Corporate Governance, Earnings Manipulation, and Information Quality in Capital Markets

by

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ABSTRACT

This thesis was inspired by the accounting scandals around the world at the beginning of the 21st century and the reforms in corporate governance law that followed. We use both theoretical and empirical analysis to focus on several aspects of corporate governance mechanisms.

The first study focuses on the board of directors. We develop a dynamic agency model with renegotiation to analyze the interaction between the board’s monitoring and the manager’s earnings manipulation in a firm. The second study broadens the perspective to consider the information in the capital markets with a focus on the role of financial disclosure regulation. It examines how financial disclosure regulation affects the information quality in capital markets, using a strategic investor model in an insider trading setting. The third study investigates these ideas empirically. We construct measures of public, private, and total information quality, and study how they change following the Sarbanes-Oxley Act of 2002 (SOX) in the United States.

The key findings of the thesis are as follows. The first study shows that the dynamic incentive contract motivates the manager to work hard on the one hand and to manipulate earnings on the other hand. Even though the board anticipates the earnings manipulation, the board does not unambiguously choose to monitor the manager. The second study demonstrates that the equilibrium market price reflects both the public and a fraction of the private information. While tightened disclosure regulation might improve the quality of public information, the changes in the quality of private information and of total information are ambiguous due to the subtle interplay between public reporting and private information acquisition. The third study provides empirical evidence showing a temporary improvement in the quality of public information following the SOX. The quality of private information decreases and there is no significant change in total information quality.

The thesis contributes to the literatures of earnings management and of corporate governance, adding to the growing debate on the costs and benefits of governance reforms. By identifying important indirect effects, we stress the need to consider “substance over form”.

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CHAPTER 1

Introduction

The corporate governance failures at the beginning of the twenty-first century often involved significant accounting scandals. For example, Enron used opaque financial disclosures related to special purpose entities (SPEs) and off-balance-sheet activities; WorldCom, Tyco, Swissair, Vivendi, and Daewoo Group manipulated their financial statements before going bankrupt. The collapse of these prominent companies caused investors to become concerned that similar failures might occur at other companies. Such concerns are bringing greater awareness and changes around the world. In Europe, investor activism and corporate control activities are becoming more common. In Asia, certain Japanese companies have implemented structural changes after the Commercial Code of 2002, including a reduction in board size, more outside directors, and an improvement in disclosure. The Korean government has also embarked on a series of governance reforms on increased financial transparency and disclosure, and board independence. In the United States, the Sarbanes-Oxley Act (SOX) of 2002 created strict rules on financial disclosure and
increased monitoring by boards of directors to facilitate the detection of disclosure failures.¹

Academics have debated which approach to regulating a corporation is most appropriate and recent governance reforms have led to an increase in research on this important issue, e.g., Holmstrom and Kaplan (2003), Mitchell (2003), Ribstein (2002, 2005) and Romano (2004). Some argue that the scandals demonstrated the need for reform. Others argue that the costs of the changes mandated by SOX are much larger than the benefits, if those benefits actually exist. The same concerns apply to governance reforms elsewhere in the world.

Motivated by these accounting scandals and the current debate on governance reforms, this thesis uses both theoretical and empirical analysis to study the effects of corporate governance. In broad terms, corporate governance is based on both internal and external mechanisms. Internal mechanisms are the ways by which individual firms implement control and accountability, including the board of directors, internal control, and ethical codes/cultures. External mechanisms include regulation, legal and bankruptcy systems, external audits, and investor activism.

The SOX is comprehensive in terms of reforming both internal and external governance mechanisms. It tightened financial disclosure regulation with the aim of creating an environment with accurate and timely disclosure of more financial information. For example, Section 203 states “The CEO and CFO of each issuer shall prepare a statement to accompany the audit report to certify the ‘appropriateness of the financial statements and disclosures … and that those financial statements and

disclosures fairly, present in all material respects, the operations and financial
condition of the issuer.' The maximum penalties for willful and knowing violations
of this section are a fine of up to $5 million and/or imprisonment of up to 20 years. In
order to enhance the internal monitoring function by the board of directors, Section
301 states “Each member of the (board) audit committee shall be ... independent.”
The New York Stock Exchange (NYSE) and NASDAQ have rules ensuring the
“independence of directors ... and to strengthen corporate governance practices”.

This thesis adds to the corporate governance literature by providing three studies
focusing on several different aspects of governance mechanisms. The first study
focuses on the board of directors because the board is an important element of
internal governance. A board’s duties include defining corporate strategy and
philosophy, compensating executive management, as well as implementing internal
controls. Our model focuses on the last two tasks. We analyze the interaction
between the board and the manager in a firm by using a dynamic agency setting. It
offers a comprehensive analysis by finding the Renegotiation-Proof Nash
Equilibrium. By jointly explaining the compensation contract, board monitoring and
earnings manipulation, this study provides insight into how well corporate
governance mechanisms limit earnings management and whether increased board
monitoring benefits shareholders. We relate the parameters of the model to various
kinds of changes in governance measures mandated by governments in many
countries and use its predictions to comment on the likely impacts of those reforms.

While the first study focuses on the quality of accounting information within a
firm, the second study broadens the perspective to consider the information in the
capital market with a focus on the role of financial disclosure regulation. Many recent corporate governance reforms around the world seek to increase public disclosure by firm management which in the hope that disclosure change will make the market prices more informative about the future values of firms. The total information impounded in the market price includes both the public information disclosed by firm management and the private information acquired by investors. This study considers the direct and indirect effects of tighter disclosure regulation on information quality through an analysis of the interplay between public reporting and private information acquisition. The study develops a strategic investor model in an insider trading setting based on Kyle (1985). The model includes four types of traders: a firm's manager (i.e., an insider), multiple privately informed rational investors, one privately uninformed rational investor (called the "market maker"), as well as liquidity traders. As an insider, the manager has knowledge about her firm that others do not. The manager can disclose some information to the public and withhold the remainder for the purpose of personal trading. Private investors can incur costs to acquire private information. Corporate governance reforms change the amount of information that a manager can withhold and, thus, change the investor's decision to acquire information. We characterize these behaviors in rational expectations equilibrium.

The reforms surrounding SOX provide a natural experiment to investigate the relationship between corporate governance and information quality. The third study investigates these ideas empirically using corporate governance data from IRRC, financial analyst data from I/B/E/S, and accounting data from Compustat. We use
earnings forecasts of financial analysts to capture the underlying information sets available to informed investors in capital markets. The qualities of public, private and total information are estimated by employing the measures proposed in Barron, Kim, Lim, and Stevens (1998) and Gu (2005). Both measures derive the properties of unobservable information quality by using observable data on the forecast dispersion, forecast error and the number of forecasts.

The key findings of the thesis are as follows. The first study shows that the dynamic incentive contract motivates the manager to work hard on the one hand and to manipulate earnings on the other hand. Earnings manipulation consisting of earnings shifting arises in equilibrium. Interestingly, even though the board anticipates the earnings manipulation, the board does not unambiguously choose to monitor the manager. This paper explores four different settings including accounting and real earnings manipulation, costly window dressing, and costless manipulation. The board prefers to not monitor at all if the manipulation is costless to the manager and has no effect on the underlying economic outcome. However, the board prefers to monitor at least a little if the manipulation is costly to the manager and/or affects the economic outcome. The mixed results imply that, while board monitoring limits manipulation, it may not always be beneficial to shareholders.

The second study demonstrates that the equilibrium market price reflects both the public and a fraction of the private information. In our stylized single-period model setting, there is prior uncertainty about the terminal firm value and it can be reduced either by releasing public information or by obtaining private information. The quality of that information is defined to be the extent to which that information
reduces prior uncertainty about the terminal value of the firm. In particular, a comprehensive measure, referred to as total information quality, is defined to be the extent to which the market price reveals the terminal firm value. The analysis shows that, while tightened regulation might improve the quality of public information, the changes in the quality of private information and of total information are ambiguous due to the subtle interplay between public reporting and private information acquisition. We show cases where tighter regulation could produce changes which conflict with the aims of SOX.

The third study provides empirical evidence showing that the quality of public information improved following the SOX. However, the increase in public information quality is offset by a decrease in private information quality. There is no significant change in total information quality in the year following the passage of the SOX. Further, the improvement of public information does not persist. We fail to find a significant association between board characteristics and information qualities during the sample period. These results are contrary to the aims and intended effects of the reforms.

The thesis makes the following contributions. First, it contributes to the earnings management literature. We explore earnings manipulation in a variety of settings, including accounting and real manipulation, costly window dressing and costless manipulation. The analysis captures earnings manipulation consisting of earnings shifting over time, and consumption smoothing without smoothing firm’s accounting earnings.
It contributes to the governance literature and to the current debate on the net benefits of governance reforms. We show that the extent to which the board engages in monitoring does not depend on earnings manipulation *per se*, but rather on its real economic effect. Due to the subtle interplay between different sources of information, we show the need to identify and consider indirect adjustments when governance mechanisms change.

Many of the reforms introduced as a result of SOX are intended to increase the quality of public information. For this reason, it is noteworthy that, according to our empirical analysis, the improvement in public information quality does not persist. The change may have been temporary because media coverage of the scandals and the failure of Arthur Andersen changed management's awareness of the issue rather than the actual passage of SOX. Writing at the time, Cunningham (2002, p. 19) argues "The changes are more likely to have psychological rather than substantive effects." The results of our studies suggest a need to consider "substance over form." When implementing a new law, as seen in the new wave of worldwide governance reforms at the beginning of this century, proper practices should be strong yet flexible in terms of time, location, industry and country.
CHAPTER 2

Board Monitoring and Earnings Manipulation

2.1 Introduction

This chapter offers a theoretical perspective to study the interaction between a manager’s earnings management behavior and corporate governance mechanisms, with a focus on the activities of a board of directors. We address the following questions. How well do corporate governance mechanisms limit earnings management? Does increased board monitoring benefit shareholders?

To study these questions, we develop a dynamic agency model with renegotiation between the board and the manager. The principal is the board representing the firm’s shareholders, and the agent is the manager hired to perform productive effort. The main duties of a board include defining corporate strategy and philosophy, compensating executive management, as well as implementing internal controls. The model focuses on two of these tasks: compensating and monitoring management. For the task of compensating management, the board writes a performance-based compensation contract. Since the manager’s productive effort is not observable and the real outcome is not contractible, we assume that accounting earnings are used as performance measures.

\[2\] See Banks (2004), chapter 2, p.34.
The incentive compensation contract is designed to motivate the manager (i.e., agent) to work hard but might also induce the agent to manipulate earnings. If the earnings manipulation causes a transfer of wealth from shareholders to the manager, then board monitoring becomes necessary. In practice, the financial monitoring by the board is often implemented by the board's audit committee. Generally, the audit committee creates internal audit mechanisms, ensures the appropriateness of reporting policies, processes, and infrastructure for producing financial statements, and reviews financial data, such as quarterly and annual financial statements, etc. In addition, an agent who is thinking about manipulating earnings needs to be aware of external governance mechanisms such as the regulatory environment, financial disclosure regulations and civil and criminal liabilities for fraud. A penalty function is used to capture both the internal and external governance mechanisms.

Unlike a standard agency model, the principal in our model setting exerts monitoring effort in addition to offering compensation contracts, and the monitoring effort is costly to the principal. Next, both the principal and the agent commit to stay for two periods but, after observing the public report at the end of the first period, the principal might renegotiate the compensation contract with the agent. Allowing for renegotiation is important, since we try to create a setting where the revelation principle does not hold, and hence earnings management can be captured. The other distinguishing feature is that, instead of the time-multiplicative preferences frequently

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3 The revelation principle (Myerson 1979) states that any equilibrium outcome of any mechanism can be replicated by a truth-telling equilibrium in another mechanism. However, the revelation principle is not a general result since it assumes: (1) communication is not blocked, (2) the form of the contract is not restricted, (3) the principal can commit to use the reports submitted by the agents in any pre-specified manner (Arya et al. 1998, p.10). In the literature, the existing papers study earnings management under settings where the revelation principle does not hold.
used in the earlier literature, we use time-additive preferences. The time-multiplicative form implies that the timing of consumption is immaterial, provided it is interest-rate adjusted. A time-additive form is more interesting in a dynamic setting since it captures the importance of the timing and the incentive to smooth consumption. With access to borrowing and lending opportunities in financial markets, the agent does not need to rely on the compensation contract to smooth income. This fact allows us to focus on other reasons for earnings manipulation.

The chapter provides the following results. Because of the principal’s inability to commit to not renegotiate the contract, along with economic differences of periods, the optimal incentive rate changes dynamically except under knife-edge conditions. This incentive scheme benefits shareholders by inducing the agent to implement productive effort but it also leads the agent to manipulate earnings (i.e., performance measures). In equilibrium, earnings manipulation consists of earnings being shifted to the period with a higher incentive rate in order to increase the agent’s compensation. This earnings manipulation does not include earnings smoothing. Consumption smoothing still occurs without smoothing firm’s accounting earnings because of borrowing and lending in financial markets.

Interestingly, even though the principal anticipates the earnings manipulation, the principal does not unambiguously choose to monitor the agent. The extent to which the board engages in monitoring depends on the real economic effect of earnings manipulation, i.e., whether there are welfare losses for shareholders. This chapter explores four different settings, including accounting earnings manipulation, real earnings manipulation, costly window dressing, and costless manipulation. The
board prefers to not monitor at all under the setting where the manipulation is costless to the agent and has no effect on the underlying economic outcome. Not monitoring is preferred in this setting because, in equilibrium, the principal anticipates and prices the amount of manipulation directly through the fixed compensation payment. Using the optimal compensation scheme is better than exerting costly monitoring since monitoring would just cause a deadweight loss to the firm's shareholders. In the settings where the manipulation is costly to the agent (referred to as "window dressing" in the literature\(^4\)) or affects the underlying economic outcome (i.e., real earnings manipulation) or both, the principal prefers to monitor at least a little because the manipulation is costly to the firm's shareholders, either directly or indirectly. The mixed results imply that, while board monitoring restricts earnings manipulation, it does not always benefit shareholders. Recent worldwide corporate governance reforms have the effect of changing certain parameters in the model. Hence, the model offers several predictions concerning the impact of various kinds of changes in governance measures mandated by governments in many countries.

The remainder of the chapter proceeds as follows. The next section reviews the related literature. Section 2.3 develops a two-period agency model with renegotiation between the board and the manager, and outlines the event structure. Section 2.4 characterizes the equilibrium, focusing on the optimal compensation contract, on induced earnings manipulation, and on optimal board monitoring. Section 2.5 provides a complete analysis of the interaction between corporate governance and earnings manipulation. Section 2.6 and Section 2.7 extend the basic model to

\(^4\) Feltham and Xie (1994) define window dressing as: "performance measures, including accounting earnings, are often subject to manipulation in the sense that the agent takes actions that improve his performance measure but contribute little or nothing to the principal's gross payoff".
window dressing and real earnings manipulation settings. The discussion of the model's implications for recent governance reforms is offered in Section 2.8. The last section contains concluding remarks.

2.2 Related Literature Review

In the accounting literature, there is no consensus on the definition of earnings management. One representative definition comes from Healy and Wahlen (1999, p.368): "Earnings management occurs when managers use judgment in financial reporting and in structuring transactions to alter financial reports to either mislead some stakeholders about the underlying economic performance of the company or to influence contractual outcomes that depend on the reported accounting numbers". Extensive empirical evidence of earnings management is well documented, e.g., reviews of Healy and Wahlen (1999), Dechow and Skinner (2000), Fields et al. (2001), and Schipper and Vincent (2003). In contrast to ample empirical research, there is little theoretical modeling on earnings management. A troublesome issue for earnings management modeling is the revelation principle (RP). The existing models study earnings management by violating RP. The internal and external sources of earnings management are studied in several papers: Dye (1988), Evans and Sridhar (1996), Demski (1998), Arya et al. (1998), and Kirschenheiter and Melumad (2002). The "internal" source is related to optimal contracting and minimizing the expected cost of getting a manager to adopt the shareholders' preferred action. The "external" source is related to the capital market and is based on current shareholders' desire to

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5 The other representative definition is by Schipper (1989, p.92): "...a purposeful intervention in the external financial reporting process, with the intent of obtaining some private gain (as opposed to, say, merely facilitating the neutral operation of the process)...."
influence perceptions of the firm’s value. A popular form of earnings management, i.e., income smoothing, is well studied. Several papers show different motives to smooth income or earnings, including consumption smoothing incentive in Lambert (1984) and Suh (1990), career concerns in Fudenberg and Tirole (1995), leverage concerns in Trueman and Titman (1988), and stock price concerns in Goel and Thakor (2003).

Earnings management can be undesirable or desirable to shareholders, depending on whether earnings management is opportunistic or informative of the firm’s economic value. Focusing on opportunistic earnings management, we extend the earlier literature to establish a link between earnings management and corporate governance. In broad terms, corporate governance is based on both internal and external mechanisms. Internal mechanisms are the ways by which individual firms implement control and accountability, including the board of directors, internal control, and ethical codes/cultures. External mechanisms include regulation, legal and bankruptcy systems, external audits, and investor activism. Our work is related to several recent papers, e.g., Ewert and Wagenhofer (2005), Christensen, Frimor and Sabac (2004), Liang (2004), and Goldman and Slezk (2003). While their work focuses on the effect of audit control, accounting standards or regulation on earnings management, we particularly focus on the roles of board of directors. The board of directors is an important element of internal governance, attracting considerable

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6 According to the corporate governance literature, there are several definitions of corporate governance. In broad terms, Banks (2004, p.3) defines corporate governance as “the structure and function of a corporation in relation to its stake-holders generally, and its shareholders specifically”. Focusing more narrowly on investor value, Shleifer and Vishny (1997, p.737) define corporate governance as “the way in which suppliers of finance to corporations assure themselves of getting a return on their investment”.

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attention from practitioners and academics. The other distinguishing feature is that, instead of time-multiplicative preferences that are frequently used in the literature, time-additive preferences are used in our model. Therefore this chapter captures earnings shifting, similar to Christensen, Frimor and Sabac (2004) and Liang (2004), and also captures consumption smoothing over time. Furthermore, the model endogenously determines earnings manipulation, board monitoring, and compensation contracts. This facilitates a comprehensive analysis of their interplay and the development of insight from that interplay. Finally, we explore a variety of settings of earnings manipulation including accounting and real earnings manipulation, costly window dressing and costless manipulation.

2.3 Dynamic Agency Model with Renegotiation

We consider a two-period agency model where the board of directors (later referred to as the “principal”), acting on behalf of the firm’s shareholders, hires the manager (later referred to as the “agent”) to provide productive effort in each of the two periods. Both the principal and agent commit to stay for two periods. The principal offers the agent a compensation contract which is subject to renegotiation at the start of the second period. Unlike standard agency models, the principal also exerts effort to monitor the agent, denoted as $e (e \geq 0)$. The principal commits to the specified level of monitoring ex ante, and $e$ is observable by the agent. That is, this is a game in which the principal moves first.

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The agent exerts productive effort $a_t$ in period $t$. The expected outcome from $a_t$ is $E[x_t | a_t] = \gamma a_t$, $t = 1, 2$, where $\gamma (\gamma > 0)$ measures the agent's productivity. The principal cannot observe the agent's productive effort, and the real outcome is not contractible. In practice, accounting earnings are often used as performance measures in management compensation contracts. The agent has ability to manipulate earnings. The existing literature distinguishes between accounting and real earnings management. In general, "accounting earnings management" changes reported earnings without changing the underlying cash flows. "Real earnings management" changes operating decisions so that there are changes in both the underlying cash flows and the reported earnings (Ziv, 1998). In the basic model, we consider accounting earnings manipulation that is costless to the agent (i.e., the agent does not exert personally costly manipulative effort). The manipulation is achieved simply by changing accounting policies, such as depreciation methods, bad debt allowance rates, or timing sales discount.

The performance measures are assumed to be represented by $y_1 = x_1 + D$ and $y_2 = x_2 - RD$, where $D$ is the amount of earnings manipulation, $R = 1 + t$ is the riskless one-period return and $t$ is the riskless one-period interest rate. $R$ is used to account for the time value of money where $R = 1$ if shifting pure accounting numbers (e.g., through accruals manipulation), and $R > 1$ if shifting real dollars (e.g., through earlier sales discount). A positive (or negative) $D$ indicates upward (or downward) manipulation in the first period. The specification of the performance measures implies that the amount of earnings manipulation in the first period is reversed in the second period.
The agent's incentive to manipulate earnings is limited by various corporate
governance mechanisms. Board monitoring, often implemented by the audit
committee, plays a significant role in discouraging and detecting earnings
manipulation. In addition, the overall external regulatory environment also helps
deter an agent from manipulating earnings, e.g., through financial disclosure
regulations, as well as civil and criminal liabilities for fraud. To represent the effect
of these governance mechanisms, we assume manipulation results in a penalty of
\[ P = \frac{1}{2} (p + e)D^2, \]
where \( p \) (\( p > 0 \)) represents the tightness of external regulatory
environment. The amount of the penalty is increasing in the absolute value of
earnings manipulation, the tightness of regulation, and the intensity of board
monitoring. In practice, the penalty that the agent faces depends on the legal system.
Shareholders, or their representative, the board, may sue the agent for her
manipulating earnings, and the penalty to be paid by the agent to shareholders is
decided by a court. A court is likely to impose a larger penalty if the level of earnings
manipulation is larger. Similarly, tighter external regulation tends to result in more
severe punishment. The size of the penalty may also depend on the intensity of
internal board monitoring because more intense monitoring is more likely to produce
the kind of convincing evidence that leads a court to impose a larger penalty.\(^8\)

For mathematical tractability, a dynamic LEN model, i.e., linear contract,
exponential utility, and normally distributed performance measures, is adopted.\(^9\) The

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\(^8\) While the penalty will only be imposed if manipulation is detected and prosecution is successful, we
simplify the analysis by ignoring the uncertainty of the penalty.

\(^9\) It is well-known that LEN models provide simplification of mathematical representations, and are
widely used in the literature. Recently, several papers employ the LEN framework in dynamic
settings, such as, Christensen et al. (2005), Feltham et al. (2004), Dutta and Reichelstein (2003).
LEN model exogenously specifies the compensation contract as a linear function of the performance measures. Further, based on the concept of renegotiation-proofness of Fudenberg and Tirole (1990), we solve for a linear renegotiation-proof contract.

The following describes the timeline of the model which highlights the sequence of events within each period, and provides important assumptions with respect to the performance measures, the agent's preferences, and the principal's preferences.

**Timeline of the Model** (see Figure 2.1):

Stage 1: At date zero, the principal designs an initial compensation contract $c'(f^i, v_1^i, v_2^i)$ and offers it to the agent, where $f^i$ is the initial fixed payment paid at the end of the first period, and $v_1^i, v_2^i$ are the incentive rates for the first and second period respectively. At the same time, the principal commits to the level of monitoring $e$.

Stage 2: At the start of the first period, the agent chooses her productive effort $a_1$, which affects the first-period performance measure and outcome to the principal.

Stage 3: At the end of the first period, after privately observing the outcome $x_1$, the agent decides whether to manipulate earnings. If so, she chooses the amount of earnings manipulation $D$, and then issues a public report $y_1$.

Stage 4: Since the principal can't observe the agent's productive effort and the real outcome, the principal uses the public report $y_1$ to pay the agent her first-period compensation $c_1 = f^i + v_1^i y_1$. 

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Stage 5: After the agent has received her compensation, and paid her first-period personal productive effort cost $k(a_1)$ as well as the penalty if she manipulates earnings, the agent chooses her first-period consumption $c_1$. The agent is allowed to borrow and lend in financial markets.

Stage 6: At the start of the second period, based on the information released at the end of the first period, the principal may offer a renegotiated compensation contract $c'(\Delta f', v'_2)$, where $\Delta f'$ represents a change in the fixed payment, and $v'_2$ is the revised incentive rate for the second period. The agent can accept or refuse the new contract. If she refuses, then the initial contract stays in effect.

Stage 7: The agent chooses her second-period productive effort $a_2$, which affects the second-period performance measure and outcome to the principal.

Stage 8: At the end of the second period, the outcome $x_2$ is realized and privately observed by the agent. The amount of earnings manipulation $D$ in the first period is reversed, and the agent issues the second-period public report $y_2$.

Stage 9: Based on $y_2$ and the possible renegotiated contract, the principal pays the agent second-period compensation $\omega_2 = \Delta f' + v'_2 y_2$.

Stage 10: After receiving her second-period compensation and paying her second-period personal productive effort cost $k(a_2)$, the agent consumes her remaining bank balance.
**Performance Measures**

The contractible performance measures \( y_t, \ t = 1,2, \) reported at the end of each period, are assumed to take the following forms:

\[
y_1 = x_1 + D, \quad x_1 = \gamma a_1 + \epsilon_1, \tag{2.1}
\]

\[
y_2 = x_2 - RD, \quad x_2 = \gamma a_2 + \epsilon_2, \tag{2.2}
\]

where \( \epsilon_t, \ t = 1,2, \) are normally distributed noise terms with zero mean and covariance matrix

\[
\Sigma = \begin{bmatrix}
\sigma_1^2 & \rho \sigma_1 \sigma_2 \\
\rho \sigma_1 \sigma_2 & \sigma_2^2
\end{bmatrix}
\text{ with } \rho \in (-1,1).
\]

The performance measures have the following features. The effect of the productive effort \( a \) on the expected performance measure \( y_t \) is linear. The noise term \( \epsilon_t \) is additive and, hence, the covariance matrix of performance measures is independent of the productive effort. The two noise terms are potentially correlated with the correlation coefficient \( \rho \).

