MIS Quarterly

RESEARCH NOTE

THE CONSEQUENCES OF INFORMATION TECHNOLOGY CONTROL WEAKNESSES ON MANAGEMENT INFORMATION SYSTEMS: THE CASE OF SARBANES–OXLEY INTERNAL CONTROL REPORTS[1]

Chan Li
Katz Graduate School of Business, University of Pittsburgh, Pittsburgh, PA 15260 U.S.A. {chanli@katz.pitt.edu}

Gary F. Peters and Vernon J. Richardson
Sam M. Walton College of Business, University of Arkansas, Fayetteville, AR 72701 U.S.A.
{gfpeters@walton.uark.edu} {vrichardson@walton.uark.edu}

Marcia Weidenmier Watson
Richard C. Adkerson School of Accountancy, Mississippi State University,
Mississippi State, MS 39762 U.S.A. {marcia.watson@msstate.edu}

In this article, the association between the strength of information technology controls over management information systems and the subsequent forecasting ability of the information produced by those systems is investigated. The Sarbanes–Oxley Act of 2002 highlights the importance of information system controls by requiring management and auditors to report on the effectiveness of internal controls over the financial reporting component of the firm's management information systems. We hypothesize and find evidence that management forecasts are less accurate for firms with information technology material weaknesses in their financial reporting system than the forecasts for firms that do not have information technology material weaknesses. In addition, we examine three dimensions of information technology material weaknesses: data processing integrity, system access and security, and system structure and usage. We find that the association with forecast accuracy appears to be strongest for IT control weaknesses most directly related to data processing integrity. Our results support the contention that information technology controls, as a part of the management information system, affect the quality of the information produced by the system. We discuss the complementary nature of our findings to the information and systems quality literature.

Keywords: Sarbanes–Oxley, internal controls, information quality, management forecast

[1]William E. McCarthy was the accepting senior editor for this paper.

Introduction

Many criticize the Sarbanes–Oxley Act of 2002 (SOX) as being bad for businesses because of the additional regulation and burdensome expense, with some suggesting that it has led to the lack of competitiveness of U.S. firms as compared to foreign firms (Zhang 2007). However, others suggest that SOX has been good because it served as a mechanism for pointing out deficiencies in a firm's information systems (Grant Thornton 2006). Although SOX was aimed at improving information for external stakeholders, identifying and rectifying control weaknesses in the financial reporting system may lead to better internal information within a firm (Feng et al. 2009). In fact, documenting the extent to which SOX compliance efforts also improve internal information is an ongoing concern for many firms.

SOX Section 404 highlights the critical importance of controls related to the financial reporting function of management information systems by requiring a regular assessment of the quality of the financial reporting function (hereafter referred to as the financial reporting system or FRS).[2] Because management uses its FRS to manage operations, monitor performance, create forecasts, and report results to firm stakeholders, the control quality of the FRS is likely to affect many management decisions. In fact, Feng et al. (2009) find that SOX Section 404 material weaknesses (related to the FRS) affect the firms' internal management information and, hence, the quality of management earnings forecasts.

Extending Feng et al., this study considers the extent that the existence and resolution of information technology control weaknesses impact the ultimate usefulness or quality of the information produced by the FRS. By doing so, we also extend the stream of research on information system quality issues (for a discussion of this literature, see Lee et al. 2002; Nelson et al. 2005; and Wixom and Todd 2005). Arguably, if there are significant weaknesses over the capturing or processing of data within the FRS, the information produced by such a system may be less effective in its ability to aid decision making. One important management decision outcome that could potentially be affected by a poor FRS is management earnings forecasts. Prior studies suggest that management earnings forecasts are very informative to market participants, including investors and analysts (e.g., Baginski and Hassell 1990; Patell 1976; Penman 1980; Pownall and Waymire 1989; Williams 1996). The extent to which management forecasts mitigate information asymmetry in the capital markets, however, largely depends on the degree of credibility, integrity, and accuracy of the forecasts (Healy and Palepu 2001). If management relies on inferior information, the quality of its forecasts will be lower. To the extent that management utilizes information about prior business transactions to formulate expectations about future performance, breakdowns in the controls over the automated means of originating, processing, storing, and communicating information can lead to poor inputs into management's production of forecasts. SOX guidance and auditing standards also emphasize the unique benefits that accompany the use of IT-related controls, including enhancing the usefulness of information produced by the system (AICPA 2002; PCAOB 2007).

In this paper, we hypothesize that the stronger (weaker) IT controls over the FRS, the higher (lower) the information quality produced by the system. We use the firm's SOX 404 Management's Report on Internal Controls to identify material weaknesses in IT controls. Firms reporting material weaknesses in IT controls are hypothesized to have weaker controls over the production of management information, which negatively impacts the quality of the information management uses in forming earnings forecasts, thus resulting in lower forecast accuracy. We also examine how the relationship between internal control material weaknesses and management forecast accuracy varies by the *type* of IT material weaknesses reported. Doyle et al. (2007) assert that the types of material weaknesses vary widely with respect to severity and underlying reason. Keeping this in mind, we use extant information system quality research as a guideline for categorizing IT control weaknesses across three dimensions: (1) data processing integrity, (2) system access and security, and (3) system structure and usage to identify the types of IT material weaknesses that have the greatest impact on the FRS (i.e., those related to information accuracy issues).

Consistent with our hypothesis, we find that firms reporting IT material weaknesses in internal controls from 2004 to 2008 under SOX 404 tend to have significantly larger management forecast errors than firms reporting either effective internal controls or non-IT material weaknesses, after controlling for size, financial performance, and earnings characteristics that make earnings more difficult to predict (e.g., losses and volatility). We also examine the impact of changes in IT control quality on the changes of management earnings forecast quality. We find that the improvement (deterioration) of IT controls is associated with decrease (increase) in forecast errors. Both of these are consistent with the argument that poor IT quality reduces the accuracy of management fore-

[2]Although the FRS is a subset of a firm's greater management information systems, we note that the FRS (and thus controls over those components) is greatly integrated with other areas of a firm's information system. Thus, improvements in the controls over the FRS should also improve the quality of the overall management information system.

casts. Furthermore, the deterioration results link the *origination* of IT control problems with an increase in management forecast errors. Examining the association between types of IT problems and management forecast quality reveals that IT material weaknesses related to the information quality dimension of *data processing integrity* are more highly associated with management forecast errors than other types of IT material weaknesses.

This study contributes to several streams in the IS literature by highlighting the implications of IT controls on information quality issues for system users and decision makers. First, this study provides empirical evidence on the importance of designing systems with appropriate IT controls to increase information quality (e.g., Ballou and Pazer 1995). It also contributes to the research stream that investigates the impact of information environment (including data and system) quality on decision making (e.g., Chengalur-Smith and Pazer 1999). For example, research to date has used experimental settings to provide insight into which type of data quality indicators are most informative (Fisher et al. 2003) or survey settings to ascertain the most important attributes influencing the overall perceived level of IS quality (e.g., Nelson et al. 2005; Wixom and Todd 2005). In contrast, this paper is the first to directly test the relation between information quality attributes and decision making in an archival setting. Our results identify which type of IT controls (i.e., those related to information accuracy issues) may warrant the most scrutiny by IS assurance providers based on their relative detrimental impact on information quality (i.e., risk) when the controls fail (e.g., ITGI 2007; Krishnan et al. 2005; Pierce 2004; Stratton 1981).

This study also contributes to the IS literature focused on the measurement and indicators of system and data quality (e.g., Agmon and Ahituv 1987; Miller and Doyle 1987; Pierce 2004). Specifically, our evidence suggests that internal control reports, mandated by SOX, can provide information to system users about the underlying system and data quality. In addition, our results complement the literature investigating the impact of IT investment on performance. Raghunathan (1999) discusses the varied approaches to studying IT investment and its impact on performance, including behavioral science and economic-data approaches. Our approach uses an empirical decision-outcome approach to study the impact of IT on managerial performance. Our results are consistent with investments in IT controls being an important contributor to organizational performance resulting from managerial decision accuracy.

Furthermore, we contribute to the literature by establishing a framework to investigate dimensions of overall IS quality to triangulate the evidence found in other IS-related studies. Our findings are particularly relevant since there is a relative dearth of archival research that explicitly considers the impact of IT control types on overall information quality or how to categorize IT controls relative to their related information quality dimensions (Siponen and Oinas-Kukkonen 2007). Finally, our findings also complement the broader internal control literature. For example, Feng et al. find internal control material weaknesses, especially control problems in revenue and cost of goods sold accounts, impact management forecast accuracy. Complementing Feng et al., we focus on the means or mechanisms of internal controls (as opposed to economic transactional foci of controls), and document that IT control material weaknesses have an incremental effect on management forecast quality, even after controlling for other types of control problems (i.e., those explicitly related to revenue and cost of goods sold accounts).

The paper is organized in the following way: The next section reviews the extant literature in information quality and relevant background information on SOX, and details the hypothesis development. The two sections following that discuss the research models and sample selection, respectively. The results and additional analyses are then provided. The final section concludes the paper.

Literature Review and Hypothesis Development

Information Quality and the Sarbanes–Oxley Act of 2002

The information quality literature commonly uses the analogy between physical manufacturing processes and information manufacturing (Pierce 2004; Wang et al. 1995). While the manufacturing process turns raw materials into physical products, information manufacturing turns raw data into information products (Wang 1998). Just as manufacturing processes focus on controls that enhance the quality of raw materials and processes used to make products, information systems focus on controls that enhance the quality of capturing and processing of data into information used to assist the decision maker. These controls (or lack of) are deemed to have an economically significant impact on managerial decision making and the firm's performance (Redman 1998).

