ARE ALL INDEPENDENT DIRECTORS CREATED EQUAL? DO THEIR PROFESSIONAL BACKGROUNDS INFLUENCE FIRMS' FINANCIAL DISCLOSURES? EVIDENCE FROM BIOTECHNOLOGY FIRMS

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Are all independent directors created equal? Do their professional backgrounds influence firms' financial disclosures? Evidence from biotechnology firms

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Abstract

The empirical evidence on the association between board structure and firms' voluntary disclosures is mixed and controversial. We extend the literature by arguing that independent directors do not represent a homogeneous group of people, as previously considered. We hypothesize that the professional backgrounds of independent directors shape their assessments of costs and benefits related to disclosure of information that potentially reduces agency costs but also lessens firms' competitive advantages. Using hand-collected data from a sample of biotechnology firms, we find results consistent with this idea. Particularly, firms whose independent directors provide links to the wider social community, but lack functional or business experience, more frequently disclose proprietary information. We find opposite results for the firms whose independent directors possess significant functional expertise. We conclude that all independent directors are not equal in their influence on firms' disclosure policies. Our study has several policy implications.

JEL classification: M40, M41, G14, G32, G34

Keywords: Biotechnology firms, Corporate governance, Voluntary disclosures, Proprietary costs, Independent directors' professional background

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Are all independent directors created equal? Do their professional backgrounds influence firms' financial disclosures? Evidence from US biotechnology firms

1. Introduction

The literature argues that the board of directors and corporate disclosure are two potential mechanisms to mitigate agency conflicts between managers and shareholders (Lambert, 2001).[1] Independent directors mitigate managers' opportunistic actions, reducing managers' incentives to withhold information and, as such, improving the quality of firms' financial disclosures.[2] However, firms' voluntary disclosures are not costless, as they impose proprietary costs. Specifically, certain disclosures reduce agency costs but also lessen firms' competitive advantages, by revealing sensitive information to firms' suppliers, competitors, regulators, and employees (Dye, 1985).

A large body of literature, however, finds mixed and often controversial evidence on the association between independent directors and corporate disclosures. This literature broadly classifies all independent directors into one category and treats them as a homogeneous group of people. We argue that the professional backgrounds of independent directors matter in their governance roles (Baysinger and Hoskisson, 1990; Hillman et al., 2000). Specifically, the independent directors' assessments of costs and benefits of firms' proprietary disclosures could differ depending on their professional backgrounds. We examine this hypothesis in a setting characterized by both high agency costs and high proprietary costs, and we find results consistent with our hypothesis. Accordingly, we extend the literature by showing that the association between governance and disclosure is shaped by independent directors' professional backgrounds.

Eng and Mak (2003) and Gul and Leung (2004) find a negative association between the proportion of outside directors and the amount of corporate voluntary disclosures. In contrast, Cheng and Courtenay (2006), Leung and Horwitz (2004), Cerbioni and Parbonetti (2007), and Li

[1] See Jensen and Meckling (1976), Fama (1980), Fama and Jensen (1983), and Williamson (1981).
[2] See Fama (1980), Leftwich et al. (1981), Fama and Jensen (1983), and Ajinkya et al. (2005).

et al. (2008) find a positive association. These differences could be driven by both the presence of proprietary costs and the differences in independent directors' professional experiences. Our motivation comes from Westphal and Milton (2000), who show that professional experience affects the directors' role in setting common objectives for the board of directors and in the novel perspectives they offer to company management; Kosnik (1987) and Kaplan and Reishus (1990), who find that directors' wider experience and expertise affect their incentives to monitor management; and Hillman et al. (2000), who show that the professional experience of independent directors affects firms' regulatory compliances.

We hypothesize that the mixed results on the association between independent directors and corporate disclosures could reflect the failure to consider the professional backgrounds of these directors. Thus, following Baysinger and Hoskisson (1990) and Hillman et al. (2000), we classify independent directors into business experts (*BussExp*), support specialists (*SuppSpec*), and community influentials (*CommInfl*). Business experts are current or past senior officers of other companies. They facilitate executive decision making and act as a sounding board for major policy decisions. Support specialists (e.g., scientists and lawyers) are experts in functional areas but lack business experience at an executive level. And community influentials (e.g., professors and retired politicians) exert significant influence over the members of the community and provide links with government and regulatory bodies, but they lack general business experience. We hypothesize that these three types of independent directors affect firms' disclosure strategies differently because, due to their diverse professional backgrounds, they assess the costs and benefits of firms' proprietary disclosures differently (Kosnik, 1987; Kaplan and Reishus, 1990).

We examine our research question using hand-collected data on product-related disclosures of biotechnology firms. We are guided by Guo, Lev, and Zhou (2004, p. 320), who argue: "The unusually fast innovation pace in the biotech sector and the low barriers to entry enhance competition and the consequent proprietary costs of disclosure, as well as create large information

asymmetries between managers and investors, which increase the benefits of disclosure." Moreover, they argue that biotechnology firms are characterized by a high level of innovation and large initial losses, especially if their research and development (R&D) activities are oriented toward products in the initial stages of development ("preclinical" products). As such, these firms find obtaining debt financing difficult. Thus, they typically fund their losses and research projects by equity financing. But equity investors in these firms demand detailed disclosures on the progress of the research projects to reduce agency costs as well as to take prompt investment and divestment decisions. However, per US GAAP, biotechnology firms cannot credibly disclose the value of their in-house investments in intangible assets via the capitalized asset category. Arguably, the firms could partly convey this information via their narrative disclosures in annual reports (for example, a product's progress from the preclinical phase to the clinical trial stage). Therefore, their narrative disclosures assume paramount importance and are often the only credible source of information on firms' future prospects in financial statements. Yet, these disclosures might impose proprietary costs because they could reduce firms' competitive advantages (Jones, 2007).

Consequently, the biotechnology sector provides a unique setting to test the role of independent directors and their professional backgrounds on the disclosures that potentially impose proprietary costs. We follow Guo et al. (2004) in determining the quality of biotechnology firms' narrative disclosures via a disclosure index. This index measures whether and how firms reveal the stage of the development of the product, the diseases that the product potentially treats, and the product formula. Guo et al. (2004) find significant differences between disclosures related to preclinical and clinical products, representing products under development and developed products, respectively.[3] Accordingly, Guo et al. (2004) conclude that proprietary costs are one of the main forces driving the disclosure policies of R&D–intensive firms. Following, Guo et al.

[3] This product classification is consistent with the US Food and Drug Administration (FDA) classification. A successful drug goes through three phases of clinical trials (on humans), after the efficacy of the compound is assessed in the preclinical stage. The probability of a chemical compound making it through from discovery to final commercialization is assessed at about one in five thousand (Healy et al., 2002)

(2004), we estimate the overall disclosure index by first separately estimating the disclosure indices for preclinical and clinical products and then summing them up. In our first set of tests, we find univariate statistics of the disclosure index and its association with product mix to be similar to Guo et al. (2004). This supports the validity of our disclosure index.