Further, the conditional expected performance measures given the productive effort and earnings manipulation are as follows.

\[
\mathbb{E}[y_1 \mid a_1, D] = \gamma a_1 + D, \quad \text{Var}[y_1 \mid a_1, D] = \sigma_1^2, \tag{2.3}
\]

\[
\mathbb{E}[y_2 \mid a_1, a_2, D, y_1] = \gamma a_2 - RD + \rho (\sigma_2 / \sigma_1)(y_1 - \gamma a_1 - D), \tag{2.4}
\]

\[
\text{Var}[y_2 \mid a_1, a_2, D, y_1] = (1 - \rho^2) \sigma_2^2. \tag{2.5}
\]

Note that the posterior mean for the second-period performance measure \( y_2 \) depends on the first-period performance measure \( y_1 \), the productive effort \( a_1, a_2 \), as well as the earnings manipulation \( D \). The posterior variance of \( y_2 \) is independent of the
specific values of $y_1$, $a_1$, $a_2$ and $D$, and lower than its prior variance unless the inter-period correlation equals zero, i.e., $\rho = 0$.

Agent's Preferences

The agent is assumed to be risk and effort averse. Her preferences for the contract period are represented by the following time-additive exponential utility function:

$$u^a = -\sum_{i=1}^{2} \beta^i \exp(-rc_i),$$

where $r > 0$ is the agent's risk aversion parameter, and $c_i$ represents consumption net of productive effort cost and the penalty. For simplicity, the market discount factor $\beta = 1/R$ is used as the agent's discount factor. Let $k(a_i)$ be the agent's productive effort cost, where $k(a_i) = \gamma_i a_i^2$ is a quadratic function as commonly assumed in the agency literature.

The agent can borrow and lend in financial markets. Let $\lambda_i$ be the amount of borrowing or lending. After the agent has received her compensation and paid her personal effort cost, as well as the penalty at the end of the first period, she has a cumulative-consumption bank balance:\textsuperscript{10}

$$B_1 = \omega_1 - k(a_1) - P = c_1 + \lambda_1.$$  

Similarly, at the end of the second period, the cumulative-consumption bank balance is

$$B_2 = R\lambda_1 + \omega_2 - k(a_2).$$

\textsuperscript{10} The agent is assumed to choose her consumption before accepting the contract at date zero.
The agent is assumed to consume her bank balance at the end of the contract, i.e., \(c_2 = B_2\), and, without loss of generality, zero reservation consumption is assumed, i.e., \(c^0 = 0\).

One feature of the agent's preferences is the time-additive form of the utility function. Mathematical complications explain why time-additive preferences have not been used as frequently as traditional time-multiplicative preferences even if the time-additive utility function is more realistic. It induces the phenomenon of consumption smoothing in dynamic settings and introduces borrowing and lending opportunities in financial markets which allow us to capture earnings management for reasons other than income smoothing.

**Principal's Preferences**

The board of directors, i.e., principal, represents the firm's well-diversified shareholders and is assumed to be risk neutral. The market discount rate \(\beta\) is applied to the principal as it is to the agent.\(^{11}\) A key feature is that the principal takes costly monitoring, and the monitoring cost is represented by \(M(e) = \frac{1}{2}m_e e^2\), where \(m_e > 0\) is the parameter of marginal monitoring cost, stated in date zero dollars. Let \(X = x_1 + \beta x_2\) be the total gross payoff to the principal, and \(W = \omega_1 + \beta \omega_2\) be the total compensation payment to the agent, both are stated in period one dollars. Thus, at the contract date, the principal's preferences are represented by:

\[
EU_0^p = \beta E_0[X] - \beta E_0[W - P] - M(e).
\]

\(^{11}\) A different discount rate can be used, but it is not essential for the subsequent results.
That is, the principal's expected utility is the expected gross payoff minus expected compensation payment (adjusted by the penalty) and monitoring cost as well. Notice that the model assumes that the board, representing the firm's shareholders, may sue the agent, and that any penalty paid by the agent goes to the shareholders. In some cases, penalties may be paid to a court or other third party.

2.4 Characterization of Equilibrium

As is commonly done in dynamic models, the equilibrium is characterized by backward induction. We discuss the concept of renegotiation-proof contracts first and then characterize the equilibrium. According to Fudenberg and Tirole (1990), a contract is renegotiation-proof if the principal will not choose to alter it at the renegotiation stage. Given the LEN (e.g., linear contract, exponential utility, and normally distributed performance measures) assumption in the model setting, we show there is no loss of generality in restricting attention to linear renegotiation-proof contracts.

Renegotiation-proof Contract

The initial-linear compensation contract is \( c'(f^i, v^i_1, v^i_2) \). At the start of \( t = 2 \), i.e., the renegotiation stage, \( f^i \) and \( v^i_1 \) are irrevocable and the principal offers a renegotiated linear compensation contract \( c'(\Delta f', v'_2) \) with a fixed payment \( \Delta f' \) and a revised incentive rate for the second period \( v'_2 \). If the agent accepts the new contract, then her second-period compensation will be \( \omega_2(c') = \Delta f' + v'_2 y_2 \). The
LEN assumption implies that, conditional on the information at the end of \( t = 1 \), her expected net compensation (i.e., the compensation net of productive effort cost) is

\[
E_i[\omega_2 - k(a_2)] = \Delta f' + v_2'[\mu_2 - RD + \rho (\sigma_2 / \sigma_1)(y_1 - \gamma a_1 - D)] - \frac{1}{2}a_2^2. 
\] (2.6)

and that the risk premium for the net compensation based on the posterior variance of \( y_2 \) is

\[
RP_1 = \frac{1}{2}r[v_2'^2(1 - \rho^2)]^2. 
\] (2.7)

Therefore, the agent’s certainty equivalent with respect to the net compensation, conditional on the information at the end of the first period, is

\[
CE_1(c') = \beta E_i[\omega_2 - k(a_2)] - \beta RP_1. 
\] (2.8)

The agent is assumed to consume her bank balance at the end of \( t = 2 \), i.e., her second-period consumption \( c_2 = B_2 \), and \( B_2 = R(B_1 - c_1) + \omega_2 - k(a_2) \). Thus, the agent’s utility maximization decision with respect to her second-period productive effort \( a_2 \) is

\[
\arg \max_{a_2} E_i[-\beta \exp(-rc_2)] \\
= \arg \max_{a_2} \{B_1 - c_1 + CE_1\} 
\] (2.9)

The first-order condition for the problem yields \( a_2^* = \nu_2^* \). This indicates that the agent optimally chooses her second-period productive effort based on the revised incentive rate \( \nu_2' \).

Given the initial contract, the public report \( y_1 \), and the principal’s conjecture of the agent’s first-period productive effort \( \hat{a}_1 \) and earnings manipulation \( \hat{D} \), the principal chooses \( \Delta f' \) and \( \nu_2' \) so as to maximize his second-period expected utility, subject to acceptance by the agent. Formally, the principal solves
The solution indicates that $\Delta f^\prime$ is a linear function of $y_1, \hat{a}_1, \hat{D}$. Furthermore, if the initial contract specifies $v_2' = v_r^2$, then $\Delta f^\prime = 0$. Thus, the linear renegotiation-proof contract is $c^{\prime\prime}(f, v_1, v_2')$.

It is worth emphasizing that this result is not true in general. The paper by Feltham; Indjejikian and Nanda (2004) shows that, even though the initial contract is linear, the renegotiation-proof contract is a quadratic function of the first-period performance measure. The difference occurs because the second-period payoff parameter is random and is correlated with the first-period performance measure in their model setting.

**Equilibrium**

Now focusing on the renegotiation-proof contract $c^{\prime\prime}(f, v_1, v_2')$, backward induction works in the following way. Since the agent is assumed to consume all the remaining bank balance at the end of the second period ($c_2 = B_2$), the second-period
consumption $c_2$ is not a decision variable. We start by characterizing the agent’s second-period productive effort choice $a_2$, followed by the principal’s renegotiated incentive rate $v'_2$ at $t=2$. Then we move back to $t=1$ to characterize the agent’s first-period consumption decision $c_1$, earnings manipulation $D$, and first-period productive effort $a_1$. Finally, we end with the principal’s compensation contract terms $(f,v_1)$ and his monitoring choice $e$ at $t=0$.

The discussion of renegotiation-proof contracts in the previous subsection shows that the agent’s optimal second-period productive effort is $a'_2 = \gamma v'_2$, and the second-period incentive rate is $v'_2 = \frac{\gamma^2}{\gamma^2 + r(1-\rho^2)\sigma_2^2}$. Increasing the incentive $v'_2$ would induce the agent to exert more productive effort $a'_2$, but would also impose higher risk as well as more effort cost on the agent. So the principal determines an optimal $v'_2$ by trading off between the benefit of the agent’s second-period productive effort and the cost of inducing it (implied by the second-period risk premium and effort cost).

At $t=1$, the agent chooses consumption $c_1$ so as to maximize her expected utility over the two-period consumption, conditional on the information available at this time, and anticipating the equilibrium solutions in the second period. Borrowing and lending opportunities are available to the agent. Given $c_2 = B_2 = R\lambda_1 + \omega_2 - k(a_2)$ and $\lambda_1 = B_1 - c_1$, the agent’s decision problem with respect to $c_1$ is

$$\max_{c_1} \{-\exp(-rc_1) - \beta E_1[\exp(-rc_2)]\}$$

$$= \{-\exp(-rc_1) - \beta \exp[-r(R(B_1-c_1) + RCE_1)]\}. \quad (2.11)$$
The first-order condition for this problem is characterized by $c_1 = R(B_1 - c_1 + CE_1)$. Rearranging it gives $c_1 = A_i(B_1 + CE_1)$ with the annuity amortization factor $A_i = (1 + \beta)^{-1}$. Thus, it is optimal for the agent to consume an amount equal to an annuity based on the sum of first-period bank balance and second-period certainty equivalent. This suggests that the agent smoothes consumption over time by borrowing and lending. Substituting the optimal $c_1$ into Equation (2.11) produces

$$\{-\exp(-rc_1) - \beta E_i[\exp(-rc_2)]\} = (1 + \beta)\{-\exp[-rA_i(B_1 + CE_1)]\}, \quad (2.12)$$

where $rA_i$ is the effective risk aversion parameter, which is the original consumption risk aversion coefficient adjusted by the annuity factor.

The agent chooses the amount of earnings manipulation $D$ after the outcome $x_i$ has been realized. At this point of time, $x_i$ is observed only by the agent, and the agent anticipates her first-period compensation $\omega_i^*(D) = f + v_i(x_i + D)$, the penalty $P = \gamma^2(p + e)D^2$, as well as the second-period certainty equivalent

$$CE_i^*(D) = \beta v_i^*[\gamma a_i^* - RD + \rho(\sigma_2 / \sigma_1)(x_i - \gamma a_i)] - \beta k(a_i^*) - \beta R_P. \quad (2.13)$$

Based on Equation (2.12), the agent’s decision problem with respect to $D$ is reduced to the following expression:

$$\max_D \{\omega_i^*(D) - k(a_i) - P(D) + CE_i^*(D)\}. \quad (2.14)$$

Then the first-order condition for the maximization problem is given by

$$v_1^* - v_2^* - (p + e)D = 0. \quad (2.15)$$

It yields $D = \frac{1}{p + e}(v_1^* - v_2^*)$. In equilibrium, the agent trades off the benefit obtained through earnings manipulation (resulting in more compensation) and the expected

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cost incurred due to the penalty. The optimal amount of manipulation is driven by the
difference between the incentive rates of the two periods, and is restricted by external
regulation and internal board monitoring.

For a given compensation contract, the agent chooses her first-period productive
effort $a_1$ at $t = 1$ to maximize her expected utility over the two periods. This is
equivalent to maximizing her total certainty equivalent $CE_0$ under the LEN
assumption,

$$\max_{a_1} CE_0 = \beta E_0 [W - K(a_1, a_2') - P] - \beta RP_0,$$  \hspace{1cm} (2.16)

where $K(a_1, a_2') \equiv k(a_1) + \beta k(a_2')$ represents the total productive effort cost, and

$$RP_0 = \frac{1}{2} \{ r A[v_1 + \rho(\sigma_2 / \sigma_1) \beta v_2']^2 \sigma_1^2 + \rho \beta [v_2']^2 (1 - \rho^2) \sigma_2^2 \}$$

is the total risk premium for the compensation, which takes account of the effect of inter-temporal correlation
captured by $\rho$. The first-order condition for the problem implies $a_1 = v_1$, i.e., the
agent chooses an optimal first-period productive effort based on the incentive rate of
this period.

Finally, we consider the compensation terms $(f, v_1)$ and monitoring choice $e$ by
the principal at $t = 0$. Anticipating the optimal solutions in the next two periods, the
principal chooses $(f, v_1, e)$ to maximize his expected utility at date zero, i.e., the
expected gross payoff minus expected compensation payment (adjusted by the
penalty) and monitoring cost, subject to the agent’s participation and incentive
constraints:

$$\max_{f, v_1, e} EU_0^P = \beta E_0 [X] - \beta E_0 [W - P] - M(e),$$  \hspace{1cm} (2.17a)

subject to

$$CE_0 = \beta E_0 [W - K(a_1, a_2') - P] - \beta RP_0 \geq c^0,$$  \hspace{1cm} (2.17b)
\[ a_1 = \gamma v_1, \quad (2.17c) \]
\[ a'_2 = \nu' v_2. \quad (2.17d) \]

The principal chooses the fixed wage \( f \) to be just sufficient to induce the agent to accept the compensation contract, i.e., the participation constraint is binding. This implies \( f = K(a_1, a'_2) + RP_0 - E_0[\omega_1' + \beta \omega_2 - P] \), where \( \omega_1' = v_1 y_1 \) is the variable first-period wage. Using the binding participation constraint, we re-express the principal’s decision problem as the following unconstrained optimization problem:

\[ \max_{v_1, e} \Pi^p_0 = \beta E_0[X] - \beta[K(a_1, a'_2) + RP_0] - M(e). \quad (2.18) \]

Therefore, \textit{ex ante}, the principal chooses \( v_1 \) and \( e \) so as to maximize his expected gross payoff net of the agent’s total productive effort cost and total consumption risk premium, minus his monitoring cost as well. Then, the first derivatives of \( \Pi^p_0 \) with respect to \( v_1 \) and \( e \) are:

\[ \frac{\partial \Pi^p_0}{\partial v_1} = \beta \frac{\partial E_0[X]}{\partial a_1} \frac{\partial a_1}{\partial v_1} - \beta \left[ \frac{\partial K(a_1, a'_2)}{\partial a_1} \frac{\partial a_1}{\partial v_1} + \frac{\partial RP_0}{\partial v_1} \right] \]
\[ = \beta \{ \gamma^2 - [\gamma^2 v_1 + rA_1 \sigma_1^2 (v_1 + \rho(\sigma_2 / \sigma_1) \beta v'_2)] \}, \quad (2.19a) \]
\[ \frac{\partial \Pi^p_0}{\partial e} = -m_e e \leq 0. \quad (2.19b) \]

Setting the first derivative with respect to \( v_1 \) equal to zero yields \( v_1 = \frac{1}{Q} \gamma^2 - \lambda \beta v'_2 \), where \( Q \equiv \gamma^2 + rA_1 \sigma_1^2, \quad \lambda \equiv \frac{1}{Q} rA_1 \rho \sigma_1 \sigma_2 \). The optimal first-period incentive rate \( v_1 \) is chosen by balancing the benefit provided by the first-period productive effort and the cost of inducing this effort, as determined by the first-period effort cost and risk.
premium. A key feature of the solution for \( v_1 \) is that it depends on the variance of the first-period performance measure \( y_1 \) and is adjusted for the inter-period correlation \( \rho \). Furthermore, the first derivative with respect to \( e \) indicates that the level of monitoring takes a corner solution, \( e = 0 \). That is, the principal optimally chooses to not monitor the agent. This result is justified by Equation (2.18) which shows that ex ante, any resource spent on monitoring creates only a deadweight loss to the principal.

2.5 The Interaction between Corporate Governance and Earnings Manipulation

This section uses the equilibrium derived in the previous section to provide a complete analysis about the interplay of the compensation contract, earnings manipulation, and board monitoring.

Proposition 2.1

The principal’s compensation contract choices are characterized as follows:

(2.1a) The first-period incentive rate \( v_1 = \frac{1}{Q} \gamma^2 - \lambda [\beta v'_2] \),

where \( Q = \gamma^2 + r_A \sigma_1^2 \), \( \lambda = \frac{1}{Q} r_A \rho \sigma_1 \sigma_2 \), \( A_t = (1 + \beta)^{-1} \).

(2.1b) The second-period incentive rate \( v'_2 = \frac{\gamma^2}{\gamma^2 + r(1 - \rho^2) \sigma_2^2} \).

(2.1c) The fixed payment \( f = K(a_1, a'_2) + R P_0 - E_0 [\alpha_1 + \beta \alpha_2 - P] \).
Due to renegotiation and inter-temporal correlation, the principal changes the incentive rate over time. Proposition (2.1b) demonstrates that the second-period incentive rate $v_2^*$ is based only on the *posterior* variance of the second-period performance measure because, at the time of renegotiation, only the second-period risk premium matters. However, the principal chooses the first-period incentive rate $v_1$ based on the total compensation risk, and hence the total risk premium paid to the agent. Specifically, Proposition (2.1a) shows that $v_1$ reflects not only the *prior* variance, but also the adjustment for the inter-period correlation $\rho$ captured by the term $\lambda \beta v_2^*$. This adjustment can be positive (or negative), depending on the sign of $\rho$.

**Proposition 2.2**

The agent's choices with respect to her productive effort, consumption and earnings manipulation, given incentive rate $v_1, v_2^*$, are characterized by

(2.2a) The first-period productive effort $a_1 = \nu_1$.

(2.2b) The second-period productive effort $a_2^* = \gamma v_2^*$.

(2.2c) The first-period consumption $c_1 = A_1(B_1 + CE_1)$.

(2.2d) The earnings manipulation $D = \frac{1}{p} (v_1 - v_2^*)$.

Consistent with a common result in the agency literature, the agent's productive effort depends on the incentive provided by the principal shown in Proposition (2.2a) and (2.2b). The incentive contract motivates the agent to work hard, and the higher incentive rates, the more productive effort. However, this incentive contract also induces the agent to manipulate earnings. This effect is highlighted by Proposition
(2.2d). The agent shifts earnings between the two periods, and an upward (or a downward) shift occurs when \( v_1 > v_2' \) (or \( v_1 < v_2' \)). That is, the agent always shifts earnings to the period with a higher incentive rate so as to maximize her total compensation over the two periods. Note that the agent has a time-additive utility function, and Proposition (2.2c) implies that she smooths consumption over time. Interestingly, the consumption smoothing is not done by smoothing accounting earnings since earnings shifting arises as an equilibrium phenomenon. Rather, the agent achieves her consumption smoothing by borrowing and lending in financial markets.

Consider a special case where \( \beta = 1 \), i.e., there is a zero interest rate, and the noise is identical in the two periods \( \sigma_1 = \sigma_2 = \sigma \), thus

**Corollary 2.1:**

i. If \( -1 < \rho < \frac{1}{2} \), then \( D > 0 \).

ii. If \( \frac{1}{2} < \rho < 1 \), then \( D < 0 \).

iii. If \( \rho = \frac{1}{2} \) or \( \rho \to \infty \), then \( D = 0 \).

Proof: See the Appendix.

This corollary establishes that, if the inter-period correlation is negative or positive but low, \( -1 < \rho < \frac{1}{2} \), then a relatively strong first-period incentive is necessary in order to induce efficient productive effort. As a result, \( v_1 > v_2' \) and the higher first-period incentive leads the agent to shift earnings to the first period, i.e., \( D > 0 \). If the correlation is positive and sufficiently high, \( \rho > \frac{1}{2} \), then the second-period incentive
becomes relatively strong \( v_1 < v'_2 \), consequently, earnings are shifted to the second period and hence \( D < 0 \). This corollary also identifies the knife-edge conditions under which no earnings manipulation exists in equilibrium i.e., \( D = 0 \). When \( \rho = \frac{1}{2} \), the principal sets equal incentives for both periods \( v_1 = v'_2 \), therefore, the agent has no desire to shift earnings. Under an extreme condition \( p \to \infty \), the threat of infinitely tight regulation deters the agent from manipulating earnings.

Note that this earnings manipulation, i.e., earning shifting, is mainly driven by contract renegotiation. From an \textit{ex post} perspective, renegotiation is beneficial to the principal. However, if the principal can fully commit to a contract with equal incentive rates for both periods, where no earnings shifting is induced, then the principal is generally better off \textit{ex ante}. On the other hand, according to Christensen and Feltham (2005, Chapter 28, p.513), "\textit{while renegotiation is generally ex ante inefficient, it may be difficult (or impossible) for the principal and the agent to commit themselves not to engage in ex post mutually beneficial renegotiation.}"

**Proposition 2.3**

The principal’s monitoring choice is \( e = 0 \).

Interestingly, the principal optimally allows the agent to manipulate earnings without any monitoring. The reason for no monitoring is that, in equilibrium, the principal anticipates the amount of earnings manipulation and prices it directly through the fixed compensation payment. This is justified by Proposition (2.1c). Re-expressing this proposition yields
\[ f = K(a_i, a_r) + RP_0 - \gamma^2 \{v_i^2 + \beta [v_r^2]\} - \frac{1}{2} p D^2. \] (2.20)

Using the optimal compensation scheme is better than exerting costly monitoring since monitoring would just cause a deadweight loss to the firm’s shareholders.

### 2.6 Window Dressing

In the basic model, the accounting earnings manipulation is costless to the agent, i.e., the manipulation is achieved without personally costly manipulative effort. However, in practice, some types of accounting earnings manipulation are costly to the agent. For example, in order to shift next period’s earnings to the current period, the agent may have to take significant time and effort to talk to some friendly customers at the end of the current period in order to arrange for shipping goods. This is referred to as costly window dressing.

In the window dressing setting, in addition to productive effort, the agent exerts manipulative effort. The manipulative effort is costly, and the cost (later referred to as “window dressing cost”) is assumed to have a quadratic functional form, i.e.,

\[ k(D_w) = \frac{1}{2} k_w [D_w]^2 \] with \( k_w > 0 \), stated in period \( t = 1 \) dollars. The window dressing cost reduces the agent’s wealth available for consumption. Formally, the agent’s utility function becomes

\[ u_w = -\sum_{t=1}^{2} \beta^t \exp(-r c_i^w), \] (2.21)

where \( c_i^w \) is the consumption net of both productive effort cost and window dressing cost. Consequently, when making an earnings manipulation decision, the agent maximizes
Comparing the agent's decision problem under costless and costly manipulation setting, i.e., (2.14) versus (2.22), shows the impact of window dressing. Now the first-order condition with respect to $D^w$ is

\[
\frac{\partial \omega_i^w(D^w)}{\partial D^w} - \frac{\partial k(D^w)}{\partial D^w} - \frac{\partial P(D^w)}{\partial D^w} + \frac{\partial CE_i^w(D^w)}{\partial D^w} = 0.
\] (2.23)

This equation indicates that, in equilibrium, the agent has to trade off the benefit of window dressing and the associated cost, as determined by both the penalty and the manipulative effort cost. The first-order condition leads to the following proposition.

**Proposition 2.4**

In the window dressing setting, the agent's earnings manipulation choice, given incentive rates $v_1^w, v_2^w$ and monitoring $e^w$, is characterized by

\[
D^w = \frac{1}{k_w + p + e^w} (v_1^w - v_2^w).
\]

Proof: See the Appendix.

Observe that the optimal earnings manipulation $D^w$ depends on the manipulative effort cost. Holding the other parameters constant, a higher window dressing cost parameter $k_w$ results in a lower level of manipulation.

Furthermore, the agent's total certainty equivalent is adjusted downward by $k(D^w)$, that is,

\[
CE_0^w = \beta E_0 [W^w - K(a_i^w, a_j^w) - k(D^w) - P^w] - \beta R P_0^w.
\] (2.24)

The adjusted total certainty equivalent alters the participation constraint ($PC^w$) in the principal's decision problem at $t = 0$:
and, as a result, the principal's unconstrained optimization problem takes the following form (see the Appendix for the derivation):

$$\max_{\nu_i^w, e^w} \Pi_0^{pw} = \beta E_0[X^w] - [K(a_1^w, a_2^w) + k(D^w) + R P_0^w] - (e^w) \geq c^0,$$  \hspace{1cm} (PC^w)

Comparing equation (2.18) in the costless manipulation setting, with equation (2.25) demonstrates that, in addition to compensating the agent for her productive effort cost and consumption risk premium, the principal must compensate the agent for her window dressing cost. Differentiating $\Pi_0^{pw}$ with respect to $\nu_i^w, e^w$ establishes:

$$\frac{d\Pi_0^{pw}}{d\nu_i^w} = \beta \left[ \frac{\partial E_0[X^w]}{\partial a_i^w} \frac{\partial a_i^w}{\partial \nu_i^w} - \frac{\partial k(a_i^w)}{\partial a_i^w} \frac{\partial a_i^w}{\partial \nu_i^w} + \frac{\partial k(D^w)}{\partial D^w} \frac{\partial D^w}{\partial \nu_i^w} + \frac{\partial R P_0^w}{\partial \nu_i^w} \right], \hspace{1cm} (2.26a)$$

$$\frac{d\Pi_0^{pw}}{d e^w} = -\beta \frac{\partial k(D^w)}{\partial D^w} \frac{\partial D^w}{\partial e^w} - \frac{\partial M(e^w)}{\partial e^w} = \beta \frac{k_w}{(k_w + p + e^w)^3} (v_i^w - e^w)^2 - m e^w. \hspace{1cm} (2.26b)$$

Observe that the term $\left\{ \frac{\partial E_0[X^w]}{\partial a_i^w} \frac{\partial a_i^w}{\partial \nu_i^w} - \frac{\partial k(a_i^w)}{\partial a_i^w} \frac{\partial a_i^w}{\partial \nu_i^w} + \frac{\partial R P_0^w}{\partial \nu_i^w} \right\}$ represents the net marginal benefit provided by the agent’s productive effort induced by the incentive rate $\nu_i^w$, and the term $\left\{ \frac{\partial k(D^w)}{\partial D^w} \frac{\partial D^w}{\partial \nu_i^w} \right\}$ is the marginal cost caused by the agent’s manipulative effort induced by $\nu_i^w$. In equilibrium, the principal determines an optimal $\nu_i^w$ by balancing the dual effects of the incentive rate, i.e., inducing the agent to provide beneficial productive effort on the one hand, and costly window dressing on the other hand. Letting (2.26a) equal zero yields

$$\nu_i^w = \frac{1}{Q^r} \gamma^2 - (\lambda^w - \frac{RG}{Q^w})[\beta v_i^w], \text{ with } Q^w = Q + G, \hspace{1cm} (2.27)$$
where \( Q = v^2 + rA_1 \sigma_i^2 \), \( G = \frac{k_w}{(k_w + p + e^w)^2} \), \( \lambda^w = \frac{1}{Q^w} rA_1 \rho \sigma_i \sigma_2 \). Notice that, the first-period incentive rate \( v^w \) is adjusted by the window dressing cost parameter \( k_w \), and also an implicit function of \( e^w \). If we define

\[
MB^w_e = -\beta \frac{\partial k(D^w)}{\partial D^w} \frac{\partial D^w}{\partial e^w} = \beta \frac{k_w}{(k_w + p + e^w)^3} (v^w_1 - v^w_2)^2,
\]

then the first derivative with respect to \( e^w \) leads to the following proposition.