Extant literature focuses on the data reliability assessments within the FRS as a determinant of information quality (Krishnan et al. 2005). At the same time, recent accounting scandals and the subsequent requirements enacted in SOX also emphasize the critical importance of data reliability assessments in the FRS. SOX was established in an attempt to strengthen internal controls over financial reporting among U.S. public firms and increase investor and stakeholder confidence in published financial reports. Among the many SOX provisions, SOX 404 requires an annual assessment by both the firm's executive management and by its external auditor of the internal controls over the firm's FRS, hereafter referred to as internal controls over financial reporting (SEC 2003). Among other objectives, the focus of these controls "pertain to the maintenance of records, which in reasonable detail, accurately and fairly reflect" the transactions and economic condition of the firm (PCAOB 2007).

The SOX internal control requirements directly integrate and reflect the importance of information quality on decision making. For example, if internal controls are not effective, the firm must identify the types of internal control material weaknesses in Management's Report on Internal Controls. For the purpose of identification, a *material weakness* is defined as a control deficiency that results in a *reasonable possibility* that a *material misstatement* of financial information will occur without the misstatement being detected or corrected (PCAOB 2007). The designation of *material* level that pervades the accounting and auditing profession represents a misstatement that makes it probable that the decisions of a reasonable person would be changed or influenced by the misstatement (FASB 1980). As such, SOX-related IT material weaknesses are especially severe because they indicate system problems that are most likely to result in poor quality information affecting decision making.

The quality of the information produced by the financial reporting function of the management information system, or the FRS, is particularly germane as it represents core data used by managerial decision makers (Krishnan et al. 2005). One decision-making outcome of the FRS is forecasts of earnings. We assert that management earnings forecasts represent a powerful setting to test the impact of IT controls on decision performance, since management is directly impacted by the relations amongst financial information variables and the quality attributes of the financial information (Raghunathan 1999).

IT Controls, IS Quality, and Earnings Forecasts

Despite the regulatory definition of *material* control weaknesses, the ultimate impact of material weaknesses can vary with the nature and characteristics of the firm and its IS. For example, Doyle et al. (2007) assert that the types of material weaknesses vary widely with respect to severity and underlying reason. Likewise, auditing standards and IT professional guidance suggests that since IT is an integral part of capturing, processing, and disseminating information, IT material weaknesses should have a pervasive impact on the informational quality of the system (e.g., AICPA 2001; ITGI 2004; PCAOB 2003). As a result, financial auditors of publicly listed firms are explicitly required to consider how an entity's use of IT affects the entity's internal controls over the FRS (AICPA 2001; PCAOB 2003).

We examine the association between IT material weaknesses and management decision-making outcomes, namely management earnings forecasts. Specifically, we compare management forecast accuracy for firms having IT material weaknesses with firms having either effective internal controls or non-IT material weaknesses. Managers utilize information coming out of the FRS to form their forecasts. Related to the FRS, regulators emphasize the importance of IT in delivering effective and efficient internal controls that enable an entity to (1) consistently apply predefined transaction rules and process large volumes of transactions, (2) enhance the usefulness of information, and (3) facilitate information analysis (PCAOB 2007).[3] To the extent that management utilizes information about prior business transactions to formulate expectation about future performance, breakdowns in the controls over the automated means of originating, processing, storing, and communicating information can lead to poor inputs into management production of forecasts. Consider the following example taken from the auditor's SOX 404 report in the 10-K filing of Oneok Inc. in 2005:

> The Company's third party software system associated with accounting for derivative hedging instruments was inadequately designed to appropriately account for certain hedges of forecasted transactions and thus did not facilitate the recognition of hedging ineffectiveness in accordance with generally accepted accounting principles. The software system incorrectly reversed previously recognized hedging ineffectiveness when additional derivative instruments (basis swaps) were incorporated into the Company's hedging strategy related to the forecasted transactions. As a result, misstatements were identified in the Company's cost of sales and fuel account and accumulated other comprehensive income (loss).

In this example, the system incorrectly recorded the applicable transaction data, thus affecting several accounts within the financial statements. When management relies on the

[3]PCAOB also points out that manual controls (non-IT controls) are often dependent upon the effective design and function of automated IT controls (PCAOB 2007).

financial data coming out of the system to form forecasts, the quality of the forecasts should be affected, resulting in less accurate forecasts.

Given the importance of IT in FRS in capturing financial transactions and in aggregating the data to produce meaningful financial reports, IT material weaknesses may be as challenging to resolve, if not more so, than non-IT material weaknesses. As a result, IT weaknesses are likely to have a significant impact on data quality above and beyond non-IT SOX 404 material weaknesses. Consistent with the asserted importance and pervasive impact of IT controls across a firm's information systems, Klamm and Watson (2009) find that IT material weaknesses are associated with other indicators of the firm's information system quality including a greater number of misstated financial accounts or incidents in the FRS. They also find that firms reporting IT material weaknesses report a broader scope of problems across more internal control components than firms which report only non-IT material weaknesses.[4] In addition, Klamm et al. (2011) provide evidence that firms with IT material weaknesses subsequently report more future years of (IT and non-IT) material weaknesses than firms with non-IT material weaknesses, indicating that firms with IT material weaknesses take longer to correct their control problems. Overall, these results are consistent with the argument that firms with IT material weaknesses appear to have a greater likelihood of financial reporting irregularities and lower levels of reporting reliability than firms with non-IT material weaknesses.[5] The above arguments lead to our first set of hypotheses.

H1a: *Management earnings forecast accuracy will be lower for firms with SOX 404 IT material weaknesses as compared to firms that have effective SOX 404 internal controls.*

H1b: *Management earnings forecast accuracy will be lower for firms with SOX 404 IT material weaknesses as compared to firms that have SOX 404 non-IT material weaknesses.*

A second objective of our study includes investigating whether certain categories of IT material weaknesses have a greater impact on the informational quality of the FRS than others. Doyle et al. suggest that the impact of internal controls varies with certain types of material weaknesses; however, it is unclear whether this also extends to specific IT control dimensions. Prior information systems research suggests that the impact of various quality dimensions on the *perceived* overall effectiveness of an IS varies in importance (e.g., Nelson et al. 2005; Strong et al. 1997; Wixom and Todd 2005). For example, Nelson et al. (2005) assert that perceived information quality (as an output of a system) reflects the strength or quality of the information processing system. Unfortunately, varied frameworks and definitions are used to investigate the dimensions of IS quality (e.g., Ballou and Pazer 1985; DeLone and McLean 1992; Nelson et al. 2005; Strong et al. 1997; Wang et al. 1995; Wixom and Todd 2005). Moreover, there is a relative dearth of archival research that explicitly considers the impact of IT control types on overall information quality or how to categorize IT controls relative to their related information quality dimensions (Siponen and Oinas-Kukkonen 2007).[6] Thus, a unique challenge exists for categorizing the different types of IT control weaknesses into exclusive classifications of the information system.

Ideally, one would categorize and test a known set of control *strengths*. However, control *strengths* represent an unknown and potentially infinite set of control observations. Thus, our IT control categorization scheme is constrained by the archival nature of the known control *weaknesses* reported within the firm's SOX 404 reports. Furthermore, our tests of the impact of IS attributes are limited to the categories we are able to identify given the reported control weaknesses. Following Nelson et al., we utilized the following goals when developing a categorization scheme for the reported IT control weaknesses: (1) encompassing overall information and system quality, (2) relatively parsimonious and coherent, (3) descriptive of the multicoated nature of IS quality, and (4) useful in the sense they can influence system design or managerial action. Moreover, we attempted to devise the IT control categories to provide archival evidence on the suppositions asserted within the qualitative survey literature on the impact of IS quality dimensions.

[4]Although IT controls are often correlated with the extent of overall control weaknesses, it still remains unclear which type of material weakness yields a greater impact on the quality of information produced by an information system. In subsequent tests of information quality, we explicitly conduct additional sensitivity testing and control for the associations between the IT and non-IT material weaknesses.

[5]Informal discussions between the authors and various CIOs and IT audit specialists who have performed SOX 404 assessments suggest that IT material weaknesses generally represent a larger issue and consume more resources to fix than non-IT material weaknesses.

[6]In a survey of information security research, Siponen and Oinas-Kukkonen observe a predominant focus on technical applications using mathematical research methods within the security and control research stream. They assert that a distinct need is present for additional research on security and control issues that use broader research questions and empirical evidence. Moreover, Wixom and Todd (2005) assert that additional types of research methods on IS quality dimensions are needed to triangulate the findings of predominant survey literature.

Prior research typically identifies *information* and *system* quality dimension across various categories such as accuracy, completeness, accessibility, and reliability (e.g., DeLone and McLean 1992; Nelson et al. 2005). Nelson et al. assert that the difficulty of differentiating between information and system quality dimensions and the crossover among the dimensions present distinct challenges from a research perspective. Likewise in our specific setting, a specific control instance could apply to more than one quality dimension commonly identified in prior literature or in professional guidance.[7] To help overcome these challenges, while still enabling us to test the suppositions identified in prior literature, we classify the control weaknesses into three high-level control categories: (1) *data processing integrity*, (2) *system access and security*, and (3) *system structure and usage*. Each category is described below. To the extent possible, we designed the categories around the dominant quality and security dimensions identified in prior literature, as well as with the intent of being able to uniquely categorize the reported IT control weaknesses. This high-level of abstraction also helps to overcome any unintended bias toward any subarea of controls (Siponen and Oinas-Kukkonen 2007).

