Board Structure and Price Informativeness*

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Abstract

We develop and test the hypothesis that private information incorporated into stock prices (*price informativeness*) affects the structure of corporate boards. We find a negative relation between measures of price informativeness and measures of board independence. This finding is robust to the inclusion of many firm-level controls − including firm fixed effects − and to the choice of the measure of price informativeness. Consistent with the hypothesis that price informativeness and board monitoring are substitutes, this relationship is particularly strong for firms more exposed to both external and internal governance mechanisms, firms for which firm-specific knowledge is relatively unimportant, and during periods of extreme abnormal stock performance. Our results suggest that firms with more informative stock prices have less demanding board structures.

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1. Introduction

The view that prices aggregate information that is dispersed among market participants dates back to Hayek (1945). The modern version of such an idea is found in, among others, the works of Grossman and Stiglitz (1980) and Kyle (1985), in which the main role of stock markets is the production and aggregation of information as a consequence of trading between speculators and other types of (perhaps less informed) investors. The idea that this type of information can also be useful for the provision of incentives in firms and for the design of corporate governance mechanisms is a more recent one. Holmstrom and Tirole (1993) and Faure-Grimaud and Gromb (2004) examine the role of stock prices in disciplining managers and providing incentives to insiders. There is also a set of related studies on the role of stock prices in guiding corporate investment decisions (Khanna, Slezak, and Bradley (1994), Dow and Gorton (1997), and Dow, Goldstein, and Guembel (2007)).

We contribute to this literature by providing robust evidence of a negative relation between proxies for price informativeness and corporate board independence. Our main proxy for price informativeness is the probability of informed trading (PIN), which was developed in a series of papers beginning with Easley, Kiefer, and O'Hara (1996) and Easley, Kiefer, and O'Hara (1997). The results are unchanged when we use alternative proxies for the impact of private information on prices, such as firm-specific stock return variation (Morck, Yeung, and Yu (2000)) and measures of illiquidity or price impact of order flow (Amihud (2002)). We also investigate the impact of price informativeness on additional characteristics of the board of directors. We find that price informativeness is positively related to the number of directors with attendance problems and negatively related to the number of board meetings. These results are compatible with board monitoring and price informativeness being substitutes.

We show that the negative correlation between price informativeness and board independence remains strong after controlling for a long list of possible covariates. This correlation is not explained by firm size and complexity, performance, governance mechanisms, ownership

structure, and earnings informativeness, among others. In fact, the results are unchanged after the inclusion of firm fixed effects, suggesting that time-invariant unobserved firm characteristics cannot explain our empirical findings. This effect is at least as strong as the ones between board independence and other firm-level variables that have been documented in the literature on corporate boards (Boone, Field, Karpoff, and Raheja (2007), Coles, Daniel, and Naveen (2008a), and Linck, Netter, and Yang (2008)). Regarding the direction of causality, we use instrumental variables methods to estimate the effect of price informativeness on board independence. As instruments, we use variables that are known to be correlated with price informativeness, such as share turnover, analyst coverage, and S&P 500 membership, but have never been used as explanatory variables in board independence regressions in previous studies. Our findings suggest that at least part of the correlation can be explained by price informativeness affecting board structure.

We also develop a simple adverse selection model that rationalizes the relation between board independence and price informativeness. The goal of the model is to clarify the role of price informativeness in the choice of board structures. We argue that the information revealed by stock prices should affect how directors perform their monitoring of management. We identify two intuitive mechanisms by which prices may affect board monitoring. On the one hand, the information revealed by stock prices allows external monitoring mechanisms to operate more efficiently. For example, if prices fall due to the announcement of value-decreasing investments, the firm becomes a cheaper takeover target. Managers who value control would thus avoid undertaking such value-destroying projects. Thus, stock markets play an important monitoring role. On the other hand, more informative prices bring new information to both markets and boards. Directors may use the information revealed by stock prices as an input to their monitoring task. Arguably, a better informed board of directors should be a better monitor.

Our model predicts that price informativeness matters for board monitoring, but that the sign of this relationship is ambiguous. Changing board structure in the direction preferred by

shareholders may be difficult (i.e., costly), especially when ownership is dispersed, in which case coordination costs arise. More informative prices make boards more effective, but also reduce the need for board independence. Thus, whether price informativeness and board independence are substitutes or complements is in the end an empirical question.

A parallel segment of the literature focuses on moral hazard models (e.g., Adams and Ferreira (2007) and Fluck and Khanna (2008)). A focus on moral hazard issues leads more naturally to the question of substitutability between board independence and managerial incentives through equity-based compensation (e.g., Coles, Lemmon, and Wang (2008b)). On the other hand, our focus on adverse selection issues (as in Hermalin and Weisbach (1998)) is a natural choice for understanding the role of stock prices in determining board structure. We thus see the two approaches as complementary and, in our empirical analysis, we also control for CEO pay-performance sensitivity as the moral hazard literature suggests. We find that the negative relationship between price informativeness and board independence is stronger in firms in which pay-performance sensitivity is high.

Our model also has some unambiguous predictions that we explore in our empirical analysis. We find that the negative relationship between price informativeness and board independence is particularly strong for firms with few takeover defenses, for firms with a high concentration of institutional ownership, and for firms with low R&D expenses. We also find that the economic significance of our main finding is particularly high for those firms that face extreme abnormal stock returns. This result is in line with the notion that the role of the board of directors is more relevant during specific events in the life of a firm such as CEO hiring and firing (Weisbach (1988) and Borokhovich, Parrino, and Trapani (1996)), adoption of takeover defenses (Brickley, Coles, and Terry (1994)), and takeover outcomes (Cotter, Shivdasani, and Zenner (1997)).

Overall, our empirical results suggest that board independence and price informativeness are substitutes rather than complements. There are few empirical studies on the interaction between different governance mechanisms. Mikkelson and Partch (1997) find evidence con-

sistent with the effectiveness of board oversight being enhanced by an active takeover market. More recent examples include Cremers and Nair (2005), who find a complementarity effect between openness to the market for corporate control and the presence of institutional investors, and Gillan, Hartzell, and Starks (2006), who find that an independent board can act as a substitute for the market for corporate control. Coles et al. (2008b) provide evidence of a substitution effect between board independence and pay-performance sensitivity. Our paper adds to this growing literature by showing that stock price informativeness also impacts organization design, in particular board structure.

Our results are also consistent with the notion that the optimal board structure depends on the characteristics of the firm; that is, "one size" does not fit all firms. In particular, there is some evidence consistent with board structure being affected by the degree of complexity of firms' operations and the trade-off between the costs and benefits of advising and monitoring management (Boone et al. (2007), Coles et al. (2008a), and Linck et al. (2008)).

Our paper is also related to the literature on how corporate governance mechanisms impact the public release of information. Warfield, Wild, and Wild (1995) find that managerial ownership improves earnings informativeness. Klein (2002) and Petra (2007) find that more independent boards improve earnings quality and informativeness, while Vafeas (2000) and Vafeas (2005) find no relationship. Leuz, Triantis, and Wang (2008) (see also Coles (2008)) find that board independence reduces the likelihood of a firm going private after Sarbanes-Oxley. Our paper differs from this strand of the literature by studying the interaction between two corporate governance mechanisms (board and market monitoring), rather than the effects of governance on a firm disclosure policy and earnings informativeness. While earnings informativeness measures the accuracy of accounting information provided to investors, price informativeness proxies for the intensity of stock market monitoring.

On the theoretical side, our model integrates two independent lines of research. The first one explains board structure as the result of optimal shareholder choices under incomplete contracts (Hermalin and Weisbach (1998), Raheja (2005), Song and Thakor (2006), Adams

and Ferreira (2007), and Harris and Raviv (2008)). The second one examines the role of stock prices in disciplining managers and providing incentives to insiders (Holmstrom and Tirole (1993), Faure-Grimaud and Gromb (2004), Almazan, Banerji, and Motta (2008), and Edmans (2008)). To the best of our knowledge, these two strands of the literature have never before been put together.

The remainder of the paper is organized as follows. In Section 2 we present a simple model to motivate the relationship between stock price informativeness and board independence. Section 3 describes the sample and the data. Section 4 presents our core evidence on the relationship between board independence and stock price informativeness. In Section 5 we further investigate some of the additional implications of the model, while in Section 6 we perform robustness checks. Section 7 concludes.

2. The Model

Using a simple model, we show that there can be a link between the board's monitoring role and the information revealed by stock prices. On the one hand, more informative prices can reinforce the internal monitoring activity performed by the board of directors. On the other hand, higher price informativeness can enhance the effectiveness of external monitoring mechanisms, such as disciplining takeovers. Hence, board independence and price informativeness can interact as either complements or substitutes. We examine this trade-off and discuss some empirical predictions that are tested later in the paper.

In what follows, we take the degree of price informativeness as exogenously given and focus on the optimal choice of board monitoring. This is not for realism, but for simplicity. Thus, we choose to keep the model as simple as possible by focusing only on what is essential for the empirical analysis.

2.1. Setup

We model the need for monitoring the CEO in a simple adverse selection setting (see for example Hermalin and Weisbach (1998)) with three dates (0, 1, and 2) and four types of participants: Shareholders, a Board of Directors, a CEO, and a Stock Market. The sequence of events is as follows. At date 0, the shareholders choose the composition of the board of directors (i.e., its level of independence i) and hire a CEO of an unknown type. At date 1, the type of the incumbent CEO may be revealed. With probability p (which we interpret as the degree of price informativeness), stock prices reveal the CEO's type to everyone. If prices do not reveal the CEO's type, the board alone can learn it with probability β. If the board is informed, it may replace the CEO with a new one. Likewise, if the market is informed, an external raider might take over the firm and replace the CEO.[1] At date 2, the value of the firm is revealed to everyone. The value of the firm depends on the type of the CEO in charge.

There are two types $j \in \{H, L\}$ of CEOs in this market. At date 0, the type of the CEO is not known by anyone. For simplicity, we assume that both types are equally likely in the population. The value of the firm, V^j, will depend on the quality j of its CEO. We assume $V^H > V^L$. The unconditional expected value of the firm when a new CEO is appointed is then $V^E = \frac{1}{2}\left(V^H + V^L\right)$.

The Board of Directors is characterized by its level of independence i. This level i corresponds to the probability that the board monitors and replaces a CEO who is revealed to be of type L at time 1. The board can learn about the CEO's type at date 1 from two sources: (1) stock prices or (2) its own assessment. We assume that, if the market is uninformed, the board unilaterally learns the CEO's type at date 1 with probability β. This is a very natural assumption: Insiders (i.e., the board) know more than outsiders.