**Proposition 2.5**

In the window dressing setting, the principal chooses to monitor, and the optimal level of monitoring \( e^w \) is characterized by the first-order condition

\[
MB^w_e - m_e e^w = 0.
\]

The first-order condition expresses \( e^w \) as an implicit function of incentive rates \( v^w_1, v^w_2 \). The first term \( MB^w_e \) represents the marginal benefit of monitoring implied by the lower induced payment to the agent to cover the window dressing cost. The second term represents the marginal cost of monitoring. In equilibrium, the principal chooses a non-zero optimal monitoring level such that the marginal benefit and the marginal cost are equal. Unlike the costless earnings manipulation setting, the principal prefers to monitor at least a little. The reason for the non-zero monitoring is that, *ex ante*, window dressing induces more payment to the agent, and hence lowers the shareholders' value.

\[\text{Note that an interior solution } e^w \text{ is implicitly assumed. This requires the second derivative to be negative, i.e., } \frac{\partial^2 \Pi^w}{\partial (e^w)^2} = \frac{\partial MB^w}{\partial e^w} - m_e < 0.\]
A related interesting question is: what happens if the principal refuses to pay for the agent's window dressing effort? Mathematically, the fixed compensation payment becomes

\[ f' = \text{cost of productive effort} + \text{risk premium} - E_0[W^v | a_1^w, a_2^w]. \]

Then the total compensation payment is

\[ E_0[W | a_1^w, a_2^w] = f' + E_0[W^v | a_1^w, a_2^w] = \text{cost of productive effort} + \text{risk premium}. \]

However, window dressing occurs anyway even though the principal ignores it, and the total payment considering window dressing is

\[ E_0[W | a_1^w, a_2^w, D^w] = f' + E_0[W^v | a_1^w, a_2^w] + (v_1^w - v_2^w)D^w \]

\[ = \text{cost of productive effort} + \text{risk premium} + (v_1^w - v_2^w)D^w. \]

Since \( (v_1^w - v_2^w)D^w = (k_w + p + e^w)(D^w)^2 > k(D^w) \), the principal ends up paying too much compensation if he tries not to pay for the window dressing effort. Therefore it is optimal for the principal to reduce the pay to the level which just covers the window dressing cost \( k(D^w) \).

### 2.7 Real Earnings Manipulation

This section extends accounting earnings manipulation to real earnings manipulation. Real earnings manipulation implies that the agent deviates from the optimal operating plan to change the underlying economic outcome, and hence manage the reported earnings. For example, by giving an early special discount, the agent can shift next-period sales to the current period. The manipulation results in a real cost to shareholders as long as the discount rate is greater than \( \frac{I}{R} \). Of course, the manipulation can go the other way, i.e., current sales are shifted to the next period
by delaying the special discount offer. This type of real manipulation affects the
underlying real outcome, but is costless to the agent in terms of manipulative effort.
Formally, we model this real earnings manipulation as follows.

Let \( D^R \) be the amount of real earnings manipulation, and let \( H(D^R) = \frac{1}{2} h_R [D^R]^2 \),
with \( h_R > 0 \), be the detrimental effect of real manipulation on the underlying
economic outcome. Then

\[
x_1^R = x_1 + D^R, \tag{2.29}
\]
\[
x_2^R = x_2 - RD^R - RH(D^R). \tag{2.30}
\]

Now the total gross payoff to the principal is \( X^R \equiv x_1^R + \beta x_2^R = x_1 + \beta x_2 - H(D^R) \),
which is directly reduced by \( H(D^R) \). Further, let the performance measures be
\( y_1^R = x_1^R \), and \( y_2^R = x_2^R \). Then the expected performance measures given the
productive effort and real manipulation are

\[
\mathbb{E}[y_1^R | a_1, D^R] = \gamma_1 + D^R, \tag{2.31}
\]
\[
\mathbb{E}[y_2^R | a_1, a_2, D^R, y_1^R] = \gamma_2 - RD^R - RH(D^R) + \rho(\sigma_2 / \sigma_1)(y_1^R - \gamma_1 - D^R). \tag{2.32}
\]

At the time when the agent chooses the amount of real manipulation \( D^R \) (i.e., after
\( x_1 \) is realized), the agent anticipates her first-period compensation, the penalty, and
the second-period certainty equivalent as follows,

\[
\omega_1^t(D^R) = f + v_1(x_1 + D^R), \quad P(D^R) = \frac{1}{2}(p + e^R)[D^R]^2, \tag{2.33}
\]
\[
CE_1^t(D^R) = \beta v_2(\gamma_2 - RD^R - RH(D^R) + \rho(\sigma_2 / \sigma_1)(x_1 - \gamma_1)) - \beta k(a_2^t) - \beta RP. \tag{2.34}
\]

Her decision problem with respect to \( D^R \) is to maximize

\[
\max_{D^R} \{ \omega_1^t(D^R) - k(a_1^t) - P(D^R) + CE_1^t(D^R) \}. \tag{2.35}
\]
The first-order condition yields $D^R = \frac{1}{v'_2 h_R + p + e^R} (v'^R - v'_2)$. In equilibrium, the agent takes account of the negative effect of the real manipulation on performance measures, and the amount of real manipulation is decreasing in $h_R$.

At date zero, the principal chooses $v^R_1$ and $e^R$ to maximize his expected gross payoff net of the agent's total productive effort cost and total compensation risk premium, as well as his monitoring cost. That is,

$$\max_{v^R_1, e^R} \Pi^R_0 = \beta \mathbb{E}_0[X^R] - \beta [K(a^R_1, a^R_2) + R^R_0] - M(e^R).$$

(2.36)

The key feature is that the principal's gross payoff $X^R = x_i + \beta k_2 - H(D^R)$, and the equilibrium $D^R$ is a function of $v^R_1$ and $e^R$. Hence, the first-order conditions with respect to $v^R_1$, and $e^R$ are as follows:\(^{13}\)

$$\frac{\partial \Pi^R_0}{\partial v^R_1} = \beta \left[ \frac{\partial \mathbb{E}_0[X^R]}{\partial a^R_1} \frac{\partial a^R_1}{\partial v^R_1} - \frac{\partial H(D^R)}{\partial D^R} \frac{\partial D^R}{\partial v^R_1} - \left[ \frac{\partial k(a^R_1)}{\partial a^R_1} \frac{\partial a^R_1}{\partial v^R_1} + \frac{\partial R^R_0}{\partial v^R_1} \right] \right] = 0.$$  \hspace{1cm} (2.37a)

$$\frac{\partial \Pi^R_0}{\partial e^R} = -\beta \frac{\partial H(D^R)}{\partial D^R} \frac{\partial D^R}{\partial e^R} - \frac{\partial M(e^R)}{\partial e^R}$$

$$= \beta \frac{h_R}{(v'_2 h_R + p + e^R)^2} (v'^R - v'_2)^2 - m_e e^R = 0.$$  \hspace{1cm} (2.37b)

The following proposition summarizes the main results.

**Proposition 2.6**

In the real earnings manipulation setting that is costless to the agent,

(2.6a) The principal chooses to monitor, and the optimal level of monitoring $e^R$ is characterized as: $MB_e^R - m_e e^R = 0$.

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\(^{13}\) Interior solutions are implicitly assumed. This requires the second derivatives to be negative.
where \( MB_e^R \equiv -\beta \frac{\partial H(D^R)}{\partial D^R} \frac{\partial D^R}{\partial e^R} = \beta \frac{h_R}{(v'_2 h_R + p + e^R)^3} (v_1^R - v'_2)^2 \).

(2.6b) Given incentive rates \( v_1^R, v'_2 \), and monitoring \( e^R \), the equilibrium real earnings manipulation is characterized by \( D^R = \frac{1}{v'_2 h_R + p + e^R} (v_1^R - v'_2) \).

The real earnings manipulation is costly to the principal directly through the term \( H(D^R) \). In equilibrium, the principal engages in monitoring so as to reduce this cost. The optimal level of monitoring occurs when the marginal benefit (implied by the lowered real cost caused by the manipulation) equals the marginal cost of monitoring. Ex post, the degree of real manipulation is limited by the principal’s monitoring and external regulation.

In practice, some real earnings manipulation could be costly to the agent directly, i.e., it requires the agent’s manipulative effort. Following the analysis in the window dressing section, let \( k(D_{rw}) = \frac{1}{2} k_w [D_{rw}]^2 \) be the manipulative effort cost. Then the agent’s decision problem with respect to \( D_{rw} \) is

\[
\max_{D_{rw}} \{ \omega_1^r(D_{rw}) - k(a_{rw}^r) - k(D_{rw}) - P(D_{rw}) + CE_1^r(D_{rw}) \}.
\]

Solving this maximization problem produces \( D_{rw} = \frac{1}{k_w + v'_2 h_R + p + e_{rw}} (v_1^{rw} - v'_2) \) (see the Appendix for the derivation). More importantly, when the principal chooses his \( ex \ ante \) monitoring \( e_{rw} \), he must take account of both the direct cost \( H(D_{rw}) \) and the induced cost \( k(D_{rw}) \). Formally, the principal maximizes the following decision problem,

\[
\max_{v_1^{rw}, e_{rw}} \Pi_0^{rw} = \beta E_0[X_{rw}] - \beta [K(a_1^{rw}, a'_2) + k(D_{rw}) + R P_0^{rw}] - M(e_{rw}).
\]
where \( X_{Rw} = x_1 + \beta x_2 - H(D_{Rw}) \). Differentiating \( \Pi_0^{p_{Rw}} \) with respect to \( v_{1_{Rw}}^{Rw}, e_{Rw}^{Rw} \) establishes the following first-order conditions:

\[
\frac{\partial \Pi_0^{p_{Rw}}}{\partial v_{1_{Rw}}^{Rw}} = \beta \left[ \frac{\partial E_1[X_{Rw}]}{\partial a_1_{Rw}^{Rw}} \frac{\partial a_1_{Rw}^{Rw}}{\partial v_{1_{Rw}}^{Rw}} - \frac{\partial H(D_{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial v_{1_{Rw}}^{Rw}} \right] \\
- \beta \left[ \frac{\partial k(a_1_{Rw}^{Rw})}{\partial a_1_{Rw}^{Rw}} \frac{\partial a_1_{Rw}^{Rw}}{\partial v_{1_{Rw}}^{Rw}} + \frac{\partial k(D_{Rw}^{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial v_{1_{Rw}}^{Rw}} + \frac{\partial R_{p_{Rw}}}{\partial v_{1_{Rw}}^{Rw}} \right] = 0, \tag{2.40a}
\]

\[
\frac{\partial \Pi_0^{p_{Rw}}}{\partial e_{Rw}^{Rw}} = -\beta \frac{\partial H(D_{Rw}^{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial e_{Rw}^{Rw}} - \beta \frac{\partial k(D_{Rw}^{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial e_{Rw}^{Rw}} - \frac{\partial M(e_{Rw}^{Rw})}{\partial e_{Rw}^{Rw}} \\
= \beta \frac{k_w + h_R}{(k_w + v_{1_{Rw}}^{Rw} h_R + p + e_{Rw}^{Rw})^3} (v_{1_{Rw}}^{Rw} - v_{2_{Rw}}^{Rw})^2 - m_e e_{Rw}^{Rw} = 0. \tag{2.40b}
\]

We summarize the characteristics of the equilibrium as follow.

**Proposition 2.7**

In the real earnings manipulation setting that is costly to the agent,

(2.7a) The equilibrium monitoring \( e_{Rw}^{Rw} \) is characterized by \( MB_{e_{Rw}}^{Rw} - m_e e_{Rw}^{Rw} = 0 \), where

\[
MB_{e_{Rw}}^{Rw} \equiv -\beta \frac{\partial H(D_{Rw}^{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial e_{Rw}^{Rw}} - \beta \frac{\partial k(D_{Rw}^{Rw})}{\partial D_{Rw}^{Rw}} \frac{\partial D_{Rw}^{Rw}}{\partial e_{Rw}^{Rw}} = \beta \frac{k_w + h_R}{(k_w + v_{1_{Rw}}^{Rw} h_R + p + e_{Rw}^{Rw})^3} (v_{1_{Rw}}^{Rw} - v_{2_{Rw}}^{Rw})^2.
\]

(2.7b) The real earnings manipulation is characterized by

\[
D_{Rw}^{Rw} = \frac{1}{k_w + v_{1_{Rw}}^{Rw} h_R + p + e_{Rw}^{Rw}} (v_{1_{Rw}}^{Rw} - v_{2_{Rw}}^{Rw}).
\]

In this real earnings manipulation setting that is also costly to the agent, the principal bears double losses implied by the detrimental effect of manipulation on the underlying real outcome and the agent's manipulative effort cost. Compared with the other earnings manipulation settings, the role of the principal's monitoring here

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14 As elsewhere, interior solutions are implicitly assumed, and the second derivatives are required to be negative.
becomes more important. The marginal benefit of monitoring comes from a reduced real cost \( H(D^{Rw}) \), and a reduced induced cost \( k(D^{Rw}) \). Therefore intense monitoring benefits shareholders both directly and indirectly.

2.8 The Impact of Corporate Governance Reforms

This section briefly discusses the model’s implications for recent corporate governance reforms. First, comparative static analysis leads to the following proposition.

Proposition 2.8:

(2.8a) In the setting where earnings manipulation is costless to the agent and has no effect on the underlying economic outcome,

i. \( \frac{\partial e}{\partial m} = 0 \).

ii. \( \frac{\partial |D|}{\partial p} < 0 \) if \( [(1 - \rho^2)\sigma_2^2 - A_1(\sigma_1^2 + \beta \rho \sigma_1 \sigma_2)] \neq 0 \).

(2.8b) In the costly window dressing and real earnings manipulation settings,

i. \( \frac{\partial e^*}{\partial m} < 0 \), where \( e^* = e^w, e^r \), or \( e^{Rw} \).

ii. Ex post, given the incentive rates which are not equal, \( \frac{\partial |D^*|}{\partial p} < 0 \) and \( \frac{\partial |D^*|}{\partial e^*} < 0 \), where \( (D^*, e^*) = (D^w, e^w), (D^r, e^r), \) or \( (D^{Rw}, e^{Rw}) \).

Proof: See the Appendix.

When the earnings manipulation is costless to the agent and has no effect on the underlying economic outcome, the optimal board monitoring is zero. But when the earnings manipulation is costly to the agent (i.e., window dressing) and/or affects the
underlying economic outcome, the board chooses to monitor management, and Proposition (2.8b - i) shows that a decrease in the monitoring cost parameter ($m_e$) induces the board to monitor more intensely. Further, Proposition (2.8b - ii) shows that, *ex post*, either more internal board monitoring ($e^*$) or tighter external regulation ($p$) induces a lower level of earnings manipulation.

Recent worldwide corporate governance reforms mandate various kinds of changes in governance measures. For example, Sarbanes-Oxley Act of 2002 in U.S.A. makes significant changes in corporate responsibility, financial disclosure, the legal status of auditors, analysts and especially board of directors. In Europe, investor activism and corporate control activity are becoming more common. In Asia, certain Japanese companies have implemented structural changes after the Commercial Code of 2002, including board size reduction, more outside directors and committees, and disclosure improvements. The Korean government has also embarked on a series of governance reforms on increased financial transparency and disclosure, board independence.

These reforms have the effect of changing certain parameters in this model. For example, the monitoring cost parameter $m_e$ might be reduced by the proposal that the audit committee structure includes members with financial background since financial experts work more efficiently than non-financial experts when dealing with issues related to financial and audit control. The suggestions and requirements of greater board independence might also lower board's overall monitoring cost. If so, the changes may facilitate more intense board monitoring under the situations in which boards choose to monitor. In addition, the requirement that Chief Executive Officers (CEOs) and Chief Financial Officers (CFOs) certify the financial statements...
of their companies with severe penalties in the event of disclosure failures results in a higher value of regulation parameter $p$. Consequently, these changes will help deter management from manipulating earnings.

### 2.9 Concluding Remarks

This chapter uses a dynamic agency model with renegotiation to study the interaction between corporate governance and earnings management. The model captures both internal and external governance mechanisms, specifically, board of directors and overall regulatory environment. Our analysis makes the following contributions. First, it contributes to the earnings management literature. We explore a variety of types of earnings manipulation, including accounting and real manipulation, costly window dressing and costless manipulation. The equilibrium captures earnings manipulation consisting of earnings shifting over time, and consumption smoothing without smoothing firm's accounting earnings.

Another contribution is that the model shows that the extent to which the board engages in monitoring does not depend on earnings manipulation *per se*, but rather on its real economic effect. For the four different earnings manipulation settings explored in the chapter, the board prefers to monitor if the manipulation is costly to the agent and/or affects the underlying economic outcome, but it prefers to not monitor at all if the manipulation is costless to the agent and does not affect the economic outcome. In the real world, some accounting accruals manipulations fall into the latter category. Through optimal contracting, this type of manipulation has
zero economic effect on shareholders' value and any resources used in monitoring create a deadweight loss to the firm.

The study contributes to the current debates about corporate governance. The chapter stresses the importance of "substance" over "form" because a regulatory change would have direct and induced effects that need to be considered. When implementing a new law, as seen in the new wave of worldwide governance reforms at the beginning of this century, proper practices should be strong yet flexible in terms of time, location, industry and country. For example, the SOX Act may be appropriate for U.S. companies, but some of its rules might not be suitable for European or Asian companies due to differences in economy, politics and culture.

One limitation of the chapter is that the board's incentive is exogenous. The board is assumed to maximize shareholders' value, and controls all of the bargaining power. In practice, this might not be true. For example, directors often desire to be re-appointed to the board, and top executives often play a considerable role in the nominating process. Subject to managerial power, the board members' own interests can be different from that of shareholders. This might be especially true for companies using the single board system which combine the roles of chairperson and CEO.\footnote{Bebchuk and Fried (2003) review paper notes how managerial power affects an executive's own pay and the board of directors' monitoring of management.} While this chapter does not explicitly model managerial power, certain parameters in the model capture this feature indirectly. For example, managerial power has the potential to increase board members' opportunity cost of monitoring due to the career concerns, that changes the monitoring cost parameter $m_e$. An increased value of $m_e$ induces the board to exert less intense monitoring in
equilibrium. This suggests that managerial power can distort the board’s incentive to act in the shareholders’ interest.
Figure 2.1
Timeline of the agency model

Date zero:
- The principal designs and offers an initial compensation contract to the agent \( c^i (f^i, v_1^i, v_2^i) \).
- The principal commits to the level of monitoring \( e \).

Period one:
- The agent chooses productive effort \( a_1 \).
- Outcome \( x_1 \) is realized and privately observed by the agent.
- The agent decides on the amount of earnings manipulation \( D \).
- Public report \( y_1 \) is issued.
- The agent receives her first-period compensation \( \omega_1 = f^i + v_1^i y_1 \).
- Penalty \( P \).
- Bank balance available for consumption \( B_1 = \omega_1 - k(a_1) - P \).
- The agent chooses consumption \( c_1 \).

Period two:
- Renegotiated compensation contract \( c^r (\Delta f^r, v_2^r) \).
- The agent chooses second-period productive effort \( a_2 \).
- Outcome \( x_2 \) is realized and privately observed by the agent.

\(^{16}\) The agent is assumed to choose her date zero consumption before accepting the contract.
- The agent reverses the amount of earnings manipulation $D$ in the previous period.

- Public report $y_2$ is issued.

- The agent receives her second-period compensation $\omega_2 = \Delta f' + v'_2 y_2$.

- Bank balance available for consumption $B_2 = R\lambda_1 + \omega_2 - k(a_2)$.

- The agent consumes her remaining bank balance $c_2 = B_2$. 
CHAPTER 3

Corporate Governance and Information Quality

3.1 Introduction

Many recent corporate governance reforms around the world aim to increase public disclosure by firm management. Making more information publicly available to the capital market is generally expected to make current market prices more informative about the future value of the firm. However, the market price is based on total information: both the public information disclosed by firm management and the private information acquired by investors. For this reason, it is relevant to ask: does forcing management to make more information available publicly change the amount of information acquired by investors? Once this question has been answered, we can ask: do the changes in public and private information result in a net increase or a net decrease in total information? McNichols and Trueman (1994) note that both academics and regulators are interested in the answers to these questions.

Based on Kyle (1985), we develop a strategic investor model in an insider trading setting. In this single-period model, four sets of traders are included: a firm’s manager (i.e., an insider), multiple privately informed rational investors, one privately uninformed rational investor called the “market maker”, as well as liquidity traders. The manager has knowledge about the terminal firm value. We assume that she
discloses at least some of that information and we consider the possibility that she is able to withhold some of the information and use it for personal trading, without incurring penalties for insider trading. The privately informed investors acquire costly private information. The manager and informed investors use their private information (in addition to the public report) when determining their market trades. While the privately uninformed investor, i.e. the market maker, can not observe their private information, he can imperfectly infer that information from the aggregated trading quantities. Hence, the market clearing price depends on both the public report and the private information.

In our stylized single-period model setting, there is prior uncertainty about the terminal firm value and it can be reduced either by releasing public information or by obtaining private information. The quality of that information is defined to be the extent to which that information reduces prior uncertainty about the terminal value of the firm. In particular, a comprehensive measure, referred to as total information quality, is defined to be the extent to which the market price reveals the terminal firm value. It is derived based on the expected square of the difference between the equilibrium price and the terminal value. An increase in total information quality means that the market price is more informative about the terminal firm value.

The equilibrium market price in our model reflects both the public and private information, but in a different way. We show that, while the public report is fully revealed, the private signals are partially revealed since the manager and informed investors partially hide their private information through strategic trading.
Consequently, the total information impounded in the market price is the aggregate of the public information and a fraction of the private information.

The manager knows more about the future events than is publicly disclosed. As a corporate insider, she may have many motives to trade, such as, realizing stock-based compensation, shedding firm-specific risk, or meeting liquidity needs. In this model, we only consider insider trading, i.e., a manager who trades with the intent to profit from her possession of nonpublic information. Such trades are illegal and we consider the implications of corporate governance mechanisms used to enforce the ban on insider trading. While tighter governance forces management to disclose inside information, and hence improve the quality of public information, the analyses show that its effect on the equilibrium total information quality is more subtle. At the same time as corporate governance changes the public information directly, the interaction between the public reporting and private information acquisition changes the amount of private information acquired in equilibrium.

More specifically, tighter governance could lead to higher qualities in both public reports and private signals if the investors obtain private signals by processing public reports. Or, tighter governance could increase the quality of public information but lower the quality of private information if both sets of information are from the same sources. In other case, more informative public reports make it more costly for the investors to obtain additional information. Of course, tighter governance could improve the quality of the public reports and have no effect on the private signals if the different types of information come from different sources. In all cases, the total information impounded in the market price is the aggregate of public and private
information. We show that the effect of tighter governance on total information quality in capital markets is case-specific.

The link between governance and total information quality depends on the interaction between public disclosure and private information acquisition. In particular, the quality of private information is an endogenous variable which is a function of the quality of public information. In the accounting literature, Demski and Feltham (1994), Kim and Verrecchia (1994), and McNichols and Trueman (1994) study similar questions in various settings. Demski and Feltham (1994) use a Grossman and Stiglitz (1980) type model to note that changes in the information content of the public report affect an investor's decision to privately acquire this costly signal. A more informative disclosure has an ambiguous effect on price change variances around the date of the announcement. Both Kim and Verrecchia (1994), and McNichols and Trueman (1994) use Kyle (1985) type models. Kim and Verrecchia focus on the issue of information asymmetry, created by investors who may process the information in financial reports to obtain extra information, and study its link to market liquidity and the bid-ask spread. They conclude that more public information reduces information asymmetries and makes the market more liquid. McNichols and Trueman study the importance of short term trading behavior prior to an announcement and show how this behavior affects price reactions to a disclosure. They conclude that an informed trader prefers to receive information about the future disclosure than about the firm's value. We use a Kyle type model and consider the role played by some investors acquire private information when insiders are endowed with information. The role of insiders is important since we
compare the equilibrium in a model which allows insiders to trade and withhold information with the equilibrium in a model in which insiders cannot trade and must disclose all inside information.

The remainder of the chapter proceeds as follows. The next section develops a model of strategic investors and outlines the information structure. Section 3 characterizes the equilibrium market behaviors. Section 4 derives the endogenous informed investor's private signal precision. Section 5 considers the effects of corporate governance on various information qualities in capital markets, i.e., public, private and total information. The last section provides the concluding remarks.