Consistent with prior findings, we make no prediction about the association between the disclosure index and the proportion of independent directors on firms' boards. Yet we hypothesize that the three types of independent directors (*BussExp, SuppSpec, CommInfl*) are associated differently with the two types of firm disclosures (those that do and do not impose a proprietary cost). That is, compared with firms with community influentials (those who lack business experience), firms with support specialists (who potentially understand the damage that the disclosures of proprietary information can cause) are more cautious in disclosing information on preclinical products. Thus, we expect no significant differences between the two types of independent directors' influence on disclosures related to clinical products (their disclosures impose less competitive costs). However, we expect significant difference between the two types of independent directors' influence on disclosures related to preclinical products (which impose significant competitive costs). This is the main thesis of our study.

Consistent with the literature, we find no significant association between the overall disclosures and the proportion of independent directors on the board. Further, we find no significant association between the disclosures of clinical products and the three types of independent directors. However, firms with community influentials disclose significantly more information about preclinical products than the other firms. In contrast, firms with support specialists disclose significantly less information about preclinical products than the other firms. Our results are consistent with the idea that firms with support specialists are more cautious with respect to proprietary disclosures. Our results also support the idea that community influentials assess the costs and benefits of proprietary disclosures differently than the other independent

directors. We find similar results by bifurcating disclosures into those related to technology versus market aspects of the products. Thus, we conclude that the professional backgrounds of independent directors matter when it comes to disclosures of firms' proprietary information. This is our main conclusion and contribution to the literature.[4]

We hesitate to assign causation because our results are consistent with at least two explanations. First, the professional backgrounds of independent directors' influence their assessments of costs and benefits of firms' proprietary disclosures. These directors thus shape their firms' disclosure policies accordingly. Second, firms select their governance structure according to their corporate and disclosure policies. Arguably, firms with higher (lower) proprietary costs of disclosures choose a higher proportion of support specialists (community influentials). Our tests cannot completely distinguish between these two explanations. However, we find no association between board structure and firms' product mix, which is inconsistent with the second explanation. Therefore, we lean toward the first explanation in our exposition, based on the argument that the principal role of board of directors is to reduce agency conflicts between management and shareholders and that independent directors influence firms' disclosure decisions (Fama, 1980; Leftwich et al., 1981; Fama and Jensen, 1983; Ajinkya et al., 2005).

We contribute to the literature on governance and disclosure by showing that the professional backgrounds of independent directors is a significant factor in firms' proprietary disclosures (e.g., Forker, 1992; Hossain et al., 1995; Chen and Jaggi, 2000; Hannifa and Cooke, 2002; Eng and Mak, 2003; Gul and Leung, 2004; Ajinkya et al., 2005; Karamanou and Vafeas, 2005; Cheng and Courtenay, 2006; Cerbioni and Parbonetti, 2007; Lim et al., 2007). Our study has at least two policy implications. It suggests that organizations representing minority shareholder interests and seeking to promote corporate governance, such as the California Public Employees' Retirement System (CalPERS) and Institutional Shareholder Services (ISS), must

[4] However, we find no significant association between business experts and proprietary disclosures.

consider the professional backgrounds of independent directors in their shaping of investee firms' governance structures. Our study also suggests that regulatory bodies [such as the Securities and Exchange Commission (SEC)] might demand the reporting of independent directors in different classifications based on their professional backgrounds. In addition, our findings indicate that any future study examining the effects of independent directors must explicitly consider the differences between their professional backgrounds. Otherwise, erroneous conclusions could be reached.

The remainder of the paper proceeds as follows. The next section reviews the literature on corporate governance and voluntary disclosure. Section 3 describes sample selection and measurement of variables. Section 4 reports the results of the study, and Section 5 concludes.

2. Literature review and motivation of hypothesis

The literature considers both governance and financial disclosures as mechanisms to reduce agency costs. Moreover, the literature shows that the professional background of an independent director influences her ability and incentives to monitor managers. In addition, the literature suggests that voluntary disclosures are related to the governance structure and the managers' assessments of trade-offs between the costs and benefits of making these disclosures voluntarily.

2.1. Voluntary disclosures

The literature identifies conditions under which firms voluntarily disclose all of their private information (Grossman and Hart, 1980; Grossman, 1981; Milgrom, 1981; Milgrom and Roberts 1986). This "unraveling result" predicts that investors would rationally infer that if managers do not disclose any information, then that information would have caused investors to revise their beliefs about firm value downward. Consistent with this prediction, theoretical and empirical studies show that voluntary disclosures reduce firms' cost of capital (Barry and Brown, 1985; Botosan, 1997; Sengupta, 1998; Easley and O'Hara, 2004; Hughes et al., 2007), improve

firm valuation and stock liquidity (Diamond and Verrecchia, 1991; Kim and Verrecchia, 1994; Healy et al., 1999), and increase shareholders' wealth.

The first condition used to derive the unraveling result is that all disclosures be costless. Some disclosures, however, impose proprietary costs (Dye, 1985, 1986; Darrough and Stoughton, 1990; Wagenhofer, 1990; Prencipe, 2004; Skinner, 1994; Leuz and Verrecchia, 2000). For example, disclosures reduce firms' competitive advantage by providing proprietary information to other players in product markets, labor unions, and regulators. Thus some disclosures impose both costs and benefits. Hence, despite investors' viewing nondisclosures as bad news, managers might not disclose news if they can achieve higher payoffs by avoiding the costs associated with its disclosure. In that case, managers disclose proprietary information only when they assess the benefits of disclosures as higher than their proprietary costs (Verrecchia, 1983). For example, Clarkson et al. (1994) find that firms' disclosures are associated with their product market competition.

2.2. Governance and voluntary disclosures: complements or substitutes

Williamson (1984) develops a theoretical framework to relate disclosure quality to corporate governance. Numerous studies use this framework to examine the impact of governance mechanisms on voluntary disclosures (Gul and Leung, 2004; Ho and Wong, 2001; Eng and Mak, 2003; Li et al., 2008). Findings from these studies indicate that the relationship between governance and disclosure could be either complementary or substitutive.

2.2.1. Complementary relationship

One stream of literature argues that governance strengthens internal control, providing an "intensive monitoring package" that constrains managers' opportunistic behavior (Leftwich et al., 1981). In such an intensive monitoring environment, managers withhold less information for their personal benefits, and disclose more information on firms' underlying performance.

Consistent with this complementary-relation hypothesis, empirical studies find a positive relationship between the proportion of outside directors and the amount of corporate voluntary disclosures (Cheng and Courtenay, 2006; Leung and Horwitz, 2004; Cerbioni and Parbonetti, 2007; Li et al., 2008).

2.2.2. Substitutive relationship

Another stream of literature argues that firms substitute better corporate governance with voluntary disclosures (Rediker and Seth, 1995). The presence of independent directors implies a close monitoring of managers that reduces the need for costly disclosures. This argument predicts that board governance is negatively associated with external disclosures. Consistent with the substitutive relationship, several studies find a negative association between the proportion of outside directors and the amount of corporate voluntary disclosures (Eng and Mak, 2003; Gul and Leung, 2004).