Shareholders are risk-neutral agents who care about the market value of the firm and

[1] Alternative interpretations are also possible. For example, the CEO could have made wrong decisions that could be reversed only if monitors intervene at this stage.

delegate firm management to the CEO. Shareholders choose the composition of the firm's board of directors, i.e., its level of independence $i \in [0,1]$. This choice is non-trivial since a more independent board is assumed to be costlier, but also generates more monitoring of the CEO. We assume that board independence has an ex ante cost $k\frac{i^2}{2}$ to shareholders.[2] As we will discuss below, this cost may arise due to the fact that dispersed shareholders may find it difficult to influence board composition.

The stock price will be informative at date 1 with probability p, in which case it reveals the CEO's type, which becomes public information. If the price does not reveal the type of the CEO (with probability $(1-p)$), or if it reveals that the CEO is of type H (with probability $\frac{p}{2}$), the probability of a takeover taking place is zero.[3]

Conditional on the market being informed that the CEO is of type L (with probability $\frac{p}{2}$), an external raider takes over the firm and replaces its CEO with probability $\tau \in [0,1]$, which we interpret as a measure of takeover threat (or an inverse measure of takeover defenses). If the market is informed that the CEO is of type L, the board may also directly monitor and replace the CEO with probability i.[4]

For simplicity, we assume that, at date 1, τ and i are independent from each other. If both the board and the market wish to replace the CEO simultaneously, we assume that they flip a coin. Because the outcome for the firm is the same regardless of who monitors, it is not relevant to know the ultimate identity of the successful monitor.

In case the CEO is replaced at date 1, his successor is randomly drawn from the population. Thus, conditional on the market and/or the board being informed, the firm's expected value is $V^M = \frac{1}{2}\left(V^H + V^E\right)$.

[2] For models that endogenize the cost of board independence, see Song and Thakor (2006) and Adams and Ferreira (2007).

[3] This assumption is not crucial. The model could easily accommodate a positive probability of a raider acquiring information and placing a takeover bid, even if prices are uninformative.

[4] If prices reveal that the CEO is of type H, neither the market nor the board are interested in monitoring and replacing the incumbent CEO.

2.2. Board Independence and Price Informativeness

The shareholders' problem at date 0 is to choose the level of monitoring of the board of directors according to:

$$\max_{i\in[0,1]} \quad p\left[(i+\tau-i\tau)\,V^M+(1-i-\tau+i\tau)\,V^E\right] + (1-p)\left[\beta i V^M+\beta\,(1-i)\,V^E+(1-\beta)\,V^E\right]-k\frac{i^2}{2}. \tag{1}$$

Assuming an interior solution, the optimal board structure is characterized by:

$$i^*=\frac{1}{k}\left[p\,(1-\tau)+(1-p)\,\beta\right]\left(V^M-V^E\right). \tag{2}$$

Proposition 1 *The optimal degree of board independence varies with the degree of price informativeness according to:*

$$\frac{\partial i^*}{\partial p}=\frac{1}{k}\,(1-\tau-\beta)\left(V^M-V^E\right). \tag{3}$$

The sign of the relationship between board independence and price informativeness is ambiguous, depending on the values of the parameters. This result is explained by the interaction of two intuitive effects. On the one hand, price informativeness and board monitoring can be complements — the better informed the board is, the more effective board monitoring becomes. This effect arises because price informativeness is a non-rival good that can be used by both insiders and outsiders. This result is a robust one, and not specific to our model: The public good nature of price informativeness would always generate a complementarity effect in any realistic model.[5] On the other hand, price informativeness can be a substitute for board monitoring. A better informed market can directly perform external monitoring via takeovers. This result arises because both internal and external monitoring mechanisms

[5] Gordon (2007) proposes the hypothesis that board independence and stock price informativeness are complements. He claims that the monitoring advantages of independent directors are more clear in an environment with increasing stock price informativeness as insiders lose their information advantage about the firm's prospects.

perform the same task of disciplining the CEO. Any model in which internal monitoring is costly would predict a lower level of board monitoring when there is an increase in the level of external monitoring (due to more information being available in the market).

If $\tau + \beta > 1$, board independence and price informativeness are substitutes, i.e., there is a negative relationship between price informativeness and board independence. Intuitively, the substitution effect is more likely when the probability of takeovers is higher and when the board's knowledge of firm-specific information is higher. Conversely, if $\tau + \beta < 1$, board independence and price informativeness are complements. Ultimately, finding out which effect dominates is an empirical question.

2.3. Takeover Threats

More external monitoring makes the substitution effect between price informativeness and board independence stronger. If a disciplining takeover is more likely when the market is informed, there is less need for boards to monitor. Hence, we expect the level of board independence of those firms that are more exposed to the market for corporate control to exhibit higher sensitivity to stock price informativeness. In sum, the substitution effect is unambiguously stronger when takeover threats are more likely.

Proposition 2 *The higher is the likelihood of a takeover, the stronger (weaker) is the substitution (complementarity) effect of price informativeness on the choice of board independence:*

$$\frac{\partial^2 i^*}{\partial p \partial \tau} = -\frac{1}{k}\left(V^M - V^E\right). \tag{4}$$

This prediction could be tested by using takeover defenses as a proxy for the likelihood of takeovers. In the empirical section, we use the Gompers, Ishii, and Metrick (2003) governance index as a proxy for takeover defenses, as well as several disaggregated defenses.

2.4. Institutional Investors

There is evidence that institutional investors also perform an active role in corporate governance (e.g., Hartzell and Starks (2003)). To examine the role played by institutional investors in the relationship between board structure and price informativeness, we interpret parameter k as a measure of how costly internal monitoring is. When institutional investors are present as large shareholders (i.e., there is a high concentration of institutional holdings), it is likely that this cost of board monitoring is lower.

Proposition 3 *The relationship between board independence and price informativeness is stronger when the marginal cost of internal monitoring is smaller:*

$$\frac{\partial^2 i^*}{\partial p \partial k} = -\frac{1}{k}\frac{\partial i^*}{\partial p}. \tag{5}$$

We can see that (in absolute values) the relation between board independence and price informativeness is less pronounced when the marginal cost of external monitoring k is higher (i.e., when $\frac{\partial i^*}{\partial p} > 0$, then $\frac{\partial^2 i^*}{\partial p \partial k} < 0$, reducing the complementarity effect; and when $\frac{\partial i^*}{\partial p} < 0$, then $\frac{\partial^2 i^*}{\partial p \partial k} > 0$, reducing the substitution effect). These results suggest that price informativeness only significantly affects board independence when the board can effectively act as an internal monitoring mechanism (low monitoring cost k).

The parameter k measures the costs to shareholders of changing the board structure. If ownership is dispersed, coordination costs are high, so k is high. On the other hand, if there is significant ownership concentration, we expect k to be low (Shleifer and Vishny (1986) and Carleton, Nelson, and Weisbach (1998)). Empirically, we use the concentration of institutional investors as a (inverse) proxy for k.

2.5. Firm-Specific Knowledge

The parameter β reflects how easy it is for the board to gather firm-specific information to assess the ability of the CEO. The model predicts that the effect of β on the board

independence-informativeness relation is as follows:

Proposition 4 *The higher is the probability that the board learns firm-specific information, the stronger (weaker) is the substitution (complementarity) effect of price informativeness on the choice of board independence:*

$$\frac{\partial^2 i^*}{\partial p \partial \beta} = -\frac{1}{k}\left(V^M - V^E\right). \tag{6}$$

The board should find it easier to acquire firm-specific information in firms that undertake simple, well-known projects. In more innovative firms, outside board members should find it harder to acquire firm-specific knowledge that is needed to assess the CEO's ability. According to our interpretation, these firms would have low β. This result suggests that the (absolute value of the) effect of price informativeness on board independence should be stronger in firms undertaking simple and well-known projects in case the overall effect is negative, but weaker in case the overall effect is positive. Empirically, we use R&D expenditures as a (inverse) proxy for β.

3. Sample and Variables

3.1. Measures and Determinants of Board Structure

Our main dependent variable is the fraction of independent directors, which is a proxy for the monitoring intensity of the board. In order for a director to qualify as independent, he must not be an employee, a former executive, or a relative of a current corporate executive of the company. In addition, the director must not have any business relations with the company.

In a later section, we also consider other board structure variables. As alternative proxies for the monitoring activity performed by the board of directors, we use the annual number of regular board meetings and the fraction of directors with attendance problems (i.e., directors

who attended less than 75% of board meetings).

In order to identify the effect of price informativeness on the structure of corporate boards, we need to control for other possible determinants of board structure. The literature provides many suggestions in this regard (Boone et al. (2007), Coles et al. (2008a), and Linck et al. (2008)). Our goal in this paper is not to replicate these works, but rather to make sure that the new results in our paper are not being driven by omitted variables that have been found to correlate with board structure. The determinants of board structure can be classified into three broadly-defined hypotheses: *The scope of operations hypothesis*, *the monitoring hypothesis*, and *the negotiation hypothesis*.

The *scope of operations hypothesis* suggests that the size and complexity of a firm's operations affect its board structure (Fama and Jensen (1983)). As a firm grows and diversifies, it faces an increasing demand for specialized board members who can perform tasks such as managerial compensation and auditing. Under this hypothesis, more complex firms face larger agency costs and thus require additional board monitoring.

We consider three proxies to capture firms' operational complexity: firm size (as measured by equity market capitalization), firm age (the number of years since the firm's stock is exchange-listed), and the number of business segments. We expect larger, older, and more diversified firms to have a higher fraction of independent directors. We also add leverage to this list, because Coles et al. (2008a) argue that more leveraged firms are more dependent on external resources and thus leverage can be considered as a proxy for firm complexity and the CEO's need for advice.

The *monitoring hypothesis* is the set of formal and informal theories emphasizing the importance of a firm's business environment for the optimal design of its board structure (e.g., Demsetz and Lehn (1985), Raheja (2005), Adams and Ferreira (2007), and Harris and Raviv (2008)). We use several control variables to capture some of the elements of these theories. To control for the costs of outside monitoring, we take into account growth opportunities as proxied by the market-to-book ratio and R&D expenditures, stock price

volatility as proxied by the variance of stock returns, and CEO pay-performance sensitivity (stock and stock options ownership). We also consider free cash flow, profitability, and industry concentration, because these variables are possibly related to agency conflicts and other opportunities for the CEO to extract private benefits. Similarly, we include as controls several of the takeover defenses found in a firm's charter. We control for staggered boards, poison pills, cumulative voting, and supermajority provisions, which have been identified to be as the most important takeover impediments (Gillan et al. (2006) and Larcker, Richardson, and Tuna (2007)).[6]

Finally, the *negotiation hypothesis* emphasizes the role of the negotiation between the CEO and outside directors as an important determinant of board composition (Hermalin and Weisbach (1998)). We include two measures of CEO influence: CEO's tenure and pay-performance sensitivity.

