words, analysts may put more weight on specific information than on base-rate information to make forecasts.

Our empirical analysis is based on a sample of 20,158 target prices issued by 221 analysts following 148 pharmaceutical firms during the period 2011-2017, and 11,450 clinical trial disclosures. Our two main results are the following. First, Phase III disclosure leads to more optimistic target prices, whereas Phase I disclosure leads to more pessimistic target prices. This result is not sensitive to controlling for the probability of success of the drug portfolio, analyst following, the seasonality and frequency of analyst reports, and the intensity of clinical trial disclosure. Second, a key difference exists between large and small firms as optimistic target prices are issued by analysts after Phase III disclosure by large firms, but after Phase II disclosure

(https://advance.lexis.com/api/document?collection=news&id=urn:contentItem:5H3V-6TR1-DYYF-M0XP-00000-00&context=151683).

[18] The rate-base fallacy is attributed to the representativeness heuristic (Tversky and Kahneman, 1974). The idea that individuals use new and existing information (i.e., information retrieved from memory) is also developed by Gennaioli and Shleifer (2010) and Bordalo et al. (2020).

[19] The analysis of historical data shows that the probability of success are equal to 24% for Phase I, 32% for Phase II and 75% for Phase III (DiMasi, 2001).

by small firms. Overall, our findings suggest that target prices are biased after clinical trial disclosure concerning later stages of drug development (i.e., Phase II for small firms and Phase III for large firms). Knowing that sell-side analysts overreact to such new and specific non-financial information, which supports the existence of a base-rate fallacy (Tversky and Kahneman, 1974; Bar-Hillel, 1980), should be of great interest to investors.

Our paper contributes to the literature on analyst optimism. Several determinants of that optimism have already been investigated. Chan et al. (2018) and Lourie (2019) show that the issuance of optimistic target prices is driven by analysts' incentives, but national institutions may discipline analysts (Bradshaw et al., 2019). Green et al. (2016) and Kim et al. (2019) highlight that analyst optimism is the result of the improper implementation of valuation models. Finally, optimism may reflect analyst behavioral biases, especially the anchoring bias (Cen et al., 2013) and the small price bias (Roger et al., 2018). Our paper shows that analyst optimism may also be driven by the misuse of new and specific non-financial information, which leads to the well-documented base-rate fallacy (Tversky and Kahneman, 1974; Bar-Hillel, 1980). Analysts put too much weight on specific clinical trial disclosure in Phase III (Phase I), which are associated with a significant decrease (increase) of uncertainty about future payoffs. We also contribute to the literature on non-financial disclosure (e.g., Amir et al., 2003; Gu and Wang, 2005; Jones, 2007; Simpson, 2010) by showing that specific non-financial information may substitute deficient financial reports regarding R&D investments.

The remainder of this paper is organized as follows. Section 2 is dedicated to our literature review and the development of our hypotheses. Our research design is

described in section 3. We present and discuss our results in section 4. A final section concludes.

3.2. Prior literature and hypotheses

We review two streams of literature. The first relates to the difficulties faced by analysts to issue accurate target prices for firms investing large resources in R&D, in a context in which limited information is provided by financial reports. The second stream concerns the importance of relevant and specific non-financial information that compensates for the deficiencies of financial statements regarding R&D.

3.2.1. The valuation of intangible intensive firms by financial analysts

3.2.1.1. The issuance of biased target prices

Financial analysts contribute to the efficiency of financial markets by detecting mispricing and making stock recommendations to investors. More precisely, they compute a target price (TP), which corresponds to the fundamental value of a firm and compare it with the actual stock price (P). As noted by Bradshaw (2002), based on this comparison, they can recommend buying a stock (if TP>P, the stock is underpriced), holding it (if TP=P, the stock is fairly priced), or selling it (if TP<P, the stock is overpriced).

To derive target prices, analysts start by collecting information from different sources about firms (e.g., annual reports), industries, and the (macro-)economy. All relevant information is then translated into earnings or cash-flow forecasts, which constitute the inputs of the valuation models (DCF or multiples) leading to the computation of a target price (Bradshaw, 2002; Asquith et al., 2005; Ramnath et al., 2008; Gleason et al., 2013; Green et al., 2016).

Each analyst report therefore contains three key pieces of information: earnings and/or cash-flow forecasts, a target price, and a recommendation. For investors, these outcomes have different properties and significance. Recommendations are discrete and depend simultaneously on the target price and the market price of the stock.[20] Earnings or cash-flow forecasts are usually formulated for a near-term horizon and do not explicitly take into account changes in firm risk. Finally, the target price is continuous and incorporates analysts' long-term assessment of earnings, or cash-flows, as well as firm risk, which makes this outcome particularly interesting for investors (Brav and Lehavy, 2003; Bilinski et al., 2013; Bradshaw et al., 2013).

Previous research has documented that analysts' earnings forecasts and stock recommendations significantly affect stock prices. The scarce literature on the market consequences of target prices shows similar results (Brav and Lehavy, 2003; Asquith et al., 2005; Da and Schaumburg, 2011; Gleason et al., 2013; Bradshaw et al., 2013; Lin et al., 2016).

This result is, however, somewhat surprising because it has been documented that analysts tend to issue optimistic target prices (for the U.S. market, see Brav and Lehavy, 2003; Asquith et al., 2005; Bradshaw et al., 2013; Roger et al., 2018; Kim et al., 2019; for Italy, see Bonini, 2010; for the U.K., see Demirakos et al., 2010; for cross-country studies, see Bilinski et al., 2013; Bradshaw et al., 2019). For instance, Brav and Lehavy (2003) show that the one-year-ahead target price is 28% higher than the current market price. Bradshaw et al. (2013) find that the implied target price-based returns exceed actual returns by an average of 15%, and absolute target price

[20] Analysts may, for instance, significantly increase the target price after including good news, but the actual market price may already incorporate this news, leading ultimately to no change in analyst recommendations.

forecast errors average 45%, and only 38% of target prices are met at the end of the 12-month forecast horizon.

Three main explanations for such optimism are proposed. First, analysts have specific incentives to provide biased numbers, and particularly when they work for banks having business relationships with the covered firms (Mehran and Stutz, 2007), or hold stocks of these firms (Chan et al., 2018), or are hired in near future by the firms they cover (Lourie, 2019). However, some other mechanisms impact analysts' incentives to produce more accurate target prices, especially the institutional context (e.g., the legal system), as shown by Bilinski et al. (2013) and Bradshaw et al. (2019). Second, analysts may use imperfect valuation models or make questionable judgments when implementing valuation models (Demirakos et al., 2010; Gleason et al., 2013; Green et al., 2016). For instance, they may not adjust their inputs for unconditional accounting conservatism, which leads to larger errors (Kim et al., 2019). Third, analyst behavioral biases may also lead to the issuance of optimistic target prices. Cen et al. (2013) highlight an anchoring bias and Roger et al. (2018) observe a small price bias. Amit and Ganzach (1998) show that analysts over-react to new information. Our paper extends their later stream of research by considering the existence of a base-rate fallacy, which reflects the tendency to ignore base-rate (or general) information on the probability of success and failure of R&D projects, and to focus on specific and relevant information, rather than correctly integrating the two (Tversky and Kahneman, 1974; Bar-Hillel, 1980).

3.2.1.2. Analyst and financial reporting deficiencies

Financial analysts face more difficulties to perform their tasks when covering firms with large intangible assets (Barth et al., 2001; Barron, 2002; Amir et al., 2003;

Kimbrough, 2007; Palmon and Yezegel, 2012), such as pharmaceutical firms investing large financial and human resources in R&D. The valuation of such firms is complex because R&D projects have a long time horizon and are very risky. In fact, it usually takes about 10 years to discover new drugs, and only a few projects succeed (DiMasi et al. 1991; DiMasi et al., 2007), which makes the payoffs highly uncertain and difficult to predict (Kothari et al., 2002; Kimbrough, 2007).

To the extent that great uncertainty is associated with R&D projects, accounting standard-setters consider that the fair value of such internally generated assets cannot be measured with sufficient reliability. Therefore, firms are required to expense R&D investments.[21] Thus, the position of the standard setters leads to a large mismatch of revenues and expenses for intangible intensive firms (Lev, 2001; Barth et al., 2001; Kimbrough, 2007). In the absence of meaningful information in the financial statements regarding R&D investments, there is a substantial information asymmetry between managers, who have access to private information about the actual status and potential consequences of R&D investments, and investors or financial analysts covering pharmaceutical firms. These deficiencies ultimately lead to less informative stock prices (Aboody and Lev, 2000; Barth et al., 2001; Palmon and Yezegel, 2012).