3.2 The Strategic Investor Model

In the model, there are four sets of risk neutral traders: a firm's manager (i.e., an insider), a single privately uninformed rational investor, multiple privately informed rational investors (Ι), and liquidity traders. The manager and the privately informed investors trade to maximize profits based on their own private information. The liquidity traders (referred to as noise traders) trade for reasons that are independent of the market price. The shares held by the liquidity traders is exogenously specified as $Z_t \sim N(0, \sigma^2_z)$. The privately uninformed investor does not observe the individual quantities traded by the manager and the privately informed investors as well as the liquidity traders, but observes the aggregate quantity. The uninformed investor imperfectly infers the manager's and the informed investors' private information based on the aggregate quantity, and sets the market price so that he expects to break

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17 As is common in Kyle type model, the preferences of liquidity traders are not modeled, so it is impossible to analyze social welfare issues.
even. The uninformed investor is called the market maker. The introduction of noisy trades is important since it ensures that market price is not fully revealing of private information.

The timeline and the sequence of events are described as follows (see Figure 3.1). At date zero, the manager has endowed information about the terminal firm value, the information set is \((y_a, y_m)\). At date one, the manager disclose \(y_u\) to the public (all investors observe the public report) and withholds \(y_m\) for the purpose of personal trading. Then the multiple investors \(I\) acquire costly private signal \(y_i\). Based on their own private information, the manager and informed investors place orders simultaneously along with liquidity traders. The uninformed investor, i.e., the market maker, does not know \(y_m, y_i\), the individual quantities traded by the manager \(z_m\), the privately informed investors \(z_i\), and the liquidity traders \((Z_i)\), but observes the aggregate quantity \((z_u)\). He absorbs the remaining shares to clear the market and sets the market price. At date two, the terminal firm value is realized. Several features of the model are as follows. First, since the manager and informed investors use their private information (in addition to the public report) to determine the trading quantities, the market clearing price depends on that information. As is common in Kyle type models, both the manager and informed investors anticipate that their choices of demand functions influence the market price, and act strategically. Therefore, instead of acting as a price taker, they have incentives to restrain their trades so as to partially hide their private information and maximize trading profits.
Figure 3.1

Timeline of the strategic investor model

\[ t=0 \quad \quad \quad t=1 \quad \quad \quad t=2 \]

- manager endowed with info. \((y_a, y_m)\)
- manager issues public report \(y_a\)
  (withholds \(y_m\))
- terminal value \((v = m_0 + e)\)
- investors acquire private signals \(y_i\)
- trade \(z_m, z_i, Z_l\)
- market maker absorbs the remaining shares
  and sets market price \(p_1\) by observing \(y_a\) and \(z_a\)

**Information Structure**

The terminal value of the firm is represented by \(v = m_0 + e\), where \(e\) is a zero mean, normally distributed random variable, i.e., \(e \sim N(0, \sigma_e^2)\). The random trade of \(Z_l\) is not correlated with the firm value \(v\), \(\text{Cov}[v, Z_l] = 0\). Further, the prior beliefs with respect to the public report \(y_a\) issued and the information withheld \(y_m\) by the manager are \(y_a \sim N(0, \sigma_a^2)\), \(y_m \sim N(0, \sigma_m^2)\), and \(\text{Cov}[y_a, y_m] = 0\). For simplicity, the multiple investors \((I)\) are assumed to receive the same private signal \(y_i\), and \(y_i \sim N(0, \sigma_i^2)\). The investors' private signal is independent of the manager's information, i.e., \(\text{Cov}[y_a, y_i] = 0\), \(\text{Cov}[y_m, y_i] = 0\). This implies that the manager
and the identically informed investors are informed about different components of the noise in the firm value.

Given the public report, the posterior belief about the noise in the firm value is $\varepsilon | y_a \sim N(y_a, \sigma_{al}^2)$. The private signals held by the manager and informed investors are informative about the noise in the public report. Specifically, $\varepsilon | y_a, y_m \sim N(y_a + y_m, \sigma_{ml}^2)$, and $\varepsilon | y_a, y_m, y_i \sim N(y_a + y_m + y_i, \sigma_{il}^2)$. Similar to Demski and Feltham (1994), our specified information structure is chosen for its algebraic simplicity:

$$\sigma_0^2 = \sigma_a^2 + \sigma_{al}^2 = \sigma_a^2 + \sigma_m^2 + \sigma_{ml}^2 = \sigma_a^2 + \sigma_m^2 + \sigma_i^2 + \sigma_{il}^2. \quad (3.1)$$

The total uncertainty about the terminal firm value, $\sigma_0^2$, is assumed to be a constant throughout the model. The total uncertainty resolved by the public report $y_a$ is $\sigma_a^2$. The incremental uncertainty resolved by the information withheld by the manager $y_m$ is $\sigma_m^2$. And the further incremental uncertainty resolved by the informed investor’s private signal $y_i$ is $\sigma_i^2$. Since $\sigma_0^2$ is constant, we interpret either $\sigma_a^2$ or $h_{al} = 1/\sigma_{al}^2$ as a measure of the quality (or informativeness) of the public report with respect to $\varepsilon$.

An increase in $\sigma_a^2$ represents an increase in quality implying a greater reduction in uncertainty by the public report. Similarly, $\sigma_m^2$ and $\sigma_i^2$ measure the qualities (or

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18 The set up of the model is stylized. The main feature of our set up is that the signals are set equal to the posterior expectation about the noise in the terminal value. Other papers, such as McNichols and Trueman (1994), use an alternative set up in which the signals provide information about the terminal value but they are not equal to the posterior expectation. The two set ups are qualitatively similar. See Demski and Feltham (1994) and Christensen and Feltham (2003) for a discussion of the fact that the scale of a signal is arbitrary and it is always possible to represent a signal in terms of the posterior mean it produces.
informativeness) of the information withheld by the manager and the private signal acquired by the informed investor, respectively.

3.3 Characterizing Market Equilibrium and Information Quality

Initially, we treat the informativeness $\sigma_i^2$ as exogenous, and consider the informed investor's private signal acquisition decision in the next section. $z_m$ and $z_i$ are the orders placed by the manager and the informed investors, respectively, and the shares sold by the liquidity trade is $Z_f$. Hence, the aggregate net quantity traded by the three sets of traders is

$$z_u = Z_i - (z_m + \sum_{j=1}^{I} z_j). \tag{3.2}$$

The uninformed investor does not observe the individual quantities traded by them, but observes the aggregate quantity $z_u$. He acquires those shares to clear the market, and sets a market price, denoted as $p_1$. Then, ignoring information acquisition costs, the trading profits for the manager, as well as for the informed and uninformed investors are

$$\pi_m = (v - p_1)z_m, \quad \pi_i = (v - p_1)z_i, \quad \pi_u = (v - p_1)z_u. \tag{3.3}$$

The uninformed investor sets the market price so that he expects to breakeven, that is, price $p_1$ equals the expected terminal value of the firm based on the information set the uniformed investor observes at this time, which includes the public report $y_a$, and the aggregate quantity $z_u$. That is,

$$p_1 = E_{u1}[v \mid y_a, z_u] = m_0 + y_a + \mu_{u1}(z_u), \tag{3.4}$$

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where $\mu_{u1}(z_u) = E[\epsilon_{av} \mid z_u]$, and $\epsilon_{av} = \epsilon - y_a$ represents the prior belief about the noise in the public report. The term $\mu_{u1}(z_u)$ is the uninformed investor’s posterior mean with respect to $\epsilon_{av}$ conditional on $z_u$. Moreover, the manager and the informed investors conjecture the posterior mean is proportional to the aggregate quantity:

$$\mu_{u1}(z_u) = E[\epsilon_{av} \mid z_u] = -b z_u. \quad (3.5)$$

At the same time, the manager and the informed investors conjecture what the other will demand as a result of their private information. The conjectured demands are

$$z_m = \alpha y_m, \quad z_i = \beta y_i. \quad (3.6)$$

Given these conjectures, the manager and the informed investors choose trading quantities to maximize their profits by anticipating the influence of their trades on the market price. Specifically, the manager’s expected price resulting from an order of $z_m$ units, given her information set $(y_a, y_m)$ is

$$E[p_1 \mid y_a, y_m, z_m] = m_0 + y_a + b z_m + b I [B E[y_i \mid y_a, y_m]]$$

$$= m_0 + y_a + b z_m. \quad (3.7)$$

The key here is that since $y_a, y_m$ and $y_i$ are all independent, $E[y_i \mid y_a, y_m] = 0$. As a result, the manager’s expectation with respect to the orders placed by the informed investor is zero. Further, the manager’s trading profit is calculated as $\pi_m = (v - p_1)z_m$. Then based on her information set $(y_a, y_m)$, the manager’s expected trading payoff is

$$U_{m1}(y_a, y_m, z_m) = \{E[v \mid y_a, y_m] - E[p_1 \mid y_a, y_m, z_m]\}z_m$$

$$= (y_m - b z_m)z_m. \quad (3.8)$$
See the Appendix for the derivations. The manager maximizes her payoff by choosing her order quantity \( z_m \), then the first-order condition yields \( z_m(y_m) = \frac{1}{2b} y_m \).

It indicates that the manager’s demand is a function of her private signal. Similarly, informed investor \( i \)'s expected price resulting from an order of \( z_i \) units, given his information set \((y_a, y_i)\) is

\[
E[p_i | y_a, y_i] = \beta y_i + b z_i + b(I-1) \beta y_i.
\] (3.9)

Note that since all investors receive the same private signal by assumption, investor \( i \)'s expectation with respect to the orders placed by the other informed investors is \( E[z_j | y_i] = \beta y_i \). Therefore, given the informed investor \( i \)'s trading profit is calculated as \( \pi_i = (v - p_i)z_i \), his expectation of the trading payoff conditional on his information set \((y_a, y_i)\) is

\[
U_i(y_a, y_i, z_i) = (y_i - b(I-1) \beta y_i - b z_i) z_i.
\] (3.10)

Maximizing the expected profit produces \( z_i(y_i) = \frac{1}{2b} [1 - b(I-1) \beta] y_i \). As with the manager, the informed investor \( i \)'s demand is a function of his private signal. Finally, based on the conjectured trading quantities by the manager and the informed investors, the uninformed investor’s posterior mean with respect to \( \varepsilon_{au} \) is

\[
\mu_{au}(z_u) = -\frac{\alpha \sigma^2_m + \beta I \sigma^2_i}{\alpha^2 \sigma^2_m + \beta^2 I^2 \sigma^2_i + \sigma^2_z} z_u.
\] (3.11)

See the Appendix for the derivation. Rational expectations require that, the conjectures must be consistent with the optimal choices. Therefore, the following proposition characterizes the market equilibrium.
Proposition 3.1

In the strategic investor model with insider trading, the equilibrium demands and market price are characterized as:

(3.1a) the manager’s demand: \( z_m = \alpha y_m \).

(3.1b) the informed investor \( i \)'s demand: \( z_i = \beta y_i \), for \( i = 1, 2, \ldots, I \).

(3.1c) the market price: \( p = m_0 + y_a - b z_u \).

where \( \alpha = \frac{1}{2b} \), \( \beta = \frac{1}{(I+1)b} \), and \( b^2 = \frac{1}{4} \frac{\sigma_m^2 + \frac{I}{(I+1)^2} \sigma_i^2}{\sigma_z^2} \).

Proof: see the Appendix.

Properties of the Equilibrium:

Observe that, the demand functions for the manager and the informed investor differ because they have different private information. Simple comparative static analyses suggest that the orders placed by the manager and informed investors are increasing in the liquidity noise \( \sigma_z^2 \), but decreasing in the precisions of their private signals \( \sigma_m^2 \) and \( \sigma_i^2 \). In this model setting, the market maker imperfectly infers the private signals. More inferred private signals lead to lower trading profits to the manager and informed investors. Therefore, they strategically restrict their trades so as to hide their private information. On the other hand, the noise created by liquidity traders helps them to hide their private signals and hence induce more trading quantities. Furthermore, substituting parameters \( \alpha \), \( \beta \), and \( b \) into the equilibrium price expression yields
\[ p_1 = m_0 + y_a + \frac{1}{2} y_m + \frac{I}{I+1} y_i - bZ_i. \] (3.12)

Grossman and Stiglitz (1980) define price-informativeness as the squared correlation between the informed posterior mean and the price. McNichols and Trueman (1994) study price-informativeness by calculating the expected change in price before and after an announcement. Similarly, we calculate the expected squared difference between \( p_1 \) and \( v \) is\(^{19} \)

\[ E[p_1 - v]^2 = \frac{1}{4} \sigma_a^2 + \frac{1}{(I+1)^2} \sigma_i^2 + b^2 \sigma_x^2 + \sigma_m^2. \] (3.13)

Based on the information structure, \( \sigma_m^2 = \sigma_0^2 - (\sigma_a^2 + \sigma_m^2 + \sigma_i^2) \). In equilibrium, \( b^2 = \frac{1}{4} \sigma_m^2 + \frac{I}{(I+1)^2} \sigma_i^2 \cdot \) Thus, the above expression becomes

\[ E[p_1 - v]^2 = \sigma_0^2 - (\sigma_a^2 + \frac{1}{2} \sigma_m^2 + \frac{I}{I+1} \sigma_i^2). \] (3.14)

It implies that, the total prior uncertainty with respect to the terminal value \( \sigma_0^2 \) is partially resolved by the public report \( y_a \) and private information \( y_m, y_i \), and the amount of uncertainty resolved is \( \Phi = \sigma_a^2 + \frac{1}{2} \sigma_m^2 + \frac{I}{I+1} \sigma_i^2 \). As \( \Phi \) increases, the market price moves closer to the terminal firm value. \( \Phi \) represents the aggregate of the informativeness of all types of information, i.e., public and private information. Therefore, we refer it to as “total information quality”. The following proposition summarizes the result.

\(^{19} \)From the information structure, \( v = m_0 + \varepsilon = m_0 + y_a + y_m + y_i + \varepsilon_m \).
Proposition 3.2

In the strategic investor model with insider trading, the equilibrium total information quality impounded in the market price is

\[ \Phi \equiv \sigma_o^2 + \frac{1}{2} \sigma_m^2 + \frac{I}{I+1} \sigma_i^2. \]

The total information quality measures the extent to which the market price reflects the terminal firm value. The public information is fully impounded in the equilibrium price, but the private signals are only partially impounded. As the number of informed investors \( I \) goes to infinity, their private information becomes closer to being fully revealed.

3.4 Endogenous Private Signals Quality

The previous sections treat the informativeness of the informed investors’ private signals as exogenous. This section endogenizes \( \sigma_i^2 \) to consider information acquisition costs. Suppose the number of the informed investors is fixed, but each individual chooses the precision of his signal. For simplicity, the cost of the signal for each informed investor is assumed to be the same, and represented by the following functional form:

\[ \kappa_i(\sigma_o^2, \sigma_i^2) = (1 + \gamma \sigma_o^2) \sigma_i^2. \]  

(3.15)

where \( \gamma \) is the private information cost parameter, which can be positive, negative, or zero, and \((1 + \gamma \sigma_o^2) > 0\). The specification indicates that the private acquisition cost increases in its own informativeness \( \sigma_i^2 \). On the other hand, the marginal information cost is affected by the informativeness of the public disclosure \( \sigma_o^2 \) when
\( \gamma \neq 0 \), and increased public information quality decreases (or increases) the information cost when \( \gamma < 0 \) (or \( \gamma > 0 \)). Considering the information cost, informed investor \( i \)'s net trading profit is

\[
\pi_i^{\text{net}} = (v - p_i)z_i - \kappa_i.
\]  

(3.16)

Based on equilibrium derived in the previous section, the informed investor \( i \)'s \textit{ex ante} expected equilibrium net payoff, given that \( I \) investors are informed, is

\[
U_i^{\text{net}}(\sigma_i^2) = \frac{1}{(I + 1)^2} \frac{\sigma_z \sigma_i^2}{\sqrt{\frac{1}{4} \sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2}} - \kappa_i(\sigma_a^2, \sigma_i^2).
\]  

(3.17)

See the Appendix for the derivation. Maximizing the \textit{ex ante} net payoff with respect to \( \sigma_i^2 \) yields the following proposition.

**Proposition 3.3**

In the strategic investor model with insider trading, given a fixed \( I \), informed investor \( i \)'s optimal choice of private signal quality is characterized as

\[
\frac{\frac{\sqrt{4} \sigma_m^2 + \sqrt{2} \frac{I}{(I + 1)^2} \sigma_i^2 ^*}{(I + 1)^2}}{\frac{\sqrt{4} \sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2 ^*}{(I + 1)^2}} = \frac{(I + 1)^2}{\sigma_z} (1 + \gamma \sigma_a^2).
\]  

(3.3a)

Comparative statics show that the optimal level of private information quality \( \sigma_i^2 ^* \) is (3.3a) increasing (or decreasing) in \( \sigma_a^2 \) if \( \gamma < 0 \) (or \( \gamma > 0 \));

(3.3b) unaffected by \( \sigma_a^2 \) if \( \gamma = 0 \).

Proof: see the Appendix.

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\(^{20}\) Note that when the informed investor makes decision on \( \sigma_i^2 \), he anticipates the equilibrium in the trading stage. It is a sequential game.
The proposition demonstrates that an informed investor acquires a less informative signal if public disclosure increases his information cost. This could happen when the public report and the private information are from the same source, and hence increased informativeness of the public report makes it more difficult for the investor to acquire additional information. In contrast, if the investor obtains private information by analyzing the public report, then a more informative public report could lead to a better quality private signal. Finally, private signal acquisition is not affected by the public report if the two information sources are independent. Notice that this intuition does not necessarily contradict the previous assumption that the public and private information are independent. For example, an expert who studies an annual report carefully may understand the implications of certain details, such as unrealized gains or special accounting practices, that affect firm value. These details could be in addition to and independent of what other investors understand from the public report. We use the simpler independence assumption for tractability considerations and because it does not affect the results qualitatively.

3.5 The Effect of Corporate Governance on Information Quality

Accounting scandals and self dealing by corporate insiders have shaken investor confidence in the integrity of securities markets. For this reason, there have been worldwide corporate governance reforms that aim at improving the quality of public disclosure through tightened regulations. Certainly, some of the new rules will help, such as, the requirement of Chief Executive Officers (CEOs) and Chief Financial

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Officers (CFOs) to certify the financial statements of their companies, and the imposition of severe penalties in the event of disclosure failures. As well, revised rules on insider trading will help to prohibit unlawful trades by insiders.

Based on the above model, we consider the setting in which the firm's manager, i.e., the insider, is not allowed to trade, and discloses all the endowed information publicly. The main differences from the previous setting with insider trading are as follows. First, the public information set is increased from one signal $y_a$ to two signals $(y_a, y_m)$, so both signals are observed by the investors. Second, traders are reduced to three sets: $I$ privately informed investors, the market maker, and the liquidity traders. Thus, the aggregate trading quantity absorbed by the market maker is $z_u = Z_t - \sum_{i=1}^{I} z_i$. The market maker sets the market price based on the two public signals and the aggregate trading quantity, i.e.,

$$p_i = E_{u_i} [v \mid y_a, y_m, z^*_u] = m_0 + y_a + y_m + \mu_{u_i}(z^*_u).$$

Finally, the total informativeness of the public signals is $(\sigma_a^2 + \sigma_m^2)$ and, hence, the private information cost function becomes

$$\kappa_i(\sigma_a^2, \sigma_m^2) = \frac{1 + \gamma(\sigma_a^2 + \sigma_m^2)\sigma_i^2}{\sigma_i^2}.$$

Following the same characterizing process as in the previous sections, the following proposition describes the market behavior.

**Proposition 3.4**

In the strategic investor model without insider trading, the market equilibrium is

(3.4a) the informed investor $i$'s demand: $z_i'(y_i) = \frac{\sigma_i^2}{\sigma_i^2 + 1} y_i$, for $i = 1, 2, ..., I$.  

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(3.4b) the market price: 
\[ p_t = m_0 + y_a + y_m - b z_u \]
where 
\[ b = \sqrt{I} \frac{\sigma_i^2}{I + 1 \sigma_z^2}. \]

Proof: see the Appendix.

Proposition 3.4 implies that the informed investors trade more aggressively if there is more liquidity noise, and hence have a larger impact on the market price. The informed trading is decreasing in the number of informed investors in the market due to competition. Further, substituting parameters \( b \) into the equilibrium price expression yields

\[ p_t = m_0 + y_a + y_m + \frac{I}{I + 1} y_t - b Z_i. \]  
(3.20)

As in the insider trading setting, we calculate the expected squared difference between \( p_t \) and \( v \):

\[ E[p_t - v]^2 = \frac{1}{(I + 1)^2} \sigma_i^2 + b^2 \sigma_z^2 + \sigma_n^2. \]  
(3.21)

Given the information structure, \( \sigma_i^2 = \sigma_0^2 - (\sigma_a^2 + \sigma_m^2 + \sigma_z^2) \), and the equilibrium condition, \( b = \frac{\sqrt{I} \sigma_i^2}{I + 1 \sigma_z^2} \), the above expression becomes

\[ E[p_t - v]^2 = \sigma_0^2 - \frac{I}{I + 1} \sigma_i^2. \]  
(3.22)

**Proposition 3.5**

In the strategic investor model without insider trading, the equilibrium total information quality impounded in the market price is

\[ \Phi = \sigma_a^2 + \sigma_m^2 + \frac{I}{I + 1} \sigma_i^2. \]
Compared to insider trading setting, the inside information $y_m$ is now fully captured in the market price. In order to compare the total information quality in the two settings, we need to solve for the equilibrium level of private signal quality without insider trading.

Given that $I$ investors are informed, informed investor $i$'s \textit{ex ante} expected equilibrium net payoff is:

$$U_i^{\text{net}}(\sigma_i) = \frac{1}{(I + 1)^{\sqrt{I}}} \sigma_i \sigma_i' - \kappa_i'(\sigma_i^2, \sigma_i^2, \sigma_i^2).$$  \hfill (3.23)

See the Appendix for the derivation. Maximizing the \textit{ex ante} net payoff produces the following proposition.

**Proposition 3.6**

In the strategic investor model without insider trading, given a fixed $I$, the optimal level of informed investor $i$'s private signal quality is

$$\sigma_i^* = \frac{1}{2[1 + \gamma(\sigma_u^2 + \sigma_m^2)](I + 1)^{\sqrt{I}}} \sigma_z.$$

Simple comparative statics demonstrate that private signal precision $\sigma_i^*$ is increasing (or decreasing) in the informativeness of public information $(\sigma_u^2 + \sigma_m^2)$ if $\gamma < 0$ (or $\gamma > 0$) and unaffected if $\gamma = 0$. This result is same as in the insider trading setting. In addition, investors acquire a less precise signal as more investors become informed, because more competition leads to lower profit.
Comparison of Information Quality in Two Settings

Based on the above analyses, we compare the equilibrium information qualities in the settings with and without insider trading. First, tighter regulation prohibits unlawful insider trading and induces higher quality public information. Specifically, the informativeness of public disclosure is increased from $\sigma_a^2$ in the insider trading setting to $(\sigma_a^2 + \sigma_m^2)$ in the setting without insider trading. Further, regulation changes the informed investors' trading profits and information acquisition costs. The change in the trading profits is due to the differential revealing of the signal $y_m$ in the market price. And, the change in the information costs is due to the interactive effect of public information on private information acquisition. The interaction is ambiguous since the change in marginal information cost $\gamma \sigma_m^2$ could be positive, negative, or zero, depending the sign of parameter $\gamma$. That is, increased informativeness of public reporting may lead to a higher / lower information cost, or have no effect. As a result, the optimal levels of private signal precisions differ substantially. Mathematically, they are characterized by

$$\frac{\gamma_4 \sigma_m^2 + \gamma_2 \frac{I}{(I+1)^2} \sigma_i^{2*}}{\left[\frac{\gamma_4 \sigma_m^2 + \frac{I}{(I+1)^2} \sigma_i^{2*}}{\sigma_z}\right]^2} = \frac{(I+1)^2}{(1+\gamma \sigma_a^2)} \text{ vs. } \sigma_i^{2*} = \frac{1}{2(1+\gamma(\sigma_a^2 + \sigma_m^2))(I+1)\sqrt{I}} \sigma_z.$$  

Then, the change of total information quality is

$$\Delta \Phi \equiv \Phi^* - \Phi = \frac{1}{2} \frac{\sigma_m^2 + \frac{I}{I+1} [\sigma_i^{2*} - \sigma_i^{2*}]}.$$  

(3.24) The total information quality improves if the private information quality increases. However, if the increased level of public information quality is offset by (or lower
than) the reduced level of private information quality, then the total information quality is unchanged (or decreases). If decreasing, it indicates that the market price is less informative about the terminal firm value. In sum, the net effect of tightened governance on information efficiency and market price is case-specific.

Table 3.1 illustrates this ambiguity with numerical examples. Both private signal qualities $\sigma_i^2$ and $\sigma_i^2$ are decreasing in the information cost parameter $\gamma$. That is, the more costly of the private information, the less precise of the signal. In the table, when $\gamma$ increases from 0.002 to 0.004, the precision $\sigma_i^2$ decreases from 302.1 to 255.9 and $\sigma_i^2$ decreases from 276.8 to 225.8. The effect of increased public disclosure on the endogenous quality of private signals is ambiguous. Comparing the settings with insider trading and without insider trading, the public information quality improves by 10 but the quality of private information does not consistently increase. The effect is ambiguous because it varies with the sign and the value of $\gamma$.