We also introduce institutional ownership variables as additional controls in our empirical specifications. Because the trading activity of large institutional investors may have a direct effect on the amount of private information revealed by stock prices, we expect institutional ownership to correlate with price informativeness. There is also evidence that institutional investors perform an active role in corporate governance (Hartzell and Starks (2003)). Institutional investors are expected to have more influence when they are large shareholders, both because they have easier access to board members (Carleton et al. (1998)) and because they benefit from economies of scale in monitoring activities. Thus, we consider the concentration of institutional ownership as measured by the Herfindahl index as in Hartzell and Starks (2003). We also control for the total institutional ownership (defined as the percentage of shares outstanding held by institutions).[7]

[6] We have also included in the regressions (results not tabulated) other important takeover defenses: blank check preferred, fair price provision, limitation of shareholders' ability to call a special meeting, limit to shareholders' action by written consent, and unequal voting rights. We find these takeover defenses to be insignificant.

[7] There is some discussion in the literature over whether some types of institutions specialize in monitoring and activism rather than trading. Research by Chen, Harford, and Li (2007b) shows that "independent institutions" (mutual fund managers and investment advisors) are effective monitors, while "grey" institutions (bank trusts, insurance companies, and other institutions) are not.

3.2. Measures of Price Informativeness

Our primary measure of stock price informativeness is the probability of information-based trading (PIN) developed by Easley et al. (1996). This measure is based on a structural market microstructure model, where trades may come from either noise traders or informed traders. The trading process is modeled in the following way. At the beginning of each day, there is a probability λ that some traders acquire new (private) information about the fundamental value of the firm. Trading orders arrive throughout the day according to three different Poisson distributions: informed trade orders come in at the average rate μ, uninformed buy orders come in at the rate ϵ_b, and uninformed sell orders come in at the rate ϵ_s. The probability that the opening trade of the day is information-based is given by

$$\text{PIN} = \frac{\lambda\mu}{\lambda\mu + \epsilon_b + \epsilon_s}. \tag{7}$$

Easley, Hvidkjaer, and O'Hara (2002) use intra-day transaction data to estimate the above parameters and thus the probability of informed trading in a stock. Notice that PIN should be low for stocks with little fluctuation in their daily buy and sell orders, which are more likely to come from liquidity or noise trading. Likewise, PIN should be high for stocks that display frequent large deviations from their normal order flows.

Previous empirical work generally supports the use of PIN as a valid measure of the probability of informed trading and a proxy for stock price informativeness. Easley et al. (2002) find that the risk of private information trading is priced, i.e. stocks with higher PIN have higher expected returns.[8] Vega (2006) shows that stocks with higher PIN have smaller reactions following an earnings announcement, which is consistent with the idea that these stock prices incorporate more private information and track their fundamental values more closely. PIN also seems to be related to managerial decisions. Chen, Goldstein, and Jiang (2007a) find a positive relation between PIN and the sensitivity of firm investment to

[8] See Mohanram and Rajgopal (2008) for a critique of this finding.

stock prices, which supports the hypothesis that managers learn from the private information incorporated into stock prices. Ferreira and Laux (2007) find a positive relation between strong corporate governance (few takeover defenses) and PIN, suggesting that strong shareholder protection induces private information collection and trading by informed market participants.

Although we use PIN as our main proxy for the amount of private information that is incorporated into prices, we acknowledge that this measure is imperfect. PIN might capture some illiquidity effects that are not related to asymmetric information.[9] Nevertheless, it is important to keep in mind that there is no reason to believe that measurement error in PIN can explain our findings; if anything, it makes it harder to detect any underlying relationship between the latent variables.

As an alternative to PIN, we also consider other price informativeness variables to corroborate our interpretation of the results. We first consider firm-specific stock return variation as a measure of price informativeness. French and Roll (1986) and Roll (1988) show that a significant portion of stock return variation is not explained by market movements. They suggest that firm-specific return variation measures the rate of private information incorporation into prices via trading. Although both uninformed trading and trading on the basis of public information can in principle explain firm-specific return variation, there is considerable empirical evidence supporting the use of firm-specific return variation as a measure of stock price informativeness and particularly of private information about firms. High levels of firm-specific return variation are associated with more efficient capital allocation (Durnev, Morck, and Yeung (2004)) and with more information about future earnings embedded in stock prices (Durnev, Morck, Yeung, and Zarowin (2003)).[10]

We estimate annual firm-specific return variation by regressing stock returns on the three

[9] A recent paper by Duarte and Young (2008) suggests that the relation between PIN and expected returns is explained by the fact that PIN is also a proxy for illiquidity that is not related to private information.

[10] Cross-country patterns of firm-specific return variation also correspond to likely patterns of price informativeness. Morck et al. (2000) and Jin and Myers (2006) find high firm-specific stock return variation in developed markets, but low firm-specific return variation in emerging markets.

factors from the Fama-French model. For each firm-year, firm-specific return variation is estimated by $1 - R^2$ from the regression:

$$r_{it} = \alpha_i + \beta_{1i} RM_t + \beta_{2i} SMB_t + \beta_{3i} HML_t + e_{it}, \tag{8}$$

using daily return data, where r_{it} is the return of stock i in day t in excess of the risk-free rate, RM_t is the value-weighted excess market return, SMB_t is the small-minus-big size factor return, and HML_t is the high-minus-low book-to-market factor return.[11] Given the bounded nature of R^2, we conduct our tests using a logistic transformation of $1 - R^2$:

$$\Psi = log\left(\frac{1 - R^2}{R^2}\right) = log\left(\frac{\sigma_e^2}{\sigma^2 - \sigma_e^2}\right). \tag{9}$$

The variable Ψ measures firm-specific stock return variation relative to market-wide variation, or lack of synchronicity with the market.[12]

Finally, as an alternative measure of price informativeness, we use the illiquidity ratio of Amihud (2002). This measure is defined as the annual average of the daily ratio between a stock's absolute return and its dollar volume (multiplied by 10^6):

$$\text{ILLIQ} = \frac{1}{D_i} \sum_{t=1}^{D_i} \frac{|r_{it}|}{\text{VOLD}_{it}}, \tag{10}$$

where D_i is the annual number of valid observation days for stock i and VOLD_{it} is the dollar volume of stock i on day t. The illiquidity ratio gives the absolute (percentage) price change per dollar of daily trading volume and is a proxy for the price impact of order flow. The magnitude of the price impact should be a positive function of the perceived amount of informed trading on a stock (Kyle (1985)), although illiquidity will also reflect the inventory costs associated with trading a given order size.

[11] The daily returns for the small-minus-big (SMB) and high-minus-low (HML) factors are drawn from French's website: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[12] Alternative estimates of firm-specific return variation are provided by a market model that assumes $\beta_{2i} = \beta_{3i} = 0$ in equation (8) and by a two-factor (market and industry) model. We obtain similar findings using these alternative estimates.

3.3. Sample

We start with firms in the Investor Responsibility Research Center (IRRC) database between 1990 and 2001.[13] The IRRC database contains detailed information on governance and director characteristics for a large number of U.S. firms. We obtain board data for these firms from Compact Disclosure for the 1990-1995 period and from IRRC for the 1996-2001 period.[14] We exclude financial firms (SIC codes 6000-6999). We winsorize variables at the bottom and top 1% level. After these adjustments the number of firms in the sample is 2,188. Next we merge the IRRC database with our main variable of price informativeness — the probability of information-based trading (PIN) for each firm-year, based on data from Easley et al. (2002).[15] The final sample contains 1,443 firms and a total of 9,447 firm-year observations.

We obtain financial and segment data from Compustat and stock returns and turnover data from CRSP. The governance index of Gompers et al. (2003) (GIM), individual takeover defenses, and board attendance problems are available from the IRRC database. We obtain data on institutional holdings and the number of analysts covering each firm from Thomson CDA/Spectrum Institutional 13f Holdings and IBES. Blockholder ownership is based on data from Dlugosz, Fahlenbrach, Gompers, and Metrick (2006). Finally, we obtain additional director characteristics such as CEO stock and stock options ownership, CEO tenure, and number of board meetings from ExecuComp. We compute a measure of CEO pay-performance sensitivity (PPS) that includes the effects of stock ownership and existing and newly granted stock options. For stock ownership, PPS is computed as the number of

[13] Our sample ends in 2001 because PIN estimates are less reliable when short sales represent a significant fraction of the trading volume. In fact, PIN relies on trade classification algorithms that in some cases fail to classify short sales correctly (Asquith, Oman, and Safaya (2007)).

[14] We thank Tina Yang for helping us with the Compact Disclosure board data. While IRRC provides detailed information on affiliation of directors, Compact Disclosure identifies only whether the director is an officer of the firm. Thus, board composition is only described in terms of the percentage of executive directors (insiders or officers) and non-executive directors on the board. In the robustness section, we report results using only IRRC data that are consistent with our primary findings.

[15] The estimates of PIN are obtained from Soeren Hvidkjaer's website: http://www.smith.umd.edu/faculty/hvidkjaer/data.htm.

shares of stock held by the CEO divided by the number of shares outstanding. For stock options, following Yermack (1995), PPS is computed as the option delta from the Black-Scholes option-pricing model multiplied by the ratio of the number of shares held to shares outstanding. Table 1 defines in detail the variables used in this study and describes their sources.

Table 2 presents descriptive statistics of our data. The median fraction of independent directors is 0.778 and the median PIN is 0.154. These statistics (and others in Table 2) are comparable to those found in similar studies, such as those of Easley et al. (2002), Gillan et al. (2006), and Coles et al. (2008a).

4. Main Evidence

In this section we present our main results on the relationship between board independence and probability of informed trading (PIN). Figure 1 presents a visual summary of the relationship between board independence and PIN. We first sort firms into quintile portfolios ranked by PIN. We then calculate the average board independence within each quintile portfolio of PIN. The main finding in this paper is clear from the figure: The average board independence for the lowest PIN (low market monitoring) portfolio (Q1) is greater than the one for the highest PIN (high market monitoring) portfolio (Q5). The low-PIN portfolio displays board independence of about 80%, while the corresponding figure for the high-PIN portfolio is about 70%. The difference between the two extreme quintile portfolios of 10 percentage points (i.e., one director for an average board size) is statistically significant (t-statistic of 22.1). Moreover, all intermediate PIN portfolios present lower board independence than the low-PIN portfolio. The economic impact of PIN on board independence is sizeable if compared to the analogous effects of other well-known determinants of board structure, as we show later.

Table 3 presents the outcome of several ordinary least squares (OLS) panel regressions,

where the dependent variable y is a logistic transformation (or the log odds ratio) of the fraction of independent directors z (i.e. $y = \ln(z/1-z)$). We use a logistic transformation because the fraction of independent directors is bounded between zero and one. Our explanatory variable of interest is PIN. All regressions include industry (two-digit SIC) and year dummy variables. All reported t-statistics are adjusted for heteroskedasticity and within-firm correlation using clustered standard errors (Petersen (2009)). In addition, the inclusion of year dummies accounts for some forms of cross-sectional dependence.