In summary, the empirical evidence on the association between board structure and voluntary disclosures is mixed and, often, controversial. Such inconsistent findings might reflect a variety of factors, such as differences in institutional settings (European Union, Hong Kong, Singapore, and US), socioeconomic and political differences between countries (Ahmed and Courtis, 1999), investor rights and legal enforcements (La Porta et al., 1998; Leuz et al., 2003), and proxies of corporate governance and voluntary disclosures (Dalton et al., 1999; Ahmed and Courtis, 1999).

2.3. Professional backgrounds of independent directors

The literature shows that the professional backgrounds of independent director influence their monitoring of company managers and the roles they play in firms' strategic decisions. For example, Mallin and Michelon (2011) show that community influentials are positively associated with corporate social performance. Baysinger and Zardkoohi (1986) find that the boards of

regulated utilities have a lower proportion of directors performing the monitoring role and a higher proportion of directors engaging in public relations. This is because the latter set promotes the social image of firms among regulators, legislators, and other external constituencies. Markarian and Parbonetti (2007) examine board of director composition by dividing firms into externally and internally complex firms. They find that each director plays a specific role consistent with her own skills, competencies, and professional expertise. They show that externally complex firms substitute community influentials for business experts, but internally complex firms opt for more support specialists. They conclude that support specialists guide managers in acquiring appropriate industry resources and in improving firms' internal processes. Markarian and Parbonetti (2007, p. 2025) summarize that the professional backgrounds of independent directors produce "a mosaic of decision making structures and subsequent firm behavior."

2.3. Motivation of hypothesis

The cited literature, mainly from the management and economics fields, clearly shows that the professional backgrounds of independent directors influence their monitoring ability and their role in setting firms' strategic priorities. More important, the findings of this literature suggest that the influences of independent directors on firms' voluntary disclosures are likely to differ based on their professional backgrounds. However, the finance and accounting literature largely examines the association between independent directors and firm disclosures by considering all independent directors as one homogeneous category. We fill the gap in the literature by hypothesizing that the different skills, experiences, competencies, and professional expertise of the independent directors (professional backgrounds) would lead to different assessments of cost-benefit trade-offs of proprietary disclosures (Kosnik 1987; Kaplan and Reishus 1990). These differences must manifest in differences in firms' proprietary disclosures to the extent that independent directors influence the disclosure policies of their firms. To test this hypothesis, we

classify all independent directors into business experts, support specialists, and community influentials, consistent with Baysinger and Hoskisson (1990).

We expect that relative to community influentials, who lack functional business expertise, support specialists make superior assessments of the costs of, and are more cautious about, the disclosure of information that potentially reduces firms' competitive advantages. We test this idea by using the context of biotechnology firms consistent with Guo et al. (2004). We examine the association between the proportion of business experts, support specialists, and community influentials and the disclosures related to early stage products of biotechnology firms.

Based on the above discussion, we hypothesize:

H1: The proportion of business experts, support specialists, and community influentials is associated differently with the proprietary disclosures of biotechnology firms.

3. Sample selection and measurement of variables

In this section, we describe the selection of sample firms from the biotechnology sector and the measurement of key variables.

3.1. Sample selection

Our sample contains all active biotechnology firms listed on the US stock exchanges without interruption from 2005 to 2009. We identify biotechnology firms by standard industrial classification (SIC) code 2836. Firms that cease to exist during the period or have missing data are excluded. We restrict our sample to firms that have products under development (other than products involving gene therapy, medical devices, and research services). We keep in the sample firms that discontinue drug development for a few years due to the failure of clinical trials (for example, Prana Biotech and PDL Biopharma), provided they have product development in the other years. In these cases, we retain only the firm-year observations in which firms conduct development activities. This results in a varying sample size across the study period, consisting of 410 firm-years observations, as described in Table 1.

[Insert Table 1 near here]

3.2. Measurement of variables

We employ a unique set of dependent and independent variables guided by prior literature.

3.2.1. Independent variable: the typology of independent directors

We hand-collect data on board composition from SEC DEF 14A proxy filings. First we calculate the proportion of independent directors on the board (*Independent*). We then calculate the proportions of these directors following the typology developed by Hillman et al. (2000) and Baysinger and Hoskisson (1990). That is, we calculate the proportion of business experts (*BussExp*), support specialists (*SuppSpec*), and community influentials (*CommInfl*) in firms' boards, using the procedure described in Appendix A.

3.2.2. Dependent variable: narrative disclosures

The development of a new biotechnology product (drug) is a complex process, as described in Appendix B. The first stage of product development involves the discovery and initial assessments of a chemical compound (the preclinical stage). The compound that passes the assessment tests undergoes three phases of clinical trials. The probability of the chemical compound making it through from discovery to final commercialization is assessed at about one in five thousand (Healy et al., 2002). Given the low rate of success, most biotechnology companies have multiple products under development, largely in preclinical phases. We read firms' Form 10-Ks and hand-collect data from their narrative disclosures. We build two disclosure indices using a procedure consistent with Guo et al. (2004): the preclinical index and the clinical index.[5]

[5] One of authors initially performed all the coding activity. To ensure reliability and validity of the disclosure score over time, another author recoded the data two months later. This generated a Cronbach's alpha of 0.96 (Krippendorf, 1980), indicating internal consistency of the coding procedure.

We first construct a disclosure score for each product in five categories.

(1) Product specifications—information on product properties, effectiveness of the product under development, and a comparison of the product with other firms' products.

(2) Target disease—information on the intended use of the product, that is, the disease for which the product is designed.

(3) Clinical trials—information on the success of the product in all clinical trials: the number of patients, patients' medical information, doses applied, methods of application, and treatment schedules.

(4) Future development plans—the firm's future plans for clinical trials, such as expected dates, number of participating patients, and duration and method of future clinical trials.

(5) Market information—the product's market potential, including the number of patients infected by the target disease, the number of cases occurring each year, and the potential dollar volume of the market.

A product can obtain a maximum score of 22 points if it is in the preclinical phase of development and 30 points if it is in the clinical phase. To ensure the cross-section comparability of the product scores, we divide the scores of the preclinical products by 22 and the scores of the clinical products by 30. Appendix C provides the components of the disclosure index and the scoring details in constructing the product disclosure index.

We calculate the overall disclosure index as follows. Consider a company that has five products under development of which three are in the preclinical phase and two are in the clinical phase. We calculate the average of product disclosure indices of the three products under the preclinical phases and call it the preclinical disclosure index. Similarly, we calculate the average of the two products under the clinical stages of development and call it the clinical disclosure index. Then we add the two disclosure indices (related to clinical and preclinical products) to obtain the firm overall disclosure index (*Discl_Index*). In addition, we build two additional

disclosure indices. The first relates to voluntary disclosures of product specifications, target disease, and clinical trials (*Tech-Discl-Index*), and the second relates to information about future plans and market disclosures (*Market-Discl-Index*). Arguably, the latter index is more forward-looking than the former because it pertains to future plans while the other looks to past developments.