As shown in the table, private signal quality increases by 42.2 when $\gamma=0.004$, but decreases by 30 when $\gamma=-0.004$. Consequently, the total information quality could be better, worse or unchanged, as shown in Figure 3.2.
Table 3.1
Comparison of equilibrium level of information quality

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<td>10</td>
<td>-30.0</td>
<td>-20.0</td>
</tr>
<tr>
<td>0.006</td>
<td>50</td>
<td>219.8</td>
<td>238.1</td>
<td>60</td>
<td>187.7</td>
<td>216.4</td>
<td>10</td>
<td>-32.0</td>
<td>-21.7</td>
</tr>
</tbody>
</table>

* The table shows the equilibrium values for varying information cost parameter γ. The other parameters: σ₂ = 500, I = 5. Here, Δi = σ⁻² - σ⁺², ΔΦ = Φ' - Φ.

Figure 3.2
Effect of corporate governance on total information quality

Change in total information

Information cost parameter

* The figure shows the equilibrium values of change in total information quality for varying information cost parameter γ. The other parameters are σ₂ = 500, I = 5. The horizontal axis is γ*1000.
3.6 Concluding Remarks

In this chapter, we analyze a simple insider trading model to examine how corporate governance affects information quality in capital markets. One feature of the model is to study the effect of governance through the analysis of the interaction between public reporting and private investor information acquisition. The model helps us to understand the direct and indirect roles of governance on the total information quality impounded in the market prices. Directly, better corporate governance helps to improve the quality of public disclosure. Indirectly, governance affects private information acquisition through its effect on public disclosure. The interplay of public disclosure and private information acquisition is subtle. Increased informativeness of public reports can lead to more or less informative private signals. Both public and private information are impounded in market prices; hence, the effects of governance on the total information quality and market prices are ambiguous. We show cases where more public disclosure can actually make the total information quality decrease.

The model is simple, and the set up is stylized, since its purpose is to focus attention on the conceptual issues surrounding corporate governance, public reporting, and private information acquisition. For this reason, and since there is a large literature which investigates related aspects, we do not consider the social costs or benefits of the proposed policy change. As in Grossman and Stiglitz (1980), there is a general presumption that it is better to have a more informationally efficient market but this remains an open question.
CHAPTER 4

Empirical Evidence

4.1 Introduction

The key prediction from the theory in the previous chapter is that, while tightened corporate governance might improve the quality of public disclosure, its effect on the total information quality is ambiguous. The reason is that increased public disclosure may lead to more or less private information acquisition. The corporate governance reforms of Sarbanes-Oxley Act (SOX) of 2002 provide a natural experiment to investigate the relationship between corporate governance and information quality in capital markets.

This chapter examines two research questions. First, we investigate the information quality surrounding the SOX reforms. In particular, we examine whether public disclosure improved after the passage of the SOX. What is the effect of SOX on private information quality? Does the total information quality increase after the SOX? The second research question considers whether boards of directors contribute to the changes in the information quality during this period. We focus on boards since, although the reforms around SOX are comprehensive, the board of directors is one of the most important internal governance mechanisms. The SOX and related reforms emphasized independent directors as a way to monitor financial information
processing and detect disclosure failures.

The previous chapter proposed a stylized model of events in a single period. In it, we defined the quality of public (private) information as the extent to which that public (private) information reduces prior uncertainty about the terminal firm value. The market price reflects both public and private information. A comprehensive measure, referred to as total information quality, is defined as the extent to which the market price reveals the terminal firm value. It is calculated as the expected square of the difference between the market price and the terminal value. An increase in total information quality means that the market price is more informative about terminal firm value.

This chapter implements this idea by using earnings forecasts of financial analysts to capture the underlying public and private information set available to informed investors in capital markets. The literature supports the use of this kind of proxy (e.g. Botosan, Plumlee and Xie, 2004; Barron, Harris and Stanford, 2003). We compute the different precisions of public, private and total information levels by employing two different information quality measures, one proposed by Barron, Kim, Lim and Stevens (1998) (hereafter BKLS), and the other proposed by Gu (2005). Both measures derive unobservable analysts' information properties by using observable analysts forecast data, i.e., forecast dispersion, forecast error, and the number of forecasts.

The empirical results document that, the quality of public disclosure improves following the SOX reforms. However, the quality of private information decreases. Further, since total information is the aggregate of the public and private information,
the increase in public information quality is offset by the decrease in private information quality, so that there is no significant change in total information quality in the year following the passage of the SOX. Moreover, the public disclosure improvement only lasts one year.

Following the prior literature on corporate governance, we measure board characteristics in terms of board independence, and board meeting frequency. We fail to find a significant positive association between board characteristics and public information quality during the sample period. The result suggests that reforms to board independence and board meeting times may not have contributed to the improvement in public disclosure after the passage of the SOX. If true, then other enhanced governance mechanisms have played a dominant role in increasing the quality of public information immediately after the passage of the SOX.

The remainder of the chapter proceeds as follows. The next section presents a history of the events surrounding the Sarbanes-Oxley Law and some related literature. Section 4.3 develops the research design and describes how the variables are measured. In particular, it illustrates the calculation of the BKLS (1998) information quality variables. Section 4.4 presents and discusses empirical results including data and sample description. Sensitivity checks are offered in Section 4.5. The last section provides the concluding remarks.

4.2 Institutional History and Literature Review

The SOX and related reforms have attracted a lot of attention from the academics, raising many debates regarding the mandated governance changes (Ribstein 2002,
Mitchell 2003, etc.). The SOX was approved at the end of July of 2002 and, in the words of Li, Pincus and Rego (2006), it is “the most important legislation affecting financial corporate reporting passed in the United States since the 1930s.” Figure 4.1 lists a number of high profile accounting scandals at large companies that occurred during the period leading up to the passage of SOX. The Enron scandal of October 2001 may be the best known of these scandals. Figure 4.2 lists related critical events in government that occurred at the same time. Starting in December 2001, Congress held hearings on the collapse of Enron. These hearings led to over 30 bills being proposed but it was unclear whether the problems were widespread or just in a few “rotten apples” (Jain and Razaee, 2005). A bill on the issue was passed by the House of Representatives in April 2002, but was not immediately considered by the Senate.

The scandal involving WorldCom occurred in May 2002, less than two months before SOX was passed. In the middle of June 2002, a jury convicted Arthur Andersen of obstructing the SEC’s investigation of Enron, just before the Senate Banking Committee met. Romana (2004) notes that the debates in the Senate and in the House of Representatives on the Sarbanes-Oxley Act itself took less than a week. The reason for the surprising speed is because events, such as those involving WorldCom and Arthur Andersen plus Global Crossing and Tyco, “changed the political landscape” (Li, Pincus and Rego, 2006, p. 12). Evidence of the high pressure to pass a law quickly can be seen in the comment of former SEC Chief Accountant Lynn Turner that “much of the content ... had been discussed previously but lacked support in Congress” (Li, Pincus and Rego, 2006, p. 12). Romano argues that the quick consideration indicates that the law has flaws. These flaws can be seen
in current attempts to revise the law\textsuperscript{22}, especially for smaller firms, and in estimates showing that the cost of compliance is high (cited in Bryan and Lilien, 2006). Ribstein (2002, p. 67) notes that some firms may be willing to pay such costs to demonstrate integrity while some commentators worry about a “race to the bottom” among securities regulators seeking to lower compliance costs.

The SOX aims to create an environment with accurate and timely disclosure of more financial information. For example, Section 203 states “The CEO and CFO of each issuer shall prepare a statement to accompany the audit report to certify the ‘appropriateness of the financial statements and disclosures … and that those financial statements and disclosures fairly present, in all material respects, the operations and financial condition of the issuer.’” The maximum penalties for willful and knowing violations of this section are a fine of up to $5 million and/or imprisonment for up to 20 years. This Section came into force in August 2002. In addition to existing extensive quarterly and annual filings, Section 401 requires more reports on off-balance-sheet transactions and on pro-forma earnings. Section 409 requires real time disclosure on material changes in financial conditions.\textsuperscript{23}

Some of the SOX reforms dealt with the board of directors. In order to enhance the monitoring function by the board of directors, Section 301 states “Each member of the (board) audit committee shall be … independent. ‘Independent’ is defined as not receiving, other than for service on the board, any consulting, advisory, or other compensatory fee from the issuer, and as not being an affiliated person of the issuer, or any subsidiary thereof.” In August 2002, the New York Stock Exchange (NYSE)\textsuperscript{22} See thomas.loc.gov/cgi-bin/query/D?c109:2:./temp/~c109RRDpVp.\textsuperscript{23} www.aicpa.org/info/sarbanes_oxley_summary.htm.
filed a proposed rule change with the SEC aimed at ensuring the "independence of directors … and to strengthen corporate governance practices". In October 2002, the NASDAQ offered a similar proposal (Carter, Lynch and Zeldman, 2005). These rules became effective in January 2003.²⁴

The results of recent event studies concerning the market effects of SOX on firm value have been mixed, according to Ribstein (2005) and Romano (2004). Li, Pincus and Rego (2006) find that passing the Act was associated with significantly positive abnormal stock return and that investors anticipated that SOX would constrain earnings management. Rezaee and Jain (2003) find that abnormal returns of firms with weak governance were negative and suggested that the costs of implementing the SOX rules for such firms would exceed the benefits. Bhattacharya, Groznik and Haslem (2002) find that executive certification of financial statements were not significantly priced by investors. Cohen, Dey and Lys (2005) investigate the trends in earnings management in the pre and post SOX periods. Distinguishing between accounting and real earnings management, they suggest that the SOX caused firms to switch from accounting to real earnings management methods.

An extensive governance literature has studied how board characteristics are related to corporate performance, and how board characteristics affect the observable actions of boards, such as CEO replacement, executive compensation and acquisitions.²⁵ The literature has shown that there is no overall positive relation


²⁵ Hermalin and Weisbach (2003) survey the economics literature and offer several key findings. For example, board composition is not related to corporate performance, but board size is negatively
between the degree of board independence and various measures of firm performance, such as earnings, Tobin’s q, and stock price (Romano, 2004). In the accounting literature, some papers study how board characteristics are related to earnings management and the quality of financial disclosures, instead of corporate performance. Klein (2002) finds a negative relation between audit committee independence and abnormal accruals. Agrawal and Chadha (2003) finds that having at least one member of the audit committee with accounting or financial expertise is more important than the independence of the committee. They also find that firms having the CFO on the audit committee were more likely to restate earnings. Romano (2004) discusses these results and worries that the findings may be biased because of self-selection, i.e., that better managed firms may choose directors with more expertise.

Few studies consider financial disclosure practices, although some papers have begun to focus on management earnings forecasts: Ajinkya, Bhojraj and Sengupta (2005) and Karamanou and Vafeas (2005). Ajinkya, Bhojraj and Sengupta (2005) finds that firms with more outside directors tend to issue management earnings forecasts more frequently, and they tend to be more accurate and less optimistically biased. Karamanou and Vafeas (2005) considers additional characteristics of the board and the audit committee, such as size, percentage of outside directors and the number of meetings. Overall, they find that effective governance is associated with more accurate forecasts. However, Felo, Krishnamurthy and Solieri (2003) find no association between board independence and the quality of financial reporting, related to corporate performance. As well, both board size and board composition appear to be related to the quality of the board’s decision on CEO replacement, executive compensation, and acquisitions.
measured by AIMR scores.

Our work considers the effect of the governance reforms around SOX on the information quality in capital markets. Instead of focusing on an individual source of information, such as management earnings forecasts, we consider more comprehensive measures that reflect the overall quality of public disclosure. In addition to testing the link between governance reforms and public information quality, we also test the link between governance reforms and private information quality. This second test is based on our theory which stresses the interaction between public and private information. We complete the analysis by looking at the total information quality, which is arguably more important because it captures the overall information efficiency in capital markets. Moreover, since the SOX and related governance reforms proposed strict rules on board structure aiming to enhance the board’s monitoring function. We therefore investigate whether board characteristics change following SOX, and whether those board characteristics contributed to the changes in public, private and total information quality. Our study adds to the growing debate on the costs and benefits of SOX and related governance reforms.

4.3 Research Design and Variable Measurement

The reforms surrounding the SOX provide a natural setting to empirically examine the association between corporate governance and information quality in capital markets. As noted above, both internal and external governance mechanisms were enhanced under the new rules.
There was a lot of pressure on Congress to pass a law, so the wording of the Sarbanes-Oxley Act that was passed on July 30, 2002 was chosen relatively quickly.\textsuperscript{26} The requirement that the CEO and CFO certify the quarterly and annual reports was implemented starting from August 2002 and was expected to immediately affect the quality of public disclosure. For this reason, we use August 2002 as the critical time of the "event" that we study. Our empirical analysis examines a three-year window, from August 2001 to July 2004, surrounding the passage of the Act. Year -1 corresponds to the fiscal year ended between August 2001 and July 2002, year 0 corresponds to the fiscal year ended between August 2002 and July 2003, and year +1 corresponds to the fiscal year ended between August 2003 and July 2004 (see Figure 4.3). The post-SOX periods are year 0 and year +1.\textsuperscript{27} Note that we also tried other months as the cutoff to define the event years, such as October 2002. This yields regression results that are similar to those reported in the chapter.

\textsuperscript{26} Ribstein (2005, p. 14) comments that "it may be difficult to decide on a relevant date for measuring the effect of SOX given continuous media reports bearing on the likelihood of adoption".

\textsuperscript{27} We do not go back further because of the consideration that the effect of SOX will be confounded with the effect of Regulation Fair Disclosure (Reg. FD). Reg. FD was approved on August 10, 2000 and went into effect on October 23, 2000. It requires that all material information be communicated to all investors at the same time to eliminate selective disclosure of information to certain preferred analysts and institutional shareholders. Mohanram and Sunder (2003) and Gu (2005) document a decrease in the precision of common information but an increase in the precision of analysts' private information after the Reg. FD.
This chapter studies two research questions. First, we investigate the information qualities surrounding the SOX reforms. In particular, we examine whether public disclosure improved after the passage of the SOX. Our first hypothesis is that the SOX and related reforms increase the quality of public information. Based on the theory in the previous chapter, which discussed the interaction between public reporting and private information acquisition, we also examine whether the SOX and related reforms increase or decrease the quality of private information. To complete the analysis, since there is a general presumption and hope that SOX and related reforms have increased the quality of total information available in capital markets, we test this hypothesis also.

The following regression model is used to investigate these questions.

\[
IQ_i = \alpha_{0i} + \alpha_{1i}D_{-yr0} + \alpha_{2i}D_{-yr1} + \alpha_{3i}Controls + \epsilon_i. \tag{4.1}
\]

where \(IQ_i\) represents the information quality measures (\(i = \) public, private, or total). \(D_{-yr0}\) and \(D_{-yr1}\) are time dummies for year 0 and year +1. They are included to capture the impact of SOX in the year immediately after the Act was passed and in
the following year. Including $D_{-yr1}$ allows us to examine whether the impact was permanent.

The following control variables are included in the model: firm size, growth, $D_{-loss}$ (equals one if the firm reports a loss), $D_{-miss}$ (equals one if the firm’s actual earnings is below the mean analysts forecasts), and $D_{-litigate}$ (equals one if the firm is in an industry with high litigation risk). The prior literature suggests that larger firms and high-growth firms attract more analysts following, and more information is available on these firms. Performance dummies are included because uncertainty about earnings is higher when earnings performance is poor. The literature typically uses mean analysts forecasts and zero profit as benchmarks to capture earnings performance. As well, existing evidence in the literature shows that firms operating in industries that are subject to higher litigation risks are likely to provide higher quality public information.

The second research question explored in this chapter investigates whether characteristics of the board are related to information quality during the governance reform period. The reforms around SOX are comprehensive, affecting both external and internal governance mechanisms. The board of directors is presumed to be an important internal governance mechanism monitoring management and overseeing disclosure policy. The strict rules proposed by SOX and related governance reforms on board structure are intended to enhance the board’s monitoring function. The

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28 The control variables are defined more fully later in the chapter.
29 We did not control for the number of analysts following a company since we include firm size and growth as control variables, and large firms and high-growth firms are associated with more analysts following.
following regression model is used to investigate the board’s impact on information quality:

\[ IQ_i = \beta_{0i} + \beta_{1i}D_{-yr0} + \beta_{2i}D_{-yr1} + \beta_{3i}Board \]

\[ + \beta_{4i}Board \times D_{-yr0} + \beta_{5i}Board \times D_{-yr1} + \beta_{6i}Controls + \eta_i. \quad (4.2) \]

The regression model aims to capture the effect of the board structure on information quality after controlling for other governance mechanisms, such as financial disclosure regulation implied by the time dummies. The variables which represent the interaction between board characteristics and the time dummies are used to capture the effect of any change in the relationship between board and information quality after the passage of the SOX.

**Measurement of Information Quality**

In the previous chapter, we offered a single period model and defined the quality of public (private) information as the extent to which public (private) information reduces prior uncertainty about the terminal value of the firm. In general, a financial analyst’s information set about earnings consists of common (public) and idiosyncratic (private) information. These analysts are employed by investment firms and their recommendations are used by investors when making decisions. This chapter uses earnings forecasts of financial analysts to capture the underlying public and private information set available to informed investors in capital markets.\(^{30}\)

\(^{30}\) As Botosan, Plumlee and Xie (2004) argue, the characteristics of analysts’ information sets may differ from the information sets used by other informed investors and this difference may introduce measurement error. However, they think that this error would not introduce bias. Barron, Harris and
In the literature, Barron, Kim, Lim and Stevens (1998) (hereafter BKLS) derives a measure of unobservable analysts' information properties by using observable analysts forecast data, i.e., forecast dispersion, forecast error, and the number of forecasts. In their theoretical model, $N$ analysts forecast future earnings that is normally distributed. The analysts have a common prior and each receives a private signal which equals the earnings plus noise. The noise terms can be correlated. Based on the key assumption that the precision of the analysts' information is identical, BKLS provide the following formulas for the precision of analysts' public and private information,

$$h = \frac{SE - D/N}{[(1-1/N)D + SE]^2},$$ \hspace{1cm} (4.3)$$

$$s = \frac{D}{[(1-1/N)D + SE]^2},$$ \hspace{1cm} (4.4)$$

where $h$ and $s$ are the precision of public and private information, respectively. $SE$ is the expected realized squared error in the mean forecast, and $D$ is the expected forecast dispersion. More specifically,

$$SE = E[(A_{jt} - \bar{F}_j)^2],$$ \hspace{1cm} (4.5)$$

$$D = E\left[\frac{1}{N-1} \sum_{i=1}^{N} (F_{ijt} - \bar{F}_j)^2\right],$$ \hspace{1cm} (4.6)$$

where $A_{jt}$ is the actual earnings for firm $j$ in year $t$, $F_{ijt}$ is analyst $i$'s forecast of earnings for firm $j$ in year $t$, and $\bar{F}_j$ is the mean of the forecasts for firm $j$ in year $t$. In their model, the precision of total information is the inverse of the analysts' 

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Stanford (2003) study this question more carefully and show that the trading behavior of investors is consistent with the changes in the information environment captured by the BKLS measure.
total uncertainty, $V$. The total uncertainty is the sum of two parts: (i) the idiosyncratic uncertainty among analysts (i.e., private), represented by the expected forecast dispersion $D$, and (ii) the uncertainty common to all analysts (i.e., public), represented by the expected squared error in the mean forecast $SE$ adjusted by the fraction of idiosyncratic uncertainty that cannot be diversified away (i.e., $D/N$). The total information precision is decomposed into public and private information precision based on the public-to-total precision ratio $\rho$, that is, $h = \rho(1/V)$ and $s = (1 - \rho)(1/V)$. Under the BKLS assumptions, the public-to-total precision ratio $\rho$ is equal to the public-to-total uncertainty ratio, i.e., $\rho = \frac{SE - D/N}{(1 - 1/N)D + SE}$.

When estimating $SE$ and $D$ using the empirical data, it is important to recognize that a data set consists of ex post realizations rather than the ex ante expectations. Substituting the realized values for expected values introduces measurement error into our measures of information quality. Barron, Byard and Kim (2002, p. 828) point out that "such measurement error is ameliorated in large samples." Like many previous studies employing the BKLS measure, such as Mohanram and Sunder (2005), Botosan and Stanford (2005), Christensen, Gaver and Stuerke (2005), Botosan and Plumlee (2004), Barron, Harris and Stanford (2003), Byard and Shaw (2003), and Barron, Byard and Kim (2002), we do not expect it to introduce bias.

To implement the BKLS measures, an important feature in the analysis of analyst forecasts literature is the choice of the scaling variable. Generally, the stock price is used. We scale forecasts and actual earnings by the stock price at $t-1$, and then multiply by 100 (i.e., expressed in percentages). Next, to meaningfully calculate the information measures, we make the following restrictions. An analyst can issue
earnings forecasts several times during a single firm-year, we use the most recent forecast before the actual earnings announcement date. This procedure mitigates data interdependence and selects the most up to date forecast. We also require that firms have at least two different analysts produce forecasts for a given year since the denominator for the calculation of the forecast dispersion $D$ would be zero if $N = 1$. Further, in expectation, all information precisions should be positive. But the estimated measures can sometimes take on negative values. For example, the precision of public information will be negative ($h < 0$) if $(SE - D/N) < 0$, i.e., when the mean forecast error is small relative to the forecast dispersion. It implies that there is little common (public) information. So a zero value is assigned to $h$ for those cases. In addition, since the estimated values of $h$ and $s$ are highly skewed, we take square roots of them as in Gu (2005). Thus, the information quality variables are measured as

$$
Pub_{IQ} = \sqrt{h}, \quad Pri_{IQ} = \sqrt{s}, \quad Total_{IQ} = \sqrt{h + s},
$$

where $Pub_{IQ}$, $Pri_{IQ}$ and $Total_{IQ}$ represent the quality of public, private and total information under BKLS measurement. Finally, we winsorize all of the information quality variables at the 1% and 99% level to reduce the impact of outliers.

It is worth mentioning that the measures rely on the following assumptions: (i) all analysts announce their forecasts simultaneously; (ii) analysts issue unbiased forecasts; (iii) analysts' private information is of equal precision. Ivkovic and Jegadeesh (2004, p. 10) point out, when analysts make forecasts sequentially instead simultaneously, it is not clear whether the BKLS measures are applicable. If
analysts’ have an optimistic bias, then one of the BKLS assumptions is not maintained, and the measures may not be valid. In addition, Gu (2005) criticizes the assumption of identical precision of private information across all analysts. In section 4.5, we use Gu’s proposal of an alternate measure to check the sensitivity of our results.

**Measurement of Board Characteristics**

In the corporate governance literature, board characteristics are measured along several dimensions, such as board size, board composition (e.g., insider-outsider ratio), board meetings, and board members with financial backgrounds. We use two board characteristics measures drawn from the literature to proxy for how boards monitor management: board independence measured by the percentage of outside directors, and board meeting frequency. A common view is that outside directors are independent and are effective monitors of managerial actions. A body of empirical work finds evidence to support this view, such as, Dechow, Hutton, and Sloan (1995), Beasley (1996), Klein (2002) and Ajinkya, Bhojraj and Sengupta (2005). However, an alternative view is that outside directors may be ineffective if they are appointed by firms’ managers, or if the board culture discourages conflict. The evidence from Yermack (1996) and Bhagat and Black (1997) is consistent with this argument. Therefore, the correlation between board independence and the quality of public disclosure is unclear. Board meeting frequency is a proxy for the time that directors devote to monitor management. In expectation, boards that meet

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31 We also used audit committee independence and meetings. It provides similar results as reported in the chapter.
more frequently are more likely to exercise more effective control over firms' disclosure practices. So, a positive relation between number of board meetings and the quality of public disclosure would be expected. On the other hand, boards may meet more often if they need to fix past disclosure flaws or deal with other financial emergencies. For example, Vafeas (1999) finds that boards meet more often after crises. Therefore, it is not clear that more board meetings necessarily lead to better quality public disclosure.

**Measurement of Control Variables**

Based on prior research, the following variables are used to control for other possible determinants of the properties of information in capital markets.

\[ \text{Ln(ta)} = \log \text{of the total assets of a firm at the beginning of the fiscal year.} \]

\[ \text{Market-to-book ratio} = \frac{\text{market value}}{\text{book value}}, \text{where, book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt.} \]

\[ \text{D_loss} = \text{One if a firm reports losses in a given year, and zero otherwise.} \]

\[ \text{D_miss} = \text{One if a firm’s actual earnings per share is below the mean forecast}\text{ for a given year, and zero otherwise.} \]

\[ \text{D_litigate} = \text{One if the firm is in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise.} \]

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\[ 32 \text{ Note that, in general, mean / median forecast is the normal target that researchers use to see if managers try to meet or beat consensus of analysts' forecasts. The measure used here is based on the mean of the forecasts that are used to calculate the information quality variables.} \]
Prior literature suggests that there is a positive association between firm size and the information quantity or quality available to investors. In line with the literature, we use the log of total assets to reduce the skewness in firm size. The market-to-book ratio at the end of the fiscal year is used to control for firms' growth opportunities. Existing evidence suggests that there is more information demand for high-growth firms (Barron, Byard, Kile and Reidl, 2002). We do not control for the number of analysts following the firms since large firms and high-growth firms are associated with more analysts following. Earnings have been shown to be more difficult to predict when earnings performance is poor (Mohanram and Sunder 2003, Gu 2005). The literature typically uses dummy variables D_loss and D_miss to capture this feature. Prior work also documents information differences among industries. Firms in the industries that are subject to higher litigation risk, such as, biotechnology, computer, electronics industries, tend to provide higher quality of public information. Therefore, we use D_litigate to control for the litigation effect.

4.4 Empirical Results

Data and Sample Description

The sample period corresponds to the fiscal year ends from August 2001 to July 2004. The data is obtained from IRRC, Compustat, and I/B/E/S databases. We start with the IRRC corporate governance database, which covers the companies that are included in the S&P 500, Midcap, or Smallcap indexes. The companies in the IRRC database are matched first with the Compustat database and then with financial

33 For example, Atiase (1985) shows that larger firms have smaller price reactions to earnings announcements.
analyst data retrieved from the I/B/E/S database. Specifically, we use the detailed analyst forecast history and actual earnings per share from I/B/E/S.