Column (1) presents the coefficients of a regression between the fraction of independent directors and PIN. There is strong evidence of a negative and significant relationship. The PIN coefficient is -3.1376, with a t-statistic of -13.60.

Controlling for other firm characteristics does not change this result qualitatively. In column (2) we present estimates for a specification that does not include PPS and tenure as controls because these variables are not available for the 1990-1991 period. The PIN coefficient is -1.9860 with a t-statistic of -7.76. In column (3) we add PPS and tenure as controls, but the PIN estimate and t-statistic are barely affected. Overall, we find that the probability of informed trading displays a significant negative relationship with board independence.

With respect to the other explanatory variables, we find that leverage, firm age, and the number of business segments are all positively and significantly related to board independence. Firm size enters with a positive but insignificant coefficient (at the 5% level) in the majority of specifications. These findings are consistent with the scope of the operations hypothesis that more complex firms require more independent boards.

Consistent with the findings of Boone et al. (2007) and Coles et al. (2008a), we find no statistically significant relationships between board independence and market-book ratio, R&D expenditures, return-on-assets, free cash flow, and stock return variance. In contrast, we find that the coefficients of PPS and tenure are both negative and statistically significant, which is consistent with the suggestion of Hermalin and Weisbach (1998) that board struc-

ture is influenced by the negotiations between CEOs and outside directors. The evidence indicates that board independence is negatively related to the degree of CEO influence. In particular, the negative and significant coefficient of PPS is consistent with board independence and managerial ownership being substitutes, as in Denis and Sarin (1999), Shivdasani and Yermack (1999), and Coles et al. (2008a).[16]

The impact of PIN on board independence is economically significant if compared to the effects of other important board structure determinants (e.g., Coles et al. (2008a)). Using the specification in column (3), a one-standard deviation increase in PIN reduces board independence by roughly 2 percentage points (at the averages of the data). If we perform the same experiment with the other variables that also enter significantly in the regression, we obtain effects of 1.2 percentage points for increasing leverage by one standard deviation, 2.2 percentage points for increasing firm age, 1.2 percentage points for increasing the number of business segments, and -1.6 percentage points for increasing PPS.[17]

In columns (4)-(5) we control for takeover defenses, total institutional ownership, and institutional ownership concentration. The staggered board, poison pill and cumulative voting coefficients are positive and statistically significant, which is consistent with the idea that board independence is higher in firms that are insulated from the market for corporate control. This finding is consistent with the empirical evidence of Gillan et al. (2006), who show that an independent board can act as a substitute for the market for corporate control. The institutional ownership variables are not significantly related to board independence.

In summary, we find that the probability of informed trading displays a statistically and economically significant negative relationship with board independence. This relationship is robust to the inclusion of many variables that are likely to correlate with board independence.

[16] Others, however, have found a positive relation between insider ownership and board independence (Ryan and Wiggins (2004) and Davila and Penalva (2006)).

[17] Coles et al. (2008b) find quantitatively stronger effects of PPS on board structure in a structural model estimation. Our reduced-form approach is bound to be less efficient. We are able to produce qualitatively similar results, but the magnitudes of the effects is smaller.

5. Interpreting the Relationship between Board Independence and the Probability of Informed Trading

In the previous section, we find evidence of a negative relation between board independence and the probability of informed trading (PIN). Our findings suggest that when more information flows to the market (via trading on private information), firms tend to choose less independent boards. The interpretation is that when stock prices are more revealing, the stock market is a substitute for the monitoring role of corporate boards. In this section, we present additional results that strengthen this interpretation by investigating whether the relation between price informativeness and board independence is heterogeneous across groups of firms in the way predicted by our model.

5.1. Takeover Defenses

If a firm adopts a large number of takeover defenses, it might become partially insulated from the market for corporate control (Field and Karpoff (2002) and Masulis, Wang, and Xie (2007)). In such cases, the takeover market cannot play an effective disciplinary role. Our hypothesis is that the trade-off between board independence and price informativeness is more relevant when there are few takeover defenses. This is implied by Proposition 2.

We use the governance index of Gompers et al. (2003) (GIM) as a proxy for the number of takeover defenses a firm has in place. Column (1) of Table 4 presents the results where we include an interaction variable of PIN and a dummy variable, which takes the value of one if a firm has a GIM index above the median in our sample (10 takeover defenses), and zero otherwise (GIM dummy). In the specifications of Table 4 we use the same set of control variables as in column (5) of Table 3 (coefficients not shown).

We find that the interaction variable (PIN $\times$ GIM dummy) coefficient is positive and significant, while the PIN coefficient remains negative and significant. The interpretation is that the negative relationship between board independence and PIN is stronger for low

GIM firms. We use alternatively an interaction variable between PIN and a particularly important individual takeover defense — the poison pill. Brickley et al. (1994) show that takeover outcomes are affected by poison pills provisions and outside directors. We find that this interaction variable coefficient is positive and significant, while the PIN coefficient remains negative and significant (see column (2) of Table 4).

We conclude that the market for corporate control does have an important role to play in shaping the relation between board independence and price informativeness. Price informativeness can only substitute for the role of independent directors when the firm is open to the market for corporate control. This finding is consistent with the evidence provided by Gillan et al. (2006), who show that if a disciplining takeover is more likely, then there is less need for board monitoring.

5.2. Institutional Ownership Concentration

If our theory is correct, shareholders should frequently intervene to change the board structure in response to exogenous changes in price informativeness.[18] Our theory is thus less plausible in dispersed ownership structures where shareholders have no incentives to engage in activism. Unlike individual investors, institutional investors (especially if they hold large blocks of stock) may have a clear incentive to maximize firm value by changing board structure whenever necessary. Thus, our hypothesis is that the trade-off between board independence and price informativeness is more relevant when there are large shareholders or when there is a higher concentration of institutional ownership. This is implied by Proposition 3.

Column (3) of Table 4 presents the results including an interaction variable of PIN and a institutional ownership concentration dummy, which takes the value of one for firms whose institutional Herfindahl index is above the median in our sample, and zero otherwise. The

[18] See Karpoff (2001) and Gillan and Starks (2007) for a summary of the evidence on shareholder activism and governance structure. The evidence suggests that active shareholders do affect governance structures, although the effect of activism on firm performance is not clear cut.

interaction variable is negative and statistically significant, i.e., PIN is more strongly negatively related to board independence for those firms with a high concentration of institutional ownership.

These results suggest that price informativeness can only be an effective substitute for internal monitoring (by the board) when large institutional shareholders supervise the board themselves. Without a substantial concentration of institutional ownership, perhaps the board only plays a minor role. In such cases, it would be natural to find a weaker relationship between board independence and stock price informativeness.

5.3. Firm-Specific Knowledge

When firm-specific knowledge is important, a board that is too independent may fail to obtain crucial information. The idea is simply that CEOs and inside directors possess more firm-specific knowledge than outside directors (Fama and Jensen (1983)). We thus expect that costs associated with the acquisition of firm-specific knowledge may affect the relationship between board structure and price informativeness. Specifically, if stock markets can substitute for corporate boards as monitors of management, we expect to find a stronger negative relationship between board independence and price informativeness when firm-specific knowledge is less important. This hypothesis is formally derived in Proposition 4.

Measuring firm-specific knowledge is a difficult task. Following Coles et al. (2008a), we use R&D expenditures as a proxy for the importance of firm-specific knowledge. If the kind of information that market prices convey cannot substitute for the knowledge that insiders possess, the substitution effect should be weaker for firms with high R&D.

Column (4) in Table 4 presents the results including an interaction between PIN and a dummy variable that takes the value of one for firms whose ratio of R&D expenditures to assets is above the 80th percentile.[19] The evidence shows that the negative relationship

[19]The 80th percentile actually corresponds to the median for firms with positive R&D expenditures as only 40% of the observations have positive R&D. The findings are similar if we use the 75th percentile as the cut-off.

between board independence and PIN is more pronounced in low R&D firms. This evidence is consistent with the hypothesis that when firm-specific knowledge is less important, the private information revealed by stock prices can substitute for the monitoring role of corporate boards.

5.4. Pay-Performance Sensitivity

We also estimate the impact of PIN on board independence including an interaction of price informativeness with the intensity of equity-based pay for the CEO. Executive compensation plans can help to align the interests of managers with those of shareholders. Although our model does not have any prediction with respect to equity-based incentives, previous models on the monitoring role of stock prices (Holmstrom and Tirole (1993) and Coles et al. (2008b)) have focused on executive compensation as the main mechanism through which stock prices discipline managers. Thus, we expect to find a stronger relationship between price informativeness and board independence in firms in which pay-performance sensitivity of CEO compensation contracts is high. Column (5) of Table 4 presents the results including an interaction of PIN and a PPS dummy, which takes the value of one for firms whose PPS is above the median in our sample. We find a negative and statistically significant interaction variable coefficient. The PIN coefficient remains negative and significant. These results suggest that price informativeness can only be an effective substitute for internal monitoring (by the board) when managerial incentives are closely tied to shareholder value.

5.5. Stock Performance

We investigate whether corporate boards matter more during certain periods. Independent boards seem to be particularly effective in performing specific tasks, such as hiring and firing the CEO (Weisbach (1988) and Borokhovich et al. (1996)), adopting and using takeover defenses (Brickley et al. (1994)), and negotiating takeovers (Cotter et al. (1997)). We proxy for these special circumstances using abnormal stock market returns. Abnormal stock returns

are calculated as a firm's stock return minus the value-weighted market index return. The idea is that a firm's stock price is likely to display sharp falls or rises during some of these events. Column (6) of Table 4 presents the results including an interaction variable between PIN and an absolute abnormal stock return dummy, which takes the value of one for firms whose absolute abnormal return is above the 80th percentile. The coefficient on the interaction variable is negative and statistically significant, suggesting that the negative relation between price informativeness and board independence is more pronounced during periods of extreme stock performance. Consistent with the hypothesis that board composition is more likely to change during "crises" and other exceptional events, the absolute abnormal stock return coefficient is positive, but it is statistically weak. Finally, in column (7) we include all interactions jointly. The results confirm the previous findings with the exception of the R&D interaction term that becomes insignificant.

6. Robustness

In this section, we check the robustness of our main results. We first present several alternative estimation methods, such as firm fixed effects and instrumental variables (2SLS). These alternative estimation methods address several concerns with our estimates, such as omitted variables, reverse causality, and measurement errors. We then present results using alternative measures of price informativeness and additional board-related variables. In the final subsection, we present additional robustness checks such as sample variations and additional control variables.