3.2.3. Control variables

Previous studies have identified a list of corporate characteristics that affect voluntary disclosures, such as corporate size, profitability, and leverage (Marston and Shrives, 1991; Ahmed and Courtis, 1999). Large firms benefit from scale effects when collecting and disseminating information, so they are likely to provide more information. We measure firm size as the natural logarithm of total assets. Agency theory predicts debt as a potential tool for mitigating agency conflict between managers and shareholders through additional monitoring. As a consequence, high-debt firms can decrease monitoring costs by disclosing more information, although our sample firms rarely obtain debt financing. We measure leverage by the ratio of a firm's total liabilities to total assets. Profitability is positively associated with voluntary disclosures (Lang and Lundholm, 1993). We define profitability by the ratio of earnings before interest and tax to the book value of total assets employed. In addition, we control for board size (i.e., the number of directors) and the type of board leadership [whether the chief executive officer (CEO) holds the position of chairman]. Finally, we use year dummies to control for year fixed effects.

4. Empirical tests

We first discuss the descriptive statistics of our key dependent and independent variables and their correlations. We then discuss the tests of the hypothesis.

4.1. Descriptive statistics

Panel A of Table 2 reports the total number of products examined in this study. Panel B presents the descriptive statistics for the dependent and independent variables used. The average disclosure index is 0.30, similar to 0.33 reported by Guo et al. (2004). The mean technical disclosure index (*Tech-Discl-Index*) is 0.22, and the mean market disclosure index (*Market-Discl-Index*) is 0.08. Nonexecutive directors (*Independent*) constitute on average 70% of the board. The proportion of business experts, support specialists, and community influentials are 0.33, 0.23, and 0.14, respectively. The average board size is 7.87, similar to the average number of directors on boards of 8.0 reported by Cerbioni and Parbonetti (2007). Approximately 42% of the sample firms have a CEO who is also the chairman of the board.

[Insert Table 2 near here]

4.2. Correlational tests

Table 3 reports the bivariate correlations among the dependent and independent variables. Clinical products (*Patents*) are positively correlated with the overall disclosure score (*Discl-Index*), the technical disclosures (*Tech-Discl-Index*), and the market disclosures (*Market-Discl-Index*). All disclosure indices are negatively correlated with the proportion of products under early stages of development (*Preclinical*). These results are consistent with Guo et al. (2004). Moreover, the independent directors bear no significant correlation with any of the disclosure indices (*Discl-Index, Tech-Discl-Index,* and *Market-Discl-Index*). This is consistent with the literature. Notably, neither *Patent* nor *Preclinical* is significantly associated with independent directors or type of independent director. This result is inconsistent with the idea that firms self-select their board composition based on the stages of product development, reducing the endogeneity concern commonly applicable to studies examining an association between governance structure and firms' business decisions.

[Insert Table 3 near here]

4.3. Multivariate analysis

We estimate the following regression to examine the association between a firm's product portfolio and its voluntary disclosures.

$$\textit{Discl-Index}_{i,t} = \beta_1 + \beta_2 \times \textit{Patents}_{i\,t} + \beta_3 \times \textit{Preclinical}_{i,t} + \Sigma\beta_s \times \textit{Controls}_{i,t} + \varepsilon_{i,t}, \quad (1)$$

where *i* identifies the company and *t* identifies the year.

The disclosure decisions are not independent across periods for the same firm. Therefore, we estimate standard errors clustered by firms. Column 1 of Table 4 shows that the developed products (*Patents*) are positively associated with the disclosure index (regression coefficient of 0.134, significant at *p*-value <0.01), but the products under development (*Preclinical*) are negatively associated with the disclosure index (regression coefficient of −0.126, significant at *p*-value <0.01). Firms thus exercise caution when providing information on early stage products, arguably to reduce proprietary costs. This is the main finding of Guo et al. (2004).

[Insert Table 4 near here]

We then estimate the regression

$$\textit{Discl-Index}_{i,t} = \beta_1 + \beta_2 \times \textit{Patents}_{i\,t} + \beta_3 \times \textit{Preclinical}_{i,t} + \beta_4 \times \textit{Independent}_{i,t} + \Sigma\beta_s \times \textit{Controls}_{i,t} + \varepsilon_{i,t}. \quad (2)$$

Eq. (2) differs from Eq. (1) because the proportion of independent directors (*Independent*) is included. Column 2 of Table 4 shows no association between the overall disclosures and the proportion of independent directors on the board. These results are consistent with the mixed results discussed in Subsection 2.2.

The next regression is

$$\textit{Discl-Index}_{i,t} = \beta_1 + \beta_2 \times \textit{Patents}_{i\,t} + \beta_3 \times \textit{Preclinical}_{i,t} + \beta_4 \times \textit{Independent}_{i,t} + \beta_5 \times \textit{Preclinical}_{i,t} \times \textit{Independent}_{i,t} + \Sigma\beta_s \times \textit{Controls}_{i,t} + \varepsilon_{i,t}. \quad (3)$$

Eq. (3) differs from Eq. (2) because of the inclusion of interaction of *Independent* with *Preclinical*. Column 3 of Table 4 shows that the coefficient on the interaction term (β_5) is not significant. This result is consistent with the idea that, when summed up across companies, the association between independent directors and proprietary disclosures is insignificant.

We next incorporate the professional backgrounds of the independent directors by estimating the regression

$$\begin{aligned} \textit{Discl-Index}_{i,t} &= \beta_1 + \beta_2 \times \textit{Patents}_{i\,t} + \beta_3 \times \textit{Preclinical}_{i,t} + \beta_4 \times \textit{Independent}_{i,t} \\ &+ \beta_5 \times \textit{Preclinical}_{i,t} \times \textit{Independent}_{i,t} \\ &+ \beta_6 \times \textit{DirectorType}_{i,t} + \beta_7 \times \textit{Preclinical}_{i,t} \times \textit{DirectorType}_{i,t} \\ &+ \Sigma\beta_s \times \textit{Controls}_{i,t} + \varepsilon_{i,t}. \end{aligned} \quad (4)$$

Eq. (4) differs from Eq. (3) because of the inclusion of the main effects of one type of independent directors as well as its interaction with *Preclinical*. The main effect (*DirectorType*) captures the difference in the overall disclosures due to the inclusion of that type of director relative to the average effects of the other two types of independent directors. Similarly, the interaction term (*Preclinical* × *DirectorType*) captures the difference in the preclinical disclosures (relative to clinical disclosures) due to that type of independent director relative to the average effects of the other two types of independent directors. Columns 4–6 of Table 4 show that the main effects of business experts, support specialists, and community influentials (β_6) are not significant. However, the interaction terms (β_7) are insignificant, significantly negative (regression coefficient of −0.318, significant at p-value <0.01), and significantly positive (regression coefficient of 0.176, significant at p-value <0.01) for the three types of directors, respectively. These results are consistent with the idea that, relative to other independent directors, support specialists are better able to distinguish between the proprietary and the nonproprietary information or are better able to assess the costs associated with proprietary

disclosures. To the extent that independent directors can influence firms' disclosure policies, results suggest that directors with functional expertise shift firms' disclosures policies toward caution. In contrast, the directors who improve a firm's image in the wider community but lack business experience shift firms' policies toward greater disclosures even when such disclosures impose proprietary costs. This is the main finding of this study.