In the context of possible stock mispricing, financial analysts must increase their effort to reduce information asymmetries by acquiring and processing additional information. The additional effort and costs borne by analysts may be compensated by

[21] In countries applying IFRS, the capitalization of some R&D expenses is allowed under very precise conditions. IAS 38 indicates that an intangible asset arising from research & development can be capitalized if an entity can demonstrate the following criteria: (1) Technical feasibility of completing the intangible asset; (2) Intention to complete and use/sell the asset; (3) Ability to use/sell the asset; (4) Existence of a market; (5) Availability of adequate technical, financial, and other resources to complete the asset; (6) Cost of the asset can be measured reliably. In practice, only a small fraction of R&D expenses are capitalized (Dinh et al., 2019).

higher trading fees associated with the disclosure of relevant investment recommendations to investors. This idea is supported by Barth et al. (2001), who find higher analyst coverage for firms with more intangible assets (especially more R&D) relative to their industry, and for firms in industries with larger R&D expenses. Furthermore, Barron et al. (2002) show that analysts will supplement firms' financial information by placing greater emphasis on their own private information when deriving their earnings forecasts, especially for high-technology manufacturing firms with large R&D expenditures (e.g., electronics, pharmaceuticals, and software). Finally, in their event study, Palmon and Yezegel (2012) show that analyst' recommendation revisions are more valuable for R&D-intensive firms. The cumulative average abnormal returns are significantly higher for upgrades concerning firms with high R&D intensity. For downgrades, the difference between both groups of firms is also significant. Overall, these studies suggest that greater effort made by analysts covering firms with large R&D investments will ultimately lead to the production of relevant information for investors in analyst reports.

3.2.1.3. Forecast errors

Even if analysts make greater efforts, they may nonetheless have major difficulties to assimilate additional information (Amir et al., 2003; Gu and Wang, 2005). To the best of our knowledge, no study has yet investigated target price errors for firms with large R&D investments (or for intangible intensive firms), but two studies focus on earnings forecast errors. Amir et al. (2003) compare analysts' forecasts for firms with and without R&D and show that earnings forecasts are more optimistic for companies with high R&D than for companies without R&D. Gu and Wang (2005) find a positive association between analysts' forecast error and the firm's intangible intensity that

deviates from the industry norm. Moreover, they also show greater forecast errors for firms with innovative technologies, because such technologies are associated with more uncertain prospects, but smaller errors for biotech/pharmaceutical and medical equipment firms that are subject to specific regulations.

3.2.2. The disclosure of relevant and specific non-financial information

3.2.2.1. The usefulness of non-financial information

One may argue that additional information could be provided voluntarily by managers to analysts and investors, in the absence of regulation. However, that is usually not the case for competitive and litigation reasons (Guo, Lev, and Zhou, 2004; Jones, 2007; Simpson, 2010; Palmon and Yezegel, 2012). Furthermore, analysts may face three issues when managers disclose non-financial information about R&D projects. First, all relevant information would probably not be disclosed because managers have incentives to disclose good news and withhold bad news (Dye, 2001). Second, such non-audited information would not be reliable and credible. Third, processing the non-standardized voluntary disclosure is costlier to analyze (Palmon and Yezegel, 2012), especially when it concerns pioneering innovations for which the economic consequences are difficult to estimate (Gu and Wang, 2005). Since analysts seek to optimize their efforts and their financial resources to perform their tasks, they prefer to focus on public and credible information, which is less costly to collect and to analyze.

3.2.2.2. Clinical trial disclosure in the pharmaceutical industry

In the pharmaceutical industry, which is highly regulated, the process of drug development is standardized, as shown in Appendix A and B. Pharmaceutical firms start with pre-clinical trials including animal testing. In case of success, they can start

clinical trials consisting of testing new drugs on human subjects to assess their effectiveness. There are three main phases (Phase I, II, III), which notably differ in terms of the number of people involved in drug testing. It usually takes about 6-7 years to pass these three steps. These clinical trials are registered in a database developed by the National Library of Medicine for the National Institute of Health, available to the public since 2000 (*ClinicalTrials.gov*). If Phase III is successful, the firm requests approval from the regulator to launch the new drug. Finally, the final post-development phase (Phase IV) consists of market monitoring (DiMasi et al., 1991; Petrova, 2014). A new drug advances into the next phase only if it successfully passes the previous phase. Thus, the probability of launching a new drug increases (i.e., uncertainty decreases) as it moves through different stages of clinical trials (Ely et al., 2003; Girotra, 2007). Disclosures about these phases reduce information asymmetry between managers and investors, as well as uncertainty regarding the future payoffs. Clinical trial disclosures are therefore very useful for analysts and investors (Ely et al., 2003; Girotra, 2007; Dedman et al., 2008; Hao et al., 2017).

3.2.2.3. The usefulness of clinical trial disclosures for investors and analysts

Some authors implement event studies to investigate the impact of new clinical trial disclosures on firm market value (Ely et al., 2003; Girtora et al., 2007; Dedman et al., 2008; Szutowski, 2018). Ely et al. (2003) focus on the various stages of product development and find a significant market response to clinical trial announcements in Phase II. They conclude that Phase II is the initial point at which investors have sufficient confidence that a new drug has reached a minimum potential for success, which leads to an increase in firm market value. Girotra et al. (2007) investigate failures in Phase III and find a negative and economically important market reaction to

such announcements. However, the impact of the failure is smaller when the firm is developing other projects for the same market as the failed project. Dedman et al. (2008) show that the drug development announcements have a greater impact on the market value than earnings announcements. They also note that firms announce more good news than bad news, and more news on late stage developments than on early ones. This pattern of disclosure, and the subsequent market reactions, varies between larger firms and their smaller counterparts. Finally, Szutowski (2018) finds that the market reaction is sensitive to the development stage as the stock returns are higher when the level of advancement is low, and smaller during the launch of new drug production for European biotechnology and pharmaceutical firms. Overall, these papers show that investors revise their expectations about the future cash-flows when uncertainty decreases.

To the best of our knowledge, only one paper focuses on the impact of such non-financial disclosure on the tasks performed by financial analysts. Hao et al. (2017) show that clinical trial disclosure improves earnings forecast accuracy, which suggests that clinical trial disclosures seem useful for assessing future payoffs of pharmaceutical companies.[22] We deepen their results by investigating whether new clinical trial disclosures impact analyst optimism for pharmaceutical firms. However, our paper differs in three dimensions. First, we focus on target prices, which reflect the fundamental value of firms and, therefore, encompasses a larger set of information than near-term earnings forecasts, especially the long term consequences of R&D

[22] Palmon and Yezegel (2012) indicate that investment banks hire analysts who possess industry-specific skills (e.g., many pharmaceutical analysts hold medical degrees), which allow them to understand scientific research, by reading publications and participating in academic conferences in the pharmaceutical field. Such industrial expertise helps them to better assess the consequences of R&D projects (i.e., the determination of the probability of success, its horizon, and the future payoffs expected).

projects and their impact on firm risk. Second, we focus on the impact of the three phases of clinical trials on analyst optimism and do not only consider an aggregate measure of drug development. Third, our research design allows us to better capture the causal relation between new clinical disclosures and revisions of target prices.

3.2.3. Hypotheses

As explained previously, clinical trial disclosures may reduce the information asymmetry and uncertainty about the future payoffs of the R&D project, especially when such disclosures concern the latest stage of drug development (Phase III). Two opposite arguments exist, however, regarding the impact of such relevant and specific non-financial disclosures on analyst optimism. On the one hand, it is possible that analysts formulate more accurate earnings and cash-flow forecasts when disclosures concern the latest phase of drug development because uncertainty is much lower and, therefore, it becomes easier to forecast future earnings, cash flows and stock prices.

On the other hand, the base-rate fallacy may exist among financial analysts. This fallacy reflects the tendency to ignore base-rate information (i.e., general information on the probability of success of clinical trials and its consequences on future cash flows in our case), and to focus on specific and relevant information (i.e., specific clinical trial disclosure in our case), rather than correctly integrating the two (Tversky and Kahneman, 1974; Bar-Hillel, 1980).

Behavioral economics has shown that individuals often use heuristics (i.e., decision-making based on simple, but imperfect, rules) in a context of uncertainty, which leads to errors. For instance, analysts frequently use (imperfect) multiples to value firms (Bradshaw et al, 2002; Asquith et al., 2005), or put too much weight on subjective probabilities to compute future earnings or cash flows when using the

discounted cash flow method to value firms (Green et al., 2016). We posit that financial analysts do not correctly take into account general information (based on historical data) regarding the probability of success and failure of clinical trials, when a firm announces the results of clinical trials. In this case, analysts may overestimate the probability of success of clinical trials in Phase III, which is usually higher than that of Phase I and II, and overestimate the probability of failure in the case of clinical trials in Phase I, which is usually higher than that of Phase II and Phase III. Thus, the argument of a base-rate fallacy among analysts leads us to formulate the two following directional hypotheses:

H1: Analyst optimism increases when clinical trial disclosure concerns the latest stage of drug development (Phase III).

H2: Analyst optimism decreases when clinical trial disclosure concerns the earliest stage of drug development (Phase I)

3.3. Research design

3.3.1. Sample

To select our sample, we identified all pharmaceutical and biotechnology firms listed on the major European and U.S. markets from 2011 to 2017. We start in 2011 to dismiss any possible effects of the financial crisis on analyst coverage. We matched this set of firms with the I/B/E/S database, which includes target prices for the period of interest. Firms without data in I/B/E/S are excluded, as well as target prices without a 12-month horizon. Moreover, we omit target price reiterations, as we investigate only target price revisions.[23] Financial data are extracted from *ThomsonReuters.* Finally, we used

[23] Analysts do not change (i.e., reiterate) their target prices in only 5% of cases, which is in conformity with prior literature (Bradshaw et al., 2019).