6.1. Endogeneity: Omitted Variables and Reverse Causality

Endogeneity problems are ubiquitous in empirical research on corporate governance. In our setting, this problem is accentuated by recent findings showing that CEO decision-making power and board size both have direct effects on corporate performance, in particular the

variability of stock returns (Adams, Almeida, and Ferreira (2005) and Cheng (2008)).[20] Furthermore, there could be other reasons for board structure and price informativeness to be jointly determined.

We first address the potential endogeneity problems using firm fixed effects methods that control for unobserved sources of firm heterogeneity. Fixed-effects methods solve "joint determination" problems in which an unobserved time-invariant variable simultaneously determines both PIN and board independence. It is also equivalent to looking only at within-firm changes in PIN.

Columns (1) and (2) of Table 5 present the firm fixed effects estimates (with t-statistics adjusted for firm-level clustering). There is still evidence of a negative relation between board independence and PIN. In column (2), the estimate of the PIN coefficient is -0.5755 with a significant t-statistic of -2.88.

The fixed effects results go a long way towards dismissing omitted variables explanations as sources of endogeneity. Because only the effects of within-firm changes in board independence are taken into account, firm-specific omitted variables cannot explain the observed relationship between PIN and board independence. An issue here is whether there is enough variation in PIN and board independence over time so that one can estimate this relationship with precision. The short answer is yes; although t-statistics are lower, suggesting a lower precision in the estimates, they are still quite high by traditional standards.[21]

We also use instrumental variables as an alternative method to fixed effects, in order to address the potential endogeneity of PIN. Instrumental variables methods allow us to address omitted variables and reverse causality issues simultaneously. The caveat is that, unlike the fixed-effects method, it requires stronger assumptions that are usually not possible

[20] We have already dealt with some of these issues in this paper. In order to be sure that our measure of price informativeness is not simply capturing the effect of stock return volatility, we have included the total stock return variance as a control variable in all specifications.

[21] Interestingly, the idea that board structure does not change much over time may be more a myth than reality. Cicero, Wintoki, and Yang (2008) find that in the 1991-2003 period, two-thirds of the firms in their sample change either board size or independence during a two-year period. They also find that firms close 63% of the gap between their actual and target board independence over a two-year period.

to test for. Under standard identification assumptions, we apply two-stage least squares (2SLS) methods to isolate the effect of PIN on board independence. To this end, we need instruments for PIN: a variable that is correlated with PIN (this assumption can be tested), but uncorrelated with board structure except indirectly through other independent variables. That is, the instrument should be a variable that can be "excluded" from the original list of control variables without affecting the results. This last requirement cannot be tested by statistical methods; it is, in the end, an act of faith.

We use analyst coverage, share turnover, and S&P 500 membership as instruments. Easley, O'Hara, and Paperman (1998) suggest that analysts may serve to turn private information into public information and do not have significant firm-specific information. Analysts may attract additional uninformed order flow to a stock, an effect that would also reduce PIN. Empirical evidence seems to support a negative relation between price informativeness and analyst coverage (Piotroski and Roulstone (2004) and Chan and Hameed (2006)). Share turnover is also likely to be negatively related to PIN, again consistent with the notion that stocks with greater trading activity tend to have more uninformed order flow (Easley et al. (2002)). We use as an additional instrument a dummy variable that takes the value of one if a stock is included in the S&P 500 index as these firms tend to attract more investor attention (Denis, McConnell, Ovtchinnikov, and Yu (2003)). Thus, our instrumental variables have been previously found to be significantly correlated with price informativeness, but have never been used as explanatory variables in board independence regressions in previous studies.[22]

Columns (3) and (4) of Table 5 present the results of the first stage regressions that uses PIN as the dependent variable. The results support the conclusion that analyst coverage and share turnover are negatively and significantly related to PIN, while the S&P 500 membership dummy is positively related to PIN. F-tests that the instruments can be excluded from the first stage regressions are strongly rejected (F-statistics are 24.47 and 10.8 in columns (3)

[22] We also use lagged PIN as an instrument and obtain consistent results (not tabulated here). See Aslan, Easley, Hvidkjaer, and O'Hara (2006) for a discussion of alternative instruments for PIN.

and (4)). Thus, we conclude that our instruments are not only associated with PIN in the predicted direction, but also that our specifications do not appear to suffer from "weak instruments" concerns.

Columns (5) and (6) present the coefficients of the second-stage regression that uses board independence as the dependent variable. There is still evidence of a negative relation between board independence and PIN after taking into account the possibility that PIN is endogenous. The evidence suggests the existence of a causal link from price informativeness to board structure. To assess the quality of the instruments formally, we also perform a Hansen $\mathcal{X}^2$-test of instrument orthogonality. This statistic jointly tests the null hypotheses of correct model specification and orthogonality between the instruments and the errors. Our instruments perform adequately in our tests (p-value is 0.12 and 0.87 in the specifications of columns (5) and (6) respectively), indicating that we cannot reject the null hypothesis of instrument suitability.

A final approach to address endogeneity concerns is to use lagged PIN as an explanatory variable. Columns (7) and (8) present the results of these estimations, confirming a negative relation between board independence and PIN. Although the finding that past PIN predicts future board structure cannot rule out all reverse causality stories, it addresses some of the most obvious ones.

Our conclusion here is twofold. Omitted variables are unlikely to explain the relationship between PIN and board independence: on top of our long list of control variables, firm fixed effects should take care of most time-invariant unobserved variables. We also find some evidence consistent with a causal effect from price informativeness to board independence. One has to keep in mind, however, that providing evidence for causality in one direction does not rule out causality running in both directions. We make no claim that board structure does not affect PIN as well, although we cannot test this hypothesis directly due to the lack of reasonable instruments for board independence.

6.2. Alternative Measures of Price Informativeness

Is the empirical relationship between board independence and PIN driven by the private informational content of stock prices? In this section, we use two alternative measures of private information incorporated into prices as determinants of board structure. First, we use firm-specific stock return variation, or non-synchronicity of stock returns, as an alternative proxy for the intensity of private information incorporated into prices (Morck et al. (2000)). Second, we use the illiquidity ratio of Amihud (2002), which is a proxy for the price impact of order flow.

We estimate board independence regressions similar to those in Table 3 using firm-specific return variation and the illiquidity ratio as measures of private information incorporated into stock prices. We report the results in Table 6. Columns (1) and (2) show results for the regressions using the logistic transformation of firm-specific return variation (Ψ) as the measure of price informativeness. We find that the coefficients on Ψ are negative and statistically significant. Thus, board independence is lower in firms whose stock returns are less synchronized with the market.

Columns (3) and (4) in Table 6 present estimates using the annual illiquidity ratio (ILLIQ). ILLIQ is also negatively related to board independence, which supports the hypothesis that firms with a higher price impact of order flow (perhaps due to private information trading) have less independent boards.

The impact of the alternative price informativeness measures on board independence is economically significant if compared to the effects of other important board independence determinants. A one-standard deviation increase in firm-specific return variation and illiquidity reduces board independence by roughly 1 and 4 percentage points respectively. If we perform the same experiment with PPS, we obtain effects of roughly 1 percentage points for increasing PPS by one standard deviation. In sum, the results using alternative proxies of price informativeness confirm our basic finding: Stock market monitoring via prices and board monitoring appear to be substitutes.

6.3. Additional Board Monitoring Variables

It is natural to ask whether price informativeness also affects other variables that are likely to be associated with the monitoring intensity of the board. Here we focus on the number of board meetings and the fraction of directors with attendance problems as alternative proxies for the monitoring intensity of the board. We also analyze the impact of PIN on board size, although previous research has found that size does not have a one-to-one relation to monitoring intensity and is likely to be influenced by firms' need for board advice (Coles et al. (2008a) and Linck et al. (2008)).

It has been argued that a board that meets more often is likely to be a better monitor (e.g., Vafeas (1999)). In Table 7, columns (1) and (2) present the estimates of regressions in which the logarithm of the annual number of board meetings is the dependent variable. We find a negative relationship between the number of board meetings and PIN. This result is compatible with board monitoring and price informativeness being substitutes.

The Securities Exchange Act of 1934 requires corporations to list in their proxy statements the name of each director who attended fewer than 75% of the number of board meetings and board committees meetings on which he serves. A higher fraction of directors with attendance problems is likely to indicate poor monitoring. Columns (3) and (4) present the estimates of regressions in which the annual fraction of directors with attendance problems is the dependent variable. We find a positive relationship between board attendance problems and PIN. Again, this result is compatible with board monitoring and price informativeness being substitutes.

Finally, columns (5) and (6) present the outcome of regressions in which the dependent variable is the logarithm of board size. We use the log transformation because board size is bounded below by zero. There is evidence of a negative and statistically significant relationship between board size and PIN. Most of the other firm-level characteristics enter with their expected signs, and are usually consistent with the literature on board structure determinants (e.g., Boone et al. (2007) and Linck et al. (2008)). It has been argued that

larger boards are poor monitors (Lipton and Lorsch (1992) and Jensen (1993)). However, some also argue that larger boards are more diverse and produce more specialized advice to managers (Coles et al. (2008a) and Linck et al. (2008)). Thus, although the evidence that we find is interesting, it is difficult to interpret. It should also be noted that size and independence are positively correlated in the sample.

6.4. Additional Robustness Checks

This subsection discusses several additional robustness checks. We check whether our findings are robust to the sample period, to functional form assumptions, and to the inclusion of additional control variables. These results appear in Table 8. In the specifications of Table 8 we use the same set of control variables as in column (5) of Table 3 (coefficients not shown).

Column (1) uses the 1996-2001 sample period, rather than 1990-2001. The 1996-2001 period corresponds to the period for which the IRRC directorship data are available. Therefore, column (1) uses only IRRC directorship data, rather than both Compact Disclosure (1990-1995) and IRRC data (1996-2001). There is a potential concern because Compact Disclosure classifies each director as either executive or non-executive, while IRRC uses a finer definition of independence. Column (2) uses board data from Compact Disclosure for the whole sample period (1990-2001) as an alternative to the IRRC directorship data.

Column (3) uses the logarithm of board independence, rather than the logistic transformation, as the dependent variable. Column (4) uses the fraction of independent directors (i.e. restricted to [0,1]) as the dependent variable. These confirm that our results are not driven by our particular functional form assumptions in the construction of the board independence variable.

Column (5) reports results after controlling for blockholder ownership, considering all types of blockholders rather than institutional investors only. Column (6) reports results after controlling for outside blockholders ownership rather than 13F institutional investors only. These blockholder ownership data are taken from Dlugosz et al. (2006) and cover the

1996-2001 sample period only.

Column (7) presents results that take into account product market competition. Shleifer and Vishny (1997) suggest that product market competition is one of the most effective mechanisms to eliminate managerial inefficiency. We try to capture the competitive structure of an industry by using the industry Herfindahl index, calculated as the sum of squared market shares of all firms in each industry (two-digit SIC) in each year. Industries with lower Herfindahl indices possess more competitive product markets.