Data Processing Integrity

Our first category of IT controls, *data processing integrity*, captures those controls most directly aligned with the accurate and reliable production of data. Nelson et al.'s information quality dimensions and Strong et al.'s (1997) data quality categories emphasize the dominant importance of a system's ability to produce accurate and reliable information. For example, Strong et al.'s categories, using a qualitative analysis of consumer data from three leading-edge organizations, highlight the predominant importance of the system's data production process and its ability to produce consistent and complete data that reflects the changing needs of users. Moreover, Nelson et al.'s analysis of data warehouse users points out the crossover between accuracy and the system's processing reliability or stability (in terms of the system's ability to adapt or meet changing user needs). They observe that processing reliability has a universal high level effect on the assessment of system quality. They emphasize that such attributes should be primary concerns in system design. In a separate survey of data warehouse users, Wixom and Todd (2005) also identify the processing attributes of accuracy, completeness, and reliability as playing particularly important roles in explaining overall information and system quality.

Given the distinct arguments for attributes related to the data processing level, we categorize appropriate controls into a *data processing integrity* category. Examples of controls that would fall within this category include controls over the input of data, changes to system design, maintenance of data, and system support. Detailed examples of IT material weaknesses and the related *data pricessing Integrity* category appear in Table 1. Consider the following example taken from the auditor's SOX 404 report in the 10-K filing of Take Two Interactive Software Inc. in 2005:

> the Company did not have effective controls to accurately prepare and review inputs to a spreadsheet application used to calculate amortization expense related to capitalized software development costs. This control deficiency resulted in audit adjustments to the 2005 annual consolidated financial statements.

In this example, the system controls for inputs to a spreadsheet application are ineffective, resulting in incorrect numbers in an expense account. This firm is coded as having data processing integrity issues. Alternatively, if the development, maintenance, and change management of programs is not properly handled, then accuracy will be threatened; if the internal control framework is not functioning properly, it is likely that risks are not recognized and controls not properly defined to help ensure reliable data. We provide additional examples of excerpts from SOX 404 reports and the respective coding of control weaknesses in Appendix A.

System Access and Security

Our second category includes IT controls related to *system access and security*. From a security perspective, Siponen and Oinas-Kukkonen (2007) reconcile prior security research literature and emphasize the distinct importance of accessibility and availability as it relates to communications issues such as user authentication and appropriate maintenance of data retention. Strong et al. also segregate and highlight the importance of accessibility as a determinant of data quality. In particular, they emphasize the importance of access security and timely availability to data. Likewise, Nelson et al.

[7]Prior to developing these three categories we also considered categorizing controls across specific quality dimensions. For example, when a company recognized "programming errors" as a control weakness we considered to which of the common *information* quality dimensions of completeness, accuracy, format, or currency (Wixom and Todd 2005) or the common control objectives (confidentiality, availability, integrity) the control instance would apply. We recognized the difficulty of assigning any given control into a unique quality or control objective category. Our ability to identify an exhaustive list of quality attributes was also limited by the reported control weaknesses. Thus, a higher-level of abstraction or categorization was considered necessary. This approach is also consistent with the security literature review of Siponen and Oinas-Kukkonen (2007).

Table 1. IT Control Quality Dimensions

Quality Dimension	Identifier	Definitions*	Examples from the SOX 404 Management's Report on Internal Control
Data processing integrity	IT PROCESS	The extent to which data is correct and reliable	• Ability to change closed accounting periods in system • Ability to delete (used) accounts from the system • Data or program changes lack user review/approval/authorization/ testing • Did not properly maintain master files (e.g., vendor, price, inventory) • Inadequate development and maintenance (e.g., new system, updates) • Inadequate IS/IT support staff • Inadequate system to support business processes (includes manually intense processes) • Integrity of computer data not verified (e.g., accuracy, validity, completeness) • Lack of IS/IT controls • Lack of IS/IT controls over subsidiary/foreign operations • Lack of IT experience (inadequate skills) • Program change controls missing or inadequate • Programming errors • Relying on systems of others (outsourcing) where controls not verified • Spreadsheet(s), lack of controls over • (Too) Functionally complex systems • Weak application controls • Weak general controls • Weak IT Control Activities • Weak IT Control Environment • Weak IT Risk Assessment • Weak IT Monitoring
System Access and Security	IT SECURITY	The extent to which: • data is available, or easily and quickly retrievable and • access to data is restricted appropriately to maintain its security	• (Business user) Segregation of duties not implemented in system • Inadequate records and storage retention • Lack of disaster recovery plan for systems • IS/IT personnel access not properly segregated • Logical access issues • Security issues
System Structure and Usage	IT STRUCTURE	The extent to which data is: • easily comprehended • presented in the same format	• Decentralized systems • Disparate (non-integrated) systems • Insufficient training on system • Lack of system documentation, policies, procedures • Weak information and communication

*Partially based on Pipino et al. 2002.

argue that accessibility represents a system attribute that is distinct but similar in importance to the system's ability to produce reliable data, although they argue that this impact of accessibility is second in order of influence to the system's processing reliability.

Detailed examples of IT material weaknesses and the related *system access and security* category appear in Table 1. Among other control weaknesses, we include logical access, and segregation of duty issues, which threaten data security, as well as a lack of disaster recovery or records storage plan, which threaten data availability, in this dimension. Consider the following example taken from the auditor's SOX 404 report the 10-K filing of Dana Holding Company in 2005:

> the Company did not maintain effective segregation of duties over automated and manual transaction processes. Specifically, certain information technology personnel had unrestricted access to financial applications, programs and data beyond that needed to perform their individual job responsibilities and without adequate independent monitoring. In addition, certain personnel with financial responsibilities for purchasing, payables and sales had incompatible duties that allowed for the creation, review and processing of certain financial data without adequate independent review and authorization.

In this example, Dana Holding Company lacks appropriate segregation of duties by business users and IT personnel, potentially threatening the functioning of the underlying systems as well as the security of the information in the system. This firm is coded as having system access and security issues.[8]

System Structure and Usage

Our final category includes controls related to *system structure and usage*. From a contextual dimension, Strong et al. identify the impact of a system's ability to integrate data across distributed locations. Moreover, they note the relative importance of communicating consistent data definitions and representations across divisions. Nelson et al. identify the integration or facilitation of combining information from various sources as having a separate and consistent effect on perceptions of system quality. However, both Strong et al. and Nelson et al. observe that these quality concerns are secondary to the issues identified under the *data processing integrity* category. Detailed examples of IT material weaknesses and the related *system structure and usage* category appear in Table 1. Among other control weaknesses, we include decentralized and disparate systems, and weak information and communication, as well as documentation and training, into this dimension, as these represent attributes consistent with the user's ability to obtain appropriate data in a multifaceted information setting. Consider the following example taken from the auditor's SOX 404 report in the 10-K filing of Leapfrog Enterprises Inc. in 2004:

> lack of appropriate training of personnel throughout the organization causing system users to be less effective due to insufficient understanding of the systems they manage and depend upon.

In the final example, Leapfrog Enterprises Inc. lacks appropriate training of personnel causing system users to have an insufficient understanding of the system they use. This firm is coded as having system structure and usage issues.

In this paper, we test whether IT material weaknesses related to the *data processing integrity* category will have the greatest impact on information quality and user decision making. The survey findings of Wang and Strong (1997), Nelson et al., and Wixom and Todd all suggest that a system's ability to produce accurate, complete, and reliable information is a predominant factor in explaining perceptions about information and system quality. However, it remains an empirical question as to whether their survey evidence holds in a setting that reflects an objective assessment of actual system controls and the quality of an actual managerial decision outcome. Regulatory requirements and professional guidance all emphasize the importance of strong IT controls to support *data processing integrity* and enable better business decisions by providing higher-quality information (e.g., AICPA 2002; ITGI 2007). Following the findings of prior survey literature and the assertions of professional guidance, we expect the IT control category, *data processing integrity*, to have the largest impact on the accuracy of forecasts. If the underlying data used by management is produced by systems with *data processing integrity* problems, forecasts should be adversely affected. All combined, we hypothesize the following:

H2: Management earnings forecast accuracy is lower for firms with data processing integrity SOX 404 IT material weaknesses than for firms without data processing integrity SOX 404 IT material weaknesses.

[8]Note that unlike Take Two Interactive, who reports an actual data integrity problem, Dana's access and security issues *potentially* threaten the integrity of the system and accuracy of the data entered into the system. Given that an actual problem with data integrity was not reported by Dana, the firm is not coded as having a data integrity problem.

Research Models

To test H1, that managers in firms with SOX 404 IT material weaknesses will have larger earnings forecast errors than firms with either effective internal controls or non-IT material weaknesses, we estimate the following OLS regression model:

$$\text{MFERROR} = b_0 + b_1\text{ITMW} + b_2\text{OTHERMW} + b_3\text{LnAT} + b_4\text{BIG4} + b_5\text{GROWTH} + b_6\text{LEVERAGE} + b_7\text{LOSS} + b_8\text{SEGMENT} + b_9\text{FOREIGN} + b_{10}\text{CFO\_VOLATILITY} + b_{11}\text{ABSCHGROA} + b_{12}\text{DISPFOR} + b_{13}\text{HORIZON} + b_{14}\text{SURPRISE} + b_{15}\text{IMR} + \sum b_i \text{ Industry and Year Indicators} + \varepsilon \quad (1)$$

In equation (1), we include management forecast error (MFERROR) as our empirical proxy for decision outcomes resulting from the quality of information produced by the FRS. MFERROR is measured as the absolute value of the management forecast error (realized earnings less the management earnings forecast) scaled by assets per share at the beginning of year t. Management forecast is the average of management annual forecasts (Ajinkya et al. 2005; Feng et al. 2009).[9] Our initial test variables are ITMW (equal to 1 if firms have IT material weaknesses, 0 otherwise)[10] and OTHERMW (equal to 1 if firms have non-IT material weaknesses, 0 otherwise).[11] We expect that both variables are positively associated with MFERROR with the coefficient on ITMW larger than that on OTHERMW.