ClinicalTrials.gov to track the various stages of drug development of the selected firms.[24] *ClinicalTrials.gov* provides information on the treated disease, the type of interventions, number, age, and gender of participants, phase of the clinical trial, and finally the start and the completion date of the clinical trial. Appendix C provides some examples of clinical trial disclosure. For the purpose of our study, we are interested in the phase of drug development and the date of phase completion. We collected this information for all selected firms and kept only the completion of the phases that occurred during our period of interest.

The sample selection process, which is summarized in Table 1, resulted in the creation of a database including 11,450 clinical trial disclosures made by 148 unique pharmaceutical firms, followed by 221 financial analysts who issued 20,158 target prices between 2011 and 2017. Table 2 reports the sample distribution by year and by country.

Panel A in Table 2 shows an increase in the number of target prices and firms during our sample period. However, we observe a decreasing number of clinical trial disclosures, in total (from 2006 in 2011 to 1321 in 2017) and for each of the three phases. This negative trend may reflect the increased cost of drug development, which leads to a reduced number of products under development (DiMasi et al., 2007). As

[24] *ClinicalTrials.gov* was created to increase transparency and public access to clinical trials as a result of the Food and Drug Administration Modernization Act (FDAMA) of 1997. FDAMA required the U.S. Department of Health and Human Services (HHS) to establish a registry of clinical trials information for both federally and privately funded trials. NIH and FDA worked together to develop the database *ClinicalTrials.gov*, which was made available to the public in February 2000. Registration of clinical trial studies on *ClinicalTrials.gov* is regulated by Section 801 of the Food and Drug Administration Amendments Act (FDAAA) of 2007. FDAAA 801 obligates the responsible party to register the clinical trial information on the *ClinicalTrials.gov* no later than 21 calendar days after enrolling the first human subject in the study. Moreover, the regulation also orders the responsible party to submit the information on clinical trial achievement no later than 12 months after the primary completion date of the clinical trial. FDAAA 801 authorizes civil monetary penalties against responsible parties who fail to comply with registration and/or results submission requirements.

expected, clinical trials in Phase I are the most frequently reported, while Phase III are the least reported. Panel B describes the sample distribution per country.

[INSERT TABLE 1]

[INSERT TABLE 2]

3.3.2. Models

We develop the following model to test our hypothesis:

$$TP\_OPTIMISM_{i,j,t} = \beta_0 + \beta_1 Phase\_I_{i,t} + \beta_2 Phase\_II_{i,t} + \beta_3 Phase\_III_{i,t} + \beta_4 RD\_Sales_{i,t} + \beta_5 LogMV_{i,t} + \beta_6 MB_{i,t} + \beta_7 ROA_{i,t} + \beta_8 Leverage_{i,t} + \beta_9 DivYield_{i,t} + \beta_{10} Volatility_{i,t} + \beta_{11} RegQua_{i,t} + \beta_{12} RuleLaw_{i,t} + Year\_FE + Analyst\_FE + \varepsilon_{i,t} \quad (Eq.\ 1)$$

where *TP_OPTIMISM* measures analyst optimism. *Phase_I, Phase_II,* and *Phase_III* are the number of clinical trial disclosures in the three respective phases. All variables are defined in the next sub-sections. Since our hypothesis states that analyst optimism should be greater for clinical trial disclosure concerning later phases (because uncertainty is reduced), we expect: $\beta_1 < \beta_2 < \beta_3$.

3.3.3. Target price measures

To capture analyst optimism (*TP_OPTIMISM*), we follow Bradshaw et al. (2019) and use three different measures. To compute them, we define: TP, the target price; P_0, the actual stock price at the target price issue date; P_{12}, the actual stock price at the end of the 12-month forecast horizon.

Our *ex-ante* measure of analyst optimism is the implied return (*IMPLIED_RET*), computed as $(TP-P_0)/P_0$. Our first *ex-post* measure of analyst optimism is the signed target price error (*SIGNED_ERROR*), calculated as $(TP-P_{12})/P_0$. Our second *ex-post*

measure (*MET_TP*) is defined as the percentage of trading days with a *TP* higher than the stock price in the twelve months after *TP* forecast.[25]

Table 3 shows the descriptive statistics. Analysts expect an average increase in the stock price of 25% (with a median of 14%) within the next 12-months (*IMPLIED_RET*), which is line with previous studies (Bilinski et al., 2013; Bradshaw et al., 2013; Roger et al., 2018; Bradshaw et al., 2019). The average target price error (*SIGNED_ERROR*) is -3%, but the median is positive (+ 2%). Finally, 72% of the target prices are greater than the daily stock prices during the 12-month period after the issuance of the target price (*MET_TP).*

[INSERT TABLE 3]

3.3.4. Clinical trial disclosure

To understand the effect of clinical trial disclosure on target prices, we define three variables: *Phase_I,* the number of disclosures of Phase I completions that occurred between two reports of analyst j following firm i; *Phase_II,* the number of disclosures of Phase II completions that occurred between two reports of analyst j following firm i; *Phase_III,* the number of disclosures of Phase III completions that occurred between two reports of analyst j following firm i.

3.3.5. Control variables

Based on prior literature, we include a set of control variables that could affect target price forecasts (Amir et al., 2003; Brav and Lehavy, 2003; Asquith et al., 2005; Gu and Wang, 2005; Bonini et al., 2010; Demirakos et al., 2010; Bradshaw et al., 2013; Bilinski

[25] Since our paper focuses on a single industry, we no not control for the potential within-industry risk, as suggested by Bradshaw et al. (2019).

et al., 2013; Roger et al., 2018; Bradshaw et al., 2019; Kim et al., 2019).[26] *RD_Sales* is the ratio of R&D expenditures scaled by sales. *LogMV* is the natural logarithm of market capitalization. *MB* is the market-to-book ratio, equal to market capitalization to total equity. *ROA* is the operating income divided by total assets. *Leverage* is the ratio of total debt to total assets. *DivYield* is the ratio of dividend per share to share price. *Volatility* is the stock's average annual price movement to a high and low from a mean price for each year. *RegQua* captures the country's quality of policies and regulations. *RuleLaw* measures the extent of the country's quality of contract enforcement, property rights, and courts. We also include a set of year dummies for target price issue date (*Year_FE*), and a set of analyst dummies to control for analyst attributes (*Analyst_FE*), as Bilinski et al. (2013) and Bradshaw et al. (2013) suggest that some analysts have superior forecasting abilities.[27] All regressions use cluster standard errors at the analyst level. Table 3 shows the descriptive statistics and Appendix D provides the description of all variables.

3.4. Empirical results

3.4.1. Main results

3.4.1.1. Full sample

Table 4 shows a positive association between disclosure concerning later stages of drug development (Phase II and Phase III) and our ex-ante measure of analyst optimism (*IMPLIED_RET*), but a negative association for disclosure on earlier stages of drug development (Phase I). Thus, analysts are more (less) optimistic when the uncertainty

[26] Roger et al. (2018) argue that small price bias is an important determinant of analyst optimism. However, given that our sample contains only a very small fraction of observations having small stock prices, we do not control for the small price bias in this paper.
[27] Bilinski et al. (2013) and Bradshaw et al. (2013) find that analyst differential and persistent abilities increase TP accuracy.

related to R&D projects is low (high). Regarding the economic impact of disclosures on implied returns, we find a standardized effect of -5% or -6% for Phase I (depending on the inclusion or not of analyst fixed-effects in our regressions), and Phase II and Phase III have an effect of 3% or 4%.

[INSERT TABLE 4]

With *SIGNED_ERROR,* analysts are also more optimistic regarding Phase II and Phase III announcements, and more pessimistic regarding Phase I disclosure. However, Phase II is economically more important than Phase III (i.e., a standardized effect of Phase II of 7% versus 2% for Phase III). With *MET_TP*, the results are similar to those obtained with *SIGNED_ERROR*. Figure 1 shows the difference in implied returns over the period 2011-2017 for clinical trials in Phase I, II and III.

[INSERT FIGURE 1]

Overall, the main results on the full sample highlight that analysts are more optimistic (pessimistic) when the number of clinical trial disclosures concerning Phase III (Phase I) increases. Thus, this finding supports our two hypotheses. However, for Phase II, we find mixed results. Analyst optimism is greater (with our three measures), which supports the findings of Ely et al. (2003) on the importance of Phase II clinical trials for investor and firm market value.

3.4.1.2. Firm size

Our sample includes very large and small pharmaceutical firms. Our main results may be sensitive to firm size for two reasons. First, information asymmetry is negatively associated with firm size. To satisfy different investors' needs, large pharmaceutical firms (with diluted ownership) disclose more information than smaller pharmaceutical firms (with concentrated ownership). In addition, large pharmaceutical firms already

have a history of drug achievement, which makes it easier for financial analysts to provide accurate target prices.

To tackle this issue, we split our sample into two sub-samples based on market capitalization, total assets, as well as R&D expenses (PwC Strategy Innovation report, 2017). The large companies in the pharmaceutical industry are the following: Amgen, AstraZeneca, Bayer, Bristol-Myers, Celgene, Eli Lilly and Company, GlaxoSmithKline, Gilead Sciences, Johnson & Johnson, Merck, Novartis, Novo Nordisk, Pfizer, Roche, Sanofi, and UCB. The other firms are considered as small pharmaceutical firms.[28]

Table 5 provides results for the subsamples. For the group of large pharmaceutical firms, analysts are more optimistic for clinical trial disclosure concerning Phase III, and more pessimistic for Phase I. However, for the group of small firms, our results suggest that analysts are more optimistic only for Phase II disclosure, which supports the results of Ely et al. (2003) on the importance of Phase II for firm market value, especially for small non profitable firms. No significant result is found for Phase I and III.