Column (8) includes lagged board size as an additional control variable following Boone et al. (2007) and Coles et al. (2008a). In order to control for the potential differences in liquidity and governance requirements between stock exchanges, in column (9) we include a dummy variable that takes the value of one if a firm is listed on the New York Stock Exchange (NYSE).

In columns (1)-(9), the estimated coefficient on the probability of informed trading remains negative and strongly significant. Our basic result is thus confirmed: more private information trading is strongly associated with less board independence, or in other words, with less need for board monitoring.

Others have shown that board structure affects firms' disclosure policy (e.g., Leuz et al. (2008)) and accounting quality (e.g., Petra (2007)). Columns (10) and (11) present results that control for earnings quality and earnings informativeness. Earnings quality is measured by the annual absolute value of firm-specific residuals from an industry regression of total accruals on lagged, contemporaneous, and leading cash flow from operations (Dechow and Dichev (2002)). This variable is an inverse index of accounting quality, in that it increases in the magnitude of unexpected accruals. Following Francis and Schipper (1999) and Bushman, Chen, Engel, and Smith (2004), we measure earnings informativeness by the R-squared of a firm-level regression of 15-month stock returns (ending 3 months after the end of fiscal year t) on income before extraordinary items (NIBE) in year t and the change in NIBE from year $t-1$ to t, scaled by market value at the beginning of year t. There is weak evidence of a

positive association between board independence and earnings quality and informativeness. Most importantly, the magnitude of the PIN coefficient is not affected by these controls.

A different concern with our measure of price informativeness is that PIN is a proxy for extreme stock performance. We find this to be true in our sample: firms with abnormal stock returns in the bottom and top quintiles have significantly higher PIN than firms with moderate levels of abnormal returns. It could be the case that PIN is simply proxying for extreme stock price performance and that board structure changes as a response to such events. To address this concern, in column (12) we include as controls two dummy variables: one indicating those firms with low past abnormal stock returns (Q1) and one indicating those firms with high abnormal stock returns (Q5). We note that the evidence that extreme abnormal returns affect board structure directly is weak, while the coefficient on the PIN variable is not materially affected.

So far we have treated PIN as a continuous variable. We now take an alternative approach and classify firms as either low PIN or high PIN. Specifically, we define two dummy variables: PIN Q5-Q1 is equal to one for firm-years with PINs above the 80th percentile (Q5) and zero for firm-years with PINs below the 20th percentile (Q1) (observations with intermediate values of PIN are not included in this regression); and a PIN dummy that equals one for firm-years above the median and zero otherwise. This procedure tackles some possible measurement errors problems in the PIN variable. Columns (13) and (14) report the results that confirm a negative relation between PIN and board independence.

Finally, as alternative procedures to tackle potential problems with outliers and cross-sectional error correlation, we present results using a least-absolute deviation (median) regression (column (15)) and the Fama-McBeth procedure (column (16)). As one can see from the point estimates, if anything, outliers seem to reduce the magnitude of the estimated effects. The results from the Fama-McBeth procedure are also qualitatively similar to those reported in Table 3.

7. Conclusion

We add a new element to the list of determinants of board structure — price informativeness. We develop and test the hypothesis that the amount of private information incorporated into stock prices affects the structure of corporate boards, in particular board independence.

We find robust empirical evidence that stock price informativeness, as measured by the probability of informed trading (PIN) and other proxies, is negatively related to board independence. The correlation between price informativeness and board independence is as strong — in both economic and statistical senses — as the ones between board independence and other firm-level variables that have been documented in the literature on corporate boards. Given our long list of control variables and the use of fixed-effects methods, it is unlikely that price informativeness is capturing the effects of omitted variables.

Consistent with our theory, the negative relationship between price informativeness and board monitoring is particularly strong for firms with few takeover defenses. We also find that ownership concentration seems to be important for the trade-off between board monitoring and price informativeness. The negative relationship between board independence and price informativeness is particularly strong for firms with less firm-specific knowledge and more pay-performance sensitivity in CEO compensation. Finally, this negative relation is stronger during periods of extreme stock performance, when board composition is likely to be particularly important.

One possible interpretation for our results suggests that if stock prices are informative, stock markets are able to perform a monitoring role like the one normally associated with the board of directors. Our results are thus consistent with the hypothesis that board monitoring and stock market monitoring are substitutes. The evidence that more informative prices are associated with a lower degree of board independence, fewer board meetings, weaker attendance at board meetings, and smaller board size all point in a similar direction: Firms with more informative stock prices require less demanding board structures. Our findings suggest that stock price informativeness affects optimal organization design.

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Table 1
Definitions of Variables

Variable	Definition
Fraction of independent directors	Ratio of number of independent directors by the board size (1990-1995 data from Compact Disclosure and 1996-2001 data from IRRC).
Board size	Number of board members (IRRC).
Number of board meetings	Number of board meetings by year (EXECUCOMP)
Board attendance problems	Ratio of directors that attended less than 75 percent of board/committee meetings by the board size (IRRC).
Probability of informed trading (PIN)	Probability of information-based trading (PIN) of Easley, Hvidkjaer, and O'Hara (2002).
Firm-specific return variation	$1 - R^2$ of of the Fama-French three-factor regression model using daily stock returns.
Illiquidity	Average daily ratio of a stock absolute return by the dollar volume (Amihud (2002)).
Firm size	Market capitalization in $ millions (COMPUSTAT: item 25 x item 199).
Leverage	Ratio of total debt to total assets (COMPUSTAT: (item 9 + item 34) / item 6).
Firm age	Number of years since the stock inclusion in the CRSP database.
Number of business segments	Number of business segments in which firm operates (COMPUSTAT).
Market-to-book	Ratio of market value of equity by book value of equity (COMPUSTAT: item 25 × item 199 / item 60).
R&D expenditures	Ratio of R&D expenditures by total assets (COMPUSTAT: item 46 / item 6).
Stock return variance	Stock return variance (annualized) estimated with daily stock returns (CRSP).
Free cash flow	Ratio of operating income before depreciation minus capital expenditures by total assets (COMPUSTAT: (item 13 - item 128) / item 6).
Return-on-assets	Ratio of operating income before depreciation by total assets (COMPUSTAT: item 13 / item 6).
CEO pay-performance sensitivity (PPS)	Sensitivity of CEO's stock and stock options holdings to changes in shareholder wealth, as a percentage of the number of shares outstanding (EXECUCOMP).
CEO tenure	Number of years since the date the director became CEO (EXECUCOMP).
Governance index (GIM)	Governance index of Gompers, Ishii, and Metrick (2003), which is based on 24 antitakeover provisions (IRRC).
Staggered board dummy	Dummy variable that takes the value of one if a firm has a staggered board, zero otherwise.
Poison pill dummy	Dummy variable that takes the value of one if a firm has a poison pill provision, zero otherwise.
Cumulative voting dummy	Dummy variable that takes the value of one if a firm has a cumulative vote provision, zero otherwise.
Supermajority dummy	Dummy variable that takes the value of one if a firm has a supermajority vote requirement, zero otherwise.
Institutional ownership	Number of shares held by institutions divided by the number of shares outstanding (Thomson 13f Holdings).
Institutional Herfindahl	Institutional Herfindahl index calculated using institutional ownership.
Blockholder ownership	Number of shares held by all blockholders divided by the number of shares oustanding (Dlugosz et al. (2006)).
Outside blockholder ownership	Number of shares held by outside blockholders divided by the number of shares oustanding (Dlugosz et al. (2006)).
Stock return	Annual abnormal stock return calculated as firm's stock return minus the return on the CRSP value-weighted index (CRSP).
Stock return (absolute)	Annual absolute abnormal stock return (CRSP).
Industry Herfindahl	Industry Herfindahl index calculated as the sum of squared market shares of firms' sales (COMPUSTAT: item 12) in the industry (2-digit SIC).
Earnings quality	Absolute value of firm-specific residuals from an annual industry regression (two-digit SIC) of total accruals on lagged, contemporaneous, and leading cash flow from operations; variables scaled by total assets.
Earnings informativeness	R^2 of a firm-level regression of 15-month stock returns (ending 3 months after the end of fiscal year t) on income before extraordinary items (NIBE) in year t and the change in NIBE from year $t-1$ to t, scaled by market value of equity at the beginning of year t.
Number of analysts	Number of analysts covering a firm (IBES).
Share turnover	Number of shares traded divided by the number of shares outstanding (CRSP).
S&P 500 dummy	Dummy variable that takes the value of one if a firm is a member of the S&P 500 index, zero otherwise.

Table 2
Summary Statistics

This table reports the mean, median, standard deviation, minimum, maximum, and number of observations (N) for each variable. The variables are defined in Table 1. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999).

	Mean	Median	Std Dev	Min	Max	N
Fraction of independent directors	0.753	0.778	0.135	0.100	0.955	9,447
Board size	9.819	10.000	2.798	3.000	17.000	9,447
Number of board meetings	7.282	7.000	2.689	3.000	16.000	6,233
Board attendance problems	0.025	0.000	0.054	0.000	0.250	4,922
Probability of informed trading (PIN)	0.162	0.154	0.056	0.068	0.357	9,447
Firm-specific return variation	0.738	0.680	0.101	0.424	0.917	14,661
Illiquidity	0.165	0.002	0.706	0.000	6.881	13,957
Firm size	3,819	1,079	7,989	14	51,179	9,236
Leverage	0.274	0.270	0.176	0.000	0.919	9,228
Firm age	32.026	39.917	15.758	1.167	50.917	9,447
Number of business segments	2.158	1.000	1.461	1.000	6.000	9,447
Market-to-book	2.861	2.063	2.979	0.528	23.957	9,236
R&D expenditures	0.019	0.000	0.038	0.000	0.368	8,774
Stock return variance	0.173	0.113	0.206	0.012	2.189	9,447
Free cash flow	0.076	0.079	0.090	-0.447	0.332	9,086
Return-on-assets	0.145	0.141	0.082	-0.352	0.409	9,241
CEO pay-performance sensitivity (PPS)	0.019	0.003	0.044	0.000	0.258	9,447
CEO tenure	4.257	1.000	6.318	0.000	27.000	9,447
Governance index (GIM)	9.433	10.000	2.746	3.000	15.000	8,404
Staggered board dummy	0.616	1.000	0.486	0.000	1.000	8,335
Poison pill dummy	0.587	1.000	0.492	0.000	1.000	8,335
Cumulative voting dummy	0.137	0.000	0.344	0.000	1.000	8,335
Supermajority dummy	0.188	0.000	0.390	0.000	1.000	8,335
Institutional ownership	0.472	0.524	0.260	0.000	0.914	9,447
Institutional Herfindahl	0.067	0.050	0.073	0.000	0.477	9,447
Blockholder ownership	0.192	0.162	0.184	0.000	0.663	5,235
Outside blockholder ownership	0.136	0.096	0.148	0.000	0.557	5,235
Stock return	-0.074	-0.053	0.412	-1.754	1.251	9,447
Stock return (absolute)	0.303	0.220	0.289	0.000	1.754	9,447
Industry Herfindahl	0.128	0.097	0.120	0.026	1.000	9,447
Earnings quality	0.100	0.056	0.127	0.005	0.578	7,783
Earnings informativeness	0.658	0.722	0.267	0.029	0.997	7,594
NYSE dummy	0.881	1.000	0.323	0.000	1.000	9,295
Number of analysts	0.909	0.727	0.699	0.068	8.136	9,447
Share turnover	0.266	0.000	0.442	0.000	1.000	9,294
S&P 500 dummy	8.322	6.000	8.205	0.000	31.000	9,447