4.4. Robustness tests

We conduct two robustness tests. We estimate the detailed regression

$$\begin{aligned} \textit{Discl-Index}_{i,t} = {} & \beta_1 + \beta_2 \times \textit{Patents}_{i\,t} + \beta_3 \times \textit{Preclinical}_{i,t} \\ & + \beta_4 \times \textit{BussExp}_{i,t} + \beta_5 \times \textit{Preclinical}_{i,t} \times \textit{BussExp}_{i,t} \\ & + \beta_6 \times \textit{SuppSpec}_{i,t} + \beta_7 \times \textit{Preclinical}_{i,t} \times \textit{SuppSpec}_{i,t} \\ & + \beta_8 \times \textit{CommInfl}_{i,t} + \beta_9 \times \textit{Preclinical}_{i,t} \times \textit{CommInfl}_{i,t} \\ & + \Sigma\beta_s \times \textit{Controls}_{i,t} + \varepsilon_{i,t}. \end{aligned} \quad (5)$$

In unreported tests, the coefficient on the second interaction term (*Preclinical* × *SuppSpec*) is negative and significant, and the coefficient on the third interaction term (*Preclinical* × *CommInfl*) is positive and significant. These results are consistent with Eq. (4).

We conduct additional tests by dividing overall disclosures into those related to product specifications, target disease, and clinical trials (*Tech-Discl-Index*) and those related to information on future plans and market disclosures (*Market-Discl-Index*). Market disclosures contain information related to future development plans as well as the size of the drug's market. Technical disclosures pertain to product specifications, target disease, and clinical aspects. Firms' costs and benefits of, and independent directors' influence on, the two types of disclosures could differ. However, Panels A and B of Table 5 show that our results hold for both types of disclosures and are consistent with our main results.

[Insert Table 5 near here]

5. Conclusions

The paper examines whether the professional backgrounds of the independent directors is associated with financial disclosures that potentially reduce agency costs but lessen firms' competitive advantages. The biotechnology sector represents a unique setting to examine these proprietary disclosures because the disclosures on early stage products can reveal valuable information to firms' employees, regulators, and competitors. We find that firms with independent directors possessing functional business expertise are relatively cautious in disclosing information on early stage products. In contrast, firms with independent directors who provide linkages to the wider community but lack business experience are more forthcoming on proprietary disclosures. These results are consistent with the idea that independent directors with dissimilar professional backgrounds evaluate the costs and benefits of proprietary disclosures differently and influence firms' disclosure policies accordingly.

Our findings clearly suggest that independent directors are not homogeneous in their ability to monitor and influence firms' financial disclosures. Thus, our conclusions lead to several policy implications. First, the professional backgrounds of independent directors must be considered in formulation of firms' governance structures, and these governance structures must be related to the extent to which firms derive competitive advantages from their proprietary information. Thus, organizations such as CalPERS and ISS that aim to promote corporate governance must consider the professional backgrounds of independent directors in shaping their investee firms' governance structures. Second, regulators could demand the reporting of details of the independent directors in categories that reflect their professional backgrounds. Based on our findings, we propose that any study examining the association between firms' corporate

governance and disclosure policies must explicitly consider the professional backgrounds of the independent directors.

APPENDIX A

Classification of independent directors

Business experts (*BussExp*) are managers, or former managers, of other companies, possessing specialized business knowledge. They are involved in strategic decision making. They are often experts in the identification of new geographic segments, new product markets, and synergistic merger targets, and they understand customer needs and are able to assess business opportunities. They can help the firms in identifying new product markets, which is fundamental to increasing market share and successfully marketing the potential products.

Support specialists (*SuppSpec*) possess specialized knowledge in a specific industrial area. They often lack formal business training and knowledge but are usually specialists in the specific industrial sector in which they operate. They advise managers and help them acquire resources and knowledge for improving the internal processes of the firm. They also provide valuable links with other industry organizations.

Community influentials (*CommInfl*) are retired politicians, are affiliated with the armed forces, belong to nonbusiness organizations, or are drawn from the local community.

Following are three examples of board member biographies, one for each classification of independent directors.

1. Gordon Binder (Acadia Pharmaceuticals): Has served as a director of our company since June 2003. Mr. Binder is the founder and managing director of Coastview Capital. Mr. Binder was the chief executive officer of Amgen, the world's largest biotechnology company, from 1988 through 2000. During his tenure as chief executive officer, Amgen grew from four hundred employees to rank within the top 20 pharmaceutical companies in worldwide revenues, the top 15 in United States sales, and the top ten in market capitalization. Mr. Binder serves on the boards of the Massachusetts Institute of Technology, the California Institute of Technology, and the American Enterprise Institute for Public Policy Research. (*BussExp*)

2. Alan B. Glassberg (Biogen Idec): Dr. Glassberg is a Venture Partner and member of the Scientific Advisory Board of Bay City Capital, a firm which manages investment funds in the life sciences industry. Dr. Glassberg has been associated with Bay City Capital since August 2006. Dr. Glassberg served as Chief Medical Officer of Poniard Pharmaceuticals, Inc. from August 2006 to March 2007, and currently serves as a consultant to Poniard and as a member of its Clinical Advisory Board. Dr. Glassberg retired from the University of California San Francisco in June, 2006, where he served as Associate Director of Clinical Care and Director of General Oncology at the University of California San Francisco Comprehensive Cancer Center. *(SuppSpec*)

3. Joseph L. Bower (Anika Therapeutics): Dr. Bower joined the Board of Directors of Anika Therapeutics in February 1993 and has served as Lead Director since April 2005. He has held various positions at the Harvard Business School since 1963, where he was named Professor of Business Administration in 1972 and Donald Kirk David Professor of Business Administration in 1986. He has served as Chairman of the Doctoral Programs, Director of Research, Senior Associate Dean for External Relations, Chair of the General Management Area and is currently Chair of the General Manager Program. Dr. Bower received an A.B. from Harvard University and an M.B.A. and a D.B.A. from the Harvard Business School. He is a director of Brown Shoe Company, Inc., New America High Income Fund, Sonesta International Hotels Corporation, Loews Corporation and TH Lee Putnam EOP. (*CommInfl*)

APPENDIX B

Stages in the development of a new biotechnology product (drug)

Drug development refers to a series of processes that are followed before a drug is brought to market. It is complex, expensive, and spread over ten to 12 years (Babiarz, 2008). The Food and Drug Administration establishes the guidelines for drug development. Based on these guidelines, the processes can be divided into two phases: preclinical and clinical.