[INSERT TABLE 5]

3.4.2. Additional results

3.4.2.1. Likelihood of success of clinical trials

Prior literature highlights that clinical trial outcomes (i.e., success or failure) matter for investors (Ely et al., 2003; Girotra et al., 2007; Dedman et al., 2008; Szutowski, 2018). Unfortunately, we are not able to analyze the effect of success or failure in clinical trials on analyst optimism because the *ClinicalTrials.gov* database does not

[28] Table 3 shows some differences between the two sub-samples. We show more clinical trial disclosure and less optimistic target prices for large pharmaceutical firms. In an additional test, we also split our sample into three groups of equal size (i.e., large, medium, and small firms), and we find similar results.

provide clear information on this outcome. To tackle this issue, we follow Ely et al. (2003) and Hao et al. (2017) by considering the probability of success of a firm's overall drug portfolio.

More precisely, Ely et al. (2003) and Hao et al. (2017) construct a measure (*DISC*), which is equal to the number of clinical trials times the pre-assigned success weight for each phase, deflated by the total assets. They note that the success rate is 24% for Phase I, 32% for Phase II, and 75% for Phase III. Since we focus on the number of clinical trial disclosures between two analyst reports, we compute *Drug_Portfolio* in the following way:

$$Drug\_Portfolio = \frac{Phase\_I * 0.24 + Phase\_II * 0.32 + Phase\_III * 0.75}{Phase\_I + Phase\_II + Phase\_III}$$

Drug_Portfolio is the sum of the clinical trial announcements between reports t0 and t+ 1 for analyst j, where each clinical trial is weighted according to its probability of success, and is deflated by the number of clinical trials announced. This approach leads to determine the impact of the change in the probability of success of the drug portfolio on analyst optimism. In our main model, we therefore replace our three variables *Phase_I*, *Phase_II,* and *Phase_III* by the aggregate variable *Drug_Portfolio*.

Table 6 indicates a positive and significant association between our three measures of analyst optimism (*IMPLIED_RET*, *SIGNED_ERROR*, and *MET_TP*) and *Drug_Portfolio.* The likelihood of success of a firm's drug portfolio increases analyst optimism by 4.4% to 11.8%. Thus, financial analysts incorporate the likelihood of success for clinical trial disclosure in the target prices. Overall, this finding supports our main results provided in Table 4, and our hypothesis.

[INSERT TABLE 6]

3.4.2.2. Analyst following

Our main result may be driven by the fact that the number of analysts changes over time. More precisely, it is possible that new analysts decide to follow a firm, especially large firms. If such analysts possess less experience or knowledge, this may affect target price errors. To tackle this issue, we follow Pae and Yoon (2012) and replicate our main analysis on a subsample of analysts that issue at least one report every year for a given firm.

Table 7 shows that the results obtained for this subsample are qualitatively similar to those observed for the full sample (in Table 4). Analysts are more optimistic for the later phases of drug development, and more pessimistic for clinical trial disclosure concerning *Phase_I*. Overall, the concern related to analyst following does not change our conclusions.

[INSERT TABLE 7]

3.4.2.3. Seasonality and frequency of analyst reports

Analysts may issue a new report more frequently following the announcements of quarterly earnings, which may lead to some seasonality issues. Figure 2 supports this idea. More analyst reports are issued during the first month of each quarter (i.e., January, April, July, October), and less reports are issued during the last month of each quarter (March, June, September, and December).

[INSERT FIGURE 2]

To tackle this issue of seasonality, we include month fixed effects in our regressions. Table 8 shows that our previous results remain unchanged for the *Phase_I*, *Phase_II*, and *Phase_III* variables with respect to TP optimism (*IMPLIED_RET*, *SIGNED_ERROR*, and *MET_TP*).

[INSERT TABLE 8]

We also consider the issue of the delay between analysts' reports by focusing on a sub-sample of 5,156 observations, which include analysts that issued at least two reports per year, within a period of 6 months. Thus, we exclude all analysts that do not issue a report on a regular basis. Our results in Table 9 support our hypotheses.

[INSERT TABLE 9]

3.4.2.4. Intensity of clinical trial disclosure

Finally, we also investigate the distribution of the number of clinical trial disclosures between two analyst reports. Our full sample is composed of: (1) 5,938 cases for which no announcement on clinical trials was made between reports t0 and t+ 1 for analyst j; (2) 3,833 cases for which only one announcement of either Phase I, Phase II, or Phase III was made between reports t0 and t+ 1 for analyst j; and (3) 10'387 cases for which at least two announcements (on Phase I, Phase II, or Phase III) were made between reports t0 and t+ 1 for analyst j. We re-estimate our analysis for this last group of reports (i.e., many announcements only). Table 10 shows that our main results still hold.

[INSERT TABLE 10]

3.5. Conclusion

This paper contributes to prior research showing that sell-side analysts issue optimistic target prices. We analyze whether the disclosure of relevant and specific non-financial information (i.e., clinical trial disclosure by pharmaceutical firms) impacts analyst optimism. In line with the well-known phenomenon called the base-rate fallacy (Tversky and Kahneman, 1974; Bar-Hillel, 1980), we expect that analysts issue more optimistic target prices after the disclosure of information concerning the

latest phase of drug development (Phase III), when the probability of success is higher, and more pessimistic target prices for clinical trials in Phase I, when the probability of failure is higher. Our results support our hypotheses.

Overall, our findings suggest that target prices are biased after the disclosure of specific and relevant non-financial information, which is a substitute to deficient annual reports regarding R&D investments by pharmaceutical firms.

Even if our research design is well suited to detect a causal relation between clinical trial disclosure and revisions of target prices, we acknowledge that other types of disclosure may influence our results. Future work is therefore needed to better understand how potential confounding events, which may not be fully captured in our paper, influence the association between clinical trial disclosure and analyst optimism. With this limitation in mind, we nevertheless hope that our findings are valuable for investors.

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Figure 1. Evolution of implied returns

Figure 1 shows the evolution of implied returns (IMPLIED_RET) for clinical trials in Phase I, II, and III during the period 2011–2017.

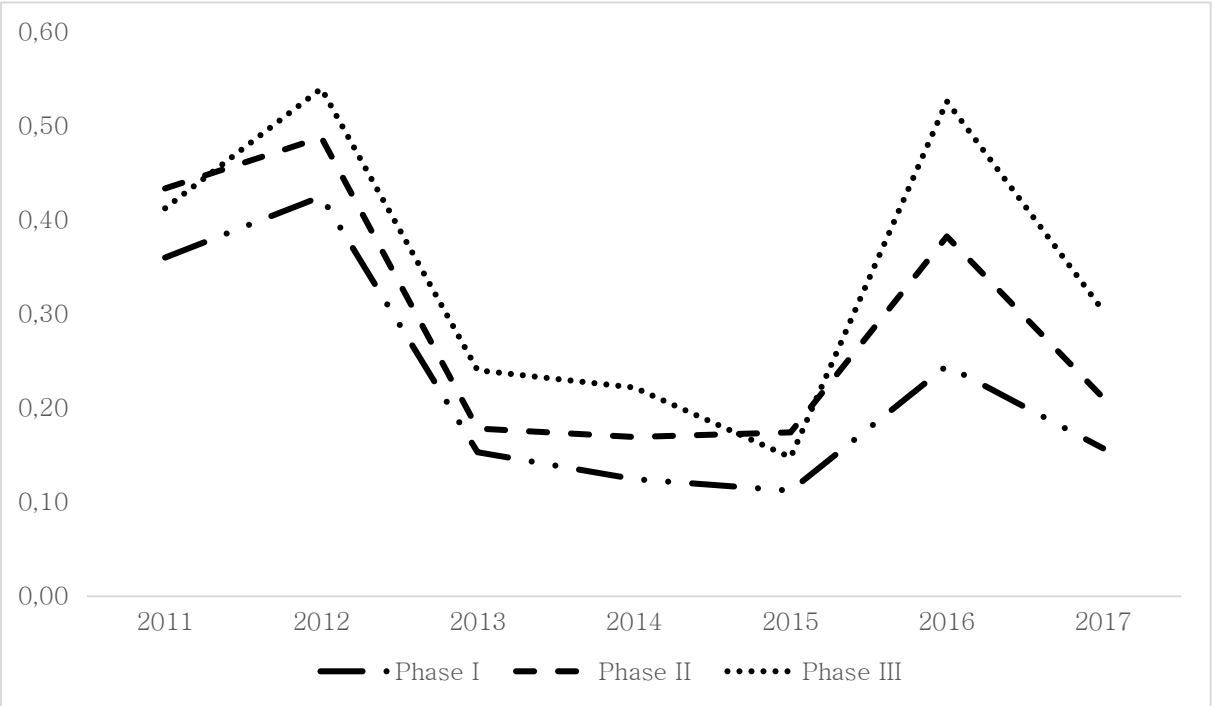

Figure 2. Distribution of analysts' reports

Figure 2 shows the number of analyst reports by month during the 2011-2017 period.