Table 3
Board Independence and Probability of Informed Trading

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)
Probability of informed trading (PIN)	-3.1376	-1.9860	-1.9204	-1.5890	-1.5830
	(-13.60)	(-7.76)	(-7.02)	(-5.32)	(-5.34)
Firm size (log)		0.0259	0.0184	0.0288	0.0275
		(1.79)	(1.27)	(1.91)	(1.78)
Leverage		0.4392	0.3812	0.3450	0.3501
		(4.33)	(3.85)	(3.26)	(3.28)
Firm age (log)		0.1566	0.1519	0.1212	0.1256
		(7.05)	(6.96)	(4.81)	(4.98)
Number of business segments (log)		0.0997	0.1062	0.0883	0.0881
		(4.14)	(4.63)	(3.79)	(3.79)
Market-to-book (log)		0.0066	0.0146	0.0235	0.0244
		(0.28)	(0.60)	(0.94)	(0.98)
R&D expenditures		0.1626	-0.0524	-0.3821	-0.3568
		(0.40)	(-0.13)	(-0.86)	(-0.80)
Stock return variance		-0.0723	-0.0381	-0.0089	-0.0115
		(-1.27)	(-0.64)	(-0.14)	(-0.18)
Free cash flow		0.3023	0.3765	0.2489	0.2431
		(1.05)	(1.33)	(0.77)	(0.75)
Return-on-assets		-0.5283	-0.5432	-0.5269	-0.5384
		(-1.56)	(-1.65)	(-1.47)	(-1.49)
CEO pay-performance sensitivity (PPS)			-1.9301	-1.4872	-1.4945
			(-5.83)	(-4.06)	(-4.08)
CEO tenure			-0.0048	-0.0065	-0.0066
			(-1.86)	(-2.50)	(-2.56)
Staggered board dummy				0.0743	0.0776
				(2.03)	(2.12)
Poison pill dummy				0.1673	0.1629
				(4.73)	(4.57)
Cumulative voting dummy				0.1375	0.1398
				(2.87)	(2.93)
Supermajority dummy				0.0009	0.0008
				(0.02)	(0.02)
Institutional ownership					0.0893
					(1.44)
Institutional Herfindahl					0.1222
					(0.46)
R^2	0.082	0.144	0.162	0.160	0.161
N	9,447	8,610	7,504	6,675	6,675

Table 4
Board Independence and Probability of Informed Trading: Interactions

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors are shown. GIM dummy takes the value of one if a firm has a governance index (GIM) above the median. Poison pill dummy takes the value of one if a firm has a poison pill provision. Institutional Herfindahl dummy takes the value of one if a firm has institutional ownership above the median. R&D dummy takes the value of one if a firm has R&D expenditures to assets ratio above the 80th percentile. PPS dummy takes the value of one if a firm has CEO pay-performance sensitivity above the median. Stock return (absolute) dummy takes the value of one if a firm has absolute abnormal stock return above the 80th percentile. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include the control variables (coefficients not shown) used in column (5) of Table 3, and industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Probability of informed trading (PIN)	-1.7810	-2.0272	-0.8873	-1.7323	-0.8364	-1.2740	-0.9626
	(-5.10)	(-4.70)	(-2.24)	(-5.48)	(-2.31)	(-4.25)	(-2.19)
PIN × GIM dummy	0.8113						
	(2.09)						
PIN × Poison pill dummy		0.8068					0.7896
		(2.39)					(2.37)
PIN × Institutional Herfindahl dummy			-1.1500				-1.0200
			(-3.27)				(-2.87)
PIN × R&D dummy				0.9609			0.4144
				(2.29)			(1.09)
PIN × PPS dummy					-0.9383		-0.8878
					(-2.42)		(-2.29)
PIN × Stock return (absolute) dummy						-0.6907	-0.6461
						(-2.09)	(-1.97)
GIM dummy	0.0177						
	(0.21)						
Poison pill dummy		0.0419					0.0633
		(0.80)					(1.21)
Institutional Herfindahl dummy			0.2153				0.1784
			(3.94)				(3.24)
R&D dummy				-0.1741			-0.1176
				(-2.68)			(-1.96)
PPS dummy					0.0572		0.0534
					(1.01)		(0.94)
Stock return (absolute) dummy						0.1190	0.0675
						(1.86)	(1.07)
R^2	0.165	0.162	0.163	0.161	0.156	0.164	0.169
N	6,675	6,675	6,675	6,675	6,675	6,675	6,675

Table 5
Board Independence and Probability of Informed Trading: Endogeneity

Estimates of panel regressions of the logistic transformed fraction of independent directors using alternative estimation methods are shown. Columns (1) and (2) present estimates of panel regressions with firm fixed effects. The two-stage least squares (2SLS) panel regression uses analyst coverage, share turnover, and S&P 500 membership as instruments for PIN. Columns (3) and (4) present first stage regression estimates with PIN as dependent variable. Columns (5) and (6) present second stage regression estimates with the logistic transformed fraction of independent directors as dependent variable. Columns (7) and (8) present estimates of regressions using lagged PIN as explanatory variable. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Firm fixed effects		Two-stage least squares (2SLS)				Lag PIN	
			First stage	First stage	Second stage	Second stage		
Probability of informed trading (PIN)	-0.6940	-0.5755			-8.8139	-17.5817	-1.6905	-1.3996
	(-3.90)	(-2.88)			(-4.54)	(-2.18)	(-6.47)	(-4.93)
Firm size (log)	0.0738	0.0730	-0.0232	-0.0212	-0.1375	-0.3100	0.0297	0.0316
	(3.29)	(3.05)	(-51.59)	(-42.28)	(-2.95)	(-1.83)	(2.08)	(2.11)
Leverage	0.3394	0.2558	-0.0154	-0.0162	0.3395	0.0934	0.4344	0.3422
	(3.42)	(2.41)	(-5.18)	(-5.07)	(5.87)	(0.63)	(4.18)	(3.16)
Firm age (log)	0.4413	0.6588	-0.0045	-0.0022	0.1303	0.0951	0.1595	0.1222
	(8.82)	(7.47)	(-6.84)	(-2.72)	(9.46)	(3.93)	(6.97)	(4.79)
Number of business segments (log)	0.0150	0.0109	-0.0056	-0.0034	0.0645	0.0369	0.1024	0.0871
	(0.84)	(0.61)	(-7.68)	(-4.44)	(3.85)	(1.18)	(4.27)	(3.72)
Market-to-book (log)	0.0098	-0.0138	0.0042	0.0046	0.0370	0.0998	0.0080	0.0259
	(0.48)	(-0.67)	(4.94)	(5.17)	(2.23)	(2.31)	(0.32)	(1.04)
R&D expenditures	-0.4203	-0.6375	0.0191	0.0299	0.2163	0.0552	0.0910	-0.4870
	(-0.96)	(-1.08)	(1.48)	(2.00)	(0.95)	(0.14)	(0.22)	(-1.07)
Stock return variance	0.2085	0.1563	-0.0277	-0.0302	-0.3181	-0.5516	-0.0746	-0.0142
	(4.26)	(2.70)	(-8.94)	(-8.86)	(-3.88)	(-1.98)	(-1.23)	(-0.22)
Free cash flow	-0.1143	-0.2589	-0.0135	-0.0113	0.2832	0.1246	0.2094	0.1690
	(-0.64)	(-1.13)	(-1.65)	(-1.21)	(1.88)	(0.57)	(0.69)	(0.52)
Return-on-assets	0.0063	0.1342	0.0091	0.0055	-0.5447	-0.5000	-0.4355	-0.4848
	(0.03)	(0.48)	(0.97)	(0.53)	(-3.08)	(-2.02)	(-1.23)	(-1.33)
CEO pay-performance sensitivity (PPS)		0.6723		-0.0035		-1.5850		-1.4900
		(2.19)		(-0.29)		(-5.43)		(-4.04)
CEO tenure		-0.0053		-0.0003		-0.0107		-0.0067
		(-2.67)		(-3.64)		(-3.92)		(-2.58)
Staggered board dummy		-0.0550		-0.0025		0.0388		0.0810
		(-0.74)		(-2.54)		(1.24)		(2.20)
Poison pill dummy		0.0339		-0.0032		0.1109		0.1635
		(1.00)		(-3.13)		(3.12)		(4.54)
Cumulative voting dummy		-0.0347		-0.0007		0.1272		0.1426
		(-0.39)		(-0.53)		(3.96)		(2.97)
Supermajority dummy		-0.0700		0.0006		0.0105		-0.0026
		(-1.03)		(0.50)		(0.36)		(-0.06)
Institutional ownership		0.0442		-0.0090		-0.0719		0.0983
		(0.61)		(-3.73)		(-0.79)		(1.56)
Institutional Herfindahl		0.2783		0.0660		1.2384		0.0535
		(1.91)		(6.55)		(2.08)		(0.20)
Number of analysts			-0.0013	-0.0042				
			(-3.11)	(-3.98)				
Share turnover			-0.0059	-0.0023				
			(-7.04)	(-2.51)				
S&P 500 dummy			0.0034	0.0016				
			(3.11)	(1.37)				
R^2	0.095	0.084	0.462	0.442			0.139	0.159
N	8,610	6,675	8,610	6,675	8,610	6,675	7,927	6,594