To investigate whether certain types of IT SOX 404 material weaknesses will have a greater impact on the informational quality of FRSs (H2), we categorize ITMW across three dimensions: (1) *data processing integrity* (hereafter, IT PROCESS), (2) *system access and security* (hereafter, IT SECURITY), and (3) *system structure and usage* (hereafter, IT STRUCTURE). Using the SOX 404 report for each firm in our sample, we identify the IT material weaknesses and code the control weaknesses among our three categories. The coding is performed by two of the authors independently. Any differences are discussed and a consensus coding achieved. The inter-rater reliability was greater than 90 percent. As discussed in the hypothesis section, we develop our IT control categories by integrating the prior data quality literature, auditing standards (i.e., AS5), and IT professional guidance. Detailed examples of the IT controls and the coding of the categories appear in Table 1. We provide additional examples of excerpts from SOX 404 reports and the respective coding of control weaknesses in Appendix A.

Following prior literature (e.g., Ajinkya et al. 2005; Feng et al. 2009), we also control for variables that may be correlated with both weak internal controls and management forecast errors: size (LnAT), audit quality (BIG4), sales growth (GROWTH), profitability (LEVERAGE and LOSS), and complexity (SEGMENT and FOREIGN). We expect larger firms, firms having Big 4 auditors, slower growth, more profitable, and less complex firms to have smaller forecast errors. As emphasized in Feng et al. (2009), firms with high innate volatility are expected to report larger management forecast errors and be more likely to have material weaknesses. We include the following variables to control for innate volatility: the standard deviation of operating cash flow (CFO_VOLATILITY), the absolute value of the change in return on assets (ABSCHGROA), and the dispersion of the analyst forecast prior to the management forecast (DISPFOR). We expect the above three variables are positively associated with management forecast errors. In addition, we control for the mean of management forecast horizon (HORIZON), and the magnitude of the revision suggested by the management forecast (SURPRISE) as both variables are the determinants of management forecast accuracy and could be correlated with internal control quality (Feng et al. 2009). We expect them to also be positively associated with forecast errors. Because the provision of management forecast is voluntary, we also control for the endogeneity of providing forecast by including the inverse mills ratio (IMR) generated from a first-stage probit regression that models the choice to provide management forecast (Feng et al. 2009).[12] Finally, we include Fama-French 48 industry and year indicators in the model.

---

[9] If we use only the most recent management forecast, our results remain the same.

[10] To the extent that an IT material weakness was not specifically disclosed as IT related, we included it in the "other" material weakness category for our study. In terms of the potential implications for our tests, this would bias our "ITMW" results away from statistical significance.

[11] OTHERMW is coded one as long as a firm has non-IT material weaknesses. So, a firm with IT material weakness(es) could also have be coded as "1" in OTHERMW if it also has non-IT material weakness(es). By explicitly controlling for non-IT material weaknesses for IT material weakness firms in the regression, the coefficient on ITMW represents the marginal effect of IT material weaknesses on forecast errors.

[12] The first-stage model is $\text{OCCUR} = b_0 + b_1\text{LnAT} + b_2\text{BIG4} + b_3\text{GROWTH} + b_4\text{LEVERAGE} + b_5\text{LOSS} + b_6\text{SEGMENT} + b_7\text{FOREIGN} + b_8\text{CFO\_VOLATILITY} + b_9\text{ABSCHGROA} + b_{10}\text{STD\_AF} + b_{11}\text{ANALYST} + b_{12}\text{ICMW}$ + Industry and Year Dummies, where OCCUR = 1 if the manager issues forecast in year *t*, and zero otherwise; STD_AF = 1 if the standard deviation of the individual analyst forecasts at the beginning of year *t*; ANALYST = 1 if the natural logarithm of the number of analysts following the firm at the beginning of year *t*; ICMW = 1 if the firm has internal control material weakness in year *t*, and zero otherwise. All other variables are discussed in conjunction with Model (1).

Sample Selection and Descriptive Statistics

We begin with all SOX 404 reports available on Audit Analytics, which are 18,203 firm-year observations for fiscal year 2004 through fiscal year 2008. We next remove observations that lack the necessary financial data from Compustat, which results in 14,091 firm-year observations. Among those firms, 250 have IT control material weaknesses, and 934 have non-IT control material weaknesses. We then exclude 8,724 firm-year observations that did not have an annual point or range forecast in the corresponding fiscal year from First Call. Finally, we remove 137 observations without analyst forecast dispersion information from First Call. Our final sample for management forecasts contains 5,230 firm years, including 74 firms with IT control material weaknesses, and 334 with non-IT control material weaknesses. Table 2 summarizes our sample construction process. Table 3 presents the industry distribution based on a two-digit SIC code for IT material weakness firms and non-IT material weakness firms. Table 3 shows that IT material weakness firms exist in 28 two-digit SIC code industries. Table 4 describes the variable definitions used in the analysis.

Table 5 presents the descriptive statistics for three groups of firms: observations with effective internal controls (N = 4,822), observations with IT-related material weaknesses (N = 74), and observations with only non-IT related material weaknesses (N = 334). The univariate results show that management forecast errors are significantly larger for firms with any material weaknesses than for firms without material weaknesses. Moreover, firms having IT material weaknesses have significantly larger forecast errors than firms having only non-IT material weaknesses (p = 0.001). As for the control variables, compared to firms with either effective internal controls or non-IT material weaknesses, IT material weakness firms are generally smaller, less likely to be Big 4 clients, more likely to report a loss, with more volatile cash flows and earnings, and have shorter forecast horizons.

Regression Results

Table 6 presents the multivariate regression results explaining the relation between IT material weaknesses and management forecast accuracy for the years 2004 through 2008. We report *t*-statistics based on robust standard errors to control for firm clustering effects (Petersen 2009).[13] The model is significant in explaining forecast errors and has an adjusted R-square of 41.5 percent, suggesting its components are explaining a relatively good proportion of the variation in management forecast errors. Both ITMW and OTHERMW are significantly positive, suggesting firms with either IT or non-IT material weaknesses have larger management forecast errors, providing support to H1a. However, the coefficient on ITMW is more than three times larger than that of OTHERMW, and the difference is statistically significant (p = 0.001).[14] These results suggest that firms with IT material weaknesses have much larger management forecast errors than firms with non-IT material weaknesses, which provides support for H1b.[15] Economically, after controlling for known determinants of material weaknesses and management forecast accuracy, firms with IT material weaknesses have management forecast errors that are 0.013 (0.009) larger, on average, than firms with effective internal controls (firms with non-IT material weaknesses). The economic significance is large, as the mean forecast error is only 0.013 in the full sample.

As for control variables, consistent with Feng et al. (2009), we find smaller firms (LnAT), loss firms (LOSS), firms with more volatile cash flows (CFO_VOLATILITY), greater change in earnings (ABSCHGROA), larger analysts forecast dispersion (DISPFOR), longer forecast horizons (HORIZON), and greater management forecast revisions (SURPRISE) have larger forecast errors.[16] In contrast to our expectation, firms with faster growth (GROWTH) have smaller forecast errors. We conjecture that is probably because growth firms are also likely to be financially healthier.[17]

[13]Because in our sample all IT material weakness firms also have non-IT material weaknesses, we code OTHERMW as one for these firms to control for the effect of non-IT problems on forecast errors. Thus, the total number of observations when OTHERMW equals one is the sum of the number of IT material weakness firms and the number of firms with only non-IT material weaknesses (74 + 334 = 408). The correlation between ITMW and OTHERMW is 0.412. The examination of multicollinearity suggests it should not be a problem because the largest variance influence factor (VIF) is only 1.49, which is well below the threshold of 10.

[14]We will further discuss the difference in the impact of IT material weaknesses and non-IT types of material weaknesses on forecast accuracy in the "Additional Analyses" section.

[15]We also rerun the analysis by restricting the sample to only firms with internal control material weaknesses. Thus, the coefficient on ITMW compares the forecast errors for firms with IT material weaknesses and for firms with only non-IT types of material weaknesses. The results show the coefficient on ITMW is still positively significant (p = 0.021).

[16]Variable SURPRISE has a very large impact on forecast error (coefficient = 1.154, and t-stat. = 13.36). If we only include this variable in the model, the model's adjusted R^2 = 0.275. The adjusted R^2 of our full model is 0.415, which indicates that our additional variables significantly improve the model's explanatory power.

[17]In Feng et al. (2009), sales growth is subsumed into a factor called *organizational change*. In their paper, organizational change is also negatively and significantly associated with forecast errors in 2004.