In the preclinical phase, after a chemical compound is discovered that can potentially treat a disease, its chemical makeup, stability, and solubility are assessed. Before testing the compound on humans, its safety, toxicity, pharmacokinetics, and metabolism also are considered. Furthermore, an assessment is made for the dosage and schedule of its administration. Tests are conducted using in vitro methods (e.g., with isolated cells) or with laboratory animals. The company submits to the FDA the results of the preclinical testing and the proposed plan for clinical testing. If the FDA approves the plan, then the company files an investigational new drug application (IND) for human testing.

In the clinical phase, testing has three phases. In Phase I, the drug is tested on 20 to 80 healthy volunteers to assess its side effects and how the drug is metabolized and excreted. In Phase II, the drug is tested on 50 to 300 patients to assess the effectiveness and its short-term side effects. In Phase III, the safety and effectiveness of the drug is assessed on up to 3,000 patients using different dosages and in combination with other drugs. Thereafter, the company submits the test results as well as the proposed manufacturing process to the FDA to seek approval for marketing the new drug.

APPENDIX C

Product disclosure index

The disclosure index is constructed for each biotechnology product by hand-collecting relevant information from annual report (Business section of Form 10-K). Information is derived for the following five categories: product specifications, target disease, clinical trials, future development plans, and market information. The procedure for assigning scores in each category is tabulated (with a detailed example) in Appendix C.2.

C*.1. Measurement of product disclosure index*

I. Product Specifications

1. How does the product work? (3 points = three sentences; 2 = two sentences; 1 = one sentence; 0 = none)
2a. Why is it better than previous products? (2 = name mentioned; 1 = no name mentioned; 0 = no discussion)
2b. Why is it better than competing products? (2 = name mentioned; 1 = no name mentioned; 0 = no discussion)
3. What is the chemical/biological structure? (2 = chemical compound; 1 = general discussion; 0 = not mentioned)
Subtotal I = total scores of (1 + max(2a, 2b) + 3)

II. Target disease

1. What kind of diseases does the product treat? (2 = disease name mentioned; 1 = disease name not mentioned; 0 = no discussion)
2. What are other possible uses of the drug? (2 = disease name mentioned; 1 = disease name not mentioned; 0 = no discussion)
Subtotal II = total scores of (1 + 2)

III. Clinical trials

1. Number of patients (1 = given; 0 = absent)
2. Patients information (with what diseases) (1 = given; 0 = absent)
3. Doses (amounts) used in the clinical trial (1 = given; 0 = absent)
4. Method used in the clinical trial (1 = given; 0 = absent)
5. Treatment schedule (duration or frequency) (1 = given; 0 = absent)
6. Trial results [detailed = pro and cons + numbers (3); general = numbers (2); brief = no numbers (1); none (0)]
Subtotal III = total scores of (1 + 2 + 3 + 4 + 5 + 6)

IV. Future plans

1a. Is there any plan to try the product on new diseases? (2 = disease name mentioned; 1 = no name mentioned; 0 = no discussion)
1b. Is there any plan to try the product with other products? (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)
2. Future plan for clinical trials
2a. Planned date (1 = mentioned; 0 = not mentioned)
2b. Number of patients for the planned trial (1 = mentioned; 0 = not mentioned)
2c. Patient information for the planned trial (what disease) (1 = mentioned; 0 = not mentioned)
2d. Duration (1 = mentioned; 0 = not mentioned)
2e. Method (1 = mentioned; 0 = not mentioned)
3. Possible alliance (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)
Subtotal IV = total scores of (max(1a, 1b) + 2a + 2b + 2c + 2d + 2e + 3)

V. Market information

1. Number of patients affected by the disease (1 = mentioned; 0 = not mentioned)
2. Number of incidents (market size) (1 = mentioned; 0 = not mentioned)
Subtotal V = total scores of scores (1 + 2)
Overall disclosure score = sum of Subtotals I–*Scaled disclosure score* = overall disclosure score divided by 30 for products either in or beyond the clinical trials phase; by 22 for the products that did not reach clinical trials

APPENDIX C continued
Product disclosure index

C.2. An example of the measurement of product disclosure index

Company	MAXYGEN
Product	MAXY-G34
Development stage	Phase II
Disclosure index (information is drawn from the Business section, Part I, of Form 10-K)	Score contents
I. Product specifications	
1. How does the product work? (3 = three sentences; 2 = two sentences; 1= one sentence; 0 = none)	1. Helps the body make blood cells.
2a. Why is it better than previous products? (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)	2. MAXY-G34 reduces the duration of neutropenia when compared with the currently marketed products (Neulasta and Neupogen).
2b. Why is it better than competing products? (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)	2. MAXY-G34 protects patients from chemotherapy and radiation therapy–related infections, shortens the duration of hospital stays, and helps keep patients on schedule for their cancer treatments.
3. What is the chemical structure in addition to its chemical name? (2= name mentioned; 0 = not mentioned)	0. Not mentioned.
Subtotal I = total scores of (1 + max (2a, 2b) + 3)	3, out of a maximum of 7.
II. Target diseases	
1. What kind of diseases does the product treat? (2 = disease name mentioned; 1 = disease name not mentioned; 0 = not mentioned)	2. Neutropenia.
2. What are the other possible uses? (2 = disease name mentioned; 1 = disease name not mentioned; 0 = not mentioned)	0. Not mentioned.
Subtotal II = total scores of (1 + 2)	2, out of a maximum of 4.
III. Clinical trials	
1. Number of patients (1= mentioned; 0 = not mentioned)	1. 47
2. Patients information (with what disease) (1 = name mentioned; 0 = not mentioned)	1. Patients with breast cancer who have failed at least one potentially curative treatment regimen.
3. Doses (amounts) used in the clinical trial (1 = mentioned; 0 = not mentioned)	1. 5 to 100 μg/kg was given.
4. Method (via what kind of media) used in the clinical trial (1 = mentioned; 0 = not mentioned)	1. Subcutaneous injection.
5. Treatment schedule (duration or frequency) (1 = given; 0 = absent)	1. Single dose MAXY-G34 therapy being administered per three-week chemotherapy cycle with each patient receiving six cycles of docetaxel.
6. Results (3 = detailed discussion; 2 = general discussion; 1 = brief discussion; 0 = no discussion)	2. The results of the Phase I clinical trial indicate that the drug MAXY-G34 was generally safe and well tolerated through the study.
Subtotal III = total scores of (1 + 2+ 3 + 4 + 5 + 6)	7, out of a maximum of 8.