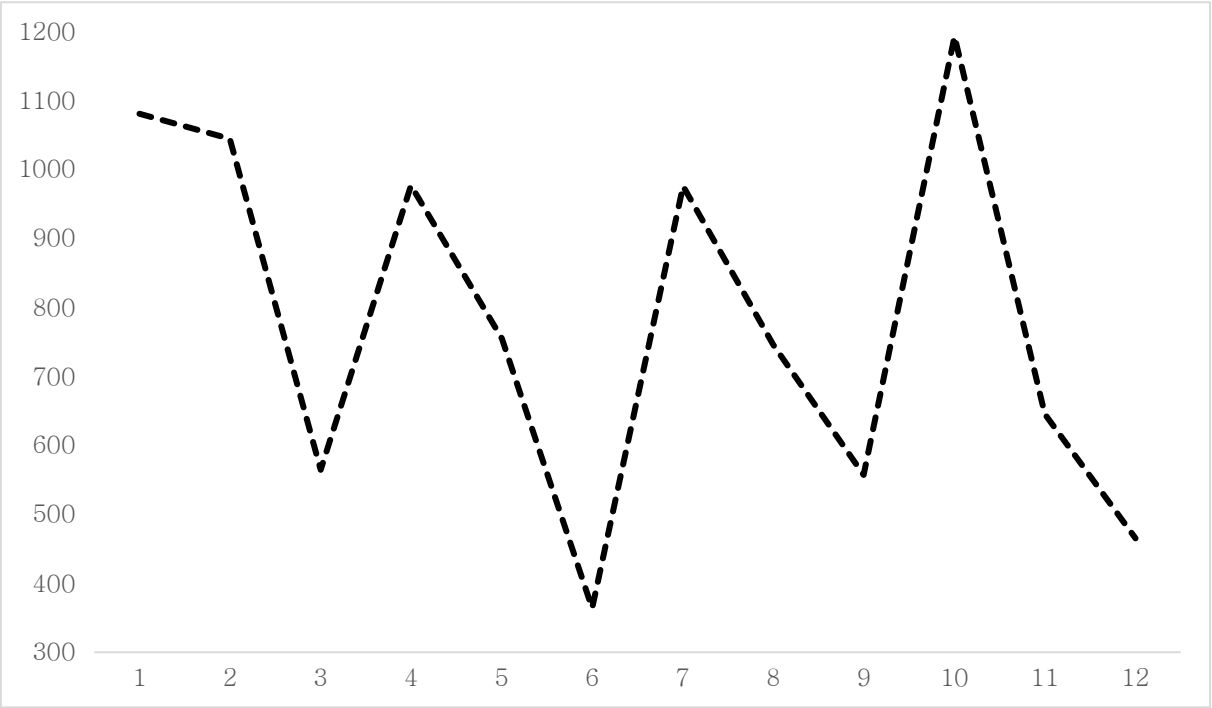

Table 1. Sample selection process

Sample selection criteria	Number of observations
All pharmaceutical and biotechnological firms followed by analysts in I/B/E/S target price database between January 2011 and December 2017	37'576
Less: Target prices without a 12-month forecast horizon	(6'837)
Less: Target prices in a different currency than stock price currency	(2'605)
Less: Observations with missing data from Worldscope	(4'327)
Less: Observations with missing data from *ClinicalTrials.gov*	(2'783)
Number of target price observations	**21'024**
Less: Observations for which target prices did not change	(866)
Final sample of target price observations	**20'158**
Number of firms	148
Number of analysts	221
Number of clinical trial disclosures	11'450

Table 2. Sample distribution

TP stands for the number of target prices; # of Firms is the number of unique firms; # of Analysts is the number of unique analysts; # of Phase I denotes the number of Phase I disclosures; # of Phase II denotes the number of Phase II disclosures; and # of Phase III denotes the number of Phase III disclosures.

Panel A. Sample distribution per year						
	# of TP	# of Firms	# of Analysts	# of Phase I	# of Phase II	# of Phase III
2011	2'364	97	132	803	675	528
2012	2'352	90	130	690	589	513
2013	3'178	106	120	615	537	529
2014	2'840	121	121	652	542	519
2015	2'920	123	116	521	474	470
2016	3'137	130	126	529	495	448
2017	3'367	130	129	520	423	378
Panel B. Sample distribution per country						
Belgium	367	2	31	77	47	65
Denmark	2'014	7	46	171	57	154
Finland	205	1	14	35	8	8
France	1'264	13	60	205	289	273
Germany	1'490	9	59	193	174	147
Italy	205	2	14	1	10	3
Netherlands	64	1	7	0	3	1
Norway	63	2	3	2	6	1
Switzerland	909	9	47	547	763	652
U.K.	1'045	12	68	847	519	535
U.S.	12'532	90	119	2'252	1'859	1'546
Total	*20'158*	*148*	–	*4'330*	*3'735*	*3'385*

Table 3. Descriptive statistics

Table 3 presents the descriptive statistics for our dependent and control variables for the full sample (Panel A), sample of large pharmaceutical firms (Panel B), and sample of small pharmaceutical firms (Panel C). All the variables are defined in Appendix D.

Panel A. Full sample					
	Mean	SD	25%	Median	75%
Dependent variables					
IMPLIED_RET	0.25	0.43	0.05	0.14	0.28
SIGNED_ERROR	-0.03	0.80	-0.26	0.02	0.29
MET_TP	0.63	0.46	0	1	1
Control variables					
RD_Sales	0.26	0.21	0.14	0.19	0.29
MarketValue (billions of $)	46.42	61.52	1.29	14.12	82.76
MB	5.53	5.50	2.69	4.65	9.25
ROA	-0.01	0.36	-0.07	0.08	0.18
Leverage	0.50	0.33	0.31	0.48	0.62
DivYield	1.25	1.73	0	0	2.42
Volatility	29.10	12.79	19.04	25.83	38.61
RegQua	1.46	0.23	1.27	1.46	1.63
RuleLaw	1.65	0.19	1.59	1.62	1.65
Panel B. Large pharmaceutical firms					
Dependent variables					
IMPLIED_RET	0.13	0.19	0.05	0.12	0.19
SIGNED_ERROR	-0.09	0.50	-0.18	-0.00	0.16
MET_TP	0.77	0.39	0.65	1	1
Control variables					
RD_Sales	0.18	0.06	0.14	0.16	0.20
MarketValue (billions of $)	112.82	60.37	67.89	103.30	139.70
MB	6.43	8.31	2.86	4.07	7.76
ROA	0.13	0.08	0.08	0.10	0.18
Leverage	0.59	0.13	0.48	0.59	0.65
DivYield	2.77	1.68	1.94	2.92	3.96
Volatility	17.63	3.98	14.18	16.71	20.82
RegQua	1.46	0.22	1.27	1.46	1.63
RuleLaw	1.64	0.12	1.60	1.62	1.64

Panel C. Small pharmaceutical firms					
Dependent variables					
IMPLIED_RET	0.29	0.46	0.05	0.17	0.36
SIGNED_ERROR	-0.05	1.17	-0.33	0.05	0.42
MET_TP	0.56	0.48	0	1	1
Control variables					
RD_Sales	0.38	0.21	0.18	0.36	0.62
MarketValue (billions of $)	15.78	28.57	0.71	2.97	16.64
MB	6.81	12.61	2.64	5.17	9.79
ROA	-0.05	0.34	-0.20	0.04	0.17
Leverage	0.45	0.30	0.27	0.38	0.54
DivYield	0.53	1.13	0.00	0.00	0.00
Volatility	34.13	11.65	24.30	31.93	41.65
RegQua	1.46	0.23	1.27	1.50	1.63
RuleLaw	1.65	0.21	1.60	1.62	1.65