Table 2. Sample Selection

	Firm-Year Observations
Firm-years with Section 404 reports for fiscal years 2004–2006	18,203
Less:	
Those missing financial information from Compustat	4,112
Firm-years with Section 404 reports and financial information	14,091
Including: Firm-years with IT control material weakness	250
Firm-years with non-IT control material weakness	934
Less:	
Those without a point or range management earnings forecast issued in year t	8,724
Firm-years with point or range management forecasts	5,367
Less:	
Those missing analyst information from First Call	137
Number of firm-years in the final sample	5,230
Including: Firm-years with IT control material weakness	74
Firm-years with non-IT control material weakness	334

Table 3. Industry Distribution for Firms with IT Material Weaknesses and Firms with non-IT Material Weaknesses

2-Digit SIC	Description of industry	ITMW N	Non-IT MW N	2-Digit SIC	Description of industry	ITMW N	Non-IT MW N
13	oil and gas extraction	1	2	52	eating and drinking places	0	1
15	general building contractors	0	3	53	general merchandise stores	1	3
17	special trade contractors	0	2	54	food stores	0	3
20	food and kindred products	4	6	55	automotive dealers & service stations	2	6
23	apparel and other textile products	1	10	56	apparel and accessory stores	1	11
24	lumber and wood products	0	3	57	furniture and home furnishings stores	1	3
25	furniture and fixtures	0	2	58	eating and drinking places	0	9
26	paper and allied products	0	2	59	miscellaneous retail	3	12
27	printing and publishing	0	4	60	depository institutions	0	16
28	chemicals and allied products	5	20	61	nondepository institutions	3	3
31	leather and leather products	0	2	62	security and commodity brokers	0	2
33	primary metal industries	0	2	63	insurance carriers	2	6
34	fabricated metal products	2	2	64	insurance agents, brokers & service	0	1
35	industrial machinery and equipment	2	15	67	holding & other investment offices	1	9
36	electronic & other electric equipment	3	14	70	Hotels, and other lodging places	0	1
37	transportation equipment	1	10	72	personal services	2	3
38	instruments and related products	5	29	73	business services	16	54
39	misc. manufacturing industries	2	5	75	auto repair, services, and parking	1	1
42	motor freight transportation	1	0	78	motion pictures	0	3
47	transportation services	1	3	79	amusement & recreation services	0	2
48	communication	0	8	80	health services	3	5
49	electric, gas, and sanitary services	5	9	82	educational services	1	8
50	wholesale trade - durable goods	2	6	87	engineering & management services	2	13

ITMW refers to the firms with IT-related material weaknesses. Non-IT MW refers to firms with non-IT material weaknesses.

Table 4. Variable Definitions	
NO MW	1 if firm has effective internal controls; 0 otherwise.
ITMW	1 if firm has IT-related internal control material weaknesses; 0 otherwise.
ITIMPROVE	1 if firm has ITMW in year t but has no ITMW in year t+1; 0 otherwise.
ITADVERSE	1 if a firm has ITMW in both year t and t+1; 0 otherwise.
ITWORSE	1 if firm has no ITMW in year t, but has ITMW in year t+1; 0 otherwise.
OTHERMW	1 if firm has internal control material weaknesses other than IT related; 0 otherwise.
OTHERIMPROVE	1 if firm has non-ITMW in year t but has no non-ITMW in year t+1; 0 otherwise.
OTHERADVERSE	1 if a firm has non-ITMW in both year t and t+1; 0 otherwise.
OTHERWORSE	1 if firm has no non-ITMW in year t, but has non-ITMW in year t+1; 0 otherwise.
NUMBERMW	the total number of internal control material weaknesses.
MFERROR	absolute error of management earnings forecast, which equals the absolute value of the difference between actual earnings and management earnings forecasts scaled by the assets per share at the beginning of year t.
LnAT	natural log of total assets at the end of year t.
BIG4	1 if the auditor is Big 4 in year t; 0 otherwise.
GROWTH	sales growth from year t-1 to year t.
LEVERAGE	total liabilities / total assets at the end of year t.
LOSS	1 if the net income is negative in year t; 0 otherwise.
SEGMENT	the natural log of the total number of geographic and operating segments at the end of year t.
FOREIGN	1 if the firm has foreign transactions in year t; 0 otherwise.
CFO_VOLATILITY	the standard deviation of quarterly operating cash flows over the prior 7 years.
ABSCHGROA	the absolute value of the change in ROA from year t-1 to year t.
DISPFOR	standard deviation of the most recent analyst forecasts before the management forecasts.
HORIZON	natural log of number of days between management forecast and the fiscal period end.
SURPRISE	absolute value of (management forecast -median analyst forecast) / assets per share at the beginning of the period.
OCCUR	1 if the manager issued earnings forecast in year *t* + 1 but did not in year *t*, negative one if the manager did not issue forecast in year *t* + 1 but did in year *t*; 0 if there was no change in the issuance of forecast.
IT PROCESS	1 if a firm has ITMW related to data processing integrity; 0 otherwise.
IT SECURITY	1 if a firm has ITMW in the data quality dimension of access; 0 otherwise.
IT STRUCTURE	1 if a firm has ITMW in IT structure quality dimensions; 0 otherwise.
DOCUMENT	1 if a firm has material weaknesses related to accounting documentation, policy and/or procedure; 0 otherwise.
ADJUSTMENT	1 if a firm has material weaknesses related to material and/or numerous auditor /YE adjustments; 0 otherwise.
RESTATE	1 if a firm has material weaknesses related to restatement or nonreliance of company filings; 0 otherwise.
PERSONNEL	1 if a firm has material weaknesses related to accounting personnel resources and competency/ training; 0 otherwise
RECONCILE	1 if a firm has material weaknesses related to untimely or inadequate account reconciliations; 0 otherwise.
TRANSACTION	1 if a firm has material weaknesses related to non-routine transaction control issues; 0 otherwise.
SEGDUTY	1 if a firm has material weaknesses related to segregation of duties/ design of controls; 0 otherwise.
JOURNAL_ENTRY	1 if a firm has material weaknesses related to journal entry control issues; 0 otherwise.
INVESTIGATE	1 if a firm has material weaknesses related to management/board/audit committee investigation; 0 otherwise.
REV/COGS	1 if a firm has material weaknesses in the revenue/cost of goods sold account; 0 otherwise.
ITMW_REV/COGS	1 if firm has ITMW and material weaknesses in the revenue/ cost of goods sold account; 0 otherwise.
ITMW_NOREV/COGS	1 if firm has ITMW but no material weaknesses in the revenue/cost of goods sold account; 0 otherwise.
NOITMW_REV/COGS	1 if firm has no ITMW but has material weaknesses in the revenue/cost of goods sold account; 0 otherwise.
NOITMW_NOREV/COGS	1 if firm has no ITMW and no material weaknesses in the revenue/cost of goods sold account; 0 otherwise.

Table 5. Descriptive Statistics on IT Material Weaknesses, Non-IT Material Weaknesses, and Management Forecast Accuracy for Years 2004–2006

	No MW (1)	ITMW (2)		OTHERMW (3)		(2) vs. (3)
N =	4822	74		334		
	mean	mean	t-stat.	mean	t-stat.	t-stat.
MFERROR	0.012	0.036	9.54	0.020	5.89	4.06
LnAT	21.272	20.137	-5.77	20.718	-5.83	-2.76
BIG4	0.923	0.649	-8.63	0.913	-0.64	-6.30
GROWTH	0.157	0.239	2.95	0.174	1.15	1.09
LEVERAGE	0.620	0.627	0.21	0.620	-0.01	0.18
LOSS	0.109	0.365	6.92	0.231	6.69	2.41
SEGMENT	0.782	0.776	-0.07	0.838	1.31	-0.60
FOREIGN	0.300	0.392	1.72	0.386	3.32	0.09
CFO_VOLATILITY	0.035	0.054	3.97	0.044	3.79	1.98
ABSCHGROA	0.045	0.088	4.02	0.061	3.24	1.96
DISPFOR	0.071	0.055	-1.80	0.073	0.57	-1.68
HORIZON	5.234	4.928	-3.79	5.238	0.09	-2.52
SURPRISE	0.005	0.006	1.93	0.005	0.42	1.56

See Table 4 for variable definitions.

Table 6. Regression Analyses on the Relations Between IT Material Weaknesses and Management Forecast Accuracy for Years 2004–2006

Dependent Variable = MFERROR				
	+/-	Coeff.	t-stat.	p-value
Intercept		0.016	1.81	0.070
ITMW	+	0.013	3.17	0.001
OTHERMW	+	0.004	2.72	0.003
LnAT	-	-0.002	-4.72	0.001
BIG4	-	0.000	-0.38	0.706
GROWTH	+	-0.005	-4.05	0.001
LEVERAGE	+	-0.001	-1.10	0.271
LOSS	+	0.013	7.78	0.001
SEGMENT	+	0.000	0.53	0.297
FOREIGN	+	0.001	0.85	0.199
CFO_VOLATILITY	+	0.024	1.72	0.043
ABSCHGROA	+	0.041	5.77	0.001
DISPFOR	+	0.026	3.96	0.001
HORIZON	+	0.004	8.92	0.001
SURPRISE	+	1.154	13.36	0.001
IMR	?	-0.002	-0.57	0.571
Industry Dummies		Included		
Year Dummies		Included		
Total Obs. =		5230		
ITMW Obs. =		74		
OTHERMW Obs. =		408		
F-value		58.07		
Adj. R^2		0.415		

All t-statistics are robust standard error adjusted. P-values are one-tailed for signed expectations, and two-tailed for unsigned expectations. See Table 4 for variable definitions.