APPENDIX C continued
Product disclosure index

C.2. An example of the measurement of product disclosure index

IV. Future development plans	
1a. Is there any plan to try the product on new diseases? (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)	2. Hemophilia.
1b. Is there any plan to try the product with other products? (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)	0. Not mentioned.
2. Future plan for clinical trials	
2a. Planned date (1 = mentioned; 0 = not mentioned)	1. 2008.
2b. Number of patients for the planned trial (what disease) (1 = mentioned; 0 = not mentioned)	0. Not mentioned.
2c. Patient information for the planned trial (what disease) (1 = mentioned; 0 = not mentioned)	1. Breast cancer patients.
2d. Duration (1= mentioned; 0 = not mentioned)	0. Not mentioned.
2e. Method (1 = mentioned; 0 = not mentioned)	0. Not mentioned.
3. Alliance (2 = name mentioned; 1 = no name mentioned; 0 = not mentioned)	2. We entered into a strategic alliance with Roche.
Subtotal IV = total scores of [max (1a, 1b) + 2a + 2b + 2c + 2d + 2e + 3)	6, out of a maximum of 9.
V. Market information	
1. Number of patients affected by the disease (1 = mentioned; 0 = not mentioned)	0. Not mentioned.
2. Number of incidents (market size) (1 = mentioned; 0 = not mentioned)	0. Not mentioned.
Subtotal V = total scores of (1 + 2)	0, out of a maximum of 2.
Overall disclosure score = sum of Subtotals I–V	18, out of a maximum of 30.
Scaled disclosure score = overall disclosure score divided by 30 because MAXY-G34 is in clinical trials phase	0.60, out of a maximum of 1.00.

APPENDIX D

Definitions of variables

Variable description	Variable name	Definition
Disclosure index	*Discl-Index*	Overall disclosure index as defined in Appendix C.
Disclosure index for technical information	*Tech-Discl-Index*	Calculated as the sum of product specifications disclosure index, target disease disclosure index, and clinical trial disclosure index.
Disclosure index for market formation	*Market-Discl-Index*	Calculated as the sum of future plan and market information disclosure index.
Patents	*Patents*	Proportion of patented products to total number of products.
Preclinical	*Preclinical*	Proportion of products under screening, development, application, and preclinical phase to total number of products.
Independent directors	*Independent*	Proportion of independent directors on board of directors.
Business experts	*BussExp*	Proportion of business experts on board of directors.
Support specialists	*SuppSpec*	Proportion of support specialists on board of directors.
Community influentials	*CommInfl*	Proportion of community influentials on board of directors.
CEO duality	*ChairCEO*	Dummy variable equal to one if CEO is also the chairman of the board and zero otherwise.
Number of board members	*BoardSize*	Total number of directors.
Profitability	*ROA*	Ratio of earnings before interests and taxes (EBIT) to the book value of total assets employed.
Leverage	*Leverage*	Ratio of total liabilities to total assets.
Firm size	*FirmSize*	Natural logarithm of total assets.
Year dummies	*Year Dummies*	Four dummy variables that take a value of one if fiscal years equal 2005, 2006, 2007, and 2008, respectively, and zero otherwise.

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Table 1

Sample selection

The table reports the total number of annual reports analyzed (firm-years). Initial firms are biotechnology firms (standard industrial classification code 2836) with valid data in Compustat. Firms are dropped due to mergers and acquisitions and for other reasons.

Fiscal year	Number of initial firms	Firms dropped	Final sample
2005	100	23	77
2006	96	16	80
2007	111	26	85
2008	112	28	84
2009	106	22	84
Total	525	115	410

Table 2

Descriptive statistics

Variables are defined in Appendix D. IND = investigational new drug; FDA = US Food and Drug

Panel A: Descriptive statistics of products for sample firms in the study years

Stage	Substage	Stage score	Number of product
Initial screening	Screening	1	51
	Development	2	15
Preclinical testing	Preclinical testing	3	617
	IND application	4	34
Clinical testing	Phase I clinical trials	5	739
	Phase II clinical trials	7	780
	Phase III clinical trials	10	354
FDA review	NDA application	12	255
Total			2,845

Panel B: Descriptive statistics for sample firms in the study years

Variable	Mean	Standard deviation	Q1	Median	Q3
Discl-Index	0.30	0.11	0.22	0.28	0.37
Tech-Discl-Index	0.22	0.08	0.15	0.19	0.25
Market-Discl-Index	0.08	0.05	0.05	0.08	0.10
Patents	0.74	0.29	0.50	0.83	1.00
Preclinical	0.29	0.29	0.00	0.25	0.50
Independent	70%	19%	57%	71%	83%
BussExp	33%	18%	20%	33%	45%
SuppSpec	23%	15%	12%	25%	33%
CommInfl	14%	14%	0%	12%	20%
ChairCEO	42%	49%	0%	0%	100%
BoardSize	7.87	1.71	7.00	8.00	9.00
ROA	−0.47	0.72	−0.64	−0.35	−0.16
FirmSize ($ millions)	918.63	3,975.24	41.23	89.62	247.40
Leverage	0.14	0.29	0.00	0.01	0.13

Table 3
Correlation table

Variable	*Discl-Index*	*Tech-Discl-Index*	*Market-Discl-Index*	*Patents*	*Preclinical*	*Independen*	*BussExp*	*SuppSpec*	*CommInfl*	*ChairCEO*	*Board Size*	*ROA*	*Firm Size*	*Leverage*
Discl-Index	1.00													
Tech-Discl-Index	0.67***	1.00												
Market-Discl-Index	0.68***	0.51***	1.00											
Patents	0.25***	0.16***	0.15**	1.00										
Preclinical	−0.38***	−0.19***	−0.21***	−0.46***	1.00									
Independent	−0.03	0.01	0.03	0.01	−0.07	1.00								
BussExp	−0.02	0.05	−0.03	0.00	−0.03	0.61***	1.00							
SuppSpec	0.07	0.05	0.10*	−0.02	0.04	0.19***	−0.29***	1.00						
CommInfl	−0.09	−0.09	−0.03	0.03	−0.09	0.26***	−0.20***	−0.40***	1.00					
ChairCEO	0.19***	0.12*	0.10*	0.07	−0.04	0.03	0.06	−0.01	−0.02	1.00				
BoardSize	−0.01	0.00	0.04	0.08	−0.04	0.13**	0.09	−0.07	0.11*	−0.09	1.00			
ROA	−0.04	−0.08	−0.03	−0.01	0.05	0.02	0.00	−0.12**	0.160**	−0.03	0.130**	1.00		
FirmSize	−0.19***	−0.28***	−0.19***	0.11*	−0.15**	0.21***	0.10*	−0.14**	0.27***	−0.02	0.35***	0.16**	1.00	
Leverage	−0.08	−0.10	−0.07	0.02	−0.09	0.06	0.06	−0.01	0.00	−0.02	0.17***	−0.04	0.06	1.00

*, **, and *** indicate significance at the *p*-level of 0.10, 0.05, and 0.01, respectively. All variables are defined in Appendix D.