Table 4. The effect of clinical trials on target price optimism

Table 4 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. *St.Eff.* are the standardized coefficients when variables are standardized so that their variances are equal to 1. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	IMPLIED RET				SIGNED_ERROR				MET_TP			
	Est.	*St.Eff.*	Est.	*St.Eff.*	Est.	*St.Eff.*	Est.	*St.Eff.*	Est.	*St.Eff.*	Est.	*St.Eff.*
Intercept	0.282**		-0.025		0.310		0.145		-2.215***		-2.212***	
	(0.016)		(0.829)		(0.456)		(0.721)		(0.180)		(0.171)	
Phase_I	-0.003***	*-6%*	-0.003***	*-5%*	-0.005***	*-4%*	-0.007***	*-5%*	-0.006***	*-8%*	-0.005***	*-9%*
	(0.000)		(0.000)		(0.001)		(0.000)		(0.001)		(0.001)	
Phase_II	0.003***	*4%*	0.002***	*3%*	0.010***	*7%*	0.010***	*7%*	0.003***	*5%*	0.002	*4%*
	(0.002)		(0.005)		(0.000)		(0.000)		(0.001)		(0.001)	
Phase_III	0.003***	*4%*	0.002***	*3%*	0.005**	*3%*	0.004**	*2%*	0.003***	*4%*	0.003***	*2%*
	(0.000)		(0.001)		(0.018)		(0.029)		(0.001)		(0.001)	
RD_Sales	0.000	*3%*	0.000	*0%*	0.000***	*4%*	0.000***	*3%*	-0.000	*-3%*	-0.000***	*-4%*
	(0.174)		(0.790)		(0.000)		(0.000)		(0.000)		(0.000)	
LogMV	-0.023***	*-10%*	-0.012	*-5%*	-0.021	*-4%*	-0.010	*-2%*	0.133***	*6%*	0.159***	*13%*
	(0.009)		(0.089)		(0.357)		(0.666)		(0.010)		(0.011)	
MB	0.000	*1%*	0.000	*2%*	0.000	*0%*	0.000	*1%*	0.000	*3%*	0.000	*2%*
	(0.477)		(0.358)		(0.525)		(0.201)		(0.000)		(0.000)	
ROA	-0.213***	*-15%*	-0.147***	*-10%*	-0.448***	*-12%*	-0.312***	*-9%*	-0.000	*-2%*	-0.010	*-3%*
	(0.000)		(0.000)		(0.000)		(0.000)		(0.020)		(0.019)	
Leverage	0.028	*2%*	0.005	*0%*	-0.197***	*-5%*	-0.191***	*-5%*	-0.097***	*-9%*	-0.071***	*-7%*
	(0.392)		(0.872)		(0.009)		(0.005)		(0.018)		(0.017)	
DivYield	0.012	*4%*	0.016**	*5%*	0.121***	*16%*	0.157***	*21%*	-0.070***	*-25%*	-0.077***	*-27%*
	(0.074)		(0.025)		(0.000)		(0.000)		(0.007)		(0.006)	
Volatility	0.011***	*27%*	0.010***	*23%*	0.023***	*22%*	0.021***	*20%*	0.000	*2%*	0.004***	*11%*
	(0.000)		(0.000)		(0.000)		(0.000)		(0.002)		(0.001)	
RegQua	0.055	*2%*	0.031	*1%*	-1.129***	*-20%*	-1.245***	*-22%*	0.544***	*26%*	0.374***	*18%*
	(0.557)		(0.567)		(0.000)		(0.000)		(0.090)		(0.085)	
RuleLaw	-0.051	*-2%*	0.012	*-0%*	0.321**	*5%*	0.517**	*8%*	0.061	*3%*	0.058	*2%*
	(0.483)		(0.834)		(0.048)		(0.014)		(0.101)		(0.077)	
Year FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Analyst FE	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES
Observations	20,158	20,158	20,158	20,158	20,158	20,158	20,158	20,158	20,158	20,158	20,158	20,158
Adj. R2	0.201	0.201	0.306	0.306	0.147	0.147	0.208	0.208	0.400	0.400	0.466	0.466

Table 5. The effect of clinical trials on target price optimism by comparing large and small pharmaceutical firms

Table 5 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	LARGE PHARMACEUTICAL FIRMS						SMALL PHARMACEUTICAL FIRMS					
	IMPLIED_RET		SIGNED_ERROR		MET_TP		IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	-0.484	-0.022	-7.246***	-6.818***	-4.054***	-3.757***	1.341***	0.904***	2.334***	2.784***	-2.460***	-2.448***
	(0.430)	(0.898)	(0.000)	(0.000)	(0.367)	(0.394)	(0.141)	(0.167)	(0.341)	(0.418)	(0.228)	(0.259)
Phase_I	-0.003***	-0.003***	-0.004***	-0.003***	-0.010***	-0.008***	-0.007	-0.005	-0.015	-0.009	-0.020***	-0.018***
	(0.001)	(0.007)	(0.000)	(0.006)	(0.001)	(0.001)	(0.004)	(0.004)	(0.008)	(0.010)	(0.003)	(0.003)
Phase_II	0.001	0.001	(0.000)	(0.000)	0.005***	0.003***	0.023***	0.018***	0.060***	0.043***	0.011***	0.017***
	(0.139)	(0.299)	(0.979)	(0.720)	(0.001)	(0.001)	(0.006)	(0.005)	(0.009)	(0.008)	(0.004)	(0.004)
Phase_III	0.003***	0.003***	0.003***	0.003***	0.005***	0.004***	0.005	0.001	0.007	0.005	0.005	0.002
	(0.000)	(0.000)	(0.009)	(0.007)	(0.001)	(0.001)	(0.004)	(0.004)	(0.007)	(0.007)	(0.003)	(0.004)
RD_Sales	-0.248	-0.183	-0.413	-0.257	0.898***	1.115***	0.000	-0.000	0.000***	0.000***	-0.001	-0.001***
	(0.084)	(0.087)	(0.096)	(0.287)	(0.114)	(0.115)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LogMV	0.059	0.020	0.421***	0.389***	0.306***	0.286***	-0.094***	-0.072***	-0.118***	-0.106***	0.157***	0.180***
	(0.159)	(0.175)	(0.000)	(0.000)	(0.020)	(0.023)	(0.012)	(0.010)	(0.021)	(0.023)	(0.013)	(0.014)
MB	0.000	0.000	-0.011***	-0.011***	0.006***	0.005***	0.000	0.000	0.000	0.000	-0.001***	-0.001***
	(0.677)	(0.728)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	-0.199***	-0.204***	-0.090	-0.010	0.339***	0.483***	-0.158***	-0.109***	-0.329***	-0.269***	-0.095***	-0.115***
	(0.007)	(0.004)	(0.446)	(0.931)	(0.110)	(0.106)	(0.037)	(0.034)	(0.062)	(0.059)	(0.033)	(0.030)
Leverage	0.407***	0.282***	1.564***	1.473***	0.144	0.141	-0.017	-0.028	-0.352***	-0.373***	-0.161***	-0.136***
	(0.001)	(0.002)	(0.000)	(0.000)	(0.089)	(0.100)	(0.036)	(0.035)	(0.085)	(0.077)	(0.019)	(0.017)
DivYield	-0.053***	-0.042***	0.059***	0.070***	-0.011	-0.018**	-0.013	-0.001	-0.016	0.057	-0.087***	-0.098***
	(0.001)	(0.000)	(0.002)	(0.000)	(0.009)	(0.008)	(0.008)	(0.008)	(0.027)	(0.030)	(0.011)	(0.011)
Volatility	-0.010**	-0.010**	0.008	0.007	0.019***	0.015***	0.013***	0.011***	0.016***	0.012***	-0.003	0.000
	(0.011)	(0.013)	(0.257)	(0.333)	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.002)	(0.002)
RegQua	-0.371***	-0.239***	-0.415**	-0.353**	1.419***	1.200***	0.176	0.239**	-1.757***	-2.128***	0.405***	0.190**
	(0.007)	(0.000)	(0.028)	(0.039)	(0.107)	(0.132)	(0.178)	(0.103)	(0.296)	(0.217)	(0.114)	(0.093)
RuleLaw	0.216	0.221	-0.704***	-0.696***	-2.121***	-1.953***	-0.244**	-0.239***	0.703***	1.011***	0.234**	0.289***
	(0.101)	(0.067)	(0.002)	(0.002)	(0.151)	(0.162)	(0.122)	(0.086)	(0.189)	(0.225)	(0.117)	(0.093)
Time FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Observations	3,547	3,547	3,547	3,547	3,547	3,547	16,611	16,611	16,611	16,611	16,611	16,611
Adj. R2	0.137	0.342	0.452	0.476	0.223	0.286	0.208	0.312	0.184	0.272	0.498	0.573

Table 6. The effect of firm drug portfolio on target price optimism

Table 6 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	0.279**	-0.024	0.357	0.178	-2.209***	-2.189***
	(0.117)	(0.117)	(0.388)	(0.386)	(0.174)	(0.165)
Drug_Portfolio	0.061***	0.049***	0.118**	0.089**	0.078***	0.063***
	(0.017)	(0.015)	(0.051)	(0.044)	(0.013)	(0.012)
RD_Sales	0.000	0.000	0.000***	0.000***	-0.000	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LogMV	-0.023***	-0.013	-0.017	-0.007	0.135***	0.160***
	(0.009)	(0.007)	(0.022)	(0.024)	(0.010)	(0.010)
MB	0.000	0.000	0.000	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	-0.215***	-0.148***	-0.457***	-0.319***	-0.005	-0.013
	(0.032)	(0.031)	(0.065)	(0.054)	(0.020)	(0.019)
Leverage	0.027	0.004	-0.195**	-0.191***	-0.099***	-0.072***
	(0.033)	(0.031)	(0.075)	(0.068)	(0.018)	(0.017)
DivYield	0.013	0.016**	0.131***	0.164***	-0.072***	-0.080***
	(0.007)	(0.007)	(0.014)	(0.019)	(0.006)	(0.006)
Volatility	0.011***	0.010***	0.023***	0.021***	-0.000	0.004**
	(0.002)	(0.002)	(0.005)	(0.004)	(0.002)	(0.001)
RegQua	0.052	0.023	-1.139***	-1.272***	0.524***	0.356***
	(0.093)	(0.054)	(0.191)	(0.144)	(0.090)	(0.085)
RuleLaw	-0.053	0.014	0.318	0.532**	0.075	0.067
	(0.072)	(0.056)	(0.164)	(0.210)	(0.101)	(0.075)
Time FE	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES
Observations	20,158	20,158	20,158	20,158	20,158	20,158
Adj. R2	0.200	0.306	0.145	0.206	0.398	0.464

Table 7. The effect of clinical trials on target price optimism by considering analysts issuing at least one report per year