Our univariate analyses indicate that firms with ITMW are more likely to be volatile firms. Because innate volatility is associated with larger forecast errors, if it is not measured properly, there is a concern of correlated omitted variables in our setting. As suggested by Feng et al., the change analysis allows us to control for inherent features of the firm that do not change over time, thus alleviating the concern of omitted variable problems.[18] If firms' IT control quality affects management forecast accuracy, we expect the management forecast error to decrease (increase) as the IT control quality improves (deteriorates). To examine the change in IT control quality on forecast accuracy, we break out our sample firms into four groups: those that have no ITMW in both years (the benchmark group), those that have IT material weaknesses in year *t*, but have no IT material weaknesses in year *t*+1 (ITIMPROVE); those that have IT material weaknesses in both year *t* and year *t*+1 (ITADVERSE); and those that have no IT material weaknesses in year *t*, but have IT material weaknesses in year *t*+1 (ITWORSE). In the same way, we also partition the non-IT material weaknesses into four groups (a benchmark group, OTHERIMPROVE, OTHERADVERSE, and OTHERWORSE). The dependent variable, ΔABSERROR, is defined as the difference in ABSERROR in year $t + 1$ and year t. If the forecast accuracy is primarily driven by the IT control material weaknesses, we expect the coefficient of ITIMPROVE to be negative, and the coefficient of ITWORSE to be positive, while we have no signed expectation for the change in other types of material weaknesses.

Table 7 presents the results of our change analysis from year *t* to year *t*+1. Consistent with the argument that poor IT quality reduces the accuracy of management forecast, the coefficient of ITIMPROVE is significantly negative, while ITWORSE is significantly positive, suggesting when a firm's IT controls improve (deteriorate), management forecast errors decrease (increase). The finding of the positive coefficient of ITWORSE also links the *origination* of IT control problems with an increase in management forecast errors.[19] As for the change in non-IT material weaknesses, OTHERWORSE is also significantly positive, suggesting that when non-IT controls deteriorate, the firm's forecast accuracy also suffers.

Our next hypothesis examines the impact of the different dimensions of IT material weaknesses (i.e., IT PROCESS, IT SECURITY, and IT STRUCTURE as described in Table 1) on management forecast accuracy. As previously discussed, we expect IT PROCESS concerns to be the most positively associated with the forecast error. The regression results are reported in Table 8. Consistent with H2, the coefficient on IT PROCESS is significantly positive; suggesting that IT material weaknesses related to the area of data processing integrity impact information quality, hence, management forecast errors. The coefficients on IT SECURITY and IT STRUCTURE are also positive, but not significant. In addition, the coefficient on IT PROCESS is significantly larger than that on IT SECURITY and IT STRUCTURE (p-values = 0.087 and 0.031, respectively), indicating that data processing integrity control problems have the largest impact on management errors.[20]

Overall, the regression results suggest that firms with IT material weaknesses have significantly larger management forecast errors, and the errors are larger than those of firms with non-IT material weaknesses. An improvement (deterioration) in IT control quality also corresponds to the decrease (increase) in management forecast errors. In addition, we find that IT material weaknesses related to controls over data processing integrity are especially important in the association between IT control quality and forecast quality. In the next section, we conduct several additional tests to further validate our main results.

---

[18]We further examine the impact of innate volatility on our results in the "Additional Analyses" section.

[19]As shown in Table 7, the number of observations for each IT control quality change category is quite small. Although we find statistical significance for several of our IT change categories, there could still be a concern of statistical power. To alleviate this concern, we use another variable to measure the change in IT control quality, ΔITMW, to replace the three dichotomous variables. ΔITMW is defined as the difference in the ITMW indicator variable in year $t + 1$ and the ITMW indictor variable in year t ($ITMW_{t+1} - ITMW_t$). The untabulated results show that ΔITMW is significantly positive with a p-value of 0.003, while ΔOTHERMW ($OTHERMW_{t+1} - OTHERMW_t$) is not significant.

Although we control for changes in each of our control variables in Table 7, it is possible that the underlying *level* of a firm's volatility affects a firm's ability to remediate the IT material weakness, and it is this underlying volatility that is driving the association in Table 7. To investigate this possibility, we correlate the level of loss, cash flow volatility, change in absolute ROA, and analyst forecast dispersion with ITIMPROVE, ITADVERSE, and ITWORSE. We find that none of the IT change variables are significantly correlated with the innate volatility variables. Thus, the underlying level of innate volatility is not driving the association between the change in IT control quality and the change in management forecast errors.

[20]It is possible that the data processing integrity control problems (IT PROCESS) are positively associated with innate volatility, and innate volatility is driving our results. We then examine the correlations among the three categories of ITMW and our innate volatility measures: loss, cash flow volatility, change in absolute ROA, and analyst forecast dispersion. The untabulated results show that none of these innate volatility measures is more significantly correlated with the incidence of data processing integrity ITMW. Therefore, firms with data processing integrity ITMW do not appear to be any more volatile than firms with other types of ITMW.

Table 7. Regression Analyses on the Relations Between the Change of IT Control Quality and the Change of Management Forecast Accuracy

Dependent Variable = ΔMFERROR				
	+/-	**Coeff.**	**t-stat.**	**p-value**
Intercept		0.002	1.41	0.158
ITIMPROVE	-	-0.013	-2.67	0.004
ITADVERSE	?	0.006	0.81	0.418
ITWORSE	+	0.014	1.42	0.079
OTHERIMPROVE	-	0.001	0.59	0.552
OTHERADVERSE	?	-0.004	-1.18	0.239
OTHERWORSE	+	0.004	1.63	0.052
ΔLnAT	-	-0.010	-3.11	0.001
ΔBIG4	?	0.002	0.58	0.561
ΔGROWTH	+	-0.003	-1.29	0.198
ΔLEVERAGE	+	0.011	5.51	0.001
ΔLOSS	+	0.011	5.55	0.001
ΔSEGNUM	+	0.000	0.06	0.476
ΔFOREIGN	+	0.003	1.75	0.040
ΔCFO_VOLATILITY	+	-0.045	-1.02	0.310
ΔABSCHGROA	+	0.028	3.10	0.001
ΔDISPFOR	+	-0.004	-0.51	0.613
ΔHORIZON	+	0.005	5.68	0.001
ΔSURPRISE	+	0.941	7.58	0.001
ΔIMR	?	0.002	0.57	0.568
Industry Dummies		Included		
Total Obs. =		3080		
ITIMPROVE Obs. =		30		
ITADVERSE Obs. =		9		
ITWORSE Obs. =		21		
OTHERIMPROVE Obs. =		179		
OTHERADVERSE Obs. =		56		
OTHERWORSE Obs. =		103		
F-value		15.15		
Adj. RK		0.230		

All t-statistics are robust standard error adjusted. P-values are one-tailed for signed expectations, and two-tailed for unsigned expectations. See Table 4 for variable definitions.

Table 8. Regression Analyses on the Relations Between Types of IT Material Weaknesses and Management Forecast Accuracy for Years 2004–2006

Dependent Variable = MFERROR				
	+/-	**Coeff.**	**t-stat.**	**p-value**
Intercept		0.016	1.79	0.073
IT PROCESS	+	0.012	2.03	0.021
IT SECURITY	+	0.004	0.45	0.325
IT STRUCTURE	+	0.001	0.16	0.435
OTHERMW	+	0.004	2.75	0.003
LnAT	-	-0.002	-4.71	0.001
BIG4	?	0.000	-0.33	0.744
GROWTH	+	-0.005	-4.05	0.001
LEVERAGE	+	-0.001	-1.08	0.285
LOSS	+	0.013	7.76	0.001
SEGMENT	+	0.000	0.58	0.281
FOREIGN	+	0.001	0.84	0.201
CFO_VOLATILITY	+	0.024	1.73	0.042
ABSCHGROA	+	0.041	5.78	0.001
DISPFOR	+	0.026	3.96	0.001
HORIZON	+	0.004	8.95	0.001
SURPRISE	+	1.153	13.33	0.001
IMR	+	-0.002	-0.56	0.573
Industry Dummies	Included			
Year Dummies	Included			
Total Obs. =	5230			
IT PROCESS Obs. =	67			
IT SECURITY Obs. =	36			
IT STRUCTURE Obs. =	26			
OTHERMW Obs. =	408			
F-value	56.40			
Adj. R^2	0.415			

All t-statistics are robust standard error adjusted. P-values are one-tailed for signed expectations, and two-tailed for unsigned expectations. See Table 4 for variable definitions.

Additional Analyses

IT Material Weaknesses and Other Types of Material Weaknesses

Our main results suggest firms with IT material weaknesses have larger management forecast errors than those with only non-IT types of material weaknesses, as problems in information systems could directly impact the FRS output data that management uses to form their forecasts. However, as we discussed earlier, IT material weakness firms are also more likely to have non-IT material weaknesses (Klamm and Watson 2009).[21] Moreover, from a financial reporting account perspective, Feng et al. (2009) find that material weaknesses affecting revenue and cost of goods sold result in the largest management forecast errors since these two line items are very important inputs to a manager's earnings forecast. Thus, our results could be driven by those non-IT material weaknesses. Although this is unlikely, given that we

[21] As discussed earlier, in our sample, all IT material weakness firms also have non-IT material weaknesses, which prevents us from comparing firms with only IT material weaknesses and firms with only non-IT material weaknesses.

(1) control for non-IT material weaknesses for firms with IT material weakness in the regression, (2) find non-IT material weaknesses by themselves have smaller impact on forecast errors, and (3) find the improvement in IT material weaknesses is corresponding to the decrease in forecast errors, while the improvement in other types of material weaknesses is not,[22] we cannot completely rule out this possibility. To provide further support that the positive association between ITMW and MFERROR is due to IT material weaknesses and not from a correlated non-IT control attribute, we examine non-IT material weaknesses in greater detail.

We categorize all non-IT material weaknesses based on the groupings provided in Audit Analytics, and conduct the following four tests.[23] First, we initially compare the number of non-IT material weaknesses for the IT material weakness firms and non-IT material weakness firms. We find, on average, that the former group has three non-IT material weaknesses and the latter group has two non-IT material weaknesses, and the difference is significant. Thus, we add a control variable measuring the number of total non-IT material weakness problems into Model (1). The untabulated results suggest that the coefficient on ITMW continues to be positive and significant (p-value = 0.009), while the coefficient on OTHERMW becomes insignificant (p-value = 0.584).