Table 4.1 Panel A shows that the initial sample of available IRRC and Compustat matched data is 4,086 firm-year observations. To calculate meaningful information quality measures, we select data from the I/B/E/S database which meets the restrictions noted in the previous section. The final sample includes 2,931 firm-years. Panel B of Table 4.1 shows that the sample size increases over time, from 919 firm-years in year -1 to 1,032 firm-years in year +1.

Panel C in Table 4.1 presents the summary statistics for the sample. Due to high skewness, large differences exist between the mean and median values with regard to total assets, sales, book value of equity, and market value of equity. For example, while the median total assets (sales) is 2,461 million (1,729 million), the mean value is 15,370 million (6,225 million). But, there is less skewness in the number of analysts following, with a mean of 12.25, and a median of 10. Overall, the sample seems to include larger firms due to the above selection restrictions.

**Tests and Results**

Table 4.2 describes the summary statistics of all variables used in the analysis over the whole sample period, including information quality variables, board characteristics, and control variables. Panel A shows the estimated quality of public information has a mean of 6.29 and a median of 2.91, which is lower than the quality of private information which has a mean of 10.07 and median of 4.44. The total information quality aggregates the public and private qualities. The mean total
information quality is 13.29, and the median is 7.13. Panel B indicates that small differences exist between the mean and median values of board characteristics variables. The mean value of board independence (and the number of board meetings) is 0.69 (7.26) and the median is 0.71 (7). This suggests that, on average, about 70% of board members are outsiders and they meet seven times per fiscal year. Finally, Panel C shows that 11% of sample firms report losses, 33% of firms report earnings below the mean forecasts and 28% of firms belong to the industries with high litigation risks. The sample firms have an average market-to-book ratio of 1.88 and a median of 1.47.

We are interested in the trend of information quality surrounding the passage of the SOX. Table 4.3 shows that the public information quality improves from a mean of 6.72 (median of 2.65) in year -1 to 6.95 (3.48) in year 0. The improvement is significant at 1% level using a Wilcoxon test (the Z statistic is 3.19) but it is not significant using a mean test (the t statistic is 0.49). Surprisingly, this improvement is not sustained. In year +1, the mean (median) drops to 5.29 (2.55). This decline is significant at the 1% level for both the mean and Wilcoxon test.

While the quality of public information increases in the year immediately after the passage of the SOX, the quality of private information decreases. On average, the quality of private information decreases from 12.25 in year -1 to 10.50 in year 0. The change is significant based on the mean test but is not significant based on the Wilcoxon test. Furthermore, in year +1, the quality of private information continues to decline to a mean of 7.71.
The total information aggregates public and private information. From year -1 to year 0, improved public disclosure is offset by the decline in the private information quality, Table 4.3-2 shows that there is no significant change in the median total information quality immediately after the passage of the SOX. Specifically, the median total information quality is 8.00 in year -1 vs. 8.30 in year 0. The Z statistic of Wilcoxon test is 0.69. Consistent with the declines in public and private information quality in year +1, the quality of total information significantly decreases, to a median of 5.60 in year +1. The mean tests show weak evidence (t = -1.73) of a decline in total information in year 0 and significant evidence (t = -5.32) of further decline in year +1.

In summary, the univariate analysis indicates that the governance reforms around SOX induced a temporary increase in the quality of public disclosure. The increase in public information is associated with less private information acquisition and hence lower quality of private signals. This could happen if both sets of information are from the same sources. If so, more public information is likely to make it more costly for investors to acquire additional private information. Furthermore, the opposite changes in the public and private information quality results in no significant change in the total information quality immediately following SOX. Another observation is that the improvement in public disclosure is not permanent, lasting only for one year. All three types of information quality drop in year +1.

Table 4.4 reports board characteristics by year. Board characteristics increase significantly after the SOX. Specifically, the portion of independent board members increases from an average 0.67 in year -1 to 0.69 in year 0, and then 0.72 in year +1.
The t test of the difference in the means is significant at 1% level. Similarly, the median jumps from 0.67 up to 0.71, and then 0.73 which is significant at the 1% level using a Wilcoxon rank test. The results suggest that firms changed their board composition to meet the requirements of SOX and the new NYSE and NASDAQ regulations. The number of board meetings increases slightly across the three periods. The median (mean) board meetings increase from 6 (7.10) in year -1 to 7 (7.26) in year 0. In year +1, the median stays unchanged although the mean increases to 7.41. The changes in the mean and median board meetings from year -1 to year 0 are not significant. However, the change from year -1 to year +1 is significant at the 5% (1%) level using a t-test (Wilcoxon test). In general, firms changed their governance structure under the heightened regulation climate.

Table 4.5 displays Pearson and Spearman correlations for variables used in the regression analysis. Results between Pearson and Spearman correlations are similar. Board variables, i.e., board independence and board meetings are positively correlated, but the Pearson correlation coefficient is only 0.10. This suggests that each measure captures a distinct dimension of a board’s monitoring process. The public information quality is positively (negatively) correlated with time dummy $D_{yr0}$ ($D_{yr1}$). Overall, the control variables, i.e., firm size, growth, $D_{loss}$ $D_{miss}$ and $D_{litigate}$, are strongly related to all three information quality variables as expected.

The regression results in Table 4.6 are consistent with the preliminary univariate analyses in Table 4.3. The year 0 dummy variable ($D_{yr0}$) has a positive and significant coefficient on the public information quality, and the year +1 dummy
variables ($D_{yr1}$) has a negative and significant coefficient. This suggests that the increased scrutiny associated with the introduction of SOX might have a significantly positive impact on firms’ public disclosure quality presumably because of the enhanced external and internal governance mechanisms. However, the positive effect is not maintained. The year 0 coefficients in the private and total information regression are insignificant (the $t$ statistics are -0.19 and 0.70 respectively), and the year +1 coefficients are significantly negative. This indicates that the SOX did not improve total information quality in capital markets. One of the goals of the SOX is to motivate information efficiency in capital markets through increased public disclosure. However, the empirical results indicate that even though the quality of public disclosure improved, the total information quality has not improved. As expected, control variables are mostly significant at the 1% level.

The changes in information qualities surrounding SOX could be attributed to several simultaneous changes in governance mechanisms. Boards of directors are presumed to play an important role in monitoring firm management. The preliminary analysis in Table 4.4 demonstrates a significant change in board characteristics around the introduction of SOX. Another question raised in this chapter is whether boards of directors contributed to the changes in the information environment around the introduction of SOX. Table 4.7 re-estimates the regressions in Table 4.6 adding board independence and board meetings, both on their own and interacted with time dummy variables. In the public information regression, the coefficient on year 0 continues to be positive and significant but the coefficient on year +1 is no longer negative. Private information quality continues to decline in year +1, however the
decline in total information quality in year +1 is no longer significant. The board independence and board meeting variables that are not interacted with the time dummies capture the relation between board characteristics and information quality in the base year, i.e., year -1. The interacted variables indicate how the relationship between information quality and board characteristics differs between year 0 or year +1 and the base year. Most of the board variables are individually insignificant, except for the effects of board independence on private and total information quality in year -1. The effects of board independence on private and total information quality are significantly negative. This suggests that, prior to the introduction of SOX, informed investors acquired less information about firms with more independent boards. The insignificant interacted variables imply that the introduction of SOX did not change this relation.

The non-association of board characteristics and public information quality is not surprising since a change in board characteristics does not necessarily lead to a change in actual board monitoring behavior. Effective board monitoring depends on several factors such as the skills of board members, their time and incentives, and the information available to the board. The literature has shown that there is no overall positive relation between the degree of board independence and various measures of firm performance, such as earnings, Tobin’s q, and stock price. Moreover, the result suggests that board of directors have not contributed to the improvement of public disclosure after the passage of the SOX, implying that other enhanced governance mechanisms might have played a more dominant role in temporarily improving the quality of public information.
We should be cautious in our interpretation of individual coefficients because of omitted variables or the potential of multi-collinearity. Table 4.8 shows that some of the interaction variables are highly correlated. For this reason, we tested whether the year dummies and the board characteristics, including interactions, are jointly insignificant using an F-test (Greene, 2000, p. 283). For both the public (F = 5.27) and total (F = 10.34) information regressions, we strongly reject the hypothesis at the 1% level (critical value F(7, 2917) = 2.66).

4.5 Sensitivity Checks

This section uses the information measures introduced in a recent working paper by Gu (2005) to check the robustness of the previous results. While the BKLS information measures are popular, they rely on some rather restrictive assumptions. In particular, the assumption of identical precision of private information across all analysts has been criticized in the recent literature. Gu (2005, p.1) argues that “... analysts' private information can come from their private communication with managers or from individual analytical skills and efforts. Neither needs to be the same across individuals....” By relaxing this assumption, Gu (2005) generalizes the BKLS (1998) measures with the following formulas.

$$h^* = \frac{N(N-1)(SE - D/N)}{N^2[(1-1/N)D + SE]^2 - \sum_{i=1}^{N} V_i^2},$$  \hspace{1cm} (4.8)

$$s_i = \frac{1}{V_i} - h^*, \hspace{0.5cm} \text{for } i = 1, \ldots, N,$$  \hspace{1cm} (4.9)

where $V_i = E[(A_{jt} - F_{jt})^2]$ is analyst $i$’s expected forecast error for firm $j$ in year $t$.

The formulas show that an individual analyst’s forecast error reflects both the public
information error and the analysts own private information error. The main
difference between the Gu and BKLS measures is that Gu utilizes individual forecast
error $V_i$ to extract the differential properties of private information, and BKLS focus
on aggregate forecast properties to extract aggregate properties of the information
environment. The BKLS measures are a special case of the Gu measures.

Similar to BKLS, we replace the expected values with the realized values to re­
calculate the information quality measures, based on the Gu (2005) formulas. When
the estimated measures take on negative values, a zero value is assigned to those
measures. If the actual earnings exactly meet a forecast, i.e., $(A_{jt} - F_{jt})^2 = 0$, the
estimated precision of individual private information goes to infinity, i.e., $s_i \to \infty$.

For this case, $s_i$ is assigned a value that is twice as large as the maximum precision of
the remaining analysts with finite precision measures.\(^{34}\) Consistent with the treatment
used for the BKLS measures, we take the square roots of $h^1$ and $s_i$.

The aggregate properties of information are measured as

\[
\begin{align*}
Pub\_Gu &= \sqrt{h^1}, \\
Pri\_Gu &= \frac{1}{N} \sum_{i=1}^{N} \sqrt{s_i}, \\
Total\_Gu &= \frac{1}{N} \sum_{i=1}^{N} \sqrt{h^1 + s_i},
\end{align*}
\]

where $Pub\_Gu$, $Pri\_Gu$ and $Total\_Gu$ represent the quality of public, private
and total information using the Gu measures. All information measures are
winsorized at the 1% and 99% level to reduce the impact of outliers.

Table 4.9 reports the summary statistics of information quality measures.

Compared with the BKLS measures in Table 4.2, the magnitudes of Gu measures are

\(^{34}\) Removing such observations yields regression results that are qualitatively similar to those reported
in the chapter.
higher for all three information quality measures. Specifically, the mean (median) of the public information quality is 6.98 (3.35) vs. 6.29 (2.91) in Table 4.2. Similarly, the private information quality has a mean (median) of 16.44 (9.88) that is higher than under BKLS measurement at 10.07 (4.44). Consequently, there is a big difference in total information quality, 20.31 vs. 13.29 with regard to the mean, and 13.42 vs. 7.13 with regard to the median.

While the magnitudes are different, the Gu measures reflect similar time trends to the BKLS measures. Table 4.10-2 shows the median of public information quality increases from 3.24 to 4.13 after the passage of the SOX, but decrease to 2.87 in year +1. The changes are significant at the 1% level. However, as in Table 4.3, the increase in the mean is not significant. Like the BKLS measures, the Gu measures reflect a significant decline of the private information quality from year -1 to year 0 and with a higher level of significance (the t statistic for the difference of mean test is -4.18, and the Wilcoxon Z statistic is -2.52). All information quality levels are decreasing in year +1.

Consistent with the univariate analyses, the regression results in Table 4.11 demonstrate that the governance reforms around SOX significantly changed both public and private information quality, but in opposite directions. Public information quality improves (the coefficient of $D_{yr0}$ is 1.21 with a $t$ statistic of 2.84), but private information quality significantly declines (the coefficient of $D_{yr0}$ is -2.18 with a $t$ statistic of -2.62). As a result, the change in total information quality is insignificant. When board characteristics are included in the information quality regressions in Table 4.12, the results are qualitatively the same as for the BKLS
measures. That is, we still fail to find a significant positive relation between board independence (board meet frequency) and the public information quality. However, the significant negative relations between board independence and both private and total information reported in Table 4.7 are no longer significant in Table 4.12. Overall, both information measures provide consistent results.

4.6 Concluding Remarks

The purpose of this chapter is to examine how corporate governance reforms surrounding the SOX affect the quality of information in capital markets. We investigate information quality at all three levels: public, private, and total information. The theory suggests that tightened corporate governance has an ambiguous effect on the total information, because while public disclosure is expected to increase, private information acquisition could either increase or decrease as a result.

To carry out the empirical tests, we calculate information quality measures using the BKLS (1998) and Gu (2005) methods. We find that the events associated with the introduction of SOX temporarily improved public disclosure quality, but the improvement is not maintained after the first year. While the precision of public information increases with the introduction of SOX, the precision of private information declines. As a result, there is no significant change of total information quality in the period immediately after SOX. Since one of the goals of SOX is to promote information efficiency through enhanced public disclosure, the results in the chapter show no evidence that SOX achieves this goal in the longer term.
Furthermore, the analyses of governance structure reports a significant change in board characteristics after the SOX. Overall, boards became more independent and met more frequently. However, the change in board independence has no significant effect on firms' public disclosure quality.

Many of the reforms introduced as a result of SOX are intended to increase the quality of public information. For this reason, our finding that the change in public information quality does not persist is noteworthy. The increase in public information quality in year 0, but decrease in year +1, may be because media coverage of the scandals and the failure of Arthur Andersen during 2002 changed management's awareness of the issue, rather than the actual passage of SOX. Writing at the time, Cunningham (2002, p. 19) argues "The changes are more likely to have psychological rather than substantive effects." Our results suggest that the introduction of the SOX had a short term impact on public information quality, but the regulated changes in board structure may not have resulted in any lasting improvement in disclosure.

Like previous studies, the measures that we use are less than ideal. For example, our board meeting measure does not distinguish between whether an increase in meetings is the result of increased scrutiny or is needed to fix past disclosure flaws, or to deal with other financial emergencies. As Vafeas (1999) notes, boards meet more often after crises. The measures are also crude in the sense that it may be difficult to distinguish between the timing of information about the Act and firm-specific effects (Jain and Razaee, 2004). The early 2000s were a time of great change for many firms. Thus, our regressions reveal correlations but not necessarily causation.
The fact that our results in year 0 do not repeat in year +1 implies that, as more data becomes available, an important question for future research would be to consider which of the new procedures initiated by SOX have lasting effects. We do not study the costs of complying with SOX. These costs may explain why some firms "went dark" (Ribstein, 2005, p. 17-18) in the second year (i.e., year +1) after the passage of SOX and this change may explain the decrease in information quality between year 0 and year +1. A firm can choose to go dark, i.e., be a public company without having to satisfy the Securities and Exchange Act of 1934, if the number of nominal shareholders falls below 300. Ribstein (2005) notes that 200 firms went dark in 2003 and that 44 of the 114 firms that went private cited the costs of complying with SOX as a reason. Since our data does not allow us to identify which firms went dark, we cannot test for the significance of this decrease in disclosure.
<table>
<thead>
<tr>
<th>Month</th>
<th>Company involved in the accounting scandal</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 2001</td>
<td>Enron</td>
</tr>
<tr>
<td>November 2001</td>
<td>Arthur Anderson</td>
</tr>
<tr>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>January 2002</td>
<td>Kmart; Homestore.com</td>
</tr>
<tr>
<td>February 2002</td>
<td>Global Crossing; Qwest</td>
</tr>
<tr>
<td>March 2002</td>
<td>Xerox</td>
</tr>
<tr>
<td>April 2002</td>
<td>AOL Time Warner; Bristol-Myers Squibb; Duke Energy; Merck; Mirant; Nicor Energy LLC</td>
</tr>
<tr>
<td>May 2002</td>
<td>WorldCom</td>
</tr>
<tr>
<td>June 2002</td>
<td>Adelphia</td>
</tr>
<tr>
<td>July 2002</td>
<td>CMS Energy; Dynergy; El Paso; Halliburton; Peregrine Systems; Reliant Energy; Tyco</td>
</tr>
</tbody>
</table>

Figure 4.2: Timeline of major government events

<table>
<thead>
<tr>
<th>Month</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 2001</td>
<td>US Congress holds hearings on corporate scandals</td>
</tr>
<tr>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>March 2002</td>
<td>President Bush offers “Ten-Point Plan” to improve corporate responsibility</td>
</tr>
<tr>
<td>April 2002</td>
<td>House of Representatives passes a bill</td>
</tr>
<tr>
<td>June 2002</td>
<td>Lots of discussions concerning various drafts of a bill</td>
</tr>
<tr>
<td>July 2002</td>
<td>President Bush signs Sarbanes-Oxley Act into law</td>
</tr>
<tr>
<td>August 2002</td>
<td>CEOs and CFOs must certify annual and quarterly reports, NYSE changes rules to strengthen independence of directors and corporate governance practices</td>
</tr>
<tr>
<td>October 2002</td>
<td>Appointment of members of the Public Company Accounting Oversight Board (PCAOB), NASDAQ offers rules to strengthen independence of directors and corporate governance practices</td>
</tr>
<tr>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>January 2003</td>
<td>Responsibilities for auditors increased, NYSE and NASDAQ require regular meetings of non-management directors without management present, NYSE requires the nominating committee and the compensation committee of Board of Directors to be composed entirely of independent directors, NASDAQ requires majority of board members be independent</td>
</tr>
<tr>
<td>April 2003</td>
<td>SEC adopts rules increasing independence of Boards of Directors</td>
</tr>
<tr>
<td>May 2003</td>
<td>Mandatory rotation of lead audit partner</td>
</tr>
<tr>
<td>July 2003</td>
<td>Audit committee required to have person with financial and accounting expertise</td>
</tr>
<tr>
<td>October 2003</td>
<td>Enhanced conflict of interest rules</td>
</tr>
</tbody>
</table>

Table 4.1 Sample selection and descriptive statistics

The sample includes firm-years in the period of August 2001- July 2004 that have sufficient IRRC, I/B/E/S, and Compustat data to meaningfully estimate the variables used in the regressions.

Panel A: Sample selection

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Number of firm years</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRRC data and Compustat data available</td>
<td>4,086</td>
</tr>
<tr>
<td>I/B/E/S data that meet the requirements to meaningfully estimate the information quality variables*</td>
<td>2,931</td>
</tr>
<tr>
<td>Final sample</td>
<td>2,931</td>
</tr>
</tbody>
</table>

* Each analyst may issue earnings forecasts several times for a firm-year, we restrict to the most recent forecast before the actual earnings announcement. We also require that the forecasts are made within 180 days prior to the announcement of actual earnings. To meaningfully estimate the information quality variables, firms are kept if they have at least two different analysts produce forecasts for a given year.

Panel B: Sample distribution over time

<table>
<thead>
<tr>
<th>Event year</th>
<th>-1</th>
<th>0</th>
<th>+1</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms</td>
<td>919</td>
<td>980</td>
<td>1,032</td>
<td>2,931</td>
</tr>
</tbody>
</table>

Panel C: Descriptive statistics for sample firms (n = 2,931)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std.</th>
<th>Min.</th>
<th>Q1</th>
<th>Med.</th>
<th>Q3</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total assets</td>
<td>15,370</td>
<td>64,992</td>
<td>28</td>
<td>825</td>
<td>2,461</td>
<td>9,397</td>
<td>1,264,032</td>
</tr>
<tr>
<td>Sales (net)</td>
<td>6,225</td>
<td>16,158</td>
<td>19</td>
<td>662</td>
<td>1,729</td>
<td>5,253</td>
<td>257,157</td>
</tr>
<tr>
<td>Book value of equity</td>
<td>2,772</td>
<td>6,476</td>
<td>-4,734</td>
<td>389</td>
<td>893</td>
<td>2,371</td>
<td>96,889</td>
</tr>
<tr>
<td>Market value of equity</td>
<td>8,734</td>
<td>25,577</td>
<td>43</td>
<td>861</td>
<td>2,154</td>
<td>6,429</td>
<td>397,831</td>
</tr>
<tr>
<td>Analysts following</td>
<td>12.25</td>
<td>7.92</td>
<td>2</td>
<td>6</td>
<td>10</td>
<td>17</td>
<td>51</td>
</tr>
</tbody>
</table>

* All variables except analyst following are measured in $ millions. Analysts following are the number of unique analysts issuing annual earnings forecasts in a firm-year.
Table 4.2 Descriptive statistics for variables used in the analyses

This table reports the descriptive statistics of board characteristics, information quality and control variables for the sample of 2,931 firm-years used in the analyses.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std</th>
<th>Min.</th>
<th>Q1</th>
<th>Med.</th>
<th>Q3</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A: Information quality variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public information quality</td>
<td>6.29</td>
<td>9.24</td>
<td>0</td>
<td>0.57</td>
<td>2.91</td>
<td>7.85</td>
<td>65.89</td>
</tr>
<tr>
<td>Private information quality</td>
<td>10.07</td>
<td>15.54</td>
<td>0</td>
<td>1.48</td>
<td>4.44</td>
<td>12.03</td>
<td>125.08</td>
</tr>
<tr>
<td>Total information quality</td>
<td>13.29</td>
<td>17.71</td>
<td>0.14</td>
<td>3.01</td>
<td>7.13</td>
<td>16.22</td>
<td>131.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: Board characteristics variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board independence</td>
<td>0.69</td>
<td>0.15</td>
<td>0.13</td>
<td>0.60</td>
<td>0.71</td>
<td>0.82</td>
<td>1</td>
</tr>
<tr>
<td>Board meetings</td>
<td>7.26</td>
<td>3.06</td>
<td>0</td>
<td>5</td>
<td>7</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Panel C: Control variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>7.90</td>
<td>1.66</td>
<td>0.30</td>
<td>6.65</td>
<td>7.74</td>
<td>9.02</td>
<td>13.91</td>
</tr>
<tr>
<td>Growth</td>
<td>1.88</td>
<td>1.14</td>
<td>0.40</td>
<td>1.14</td>
<td>1.47</td>
<td>2.14</td>
<td>11.10</td>
</tr>
<tr>
<td>D_loss</td>
<td>0.11</td>
<td>0.31</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>D_miss</td>
<td>0.33</td>
<td>0.47</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>D_litigate</td>
<td>0.28</td>
<td>0.45</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Variable measurement (all variables are measured for a firm-year):
- Board independence = Percent of independent directors on the board;
- Board meetings = Number of regular and special board meetings held through a year;
- Firm size = Log of the total assets of a firm at the beginning of a given year;
- Growth = The market-to-book ratio, where book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt;
- D_loss = One if the firm report losses in a given year, and zero otherwise;
- D_miss = One if a firm's actual earnings is below the mean forecast for a given year, and zero otherwise;
- D_litigate = One if the firm in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise;

Information quality variables: are measured based on BKLS (1998) model. See the main text for the detailed variable calculations.
This table compares the mean and median values for information quality variables surrounding SOX. T statistics are from pooled difference of mean test, and Z statistics are for Wilcoxon rank test. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively (two-tailed).

### Table 4.3 - 1 Univariate comparision of the mean value of information quality

<table>
<thead>
<tr>
<th></th>
<th>Year -1 mean</th>
<th>Year 0 mean</th>
<th>Year +1 mean</th>
<th>T stat. for diff. 2&amp;1</th>
<th>T stat. for diff. 3&amp;2</th>
<th>T stat. for diff. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public information quality</td>
<td>6.72</td>
<td>6.95</td>
<td>5.29</td>
<td>0.49</td>
<td>-4.47***</td>
<td>-3.44***</td>
</tr>
<tr>
<td>Private information quality</td>
<td>12.25</td>
<td>10.50</td>
<td>7.71</td>
<td>-2.21**</td>
<td>-4.81***</td>
<td>-6.29***</td>
</tr>
<tr>
<td>Total information quality</td>
<td>15.62</td>
<td>14.07</td>
<td>10.47</td>
<td>-1.73*</td>
<td>-5.32***</td>
<td>-6.37***</td>
</tr>
</tbody>
</table>

### Table 4.3 - 2 Univariate comparison of the median value of information quality

<table>
<thead>
<tr>
<th></th>
<th>Year -1 median</th>
<th>Year 0 median</th>
<th>Year +1 median</th>
<th>Wilcoxon Z stat. 2&amp;1</th>
<th>Wilcoxon Z stat. 3&amp;2</th>
<th>Wilcoxon Z stat. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public information quality</td>
<td>2.65</td>
<td>3.48</td>
<td>2.55</td>
<td>3.19***</td>
<td>-3.84***</td>
<td>-0.14</td>
</tr>
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<td>Private information quality</td>
<td>5.43</td>
<td>5.34</td>
<td>3.16</td>
<td>-0.44</td>
<td>-6.34***</td>
<td>-6.49***</td>
</tr>
<tr>
<td>Total information quality</td>
<td>8.00</td>
<td>8.30</td>
<td>5.60</td>
<td>0.69</td>
<td>-6.54***</td>
<td>-5.42***</td>
</tr>
</tbody>
</table>

Variable measurement (all variables are measured for a firm-year):
Information quality variables: are measured based on BKLS (1998) model. See the main text for the detailed variable calculations.
Table 4.4 Univariate comparisons of board characteristics variables before and after SOX

This table compares the mean and median value for board characteristics variables before and after SOX. T statistics are from pooled difference of mean test, and Z statistics are for Wilcoxon two-sample rank test. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively (two-tailed).