Table 7 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	-0.149	-0.261	-1.663	0.205	-2.190***	-2.761***
	(0.458)	(0.179)	(0.109)	(0.834)	(0.358)	(0.425)
Phase_I	-0.004***	-0.004***	-0.013***	-0.015***	-0.008***	-0.007***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)
Phase_II	0.003***	0.002**	0.018***	0.019***	0.004***	0.003
	(0.009)	(0.048)	(0.000)	(0.000)	(0.002)	(0.002)
Phase_III	0.005***	0.003***	0.011***	0.009***	0.004**	0.004**
	(0.002)	(0.001)	(0.000)	(0.005)	(0.002)	(0.002)
RD_Sales	0.001	-0.001	0.001	0.000	-0.006***	-0.004**
	(0.509)	(0.459)	(0.449)	(0.898)	(0.001)	(0.002)
LogMV	-0.003	0.012	0.044	-0.071	0.125***	0.154***
	(0.806)	(0.094)	(0.425)	(0.219)	(0.020)	(0.022)
MB	0.002	0.002	0.002	0.002	0.003***	0.003***
	(0.162)	(0.155)	(0.307)	(0.269)	(0.001)	(0.001)
ROA	-0.199**	-0.126	-0.653***	-0.255	-0.015	-0.068
	(0.013)	(0.099)	(0.000)	(0.179)	(0.085)	(0.088)
Leverage	0.099	0.078	-0.099	-0.080	-0.187***	-0.189***
	(0.210)	(0.226)	(0.578)	(0.610)	(0.056)	(0.059)
DivYield	-0.001	-0.005	0.171***	0.190***	-0.047***	-0.043***
	(0.922)	(0.677)	(0.000)	(0.000)	(0.011)	(0.010)
Volatility	0.011	0.007	0.037***	0.017**	0.008**	0.014***
	(0.054)	(0.139)	(0.005)	(0.026)	(0.004)	(0.004)
RegQua	0.141	0.032	-1.308***	-1.457***	0.538***	0.525***
	(0.282)	(0.617)	(0.000)	(0.000)	(0.101)	(0.100)
RuleLaw	-0.094	-0.017	0.537***	1.060***	0.007	-0.144
	(0.252)	(0.828)	(0.010)	(0.000)	(0.111)	(0.104)
Year FE	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES
Observations	8,863	8,863	8,863	8,863	8,863	8,863
Adj. R2	0.123	0.278	0.182	0.326	0.315	0.400

Table 8. The impact of clinical trial disclosure on target price optimism by controlling for month fixed effects

Table 8 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	0.268***	0.011	0.364	0.184	-2.307***	-2.277***
	(0.099)	(0.098)	(0.349)	(0.338)	(0.187)	(0.175)
Phase_I	-0.002***	-0.002***	-0.005***	-0.006***	-0.006***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Phase_II	0.002**	0.001**	0.004**	0.003*	0.003***	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Phase_III	0.003***	0.002***	0.010***	0.009***	0.003***	0.003***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
RD_Sales	0.001*	0.001	0.000	0.000	-0.001***	-0.001***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
LogMV	-0.017**	-0.009	-0.034**	-0.034*	0.137***	0.162***
	(0.007)	(0.007)	(0.016)	(0.018)	(0.010)	(0.011)
MB	-0.001**	-0.001**	0.001	0.001	0.001***	0.001**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)
ROA	-0.236***	-0.171***	-0.582***	-0.390***	-0.024	-0.051
	(0.036)	(0.039)	(0.063)	(0.066)	(0.035)	(0.035)
Leverage	0.050	0.028	-0.118**	-0.100**	-0.154***	-0.122***
	(0.032)	(0.029)	(0.051)	(0.044)	(0.020)	(0.017)
DivYield	0.005	0.010*	0.103***	0.133***	-0.068***	-0.076***
	(0.005)	(0.006)	(0.010)	(0.013)	(0.007)	(0.006)
Volatility	0.009***	0.008***	0.015***	0.013***	0.001	0.004***
	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)	(0.001)
RegQua	0.025	0.032	-0.975***	-1.146***	0.535***	0.381***
	(0.061)	(0.045)	(0.150)	(0.132)	(0.091)	(0.085)
RuleLaw	-0.029	-0.005	0.383***	0.644***	0.084	0.063
	(0.060)	(0.052)	(0.126)	(0.179)	(0.104)	(0.078)
Time FE	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES
Observations	20,158	20,158	20,158	20,158	20,158	20,158
Adj. R2	0.260	0.358	0.200	0.248	0.406	0.470

Table 9. The impact of clinical trial disclosure on target price optimism by considering the delay of analyst reports

Table 9 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

VARIABLES	IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	-0.763	-0.234	-4.129***	-3.841***	-7.365***	-6.621***
	(0.472)	(0.263)	(0.408)	(0.423)	(0.736)	(0.629)
Phase_I	-0.003***	-0.003***	-0.015***	-0.013***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Phase_II	0.001*	0.001	0.004**	0.003	-0.004**	-0.004*
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Phase_III	0.002***	0.003***	0.008***	0.005**	0.006***	0.005***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
RD_Sales	-0.295***	-0.239***	0.898***	1.087***	-0.459***	-0.318**
	(0.101)	(0.077)	(0.113)	(0.114)	(0.149)	(0.142)
LogMV	0.069**	0.032*	0.306***	0.287***	0.438***	0.398***
	(0.030)	(0.019)	(0.022)	(0.024)	(0.047)	(0.041)
MB	0.001	0.001	0.005***	0.004***	-0.010***	-0.010***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
ROA	-0.149***	-0.130**	0.412***	0.541***	-0.279**	-0.228*
	(0.051)	(0.051)	(0.129)	(0.124)	(0.109)	(0.117)
Leverage	0.395***	0.298***	0.207*	0.235*	1.700***	1.610***
	(0.068)	(0.060)	(0.121)	(0.130)	(0.181)	(0.186)
DivYield	-0.045***	-0.035***	0.001	-0.006	0.028***	0.031***
	(0.009)	(0.008)	(0.011)	(0.010)	(0.009)	(0.010)
Volatility	-0.005**	-0.005**	0.021***	0.017***	0.002	-0.001
	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
RegQua	-0.415***	-0.318***	1.414***	1.216***	-0.398***	-0.327***
	(0.093)	(0.060)	(0.124)	(0.157)	(0.097)	(0.087)
RulefLaw	0.247**	0.248***	-2.124***	-1.994***	-0.739***	-0.733***
	(0.105)	(0.092)	(0.171)	(0.188)	(0.178)	(0.177)
Time FE	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES
Observations	5,156	5,156	5,156	5,156	5,156	5,156
Adj. R2	0.140	0.295	0.235	0.292	0.455	0.476

Table 10. The impact of clinical trial disclosure on target price optimism by focusing on the cases of multiple disclosures

Table 10 shows the results for *IMPLIED_RET*, *SIGNED_ERROR*, *MET_TP*. All variables are described in Appendix D. Depending on specification, the model includes year and analyst fixed effects. Standard errors are clustered at the analyst level. *** and ** represent significance at 0.01 and 0.05 level.

	IMPLIED_RET		SIGNED_ERROR		MET_TP	
Intercept	-0.431***	-0.361**	-1.933***	-1.362***	0.007	0.327*
	(0.145)	(0.158)	(0.518)	(0.500)	(0.165)	(0.188)
Phase_I	-0.002***	-0.002***	-0.005***	-0.006***	0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Phase_II	0.001	0.001	0.009***	0.009***	-0.001	-0.000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Phase_III	0.002***	0.002***	0.002	0.002	0.001**	0.002**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
RD_Sales	0.000	0.000	0.000***	0.000**	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
LogMV	0.020***	0.017***	0.075***	0.058*	0.053***	0.052***
	(0.005)	(0.005)	(0.025)	(0.030)	(0.007)	(0.008)
MB	0.000	0.000	-0.001**	-0.001**	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	-0.174***	-0.139***	-0.197***	-0.100	-0.114***	-0.100**
	(0.039)	(0.037)	(0.074)	(0.081)	(0.036)	(0.041)
Leverage	-0.010	-0.012	0.085	0.117	0.043*	0.042
	(0.032)	(0.031)	(0.091)	(0.088)	(0.024)	(0.026)
DivYield	0.001	0.004	0.153***	0.170***	-0.014**	-0.010
	(0.007)	(0.008)	(0.013)	(0.015)	(0.007)	(0.007)
Volatility	0.013***	0.011***	0.035***	0.032***	0.004***	0.004**
	(0.003)	(0.002)	(0.005)	(0.005)	(0.001)	(0.001)
RegQua	-0.069	-0.059	-0.825***	-0.940***	0.035	0.084
	(0.043)	(0.051)	(0.135)	(0.169)	(0.051)	(0.054)
RuleLaw	0.065	0.106	-0.099	0.276	-0.191**	-0.243**
	(0.049)	(0.084)	(0.133)	(0.253)	(0.076)	(0.100)
Time FE	YES	YES	YES	YES	YES	YES
Analyst FE	NO	YES	NO	YES	NO	YES
Observations	10,387	10,387	10,387	10,387	10,387	10,387
Adj. R2	0.153	0.212	0.204	0.221	0.068	0.101

Appendix A. Research and development process

Pre-development	Development			Post-development
Drug discovery & Animal testing	Clinical trials			FDA review & Post-market monitoring
	Phase 1	Phase 2	Phase 3	
3-6 years	6-7 years			0.5-2 years

Note: This figure is adapted from Petrova (2014).