Second, we use the material weakness types provided in Audit Analytics and include all of them in our model 1.[24] Each type of material weaknesses is not mutually exclusive. In other words, a firm could have ITMW equaling one and other types of material weaknesses also equaling one. By doing so, we try to control for other types of material weaknesses more thoroughly when firms have IT material weaknesses. The results are reported in Table 9. The coefficient on ITMW continues to be positively significant, which suggests that IT material weaknesses still have a negative impact on earnings forecast accuracy even after explicitly controlling for all other individual types of non-IT material weaknesses.[25]

Third, because firms often have multiple types of material weaknesses, we also focus on firms having the five most frequent types of material weaknesses (DOCUMENT, PERSONNEL, ADJUSTMENT, RESTATE, and RECONCILE), and compare management forecast errors for firms also with IT material weaknesses and without IT material weaknesses. In this case, 44 observations have all five types of non-IT material weaknesses, including 17 observations also with IT material weaknesses, and 27 observations without IT material weaknesses. The t-test (untabulated) shows the observation group also with IT material weaknesses has significantly larger management forecast errors compared to the observation group without IT material weaknesses (p-value = 0.022), which provides further evidence that IT material weaknesses have a larger impact on firm forecast accuracy than other types of material weaknesses.

Last, we exclude firms with internal control problems in ADJUSTMENT and JOURNAL_ENTRY, which are shown to be positively associated with forecast errors. By doing so, we try to exclude firms with non-IT problems that could impact management forecast accuracy. This procedure results in 161 material weakness firms including 20 that also have IT material weaknesses. We rerun Model (1). The untabulated results show that firms with IT material weaknesses still have larger forecast errors (p-value = 0.006), while the forecast errors for firms with non-IT material weaknesses do not differ from firms with effective internal controls (p-value = 0.719).

In sum, all the above four tests suggest that the impact of IT material weaknesses on forecast quality is not driven by the impact of other types of material weaknesses. The evidence supports that IT-related internal control problems, by themselves, have a significantly negative effect on management forecast accuracy.

From the financial reporting account perspective, we examine whether problems in revenue and cost of goods sold accounts

[22]Please note that as long as IT material weakness firms do not have IT material weaknesses in the next year, we assign them to ITIMPROVE group. Thus, it is possible that firms in the ITIMPROVE group still have non-IT material weaknesses. This logic also applies to the categorization of ITADVERSE and ITWORSE.

[23]There are 10 types of material weaknesses for our sample (ordered according to the frequency): (1) accounting documentation, policy and/or procedure (DOCUMENT); (2) material and/or numerous auditor/YE adjustments (ADJUSTMENT); (3) restatement or nonreliance of company filings (RESTATE); (4) accounting personnel resources and competency/training (PERSONNEL); (5) untimely or inadequate account reconciliations (RECONCILE); (6) IT control issues (ITMW); (7) nonroutine transaction control issues (TRANSACTION); (8) segregation of duties/design of controls (SEGDUTY); (9) journal entry control issues (JOURNAL_ENTRY); and (10) management/board/audit committee investigation (INVESTIGATE).

[24]Compared to non-IT material weakness group, IT material weakness group is significantly more likely to have control problems in ADJUSTMENT, PERSONNEL, RECONCILE, SEGDUTY, and JOURNAL_ENTRY. Thus, we control for all other types of material weaknesses to try to tease out the impact of these other types of material weaknesses on forecast errors for IT material weakness firms.

[25]JOURNAL_ENTRY and ADJUSTMENT are also positively and significantly associated with forecast errors.

Table 9. Regression Analyses on the Relations between IT Material Weaknesses and Management Forecast Accuracy after Considering All Other Types of Material Weaknesses

Dependent Variable = MFERROR				
	+/-	**Coeff.**	**t-stat.**	**p-value**
Intercept		0.018	2.03	0.042
ITMW	+	0.010	2.15	0.016
DOCUMENT	+	-0.001	-0.15	0.882
ADJUSTMENT	+	0.005	1.35	0.088
RESTATE	+	0.000	0.14	0.443
PERSONNEL	+	0.002	0.87	0.192
RECONCILE	+	-0.000	-0.12	0.903
TRANSACTION	+	0.000	0.10	0.459
SEGDUTY	+	-0.002	-0.42	0.674
JOURNAL_ENTRY	+	0.007	1.29	0.098
INVESTIGATE	+	0.017	1.23	0.109
LnAT	-	-0.002	-4.92	0.001
BIG4	-	-0.001	-0.51	0.608
GROWTH	+	-0.005	-4.13	0.001
LEVERAGE	+	-0.001	-1.23	0.220
LOSS	+	0.013	7.87	0.001
SEGMENT	+	0.000	0.42	0.338
FOREIGN	+	0.000	0.76	0.224
CFO_VOLATILITY	+	0.024	1.76	0.040
ABSCHGROA	+	0.041	5.81	0.001
DISPFOR	+	0.026	4.04	0.001
HORIZON	+	0.004	8.74	0.001
SURPRISE	+	1.153	13.32	0.001
IMR	?	-0.003	-0.81	0.418
Year and Industry Dummies Included				
Total Obs. =	5230			
ITMW Obs. =	74			
DOCUMENT Obs. =	399			
ADJUSTMENT Obs. =	238			
RESTATE Obs. =	214			
PERSONNEL Obs. =	181			
RECONCILE Obs. =	123			
TRANSACTION Obs. =	72			
SEGDUTY Obs. =	51			
JOURNAL_ENTRY Obs. =	45			
INVESTIGATE Obs. =	8			
F-value	52.40			
Adj. R^2	0.418			

All t-statistics are robust standard error adjusted. P-values are one-tailed for signed expectations, and two-tailed for unsigned expectations. See Table 4 for variable definitions.

drive our results regarding the impact of IT material weaknesses on forecast accuracy (Feng et al. 2009). Among firms with IT material weaknesses, we find that 59 percent also have material weaknesses related to revenue and cost of goods sold. In comparison, among firms without IT material weaknesses, only 31 percent also have material weaknesses related to revenue and cost of goods sold. The difference is significant at the 0.001 level. We perform the following two tests to examine the possibility that our results are driven by firms with revenue and cost of goods sold problems. First, we control for revenue and cost of goods sold material weaknesses in the model. The results, presented in Panel A of Table 10, show that ITMW continues to be positive and significant.

To test which is the main driver of the Panel A results, we partition the internal control material weakness firms into four groups: firms with both ITMW and revenue/cost of goods sold MW (ITMW_REV/COGS); firms with ITMW but no revenue/cost of goods sold MW (ITMW_NOREV/COGS); firms with no ITMW but with revenue/cost of goods sold MW (NOITMW_REV/COGS); and firms with no ITMW and no revenue/cost of goods sold MW (NOITMW_NOREV/COGS). The results are presented in Panel B of Table 10. All four of the groups are positively associated with forecast errors. Examining differences in the coefficients on the types of material weaknesses reveal that the coefficient on ITMW_REV/COGS and ITMW_NOREV/COGS are significantly larger than the coefficient on NOITMW_REV/COGS and NOITMW_NOREV/COGS, while the coefficient on ITMW_REV/COGS is not significantly different from that on ITMW_NOREV/COGS. These results suggest that both the overall IT control quality and the control quality related to revenue and cost of goods sold accounts impact the management forecast accuracy, and the impact of IT control quality is not solely through revenue and cost of goods sold accounts.

Management Choice to Issue Forecasts

We find that after controlling for known determinants of management forecast error, firms reporting IT material weaknesses have larger forecast errors than firms reporting effective internal controls (Table 6). However, due to the data requirement on point or range forecasts, only 14 percent of the firms with internal control material weaknesses in our analyses have ITMW.[26] For additional insight into the economic significance of our findings, we relax the above data requirement, and examine the association between the disclosure of ITMWs and subsequent changes in a firm's choice on whether or not to issue a voluntary earnings forecast. If IT control quality impacts the accuracy of management forecasts, when managers know that the informational quality of the system is low, they should be reluctant to issue an earnings forecast.

Using an ordered probit model with variables similar to the ones defined in Table 7 (the change of IT control quality and the change of management forecast accuracy), we report the results of the change in forecast choice after the disclosure of IT material weaknesses in Table 11. The dependent variable, OCCUR, is defined as 1 if the manager issued a forecast in year $t + 1$ but did not in year t, -1 if the manager did not issue a forecast in year $t + 1$ but did in year t, and 0 if there was no change in the issuance of forecasts. The results show that managers in firms reporting ITMW in year t followed by no ITMW in year $t + 1$ (ITIMPROVE) do not appear to change their likelihood of issuing guidance (OCCUR). However, the coefficients of both ITADVERSE and ITWORSE are significantly negative, suggesting that when firms continue to have IT material weaknesses or have newly reported IT material weaknesses, they are less likely to issue a management forecast. OTHERADVERSE is also negative and significant, which indicates that firms having two consecutive years of non-IT material weaknesses are also likely to stop issuing forecasts.

Correlated Omitted Variables: Innate Volatility

Because innate volatility could affect both IT material weaknesses and management forecast accuracy, if not measured properly, it could be a potential omitted variable. Although we include variables intended to control for innate volatility in our analyses, such controls could be incomplete. In this section, we further explore the possibility of endogeneity caused by the possible omission of the construct, innate volatility. First, we employ the "omitted variables" variant of the Hausman (1978, 1983) test to determine if ITMW exhibits evidence of endogeneity, possibly caused by the omitted variable, innate volatility.[27] The test is unable to reject the null of no endogeneity.