Table 4.4 -1 Univariate comparison of the mean values of board variables

<table>
<thead>
<tr>
<th>Year -1 mean</th>
<th>Year 0 mean</th>
<th>Year +1 mean</th>
<th>T stat. for diff. 2&amp;1</th>
<th>T stat. for diff. 3&amp;2</th>
<th>T stat. for diff. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board independence</td>
<td>0.67</td>
<td>0.69</td>
<td>0.72</td>
<td>3.68***</td>
<td>3.30***</td>
</tr>
<tr>
<td>Board meetings</td>
<td>7.10</td>
<td>7.26</td>
<td>7.41</td>
<td>1.17</td>
<td>1.10</td>
</tr>
</tbody>
</table>

Table 4.4 -2 Univariate comparison of the median values of board variables

<table>
<thead>
<tr>
<th>Year -1 median</th>
<th>Year 0 median</th>
<th>Year +1 median</th>
<th>Wilcoxon Z stat. 2&amp;1</th>
<th>Wilcoxon Z stat. 3&amp;2</th>
<th>Wilcoxon Z stat. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board independence</td>
<td>0.67</td>
<td>0.71</td>
<td>0.73</td>
<td>3.35***</td>
<td>2.64***</td>
</tr>
<tr>
<td>Board meetings</td>
<td>6</td>
<td>7</td>
<td>7</td>
<td>1.48</td>
<td>1.02</td>
</tr>
</tbody>
</table>

Variable measurement (the variables are measured for a firm-year):
- Board independence = Percent of independent directors on the board;
- Board meetings = Number of regular and special board meetings held through a year.
Table 4.5 Pearson (Spearman) correlations above (below) the diagonal

This table displays Pearson (spearman) correlations for the sample of 2,931 firm-years in the period August 2001-July 2004. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively (two-tailed).

<table>
<thead>
<tr>
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<th>Public info.</th>
<th>Private info.</th>
<th>Total info.</th>
<th>$D_{yr0}$</th>
<th>$D_{yr1}$</th>
<th>Board inde.</th>
<th>Board meet</th>
<th>Firm Size</th>
<th>Growth</th>
<th>$D_{loss}$</th>
<th>$D_{miss}$</th>
<th>$D_{litigate}$</th>
</tr>
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<td>Public info.</td>
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<td>0.35</td>
<td>-0.17</td>
<td>-0.16</td>
<td>0.07</td>
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<td>Private info.</td>
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<td>0.94</td>
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<td>-0.07</td>
<td>0.08</td>
<td>0.31</td>
<td>-0.16</td>
<td>-0.02</td>
<td>0.05</td>
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<td>0.03</td>
<td>-0.12</td>
<td>-0.08</td>
<td>-0.10</td>
<td>0.06</td>
<td>0.34</td>
<td>-0.19</td>
<td>-0.06</td>
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<td>$D_{yr0}$</td>
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<td>-0.00</td>
<td>-0.01</td>
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<td>0.01</td>
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<td>$D_{yr1}$</td>
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<td>Board inde.</td>
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<tr>
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<tr>
<td>Growth</td>
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<td>0.11</td>
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<td>$D_{miss}$</td>
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<td>-0.05</td>
<td>-0.00</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.11</td>
<td>0.15</td>
<td>-0.04</td>
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<tr>
<td>$D_{litigate}$</td>
<td>0.09</td>
<td>0.05</td>
<td>0.06</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
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</tr>
</tbody>
</table>

* $D_{yr0}$ and $D_{yr1}$ are dummy variables for year 0 and +1. See Table 4.2 for the detailed definitions of other variables.
Table 4.6 Ordinary least squares regressions examining the impact of SOX on the information quality in capital markets

This table reports results from the following regression:

\[ IQ_t = \alpha_0 + \alpha_1 D_{yr0} + \alpha_2 D_{yr1} + \alpha_3 Size + \alpha_4 Growth + \alpha_5 D_{loss} + \alpha_6 D_{miss} + \alpha_7 D_{litigate} + \epsilon_i \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Public info. quality</th>
<th>Private info. quality</th>
<th>Total info. quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.21</td>
<td>-7.31***</td>
<td>-5.97***</td>
</tr>
<tr>
<td></td>
<td>(-0.21)</td>
<td>(-4.44)</td>
<td>(-3.26)</td>
</tr>
<tr>
<td>Time dummy variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D_{yr0})</td>
<td>1.15***</td>
<td>-0.13</td>
<td>0.51</td>
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<tr>
<td></td>
<td>(2.94)</td>
<td>(-0.19)</td>
<td>(0.70)</td>
</tr>
<tr>
<td>(D_{yr1})</td>
<td>-1.56***</td>
<td>-4.51***</td>
<td>-5.22***</td>
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<tr>
<td></td>
<td>(-4.08)</td>
<td>(-6.94)</td>
<td>(-7.23)</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>0.30***</td>
<td>1.34***</td>
<td>1.34***</td>
</tr>
<tr>
<td></td>
<td>(3.06)</td>
<td>(7.95)</td>
<td>(7.18)</td>
</tr>
<tr>
<td>Growth</td>
<td>2.93***</td>
<td>4.75***</td>
<td>6.21***</td>
</tr>
<tr>
<td></td>
<td>(19.73)</td>
<td>(18.83)</td>
<td>(22.20)</td>
</tr>
<tr>
<td>D_loss</td>
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<td>-5.89***</td>
<td>-7.69***</td>
</tr>
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<td>(-6.56)</td>
<td>(-6.68)</td>
<td>(-7.86)</td>
</tr>
<tr>
<td>D_miss</td>
<td>-2.26***</td>
<td>0.85</td>
<td>-0.65</td>
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<tr>
<td></td>
<td>(-6.72)</td>
<td>(1.48)</td>
<td>(-1.02)</td>
</tr>
<tr>
<td>D_litigate</td>
<td>-0.43</td>
<td>-0.42</td>
<td>-1.11</td>
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<tr>
<td></td>
<td>(-1.14)</td>
<td>(-0.66)</td>
<td>(-1.58)</td>
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<tr>
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<td>2931</td>
<td>2931</td>
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<td>F-statistic</td>
<td>86.87</td>
<td>76.19</td>
<td>102.28</td>
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<tr>
<td>Adjusted R^2</td>
<td>17.02%</td>
<td>15.23%</td>
<td>19.48%</td>
</tr>
</tbody>
</table>

* Figures in brackets are t-statistics for OLS regressions. One-sided (two-sided) critical t-values for significance levels of 10%, 5%, and 1% are 1.28, 1.65, 2.33 (1.65, 1.96, 2.58), respectively.

Variable measurement (all variables are measured for a firm-year):

- \(D_{yr0}\): One if year 0, and zero otherwise;
- \(D_{yr1}\): One if year +1, and zero otherwise;
- Firm size: The market-to-book ratio, where book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt;
- Growth: Log of the total assets of a firm at the beginning of a given year;
- D_loss: One if the firm report losses in a given year, and zero otherwise;
- D_miss: One if a firm's actual earnings is below the mean forecast for a given year, and zero otherwise;
- D_litigate: One if the firm in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise;

Information quality \(IQ_t\): are measured based on BKLS (1998). See the main text for the detailed variable calculations.
Table 4.7 The association between board characteristics and information quality

This table reports results from the following regression:

\[ IQ_i = \beta_{0i} + \beta_{1i}D_{-yr0} + \beta_{2i}D_{-yr1} + \beta_{3i}Inde. + \beta_{4i}Meet. \\
+ \beta_{5i}Inde. \times D_{-yr0} + \beta_{6i}Meet. \times D_{-yr0} + \beta_{7i}Inde. \times D_{-yr1} + \beta_{8i}Meet. \times D_{-yr1} \\
+ \beta_{9i}Size + \beta_{10i}Growth + \beta_{11i}D_{-loss} + \beta_{12i}D_{-miss} + \beta_{13i}D_{-litigate} + \eta_i \]

<table>
<thead>
<tr>
<th></th>
<th>Public info. Quality</th>
<th>Private info. Quality</th>
<th>Total info. Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>-2.63</td>
<td>-2.14</td>
</tr>
<tr>
<td></td>
<td>(-0.10)</td>
<td>(-1.02)</td>
<td>(-0.75)</td>
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<tr>
<td>Time dummy variables</td>
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</tr>
<tr>
<td>( D_{-yr0} )</td>
<td>4.76**</td>
<td>-1.90</td>
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<tr>
<td></td>
<td>(2.56)</td>
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<td>(0.42)</td>
</tr>
<tr>
<td>( D_{-yr1} )</td>
<td>1.27</td>
<td>-6.29*</td>
<td>-4.57</td>
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<tr>
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<td>(0.65)</td>
<td>(-1.90)</td>
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<td>Board characteristics variables</td>
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<tr>
<td>( Board independence )</td>
<td>-0.87</td>
<td>-7.79***</td>
<td>-6.83**</td>
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<td></td>
<td>(-0.52)</td>
<td>(-2.71)</td>
<td>(-2.14)</td>
</tr>
<tr>
<td>( Board meetings )</td>
<td>-0.02</td>
<td>-0.08</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>(-0.25)</td>
<td>(-0.50)</td>
<td>(-0.52)</td>
</tr>
<tr>
<td>( Board independence \times D_{-yr0} )</td>
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<td>5.96</td>
<td>2.83</td>
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<td>4.14</td>
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<td>(0.37)</td>
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</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( Firm size )</td>
<td>0.40***</td>
<td>1.49***</td>
<td>1.54***</td>
</tr>
<tr>
<td></td>
<td>(3.91)</td>
<td>(8.59)</td>
<td>(7.97)</td>
</tr>
<tr>
<td>( Growth )</td>
<td>2.86***</td>
<td>4.68***</td>
<td>6.13***</td>
</tr>
<tr>
<td></td>
<td>(19.42)</td>
<td>(18.54)</td>
<td>(21.86)</td>
</tr>
<tr>
<td>( D_{-loss} )</td>
<td>-3.21***</td>
<td>-5.52***</td>
<td>-7.25***</td>
</tr>
<tr>
<td></td>
<td>(-6.17)</td>
<td>(-6.24)</td>
<td>(-7.38)</td>
</tr>
<tr>
<td>( D_{-miss} )</td>
<td>-2.24***</td>
<td>0.87</td>
<td>-0.61</td>
</tr>
<tr>
<td></td>
<td>(-6.65)</td>
<td>(1.53)</td>
<td>(-0.95)</td>
</tr>
<tr>
<td>( D_{-litigate} )</td>
<td>-0.43</td>
<td>-0.48</td>
<td>-1.16*</td>
</tr>
<tr>
<td></td>
<td>(-1.15)</td>
<td>(-0.77)</td>
<td>(-1.65)</td>
</tr>
<tr>
<td>Sample size</td>
<td>2931</td>
<td>2931</td>
<td>2931</td>
</tr>
<tr>
<td>F-statistic</td>
<td>48.56</td>
<td>42.51</td>
<td>67.19</td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>17.42%</td>
<td>15.55%</td>
<td>19.90%</td>
</tr>
</tbody>
</table>

* Figures in brackets are t-statistics for OLS regressions. One-sided (two-sided) critical t-values for significance levels of 10%, 5%, and 1% are 1.28, 1.65, 2.33 (1.65, 1.96, 2.58), respectively.
Variable measurement in Table 4.7 (all variables are measured for a firm-year):

\[ D_{yr0} = \text{One if year 0, and zero otherwise;} \]
\[ D_{yr1} = \text{One if year +1, and zero otherwise;} \]

**Board independence** = Percent of independent directors on the board;

**Board meetings** = Number of regular and special board meetings held through a year;

**Firm size** = Log of the total assets of a firm at the beginning of a given year;

**Growth** = The market-to-book ratio, where book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt;

\[ D_{loss} = \text{One if the firm report losses in a given year, and zero otherwise;} \]
\[ D_{miss} = \text{One if a firm's actual earnings is below the mean forecast for a given year, and zero otherwise;} \]

\[ D_{litigate} = \text{One if the firm in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise;} \]

Information quality \( IQ_i \): are measured based on BKLS (1998). See the main text for the detailed variable calculations.
Table 4.8 Correlations between time dummies and board interaction variables

This table reports Pearson (Spearman) correlations above (below) the diagonal for the time dummies and board interaction variables. All correlations are significant at < 0.0001 level.

<table>
<thead>
<tr>
<th></th>
<th>$D_{yr0}$</th>
<th>$D_{yr1}$</th>
<th>Board inde. $\times D_{yr0}$</th>
<th>Board meet. $\times D_{yr0}$</th>
<th>Board inde. $\times D_{yr1}$</th>
<th>Board meet. $\times D_{yr1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{yr0}$</td>
<td></td>
<td></td>
<td>0.97</td>
<td>0.89</td>
<td>-0.51</td>
<td>-0.46</td>
</tr>
<tr>
<td>$D_{yr1}$</td>
<td>-0.52</td>
<td></td>
<td>-0.50</td>
<td>-0.46</td>
<td>0.97</td>
<td>0.88</td>
</tr>
<tr>
<td>Board inde. $\times D_{yr0}$</td>
<td>0.97</td>
<td></td>
<td>-0.51</td>
<td>0.87</td>
<td>-0.49</td>
<td>-0.45</td>
</tr>
<tr>
<td>Board meet. $\times D_{yr0}$</td>
<td>0.97</td>
<td></td>
<td>-0.51</td>
<td>0.95</td>
<td>-0.45</td>
<td>-0.41</td>
</tr>
<tr>
<td>Board inde. $\times D_{yr1}$</td>
<td>-0.51</td>
<td></td>
<td>0.97</td>
<td>-0.49</td>
<td>-0.49</td>
<td>0.87</td>
</tr>
<tr>
<td>Board meet. $\times D_{yr1}$</td>
<td>-0.51</td>
<td></td>
<td>0.97</td>
<td>-0.49</td>
<td>-0.49</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Variable measurement (all variables are measured for a firm-year):

- $D_{yr0} =$ One if year 0, and zero otherwise;
- $D_{yr1} =$ One if year +1, and zero otherwise;
- Board independence = Percent of independent directors on the board;
- Board meetings = Number of regular and special board meetings held through a year;
Table 4.9 Descriptive statistics for information quality variables
– Gu measures

This table reports the descriptive statistics of information quality variables based on Gu measures for the sample of 2,931 firm-years.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std.</th>
<th>Min.</th>
<th>Q1</th>
<th>Med.</th>
<th>Q3</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public information quality</td>
<td>6.98</td>
<td>10.06</td>
<td>0</td>
<td>0.72</td>
<td>3.35</td>
<td>8.87</td>
<td>70.96</td>
</tr>
<tr>
<td>Private information quality</td>
<td>16.44</td>
<td>19.74</td>
<td>0</td>
<td>2.82</td>
<td>9.88</td>
<td>22.75</td>
<td>143.91</td>
</tr>
<tr>
<td>Total information quality</td>
<td>20.31</td>
<td>21.57</td>
<td>0.22</td>
<td>5.60</td>
<td>13.42</td>
<td>27.46</td>
<td>143.91</td>
</tr>
</tbody>
</table>

* Information quality variables are measured for a firm-year. They are calculated by using Gu (2005) model. See the main text for the detailed variable calculations.
Table 4.10 Univariate comparisons of information quality variables
surrounding SOX – Gu measures

This table compares the mean and median value for information quality variables based on Gu measures surrounding SOX. T statistics are from pooled difference of mean test, and Z statistics are for Wilcoxon rank test. *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively (two-tailed).

Table 4.10-1 Univariate comparison of the mean value of information quality

<table>
<thead>
<tr>
<th></th>
<th>Year -1 mean</th>
<th>Year 0 mean</th>
<th>Year +1 mean</th>
<th>T stat. for diff. 2&amp;1</th>
<th>T stat. for diff. 3&amp;2</th>
<th>T stat. for diff. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public information quality</td>
<td>7.48</td>
<td>7.72</td>
<td>5.82</td>
<td>0.46</td>
<td>-4.68***</td>
<td>-3.67***</td>
</tr>
<tr>
<td>Private information quality</td>
<td>20.82</td>
<td>16.68</td>
<td>12.32</td>
<td>-4.18***</td>
<td>-5.97***</td>
<td>-9.31***</td>
</tr>
<tr>
<td>Total information quality</td>
<td>24.83</td>
<td>20.96</td>
<td>15.68</td>
<td>-3.60***</td>
<td>-6.48***</td>
<td>-9.23***</td>
</tr>
</tbody>
</table>

Table 4.10-2 Univariate comparison of the median value of information quality

<table>
<thead>
<tr>
<th></th>
<th>Year -1 median</th>
<th>Year 0 median</th>
<th>Year +1 median</th>
<th>Wilcoxon Z stat. 2&amp;1</th>
<th>Wilcoxon Z stat. 3&amp;2</th>
<th>Wilcoxon Z stat. 3&amp;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>919</td>
<td>980</td>
<td>1032</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public information quality</td>
<td>3.24</td>
<td>4.13</td>
<td>2.87</td>
<td>3.02***</td>
<td>-4.23***</td>
<td>-0.68</td>
</tr>
<tr>
<td>Private information quality</td>
<td>12.83</td>
<td>11.06</td>
<td>6.71</td>
<td>-2.52**</td>
<td>-6.11***</td>
<td>-8.17***</td>
</tr>
<tr>
<td>Total information quality</td>
<td>16.11</td>
<td>15.02</td>
<td>10.21</td>
<td>-1.67*</td>
<td>-7.17***</td>
<td>-8.24***</td>
</tr>
</tbody>
</table>

* Information quality variables are measured for a firm-year. They are calculated by using Gu (2005) model. See the main text for the detailed variable calculations.
Table 4.11 Ordinary least squares regressions examining the impact of SOX on the information quality – Gu measures

This table reports results from the following regression:

\[ IQ_{j,Gu} = \alpha_{0,j} + \alpha_{1,j}D_{-yr0} + \alpha_{2,j}D_{-yr1} + \alpha_{3,j}Size + \alpha_{4,j}Growth \]
\[ + \alpha_{5,j}D_{-loss} + \alpha_{6,j}D_{-miss} + \alpha_{7,j}D_{-litigate} + \epsilon_{j} \]

<table>
<thead>
<tr>
<th></th>
<th>Public info. Quality</th>
<th>Private info. Quality</th>
<th>Total info. Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.55</td>
<td>-10.33***</td>
<td>-7.54***</td>
</tr>
<tr>
<td></td>
<td>(0.52)</td>
<td>(-5.01)</td>
<td>(-3.43)</td>
</tr>
<tr>
<td>Time dummy variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(D_{-yr0})</td>
<td>1.21***</td>
<td>-2.18***</td>
<td>-1.38</td>
</tr>
<tr>
<td></td>
<td>(2.84)</td>
<td>(-2.62)</td>
<td>(-1.56)</td>
</tr>
<tr>
<td>(D_{-yr1})</td>
<td>-1.81***</td>
<td>-8.48***</td>
<td>-9.23***</td>
</tr>
<tr>
<td></td>
<td>(-4.32)</td>
<td>(-10.42)</td>
<td>(-10.64)</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>0.27***</td>
<td>2.60***</td>
<td>2.44***</td>
</tr>
<tr>
<td></td>
<td>(2.49)</td>
<td>(12.31)</td>
<td>(10.87)</td>
</tr>
<tr>
<td>Growth</td>
<td>3.11***</td>
<td>5.60***</td>
<td>7.30***</td>
</tr>
<tr>
<td></td>
<td>(19.19)</td>
<td>(17.74)</td>
<td>(21.70)</td>
</tr>
<tr>
<td>(D_{-loss})</td>
<td>-3.84***</td>
<td>-8.54***</td>
<td>-11.01***</td>
</tr>
<tr>
<td></td>
<td>(-6.78)</td>
<td>(-7.74)</td>
<td>(-9.37)</td>
</tr>
<tr>
<td>(D_{-miss})</td>
<td>-2.35***</td>
<td>1.95***</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>(-6.38)</td>
<td>(2.72)</td>
<td>(0.69)</td>
</tr>
<tr>
<td>(D_{-litigate})</td>
<td>-0.45</td>
<td>-0.82</td>
<td>-1.40*</td>
</tr>
<tr>
<td></td>
<td>(-1.10)</td>
<td>(-1.04)</td>
<td>(-1.67)</td>
</tr>
<tr>
<td>Sample size</td>
<td>2931</td>
<td>2931</td>
<td>2931</td>
</tr>
<tr>
<td>F-statistic</td>
<td>83.67</td>
<td>91.34</td>
<td>117.50</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>16.49%</td>
<td>17.75%</td>
<td>21.77%</td>
</tr>
</tbody>
</table>

* Figures in brackets are t-statistics for OLS regressions. One-sided (two-sided) critical t-values for significance levels of 10%, 5%, and 1% are 1.28, 1.65, 2.33 (1.65, 1.96, 2.58), respectively.

Variable measurement (all variables are measured for a firm-year):

- \(D_{-yr0}\) = One if year 0, and zero otherwise;
- \(D_{-yr1}\) = One if year +1, and zero otherwise;
- Firm size = Log of the total assets of a firm at the beginning of a given year;
- Growth = The market-to-book ratio, where book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt;
- \(D_{-loss}\) = One if the firm report losses in a given year, and zero otherwise;
- \(D_{-miss}\) = One if a firm’s actual earnings is below the mean forecast for a given year, and zero otherwise;
- \(D_{-litigate}\) = One if the firm in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise;

Information quality \(IQ_{j,Gu}\): are measured based on Gu (2005). See the main text for the detailed variable calculations.
Table 4.12 The association between board characteristics and information quality – Gu measures

This table reports results from the following regression:

\[ IQ_{ij} - Gu = \beta_0 + \beta_1 D_{yr0j} + \beta_2 D_{yr1j} + \beta_3 Inde._j + \beta_4 Meet._j + \beta_5 Inde._j \times D_{yr0j} + \beta_6 Meet._j \times D_{yr0j} + \beta_7 Inde._j \times D_{yr1j} + \beta_8 Meet._j \times D_{yr1j} + \beta_9 Size + \beta_{10j} Growth + \beta_{11j} D_{loss} + \beta_{12j} D_{miss} + \beta_{13j} D_{litigate} + \eta_{ij} \]

<table>
<thead>
<tr>
<th>Public info. quality</th>
<th>Private info. quality</th>
<th>Total info. Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.53</td>
<td>-8.86***</td>
</tr>
<tr>
<td>(0.32)</td>
<td>(-2.74)</td>
<td>(-1.81)</td>
</tr>
<tr>
<td>Time dummy variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( D_{yr0j} )</td>
<td>5.03**</td>
<td>-1.71</td>
</tr>
<tr>
<td>(2.47)</td>
<td>(-0.43)</td>
<td>(0.20)</td>
</tr>
<tr>
<td>( D_{yr1j} )</td>
<td>1.26</td>
<td>-5.84**</td>
</tr>
<tr>
<td>(0.59)</td>
<td>(-1.40)</td>
<td>(-1.10)</td>
</tr>
<tr>
<td>Board characteristics variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Board independence</td>
<td>-0.75</td>
<td>-3.43</td>
</tr>
<tr>
<td>(-0.41)</td>
<td>(-0.95)</td>
<td>(-0.88)</td>
</tr>
<tr>
<td>Board meetings</td>
<td>-0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>(-0.23)</td>
<td>(0.03)</td>
<td>(-0.10)</td>
</tr>
<tr>
<td>Board independence ( \times D_{yr0j} )</td>
<td>-3.77</td>
<td>3.44</td>
</tr>
<tr>
<td>(-1.42)</td>
<td>(0.66)</td>
<td>(0.25)</td>
</tr>
<tr>
<td>Board meetings ( \times D_{yr0j} )</td>
<td>-0.16</td>
<td>-0.38</td>
</tr>
<tr>
<td>(-1.16)</td>
<td>(-1.39)</td>
<td>(-1.45)</td>
</tr>
<tr>
<td>Board independence ( \times D_{yr1j} )</td>
<td>-2.33</td>
<td>-1.84</td>
</tr>
<tr>
<td>(-0.84)</td>
<td>(-0.34)</td>
<td>(-0.52)</td>
</tr>
<tr>
<td>Board meetings ( \times D_{yr1j} )</td>
<td>-0.18</td>
<td>-0.15</td>
</tr>
<tr>
<td>(-1.32)</td>
<td>(-0.58)</td>
<td>(-0.95)</td>
</tr>
<tr>
<td>Control variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm size</td>
<td>0.36***</td>
<td>2.70***</td>
</tr>
<tr>
<td>(3.25)</td>
<td>(12.42)</td>
<td>(11.20)</td>
</tr>
<tr>
<td>Growth</td>
<td>3.07***</td>
<td>5.55***</td>
</tr>
<tr>
<td>(18.91)</td>
<td>(17.52)</td>
<td>(21.42)</td>
</tr>
<tr>
<td>( D_{loss} )</td>
<td>-3.65***</td>
<td>-8.26***</td>
</tr>
<tr>
<td>(-6.43)</td>
<td>(-7.45)</td>
<td>(-9.02)</td>
</tr>
<tr>
<td>( D_{miss} )</td>
<td>-2.32***</td>
<td>1.96***</td>
</tr>
<tr>
<td>(-6.31)</td>
<td>(2.73)</td>
<td>(0.73)</td>
</tr>
<tr>
<td>( D_{litigate} )</td>
<td>-0.45</td>
<td>-0.84</td>
</tr>
<tr>
<td>(-1.11)</td>
<td>(-1.06)</td>
<td>(-1.67)</td>
</tr>
<tr>
<td>Sample size</td>
<td>2931</td>
<td>2931</td>
</tr>
<tr>
<td>F-statistic</td>
<td>46.54</td>
<td>49.75</td>
</tr>
<tr>
<td>Adjusted ( R^2 )</td>
<td>16.81%</td>
<td>17.78%</td>
</tr>
</tbody>
</table>

* Figures in brackets are \( t \)-statistics for OLS regressions. One-sided (two-sided) critical \( t \)-values for significance levels of 10%, 5%, and 1% are 1.28, 1.65, 2.33 (1.65, 1.96, 2.58), respectively.
Variable measurement in Table 4.12 (all variables are measured for a firm-year):

- $D_{yr0} =$ One if year 0, and zero otherwise;
- $D_{yr1} =$ One if year +1, and zero otherwise;
- Board independence = Percent of independent directors on the board;
- Board meetings = Number of regular and special board meetings held through a year;
- Postsox = One if year 0 or year +1, and zero otherwise;
- Firm size = Log of the total assets of a firm at the beginning of a given year;
- Growth = The market-to-book ratio, where book value is the book value of total assets in a given year, and market value is the market value of equity plus book value of debt;
- $D_{loss} =$ One if the firm report losses in a given year, and zero otherwise;
- $D_{miss} =$ One if a firm’s actual earnings is below the mean forecast for a given year, and zero otherwise;
- $D_{litigate} =$ One if the firm in the biotechnology (four-digit SICs are 2833-2836, 8731-8734), computer (3570-3577, 7370-7374), electronics (3600-3674), and retail (5200-5961) industries, and zero otherwise;

Information quality $IQ_{j} - Gu$: are measured based on Gu (2005). See the main text for the detailed variable calculations.
Bibliography


APPENDIX 1

Proofs for Chapter 2

Solving the Principal’s Decision Problem at the Renegotiation Stage

At the start of $t = 2$, i.e., the renegotiation stage, the principal chooses $\Delta f'$ and $v'_2$ so as to maximize his second-period expected utility given the initial contract, the public report $y_1$, as well as his conjecture of the agent’s first-period productive effort $\hat{a}_1$ and earnings manipulation $\hat{D}$, subject to acceptance by the agent,

$$\max_{\Delta f', v'_2} \mathbb{E} U_f'(c') = \beta \{ y_2 v_2 - \mathbb{E}_1[\omega_2(c')] \},$$

subject to

$$CE_i(c') \geq CE_i(c),$$

$$a'_2 = \nu'_2.$$

Let the participation constraint be binding. Thus

![](https://latex.codecogs.com/latex?decode=true&latex=\Delta f' = \frac{1}{2} \{ [a'_2]^2 - [a'_2]^2 \} + \frac{1}{2} \{ [v'_2]^2 - [v'_2]^2 \}$$

$$\left[ y_2 \{ y_2 v_2 - \mathbb{E}_1[\omega_2(c')] \} - v_2 \{ y_2 \{ y_2 v_2 - \mathbb{E}_1[\omega_2(c')] \} - \rho (\sigma_2 / \sigma_1) (y_1 - \hat{a}_1 - \hat{D}) \right].$$

(A1.1)

Substituting (A1.1) and the incentive constraint into the objective function, the principal’s decision problem becomes an unconstrained optimization problem,

$$\max_{v'_2} \Pi_f' = \beta \{ y^2 v'_2 - \gamma^2 [v'_2]^2 - [a'_2]^2 \} - \gamma^2 r (1 - \rho^2) \sigma_2^2 \{ [v'_2]^2 - [v'_2]^2 \}$$

$$- v'_2 [y_2 \{ y_2 v_2 - \mathbb{E}_1[\omega_2(c')] \} - \rho (\sigma_2 / \sigma_1) (y_1 - \hat{a}_1 - \hat{D})].$$

(A1.2)

The first-order condition with respect to $v'_2$ is

$$\gamma^2 - y^2 v'_2 - r (1 - \rho^2) \sigma_2^2 v'_2 = 0.$$
Therefore, the revised incentive rate is
\[ v'_2 = \frac{\gamma^2}{\gamma^2 + r(1 - \rho^2)\sigma_2^2}. \]

Q.E.D.