Appendix B. Clinical trial specificities

	Phase I	Phase II	Phase III
Panel A. Phase specifications			
Number of participants	20-100 volunteers	100-500 volunteers	1000-5000 volunteers
Goal of the study	Evaluates safety and side effects	Efficacy at treating the disease	Larger scale efficacy and safety evaluation
Panel B. Phase economics			
Part of R&D expenses	≈ 8%	≈ 15%	≈ 35%
Mean cost (millions $)	32.28	37.69	96.09
Transition probability	24%	32%	75%

Adapted from: DiMasi (2001); DiMasi and Grabwoski, 2007; PhRMA Pharmaceutical Industry Profile, 2011; Elina Petrova, Innovation in the Pharmaceutical Industry: The Process of Drug Discovery and Development (2014).

Appendix C. Examples of clinical trial disclosures available on *ClinicalTrials.gov*

Sponsor	Title of the study	Treated condition	Drug intervention	Outcome Measures	Age	Phase	# of Patients	Start Date	Completion Date
AstraZeneca	A Single Dose PD & PK Study With Two Formulations of Abediterol in Patients With Asthma	Asthma	Drug: Abediterol 0.156 µg|Drug: Abediterol 2.5 µg|Drug: Abediterol 0.05 µg|Other: Placebo	Change From Baseline in Trough Forced Expiratory Volume in 1 Second (FEV1)	18 Years to 75 Years (Adult, Older Adult)	Phase 1	30	June 21, 2016	Nov. 29, 2016
Bayer	Phase II Copanlisib in Relapsed/Refractory Diffuse Large B-cell Lymphoma (DLBCL)	Diffuse, Large B-Cell, Lymphoma	Drug: Copanlisib (Aliqopa, BAY80-6946)	Objective Response Rate (ORR) in Total Population Based on Investigator Assessment|ORR by CD79b Status Based on Investigator Assessment	18 Years and older (Adult, Older Adult)	Phase 2	67	May 8, 2015	Jan. 19, 2018
Eli Lilly and Company	Evaluation of Galcanezumab in the Prevention of Chronic Migraine	Chronic Migraine	Drug: Galcanezumab|Drug: Placebo	Overall Mean Change From Baseline in the Number of Monthly Migraine Headache Days (MHD)|Number of Participants With Reduction From Baseline ≥50%, ≥75% and 100% in Monthly Migraine Headache Days	18 Years to 65 Years (Adult, Older Adult)	Phase 3	1113	November 30, 2015	May 3, 2021
Guerbet	Safety and Efficacy Evaluation of DOTAREM® in MRI of Central Nervous System (CNS) Lesions	Diagnostic Self Evaluation|Central Nervous System Diseases	Drug: Dotarem (gadoterate meglumine)|Drug: Magnevist (gadopentetate dimeglumine)	MRI Lesion Visualization (Border Delineation, Internal Morphology and Contrast Enhancement) at Patient Level for Both "Pre" and "Paired" Evaluation	2 Years and older (Child, Adult, Older Adult)	Phase 3	416	September 21, 2010	Nov. 14, 2011
Ipsen	Dysport® Pediatric Lower Limb Spasticity Study	Cerebral Palsy|Muscle Spasticity|Children	Drug: Botulinum type A toxin (Dysport®)|Drug: Placebo	Change in MAS Score in the Gastrocnemius-soleus Complex (GSC) at the Ankle Joint of the (Most) Affected Lower Limb	2 Years to 17 Years (Child)	Phase 3	241	July 12, 2011	June 3, 2014
MorphoSys	Study of Fc-Optimized Anti-CD19 Antibody (MOR00208) to Treat B-cell Acute Lymphoblastic Leukemia(B-ALL)	Acute Lymphoblastic Leukemia	Drug: MOR00208 (formerly Xmab5574)	Overall Response Rate (ORR)|Patients Response Duration Evaluation by Hematology, Bone Marrow Aspirates or Biopsy, CT	16 Years and older (Child, Adult, Older Adult)	Phase 2	22	April 17, 2013	March 28, 2015
Novartis	Efficacy and Safety of SPA100 (Fixed-dose Combination of Aliskiren/Amlodipine) in Patients With Essential Hypertension	Essential Hypertension	Drug: Aliskiren/Amlodipine 150/2.5 mg|Drug: Aliskiren/amlodipine 150/5 mg	Change From Baseline in Mean Sitting Diastolic Blood Pressure (msDBP) to End of Study (Week 8)	20 Years and older (Adult, Older Adult)	Phase 3	1342	October 11, 2010	May 18, 2011
Sanofi	Comparison of a New Formulation of Insulin Glargine With Lantus in Patients With Type 1 Diabetes Mellitus on Basal Plus Mealtime Insulin	Type 1 Diabetes Mellitus	Drug: HOE901-U300 (new formulation of insulin glargine)|Drug: Lantus (insulin glargine)	Percentage of Time in Target Plasma Glucose Range (4.4-7.8 mmol/L [80-140 mg/dL])	18 Years to 70 Years (Adult, Older Adult)	Phase 2	59	August 19, 2012	May 2, 2013

Appendix D. Variable definitions

This table presents the definitions of the variables used in our study. We divide the variables into three categories: (1) dependent variables; (2) independent variables of interest; and (3) control variables.

Variable	Definition
PANEL A. Dependent variables	
IMPLIED_RET	The ratio of target price issued by analyst *j* on firm *i* in period *t* divided by the stock price of firm *i* in period *t*, minus 1.
SIGNED_ERROR	The difference between the target price and the actual stock price at the end of the 12-month forecast horizon, scaled by the stock price at the target price issue date.
MET_TP	The percentage of trading days that a stock price is lower than target price in the twelve months after target price issue date.
PANEL B. Independent variables	
Phase_I	Number of completed products in Phase I between reports t0 and t+ 1 of analyst j that follows firm i.
Phase_II	Number of completed products in Phase II between reports t0 and t+ 1 of analyst j that follows firm i.
Phase_III	Number of completed products in Phase III between reports t0 and t+ 1 of analyst j that follows firm i.
Drug_Portfolio	The sum of the clinical trial announcements between reports t0 and t+ 1 of analyst j, where each clinical trial is weighted according to its potential for success as per DiMasi (2001), deflated by the number of clinical trial announcements.
PANEL C. Control variables	
RD_Sales	R&D expenditures scaled by sales.
LogMV	Natural logarithm of the firm's market capitalization.
MB	Market-to-book ratio, measured as the ratio of market capitalization to total common equity.
ROA	Return-to-assets, defined as operating income divided by total equity.
Leverage	Ratio of total debt to total assets.
DivYield	Ratio of dividend per share to share price.
Volatility	Measure of a stock's average annual price movement to a high and low from a mean price for each year.
RegQua	Captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Ranges from -2.5 (weak) to 2.5 (strong).
RuleLaw	Captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular, the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Ranges from -2.5 (weak) to 2.5 (strong).
Year_FE	Year dummies for target price issue year.
Analyst_FE	Analyst dummies for specific target price issue analyst.

Conclusion

Innovation in the pharmaceutical industry is critical for the treatment of diseases and improving human well-being. To produce new drugs, pharmaceutical firms engage in risky and long-term R&D investments.

This thesis contributes to the debate on the determinants and consequences of R&D investments, by providing some insights on: 1) the influence of corporate governance on R&D strategy; 2) the market reaction to various strategic choices; 3) the reaction of financial analysts to clinical trial disclosure.

In the first chapter, we investigate whether the implementation of R&D committee at the board level impacts R&D strategy. We find a positive association between the existence of a R&D committee and R&D intensity, the numbers of products in clinical trial development, approved drugs by the regulator, and acquisitions of pharmaceutical firms.

In the second chapter, we investigate whether the existence of a R&D alliance impacts the market reaction to clinical trial announcements by large pharmaceutical firms and whether the market reaction differs for alliances with large and small firms. We find that R&D alliances with small firms are not perceived as beneficial to investors of large pharmaceutical firms, when compared with alliances with other large firms or with the absence of an alliance.

In the third chapter, we investigate whether the disclosure of specific non-financial information (i.e., clinical trial disclosure) impacts analysts' optimism in the pharmaceutical industry. We find that Phase III disclosures lead to more optimistic target prices, whereas Phase I disclosures lead to more pessimistic target prices,

which suggests that target prices are biased after the disclosure of that specific non-financial information by pharmaceutical firms.

This thesis provides some original results, but there are still many interesting topics to explore. For instance, it has been documented that the board of directors may influence R&D investments (e.g., Adams et al., 2010; Dalziel et al., 2011). However, little is known on the interaction between compensation incentives (i.e., long term compensation of CEOs) and monitoring of CEOs by boards of directors. Furthermore, the role of the chief scientific officer (CSO) could be also examined. Given that many pharmaceutical firms have a CSO within their top management team, it could be interesting to examine the influence of the CSO on the R&D strategy proposed by the CEO and the board of directors. Finally, it could be interesting to analyze whether specific characteristics of financial analysts (e.g., previous experience in a pharmaceutical firm, scientific background) impact their ability to forecasts earnings, cash flows, and target prices of pharmaceutical firms.

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