Table 6
Board Independence and Alternative Measures of Price Informativeness

Estimates of OLS panel regressions of alternative price informativeness measures are shown. Columns (1) and (2) use the logistic transformed relative firm-specific return variation as dependent variable. Columns (3) and (4) use the logarithm of the illiquidity measure of Amihud (2002). Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)
Firm-specific return variation (logistic)	-0.0877	-0.0597		
	(-4.88)	(-3.01)		
Illiquidity (log)			-0.0829	-0.0781
			(-6.96)	(-4.71)
Firm size (log)	0.0748	0.0653	-0.0208	-0.0303
	(7.23)	(5.58)	(-1.07)	(-1.32)
Leverage	0.2839	0.2217	0.3264	0.2619
	(3.79)	(2.59)	(4.46)	(3.12)
Firm age (log)	0.1417	0.1158	0.1500	0.1293
	(8.64)	(5.58)	(9.22)	(6.21)
Number of business segments (log)	0.0996	0.0645	0.1111	0.0815
	(4.92)	(3.14)	(5.42)	(4.02)
Market-to-book (log)	0.0137	0.0374	-0.0262	0.0110
	(0.85)	(2.02)	(-1.40)	(0.52)
R&D expenditures	0.9549	0.4927	0.6232	0.1074
	(4.47)	(1.78)	(2.85)	(0.38)
Stock return variance			-0.0266	-0.0285
			(-0.83)	(-0.70)
Free cash flow	0.4644	0.3398	0.6486	0.5587
	(2.09)	(1.30)	(2.94)	(2.11)
Return-on-assets	-0.9283	-0.7424	-1.0350	-0.9125
	(-3.80)	(-2.64)	(-4.17)	(-3.18)
CEO pay-performance sensitivity (PPS)		-1.3878		-1.4063
		(-4.78)		(-4.74)
CEO tenure		-0.0058		-0.0067
		(-2.72)		(-3.09)
Staggered board dummy		0.0958		0.0889
		(3.06)		(2.85)
Poison pill dummy		0.1844		0.1757
		(6.23)		(5.90)
Cumulative voting dummy		0.0888		0.0809
		(2.18)		(1.98)
Supermajority dummy		-0.0213		-0.0194
		(-0.53)		(-0.48)
Institutional ownership		0.1015		0.0596
		(1.92)		(1.10)
Institutional Herfindahl		0.0373		0.3003
		(0.17)		(1.34)
R^2	0.151	0.157	0.159	0.159
N	11,755	9,196	12,964	8,911

Table 7
Additional Board Monitoring Variables and Probability of Informed Trading

Estimates of OLS panel regressions of the logarithm of the number of board meetings, the fraction of directors with board attendance problems, and the logarithm of board size are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Number of Board Meetings (log)		Board Attendance Problems		Board Size (log)	
Probability of informed trading (PIN)	-0.3878	-0.4174	0.0477	0.0485	-0.2942	-0.2939
	(-2.08)	(-2.16)	(2.11)	(2.12)	(-2.51)	(-2.28)
Firm size (log)	0.0415	0.0359	0.0018	0.0016	0.0844	0.0848
	(5.06)	(4.02)	(2.30)	(1.86)	(16.84)	(14.86)
Leverage	0.0965	0.1163	0.0050	0.0035	0.1183	0.0714
	(1.82)	(2.05)	(0.96)	(0.62)	(3.37)	(1.93)
Firm age (log)	0.0316	0.0199	-0.0002	-0.0010	0.0676	0.0696
	(2.87)	(1.43)	(-0.19)	(-0.71)	(8.19)	(7.17)
Number of business segments (log)	0.0272	0.0192	0.0011	0.0008	0.0295	0.0197
	(2.15)	(1.50)	(0.84)	(0.63)	(3.19)	(2.14)
Market-to-book (log)	0.0054	-0.0034	0.0001	0.0003	-0.0457	-0.0393
	(0.47)	(-0.28)	(0.10)	(0.23)	(-5.11)	(-4.13)
R&D expenditures	0.0571	0.3698	0.0249	0.0444	-0.5089	-0.6932
	(0.24)	(1.47)	(0.99)	(1.54)	(-2.89)	(-3.56)
Stock return variance	0.1895	0.1558	0.0023	0.0001	-0.1330	-0.1204
	(3.98)	(3.20)	(0.52)	(0.01)	(-4.54)	(-3.52)
Free cash flow	0.0262	0.0247	0.0257	0.0214	0.0892	0.1269
	(0.17)	(0.14)	(1.97)	(1.45)	(0.86)	(1.04)
Return-on-assets	-0.4269	-0.4464	-0.0279	-0.0174	-0.3287	-0.3445
	(-2.51)	(-2.35)	(-1.78)	(-1.00)	(-2.73)	(-2.51)
CEO pay-performance sensitivity (PPS)		-0.6948		-0.0550		-0.6388
		(-3.05)		(-2.86)		(-3.90)
CEO tenure		-0.0046		0.0003		0.0009
		(-3.11)		(2.30)		(0.90)
Staggered board dummy		-0.0159		0.0050		0.0236
		(-0.80)		(2.64)		(1.76)
Poison pill dummy		-0.0126		-0.0056		0.0164
		(-0.67)		(-2.86)		(1.20)
Cumulative voting dummy		-0.0058		0.0029		-0.0145
		(-0.22)		(1.12)		(-0.74)
Supermajority dummy		0.0008		-0.0037		0.0109
		(0.04)		(-1.73)		(0.63)
Institutional ownership		-0.0847		-0.0094		-0.0397
		(-2.39)		(-2.56)		(-1.68)
Institutional Herfindahl		-0.0598		0.0275		0.1334
		(-0.40)		(1.85)		(1.43)
R^2	0.091	0.113	0.006	0.013	0.329	0.333
N	4,827	4,151	5,031	4,664	8,923	6,965

Table 8
Board Independence and Probability of Informed Trading: Additional Robustness Checks

Estimates of OLS panel regressions of the logistic transformed fraction of independent directors, the log fraction of independent directors (column (3)), and the fraction of independent directors (column (4)) are shown. Refer to Table 1 for variables definition. The sample consists of IRRC firms from 1990 to 2001. Financial industries are omitted (SIC 6000-6999). Regressions include industry and year dummies. Robust t-statistics adjusted for firm-level clustering are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1996 -2001	Compact Disclosure	Board indep. (log)	Board indep.	All blockholders	Outside blockholders	Industry Herfindahl	Board size
Probability of informed trading	-0.9345	-0.9884	-0.3668	-0.1975	-0.9084	-0.9871	-1.5924	-1.5657
	(-2.56)	(-3.52)	(-4.23)	(-2.99)	(-2.44)	(-2.63)	(-5.38)	(-5.15)
Blockholders ownership					0.0325			
					(0.31)			
Outside blockholders ownership						0.3567		
						(3.11)		
Industry Herfindahl							0.1393	
							(1.08)	
Board size (lag)								0.0196
								(2.44)
R^2	0.162	0.155	0.143	0.092	0.162	0.167	0.161	0.169
N	4,439	5,955	6,827	6,965	4,439	4,439	6,675	6,133

Table 8: continued

	(9) NYSE	(10) Earnings quality	(11) Earnings informat.	(12) Abnormal stock return	(13) PIN Q5-Q1	(14) PIN dummy	(15) Median regression	(16) Fama-MacBeth
Probability of informed trading	-1.5464	-1.3023	-1.6186	-1.5887			-1.9516	-0.8826
	(-5.21)	(-4.48)	(-4.93)	(-5.28)			(-5.92)	(-3.61)
Probability of informed trading (Q5-Q1)					-0.2923			
					(-5.04)			
Probability of informed trading (dummy)						-0.1247		
						(-4.89)		
NYSE dummy	0.0953							
	(1.62)							
Earnings quality		-0.1487						
		(-1.77)						
Earnings informativeness			-0.0168					
			(-0.40)					
Abnormal stock return (Q1 bottom dummy)				0.0131				
				(0.55)				
Abnormal stock return (Q5 top dummy)				0.0079				
				(0.34)				
R^2	0.162	0.182	0.174	0.161	0.182	0.159		0.157
N	6,675	5,664	5,751	6,675	2,722	6,675	6,675	6,675

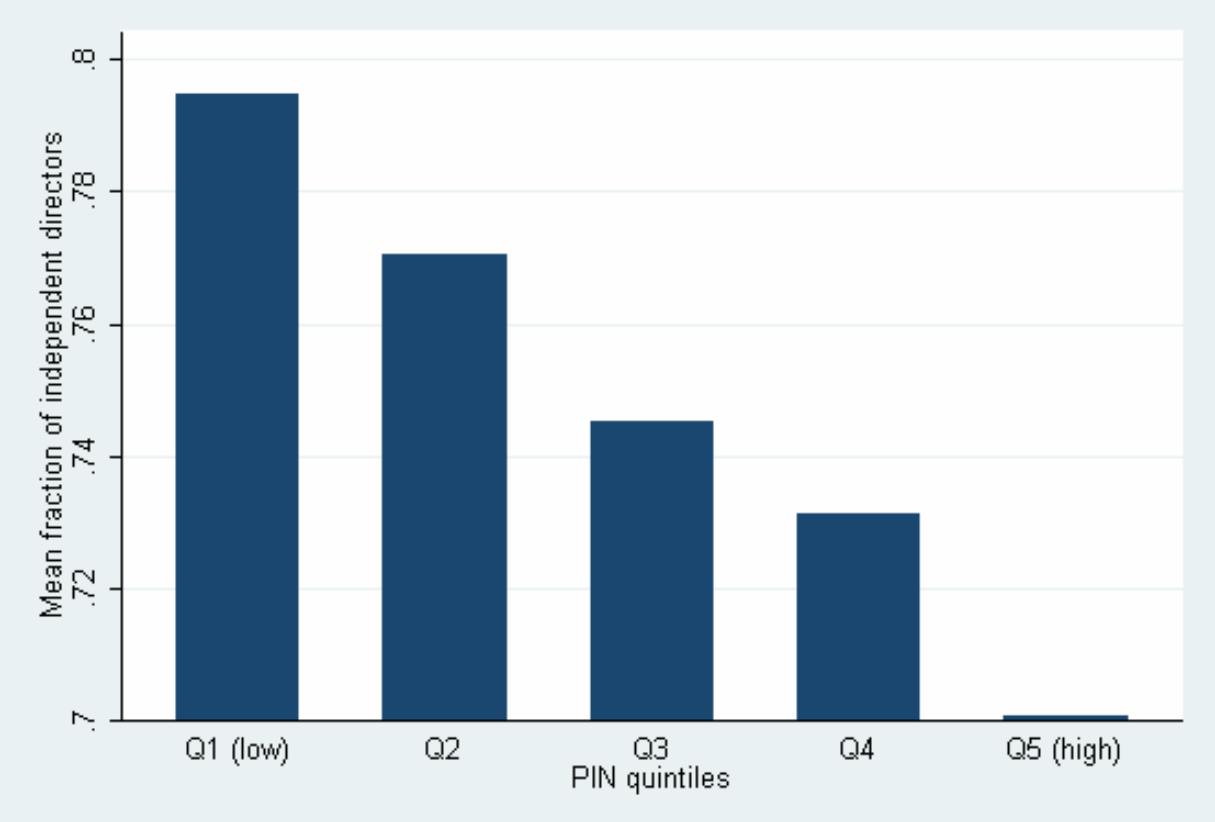

Figure 1. Board Independence by Probability of Informed Trading Quintiles. This figure plots the mean fraction of independent directors by probability of informed trading (PIN) quintiles for the period from 1990 to 2001.