Proof of Corollary 2.1

The agent's equilibrium earnings manipulation is
\[ D = \frac{1}{p} (v_1 - v'_2). \]
First, it is obvious that if \( p \to \infty \), i.e., infinitely tight regulation, then \( D = 0 \). Next, since parameter \( p > 0 \),
\[ \text{Sign} (D) = \text{Sign} (v_1 - v'_2). \quad (A1.4) \]
Given equilibrium solutions \( v_1 = \frac{1}{Q} \gamma^2 - \lambda [\beta v'_2] \) with \( Q = \gamma^2 + rA_1\sigma_1^2 \),
\[ \lambda = \frac{1}{Q} rA_1\rho \sigma_1 \sigma_2, \quad A_1 \equiv (1 + \beta)^{-1}, \quad \text{and} \quad v'_2 = \frac{\gamma^2}{\gamma^2 + r(1 - \rho^2)\sigma_2^2}, \]
then
\[ v_1 - v'_2 = \frac{r\gamma^2}{Q[\gamma^2 + r(1 - \rho^2)\sigma_2^2]} \left[ (1 - \rho^2)\sigma_2^2 - A_1 (\sigma_1^2 + \beta \rho \sigma_1 \sigma_2) \right]. \quad (A1.5) \]
Since \( \gamma > 0, r > 0, \beta > 0, \rho \in (-1,1) \),
\[ \text{Sign} (v_1 - v'_2) = \text{Sign} \{ (1 - \rho^2)\sigma_2^2 - A_1 (\sigma_1^2 + \beta \rho \sigma_1 \sigma_2) \}. \quad (A1.6) \]
Let \( \Delta \equiv (1 - \rho^2)\sigma_2^2 - A_1 (\sigma_1^2 + \beta \rho \sigma_1 \sigma_2), \) if \( \beta = 1 \) and \( \sigma_1 = \sigma_2 = \sigma \), then
\[ \Delta = \sigma^2 (\gamma_2 - \gamma \rho - \rho^2). \quad (A1.7) \]
Hence \( \text{Sign} (D) = \text{Sign} (\gamma_2 - \gamma \rho - \rho^2) \), we obtain the following relationship between inter-temporal correlation \( \rho \) and earnings manipulation \( D \) under \( \beta = 1 \) and \( \sigma_1 = \sigma_2 = \sigma \):
i. If $-1 < \rho < \frac{1}{2}$, then $D > 0$.

ii. If $\frac{1}{2} < \rho < 1$, then $D < 0$.

iii. If $\rho = \frac{1}{2}$ or $\rho \rightarrow \infty$, then $D = 0$.

Q.E.D.

Proof of Proposition 2.4

In window dressing setting, the agent's decision problem with respect to earnings manipulation is

$$\max_{D^w} \{ \omega_t^v(D^w) - k(a^w_t) - k(D^w) - P(D^w) + CE_t^v(D^w) \}.$$  

where $\omega_t^v(D^w) = f + v_t^w(x_t + D^w)$, $k(D^w) = \frac{1}{2} k_w [D^w]^2$, $P(D^w) = \frac{1}{2} (p + e^w) [D^w]^2$, and $CE_t^v(D^w) = \beta v_t^2 [\alpha_t^2 - RD^w + \rho(\sigma_2 / \sigma_1)(x_t - \gamma x_t)] - \beta k(a_t^w) - \beta R P_t$.

Differentiating it with respect to $D^w$ yields:

$$\frac{\partial \omega_t^v(D^w)}{\partial D^w} - \frac{\partial k(D^w)}{\partial D^w} - \frac{\partial P(D^w)}{\partial D^w} + \frac{\partial CE_t^v(D^w)}{\partial D^w}$$

$$= v_t^w - k_w D^w - (p + e^w) D^w - v_t^2 = 0. \quad (A1.8)$$

Thus, the optimal earnings manipulation in window dressing setting is given by

$$D^w = \frac{1}{k_w + p + e^w} (v_t^w - v_t^2).$$

Q.E.D.

Derivation of $\Pi_t^{pw}$ in Window Dressing Setting

At $t = 0$, the principal's decision problem with respect to $f^w, v_0^w, e^w$ in window dressing setting is
\[
\max_{f^w, v^w, e^w} EU_0^{pw} = \beta E_0[X^w] - \beta E_0[W^w - P^w] - M(e^w), \tag{A1.9a}
\]

subject to \(CE_0^w = \beta E_0[W^w - K(a_1^w, a_2^w) - k(D^w) - P^w] - \beta RP_0^w \geq c^0, \tag{A1.9b}\)

\[a_1^w = \nu_1^w, \tag{A1.9c}\]

\[a_2^w = \nu_2^w. \tag{A1.9d}\]

Given zero reservation consumption assumption, i.e., \(c^0 = 0\), binding participation constraint (A1.9b) implies

\[f^w = K(a_1^w, a_2^w) + k(D^w) + RP_0^w - E_0[a_1^w + \beta a_2^w - P^w]. \tag{A1.10}\]

Substituting the binding participation constraint (A1.10) and incentive constraints (A1.9c) and (A1.9d) into the objective function (A1.9a), the principal’s decision problem becomes the following unconstrained optimization problem,

\[\max_{v^w, e^w} \Pi_0^{pw} = \beta E_0[X^w] - \beta \left[K(a_1^w, a_2^w) + k(D^w) + RP_0^w\right] - M(e^w).\]

That is, the principal chooses \(v_1^w, e^w\) to maximize his expected gross payoff net of compensation for the agent’s productive effort cost, window dressing cost and consumption risk premium, minus his monitoring cost.

Q.E.D.

Derivation of \(D^{Rw}\) in Real Earnings Manipulation Setting

The agent’s decision problem with respect to \(D^{Rw}\) in the real earnings manipulation setting that is costly to the agent is
\[
\max_{D^{rw}} \{ \omega_i^x(D^{rw}) - k(D^{rw}) - k(D^{rw}) - P(D^{rw}) + CE_i^x(D^{rw}) \}.
\]

where \( \omega_i^x(D^{rw}) = f + v_i^{rw}(x_i + D^{rw}) \), \( k(D^{rw}) = \frac{1}{2} k_w[D^{rw}]^2 \),

\( CE_i^x(D^{rw}) = \beta v_i^r[\gamma a_i^r - RD^{rw} - RH(D^{rw}) + \rho(\sigma_2 / \sigma_1)(x_i - \gamma a_i)] - \beta k(a_i^r) - \beta R P \),

\( H(D^{rw}) = \frac{1}{2} h_R[D^{rw}]^2 \), \( P(D^{rw}) = \frac{1}{2} (p + e^{rw})[D^{rw}]^2 \).

The first-order condition for the maximization problem is

\[
\frac{\partial \omega_i^x(D^{rw})}{\partial D^{rw}} - \frac{\partial k(D^{rw})}{\partial D^{rw}} - \frac{\partial P(D^{rw})}{\partial D^{rw}} + \frac{\partial CE_i^x(D^{rw})}{\partial D^{rw}} = v_i^{rw} - k_w D^{rw} - (p + e^{rw}) D^{rw} - v_i^r - v_i^{hr} D^{rw} = 0. \tag{A1.11}
\]

Therefore the optimal earnings manipulation in the real manipulation setting is characterized by \( D^{rw} = \frac{1}{k_w + v_i^{hr} h_R + p + e^{rw}} (v_i^{rw} - v_i^r) \).

Q.E.D.

Proof of Proposition 2.8

(2.8a) In the setting where earnings manipulation is costless to the agent and has no effect on the underlying economic outcome, the equilibrium earnings manipulation is

\( D = \frac{1}{p} (v_1 - v_2) \). Based on the proof of Corollary 2.1,

\[
v_1 - v_2^r = \frac{r \gamma^2}{Q[\gamma^2 + r(1 - \rho^2) \sigma_2^2]} [(1 - \rho^2) \sigma_2^2 - A_i(\sigma_1^2 + \beta \rho \sigma_1 \sigma_2)]
\]

and \( \text{Sign}(D) = \text{Sign}(v_1 - v_2) \).

Further, given \( \gamma > 0 \), \( r > 0 \), \( \rho \in (-1,1) \), \( \beta > 0 \) and \( Q = \gamma^2 + r A_i \sigma_1^2 > 0 \), therefore

\[
\frac{\partial |D|}{\partial p} < 0 \text{ as long as }
\]

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\[ [(1 - \rho^2)\sigma_2^2 - A_1(\sigma_1^2 + \beta\rho\sigma_1\sigma_2)] \neq 0. \]

(2.8b) In the costly window dressing setting, the equilibrium \( e^w \) is characterized by the following equation,

\[ MB_e^w - m_e e^w = 0, \text{ where } MB_e^w \equiv \beta \frac{k_w}{(k_w + p + e^w)^3} (v_i^w - \bar{v}_i)^2. \]

Differentiating the equation with respect to \( m_e \) yields

\[ \frac{\partial MB_e^w}{\partial e^w} \frac{\partial e^w}{\partial m_e} - [e^w + m_e \frac{\partial e^w}{\partial m_e}] = 0. \]

(A1.13)

The existence of the interior solution of \( e^w \) requires

\[ \frac{\partial^2 \Pi_0^w}{\partial e^w^2} = \frac{\partial MB_e^w}{\partial e^w} - m_e < 0. \]

(A1.14)

This leads to \( \frac{\partial e^w}{\partial m_e} < 0 \). Similarly, we prove \( \frac{\partial e^w}{\partial m_e} < 0 \); \( \frac{\partial e^w}{\partial m_e} < 0 \) in the real earnings manipulation settings.

Q.E.D.
APPENDIX 2

Proofs for Chapter 3

Derivation of Equation 3.7 & 3.8

According to equation (3.4), the market price $p_1$ is

$$p_1 = E_u [v \mid y_a, z_u] = m_0 + y_a + \mu_u (z_u),$$

where the aggregate trading quantity equals

$$z_u = Z_t - \left(z_m + \sum_{i=1}^I z_i \right).$$

The conjectures are $\mu_u (z_u) = -bz_u$, and $z_i = \beta y_i$. The manager anticipates the market price based on her own information set $(y_a, y_m)$. Then given the assumptions $\text{Cov}[y_a, y_i] = 0$, $\text{Cov}[y_m, y_i] = 0$, as well as $E[Z_t] = 0$, the manager’s expected price resulting from an order of $z_m$ units, given her information set $(y_a, y_m)$,

$$E[p_1 \mid y_a, y_m, z_m] = m_0 + y_a + bz_m + bI\beta E[y_i \mid y_a, y_m]$$

$$= m_0 + y_a + bz_m. \quad (A2.1)$$

The key here is that since $y_a$, $y_m$ and $y_i$ are all independent, $E[y_i \mid y_a, y_m] = 0$. As a result, the manager’s expectation with respect to the orders placed by the informed investor is zero. Further, the manager’s trading profit is calculated as $\pi_m = (v - p_1)z_m$. In addition, $v = m_0 + \varepsilon$ and $E[\varepsilon \mid y_a, y_m] = y_a + y_m$. Based on her information set $(y_a, y_m)$, the manager’s expected trading payoff is

$$U_{m1}(y_a, y_m, z_m) = \{E[v \mid y_a, y_m] - E[p_1 \mid y_a, y_m, z_m]\}z_m$$
Derivation of Equation 3.9 & 3.10

The derivation is similar as for Equation (3.7) and (3.8). By assumption, all informed investors receive the same private signal. Then the investor $i$'s expectation with respect to the orders placed by the other informed investors are

$$ E[z_j | y_a, y_i] = \beta y_i. \quad (A2.3) $$

Thus, the informed investor $i$'s expected price resulting from an order of $z_i$ units, given his information set $(y_a, y_i)$, is

$$ E[p_i | y_a, y_i, z_i] = m_0 + y_a - b\{E[Z_i] - (z_i + E[\sum_{j=1}^{i-1} z_j | y_i] + E[z_m | y_i])\} $$

$$ = m_0 + y_a + bz_i + b(I-1)\beta y_i. \quad (A2.4) $$

Further, given the informed investor $i$'s trading profit is calculated as $\pi_i = (v - p_i)z_i$, and $E[\epsilon | y_a, y_i] = y_a + y_i$, his expectation of the trading payoff conditional on his information set $(y_a, y_i)$ is

$$ U_{il}(y_a, y_i, z_i) = \{E[v | y_a, y_i] - E[p_i | y_a, y_i, z_i]\}z_i $$

$$ = \{y_i - b(I-1)\beta y_i - bz_i\}z_i. \quad (A2.5) $$

Q.E.D.
Derivation of Equation 3.11

The uninformed investor's posterior mean with respect to $\varepsilon_{av}$ conditional on $z_u$ is calculated as

$$\mu_{u1}(z_u) = E[\varepsilon_{av} | z_u] = E[\varepsilon_{av}] + \frac{\text{Cov}(\varepsilon_{av}, z_u)}{\text{Var}(z_u)} \{z_u - E[z_u]\}. \tag{A2.6}$$

Here $z_u = Z_l - (z_m + \sum_{i=1}^{l} z_i)$ with $Z_l \sim N(0, \sigma_Z^2)$ and the conjectures $z_m = \alpha y_m$, $z_i = \beta y_i$. Further, $\varepsilon_{av} = \varepsilon - y_a \sim N(0, \sigma_{\varepsilon_{av}}^2)$, and the random trade of $Z_l$ is not correlated with the firm value. Therefore, we have

$$\mu_{u1}(z_u) = \frac{\text{Cov}(\varepsilon_{av}, (-\alpha y_m - \sum_{i=1}^{l} \beta y_i))}{\text{Var}[Z_l - (\alpha y_m + \sum_{i=1}^{l} \beta y_i)]} \{z_u - E[z_u]\}. \tag{A2.7}$$

Given the assumptions $\varepsilon_{av} | y_m, y_i \sim N(y_m + y_i, \sigma_i^2)$, $y_i \sim N(0, \sigma_i^2)$, $\text{Cov}[y_m, y_i] = 0$, and identical $y_i$, we obtain

$$\mu_{u1}(z_u) = -\frac{\alpha \sigma_m^2 + \beta \sigma_i^2}{\alpha^2 \sigma_m^2 + \beta^2 \sigma_i^2 + \sigma_Z^2} z_u. \tag{A2.8}$$

Q.E.D.

Proof of Proposition 3.1

In rational expectations equilibrium, the demand functions and the uninformed investor's posterior belief must be consistent with conjectures. This implies

$$z_m = \alpha y_m = \frac{1}{2b} y_m, \quad z_i = \beta y_i = \frac{1}{2b} [1 - b(I - 1)\beta] y_i,$$
\[ \mu_{a1}(z_u) = -b z_u = -\frac{\alpha \sigma^2 + \beta \sigma^2_i}{\alpha^2 \sigma^2_m + \beta^2 \sigma^2_i + \sigma^2_z} z_u. \] 

(A2.9)

Solving the equations provides the following solutions:

\[ \alpha = \frac{1}{2b}, \quad \beta = \frac{1}{(I+1)b}, \quad b^2 = \frac{1}{4} \frac{\sigma^2 + \frac{I}{(I+1)^2 \sigma_i^2}}{\sigma^2_z} \frac{1}{\sigma_z^2}. \]

Q.E.D.

### Derivation of Equation 3.17

The informed investor \(i\)'s expected trading profit at date one is (see equation (3.10))

\[ U_{II}(y_a, y_i, z_i) = \{y_i - b(I-1)\beta y_i - bz_i\} z_i. \]

Given equilibrium \(z_i = \beta y_i\), and \(y_i \sim N(0, \sigma^2_i)\), taking expectation yields

\[ E[U_{II}(y_a, y_i, z_i)] = (1-b\beta I) \beta \sigma^2_i. \]

(A2.10)

Further, substituting equilibrium parameters \(\beta = \frac{1}{(I+1)b}\) and

\[ b^2 = \frac{1}{4} \frac{\sigma^2 + \frac{I}{(I+1)^2 \sigma_i^2}}{\sigma^2_z} \frac{1}{\sigma_z^2}, \]

the above expression becomes

\[ E[U_{II}(y_a, y_i, z_i)] = \frac{1}{(I+1)^2} \frac{\sigma z \sigma^2_i}{\sqrt{1 + \frac{\sigma^2}{(I+1)^2 \sigma_i^2}}}, \]

(A2.11)

Considering the information acquisition cost \(\kappa_i\), the informed investor \(i\)'s \textit{ex ante} expected equilibrium net payoff, given that \(I\) investors are informed, is

\[ U_{i^{net}}(\sigma_i^2) = \frac{1}{(I+1)^2} \frac{\sigma z \sigma^2_i}{\sqrt{1 + \frac{\sigma^2}{(I+1)^2 \sigma_i^2}}} - \kappa_i(\sigma^2_a, \sigma^2_i). \]

Q.E.D.
Proof of Proposition 3.3

The informed investor investor $i$'s decision with respect to the informativeness of private signal $\sigma_i^2$ is

$$\max U_i^m(\sigma_i^2) = \frac{1}{(I + 1)^2} \frac{\sigma_z \sigma_i^2}{\frac{1}{4} \sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2} - (1 + \gamma \sigma_a^2) \sigma_i^2.$$

Thus, the first order condition is

$$\frac{\gamma_4 \sigma_m^2 + \gamma_2 \frac{I}{(I + 1)^2} \sigma_i^2}{[\gamma_4 \sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2]^{\gamma_4}} = \frac{(I + 1)^2}{\gamma z} (1 + \gamma \sigma_a^2). \quad (A2.12)$$

Then the partial derivative of $\sigma_i^{2*}$ with respect to $\sigma_a^2$ is

$$\frac{\partial \sigma_i^{2*}}{\partial \sigma_a^2} = \frac{-4(I + 1)^4}{I \sigma_z \Omega} \gamma, \quad \text{where} \quad \Omega = \frac{\sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2}{[\gamma_4 \sigma_m^2 + \frac{I}{(I + 1)^2} \sigma_i^2]^{\gamma}} > 0. \quad (A2.13)$$

That is, the sign of $\frac{\partial \sigma_i^{2*}}{\partial \sigma_a^2}$ depends on the sign of information cost parameter $\gamma$, and $\sigma_i^{2*}$ is increasing (or decreasing) in $\sigma_a^2$ if $\gamma < 0$ (or $\gamma > 0$), and unaffected by $\sigma_a^2$ if $\gamma = 0$.

Q.E.D.

Proof of Proposition 3.4

In the setting without insider trading, the manager, i.e., the insider, discloses all the endowed information to the public $(y_a, y_m)$. Since the manager does not engage in trade, there are only three sets of traders in the market: $I$ privately informed investors,
the market maker, and the liquidity traders. Then the aggregate trading quantity absorbed by the market maker is

\[ z_u' = Z_i - \sum_{i=1}^l z_i' . \]  

(A2.14)

Since he observes the two public signals \((y_a, y_m)\) and the aggregate trading quantity \(z_u'\), he uses this information to set the market price, i.e.,

\[ p_i' = E_{u1}[v \mid y_a, y_m, z_u'] = m_0 + y_a + y_m + \mu_{u1}(z_u') . \]  

(A2.15)

As in the setting with insider trading, the conjecture of \(\mu_{u1}(z_u')\) is

\[ \mu_{u1}(z_u') = E[\varepsilon_{av} \mid z_u'] = -b' z_u' . \]  

(A2.16)

The informed investor \(i\)’s expected price resulting from an order of \(z_i\) units, given his information set \((y_a, y_m, y_i)\) is

\[ E[p_i' \mid y_u, y_m, y_i, z_i'] = m_0 + y_a + y_m + b' z_i' + b \sum_{j=1}^{l-1} z_j' . \]  

(A2.17)

Therefore, his expectation of the trading payoff is

\[ U_i(y_a, y_m, y_i, z_i') = \{ y_i - b' z_i' - b \sum_{j=1}^{l-1} z_j' \} z_i' . \]  

(A2.18)

Maximizing the expected profit produces \(z_i'(y_i) = \frac{1}{2b} [y_i - b \sum_{j=1}^{l-1} z_j']\). The \(l\) informed investors are identical, \(z_i' = z_j'\). Hence, \(z_i'(y_i) = \frac{1}{(l+1)b} y_i\). Finally, the uninformed investor’s posterior mean with respect to \(\varepsilon_{av}\) is
Rational expectation equilibrium requires that, the uninformed investor's posterior mean should be consistent with the conjecture, which implies

$$b' = \frac{\frac{I}{(I+1)b} \sigma_i^2}{\left(\frac{I}{I+1}\right)^2 \frac{1}{[b']^2} \sigma_i^2 + \sigma_z^2}$$

(A2.20)

To summarize, the market equilibrium is characterized as:

$$z_i'(y_i) = \frac{\sigma_z}{\sigma_i \sqrt{I}} y_i, \quad p_i = m_0 + y_a + y_m - b' z_u, \quad \text{where } b' = \frac{\sqrt{I} \sigma_i'}{I + 1 \sigma_z}.$$

Q.E.D.

**Derivation of Equation 3.23**

In the strategic investor model without insider trading, the informed investor $i$'s expectation of the gross trading payoff at date one is (see equation (A2.18))

$$U_{ii}(y_u, y_m, y_i, z_i) = \{ y_i - b' z_i - b' \sum_{j=1}^{l-1} z_j \} z_i.$$

Substituting the equilibrium solutions

$$z_i'(y_i) = \frac{\sigma_z}{\sigma_i \sqrt{I}} y_i, \quad b' = \frac{\sqrt{I} \sigma_i'}{I + 1 \sigma_z}, \quad z_i = z_i', \quad \text{and taking expectation gives}

E[U_{ii}(y_u, y_m, y_i, z_i)] = \frac{1}{(I + 1)\sqrt{I}} \sigma_z \sigma_i'.$$

(A2.21)
Taking the information acquisition cost $\kappa_i$ into account, the informed investor $i$'s ex ante expected equilibrium net payoff, given that $I$ investors are informed, is

$$U_i^{\text{net}}(\sigma_i) = \frac{1}{(I+1)\sqrt{T}} \sigma_z \sigma_i - \kappa_i^t(\sigma_a^2, \sigma_m^2, \sigma_i^2).$$  \hspace{1cm} (A2.22)

Q.E.D.