Table 4

Association between disclosure index and the type of independent directors

$$Discl\text{-}Index_{i,t} = \beta_1 + \beta_2 \times Patents_{i\,t} + \beta_3 \times Preclinical_{i,t} + \beta_4 \times Independent_{i,t} + \beta_5 \times Preclinical_{i,t} \times Independent_{i,t} + \beta_6 \times DirectorType_{i,t} + \beta_7 \times Preclinical_{i,t} \times DirectorType_{i,t} + \Sigma\beta_s \times Controls_{i,t} + \varepsilon_{i,t}.$$

Variable				Director type		
				BussExp	*SuppSpec*	*CommInfl*
Patents	0.134***	0.133***	0.132***	0.127***	0.128***	0.130***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Preclinical	−0.126***	−0.126***	−0.123***	−0.129***	−0.118***	−0.074**
	(0.028)	(0.028)	(0.028)	(0.036)	(0.028)	(0.035)
Ind		0.011	0.013	−0.032	0.046	0.049
		(0.051)	(0.051)	(0.057)	(0.054)	(0.053)
Independent × *Preclinical*			−0.005	−0.005	0.091***	−0.097**
			(0.010)	(0.019)	(0.034)	(0.041)
BussExp				0.076		
				(0.049)		
BussExp × *Preclinical*				0.001		
				(0.092)		
SuppSpec					0.004	
					(0.055)	
SuppSpec × *Preclinical*					−0.318***	
					(0.105)	
CommInfl						−0.018
						(0.069)
CommInfl × *Preclinical*						0.176**
						(0.077)
ChairCEO	−0.027	−0.027	−0.027	−0.028*	−0.025	−0.029*
	(0.017)	(0.017)	(0.017)	(0.017)	(0.016)	(0.017)
BoardSize	−0.003	−0.003	−0.003	−0.004	−0.001	−0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
ROA	−0.002	−0.002	−0.002	−0.003	−0.002	−0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
LogSize	0.003	0.003	0.003	0.002	0.000	0.001
	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)
Leverage	−0.010	−0.009	−0.009	−0.009	−0.013	−0.006
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Control for year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	410	410	410	410	410	410
R-squared	39%	39%	39%	40%	42%	40%

*, **, and *** indicate significance at the *p*-level of 0.10, 0.05, and 0.01, respectively. Standard errors are clustered on firms and are presented in parentheses. All variables are defined in Appendix D.

Table 5

Association between technical disclosure index and the type of independent directors

$$Tech\text{-}Discl\text{-}Index_{i,t} = \beta_1 + \beta_2 \times Patents_{i,t} + \beta_3 \times Preclinical_{i,t} + \beta_4 \times BussExp_{i,t} + \beta_5 \times Preclinical_{i,t} \times BussExp_{i,t} + \beta_6 \times SuppSpec_{i,t} + \beta_7 \times Preclinical_{i,t} \times SuppSpec_{i,t} + \beta_8 \times CommInfl_{i,t} + \beta_9 \times Preclinical_{i,t} \times CommInfl_{i,t} + \Sigma\beta_s \times Controls_{i,t} + \varepsilon_{i,t}.$$

Panel A:

				Director type is		
Variable				*BussExp*	*SuppSpec*	*CommInfl*
Patents	0.027	0.028	0.026	0.024	0.024	0.025
	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)	(0.020)
Preclinical	−0.045**	−0.045**	−0.038**	−0.034	−0.035*	−0.009
	(0.018)	(0.018)	(0.018)	(0.023)	(0.018)	(0.022)
Independent		−0.026	−0.021	−0.036	−0.010	0.001
		(0.033)	(0.033)	(0.037)	(0.035)	(0.034)
Independent × Preclinical			−0.013**	−0.009	0.036	−0.067**
			(0.006)	(0.012)	(0.022)	(0.026)
BussExp				0.029		
				(0.031)		
BussExp × Preclinical				−0.023		
				(0.059)		
SuppSpec					0.014	
					(0.035)	
SuppSpec × Preclinical					−0.161**	
					(0.068)	
CommInfl						−0.000
						(0.044)
CommInfl × Preclinical						0.104**
						(0.049)
ChairCEO	−0.001	0.000	0.000	−0.000	0.001	−0.001
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
BoardSize	0.002	0.002	0.002	0.002	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
ROA	−0.008**	−0.008**	−0.008**	−0.008**	−0.008**	−0.008**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
LogSize	0.004	0.003	0.003	0.003	0.002	0.002
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Leverage	0.010	0.009	0.010	0.010	0.008	0.011
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Control for year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	410	410	410	410	410	410
R-squared	18.00%	18.10%	19.20%	19.50%	21.20%	20.05%

*, **, and *** indicate significance at the *p*-level of 0.10, 0.05, and 0.01, respectively. Standard errors are clustered on firms and are presented in parentheses. All variables are defined in Appendix D.

Table 5 continued

Association between market disclosure index and type of independent directors

$$Market\text{-}Discl\text{-}Index_{i,t} = \beta_1 + \beta_2 \times Patents_{i,t} + \beta_3 \times Preclinical_{i,t} + \beta_4 \times BussExp_{i,t} + \beta_5 \times Preclinical_{i,t} \times BussExp_{i,t} + \beta_6 \times SuppSpec_{i,t} + \beta_7 \times Preclinical_{i,t} \times SuppSpec_{i,t} + \beta_8 \times CommInfl_{i,t} + \beta_9 \times Preclinical_{i,t} \times CommInfl_{i,t} + \Sigma\beta_s \times Controls_{i,t} + \varepsilon_{i,t}.$$

Panel B

				Director type		
Variable				*BussExp*	*SuppSpec*	*CommInfl*
Patents	0.030*	0.029*	0.030*	0.030*	0.030*	0.028*
	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)	(0.017)
Preclinical	−0.027*	−0.027*	−0.028*	−0.038*	−0.022	−0.009
	(0.015)	(0.015)	(0.015)	(0.019)	(0.015)	(0.019)
Independent		0.012	0.011	0.011	0.004	0.024
		(0.028)	(0.028)	(0.031)	(0.029)	(0.029)
Independent × Preclinical			0.002	−0.005	0.059***	−0.034
			(0.005)	(0.010)	(0.018)	(0.022)
BussExp				−0.008		
				(0.026)		
BussExp × Preclinical				0.039		
				(0.050)		
SuppSpec					0.060**	
					(0.030)	
SuppSpec × Preclinical					−0.187***	
					(0.057)	
CommInfl						−0.026
						(0.037)
CommInfl × Preclinical						0.070*
						(0.041)
ChairCEO	−0.016*	−0.017*	−0.017*	−0.016*	−0.016*	−0.017*
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
BoardSize	−0.000	−0.000	−0.000	−0.000	0.001	−0.000
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ROA	0.000	0.000	0.000	0.000	0.001	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LogSize	0.002	0.003	0.003	0.003	0.002	0.002
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
Leverage	0.004	0.004	0.004	0.003	0.003	0.006
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Control for year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
N	410	410	410	410	410	410
R-squared	11.80%	11.90%	11.90%	12.10%	14.90%	12.70%

*, **, and *** indicate significance at the *p*-level of 0.10, 0.05, and 0.01, respectively. Standard errors are clustered on firms and are presented in parentheses. All variables are defined in Appendix D.