Second, following DeFond et al. (2002) and Feng et al. (2009), we implement a two-stage procedure from Nelson and Olson (1978) to estimate a simultaneous equations model. Specifically, in the first stage, we estimate a probit model of

[26]Without the data requirement of point or range management forecast, 18% of internal control material weakness firms have IT control material weaknesses. For firms with control deficiencies, or significant deficiencies in the IT area, our study is likely to have similar implications.

[27]To conduct the Hausman test, we use the following equation: $ITMW = b_0 + b_1 LnAT + b_2 BIG4 + b_3 GROWTH + b_4 LEVERAGE + b_5 LOSS + b_6 SEGMENT + b_7 FOREIGN + b_8 CFO\_VOLATILITY + b_9 ABSCHGROA + b_{10} STD\_AF + b_{11} ANALYST$ + Industry and Year Dummies.

Table 10. Regression Analyses on the Relationship Between IT Material Weaknesses and Management Forecast Accuracy after Considering the Material Weaknesses Related to Revenue and Cost of Goods Sold

Dependent Variable = MFERROR

		Panel A			Panel B		
	+/-	Coeff.	t-stat.	p-value	Coeff.	t-stat.	p-value
Intercept		0.016	1.80	0.071	0.016	1.80	0.071
ITMW	+	0.012	2.79	0.002			
OTHERMW	+	0.002	1.58	0.058			
REV/COGS	+	0.004	1.40	0.080			
ITMW_REV/COGS	+				0.018	3.64	0.001
ITMW_NOREV/COGS	+				0.015	2.39	0.009
NOITMW_REV/COGS	+				0.007	2.55	0.005
NOITMW_NOREV/COGS	+				0.002	1.50	0.067
LnAT	-	-0.002	-4.68	0.001	-0.002	-4.69	0.001
BIG4	?	-0.001	-0.45	0.655	-0.001	-0.44	0.664
GROWTH	+	-0.005	-3.98	0.001	-0.005	-3.98	0.001
LEVERAGE	+	-0.001	-1.15	0.251	-0.001	-1.15	0.251
LOSS	+	0.000	0.55	0.290	0.000	0.55	0.292
SEGMENT	+	0.001	0.79	0.215	0.001	0.79	0.213
FOREIGN	+	0.013	7.79	0.001	0.013	7.79	0.001
CFO_VOLATILITY	+	0.024	1.74	0.041	0.024	1.75	0.040
ABSCHGROA	+	0.041	5.75	0.001	0.041	5.75	0.001
DISPFOR	+	0.026	3.94	0.001	0.026	3.94	0.001
HORIZON	+	0.004	8.82	0.001	0.004	8.76	0.001
SURPRISE	+	1.155	13.36	0.001	1.155	13.38	0.001
IMR	+	-0.002	-0.56	0.573	-0.002	-0.57	0.568
Industry Dummies		Included			Included		
Year Dummies		Included			Included		
Total Obs. =		5230			5230		
ITMW Obs. =		74					
OTHERMW Obs. =		408					
REV/COGS Obs. =		149					
ITMW_REV/COGS Obs. =					44		
ITMW_NOREV/COGS Obs. =					30		
NOITMW_REV/COGS Obs. =					105		
NOITMW_NOREV/COGS Obs. =					229		
F-value		57.32			56.45		
Adj. R^2		0.416			0.415		

All t-statistics are robust standard error adjusted. P-values are one-tailed for signed expectations, and two-tailed for unsigned expectations. See Table 4 for variable definitions.

Table 11. Ordered Probit Regression Analyses on the Relations Between the Change of IT Control Quality and the Change of Management Forecast Occurrence

Dependent Variable = OCCUR				
	+/-	**Coeff.**	**Chi-square**	**p-value**
Intercept1		1.622	29.46	<.0001
Intercept2		-3.246	11736.10	<.0001
ITIMPROVE	+	-0.051	0.14	0.711
ITADVERSE	-	-0.290	2.18	0.070
ITWORSE	-	-0.266	2.12	0.073
OTHERIMPROVE	+	-0.087	1.70	0.192
OTHERADVERSE	-	-0.379	9.31	0.001
OTHERWORSE	-	0.072	0.73	0.391
ΔLnAT	+	-0.005	3.66	0.056
ΔBIG4	?	0.101	0.81	0.368
ΔGROWTH	-	-0.005	0.02	0.438
ΔLEVERAGE	-	-0.025	0.22	0.320
ΔLOSS	-	-0.108	7.23	0.004
ΔSEGMENT	-	-0.024	0.10	0.377
ΔFOREIGN	-	-0.142	5.56	0.009
ΔCFO_VOLATILITY	-	-0.090	0.01	0.469
ΔABSCHGROA	-	-0.076	0.35	0.276
ΔSTD_AF	-	-0.199	4.08	0.022
ΔANALYST	+	0.134	9.57	0.001
Industry Dummies		Included		
Total Obs. =		9553		
ITIMPROVE Obs. =		117		
ITADVERSE Obs. =		51		
ITWORSE Obs. =		66		
OTHERIMPROVE Obs. =		533		
OTHERADVERSE Obs. =		141		
OTHERWORSE Obs. =		333		
Log Likelihood		3987.37		

All p-values are one-tailed for signed expectations, and two-tailed for unsigned expectations.

ΔOCCUR = 1 if the manager issued forecast in year *t* + 1 but did not in year *t*, -1 if the manager did not issue forecast in year *t* + 1 but did in year *t*, and 0 if there was no change in the issuance of forecast.

ΔSTD_AF = the change in the standard deviation of the individual analyst forecasts at the beginning of year *t*.

ΔANALYST = the change in the natural log of total numbers of analysts following.

See Table 4 for other variable definitions.

ITMW on its exogenous determinants (see footnote 27) and calculate the predicted probability of ITMW. We also estimate a linear regression model of ABSERROR on its exogenous determinants (excluding ITMW) and calculate the predicted ABSERROR. In the second stage, we estimate a system of two structural models: a model of ITMW on its exogenous determinants and the predicted ABSERROR estimated by the first stage linear model, and a model of ABSERROR on its own exogenous determinants and the predicted probability of ITMW estimated using the first stage probit model. The untabulated results show the coefficient on the predicted probability of ITMW remains significantly positive (p-value = 0.039). Thus, our results remain the same even after controlling for potential simultaneity bias that may have been induced by innate firm volatility.

Conclusions

Data quality research discusses the pervasive impact of the quality of an organization's management information systems on management decision making. However, prior studies generally do not have direct data to test the link between systems quality and information quality, via actual decision-making outcomes. SOX 404 requires management and auditors to report on the effectiveness of internal controls over the financial reporting component of the management information system. Managers make critical decisions, in the form of earnings forecasts, using the data produced by these systems. Using SOX 404 control reports, we assess the impact of controls on the informational quality of these systems, via decision-making outcomes, by assessing the accuracy of the management forecasts when IT material weaknesses are present.

We hypothesize and find evidence that firms with IT material weaknesses in their financial reporting system are associated with less accurate management forecasts than the forecasts for firms that do not have material weaknesses as well as firms that have non-IT material weaknesses in their FRS. Change analyses suggest that the improvement (deterioration) of IT control quality is associated with a decrease (increase) in the forecast errors. In addition, using IT control categories based on prior literature, we find that systems with IT material weaknesses related to data processing integrity have the least accurate management earnings forecasts. We conclude that systems with IT control problems related to data processing issues are negatively associated with the quality of decision-making outcomes compared to other types of IT control problems.

Our study has several limitations. First, it is possible that firms reporting IT material weaknesses have greater innate volatility, and this volatility could drive our results. Although we include several controls intended to capture firm innate volatility, conduct change analyses, and explicitly test for endogeneity, we cannot completely rule out this alternative explanation. Second, there is a lack of consensus regarding what exactly are the best IT control categories and how each one should be defined. We based our categories on a synthesis of prior data and system quality literature; however, an argument could be made for different dimensions. Third, the coding of IT material weaknesses is based upon what firms report. While we tried to be as systematic as possible with our coding, there are no guarantees that the reported weaknesses have the same level of severity at different firms as the level of granularity is difficult to determine based on the SOX 404 reports.

Subject to these caveats, our study contributes to the IS literature by providing initial archival evidence linking overall IT controls and their relative quality dimensions to the quality of management decision outcomes. We call on future research to assess the impact of different information quality dimensions as well as COBIT-inspired information criteria to see how they impact various types of management and other system user decisions. Decision support, enterprise, and business intelligence systems exist to provide more, and hopefully better quality, information to the users. Linking the data quality to the ultimate decision-making quality can only enhance the development and use of such systems.

Acknowledgments

Thanks to Matt Bovee, Fred Davis, and Suzanna Hicks for comments and suggestions.

References

Agmon, N., and Ahituv, N. 1987. "Assessing Data Reliability in an Information System," *Journal of Management Information Systems* (4:2), pp. 34-44.

Ajinkya, B., Bhojraj, S., and Sengupta, P. 2005. "The Association Between Outside Directors, Institutional Investors and the Properties of Management Earnings Forecasts," *Journal of Accounting Research* (43:3), pp. 343-376.

AICPA. 2001. *The Effect of Information Technology on the Auditor's Consideration of Internal Control in a Financial Statement Audit.* Statement on Auditing Standards No. 94, American Institute of Certified Public Accountants.

AICPA. 2002. *Consideration of Internal Control in a Financial Statement Audit,* Interim Auditing Standard AU Section 319, American Institute of Certified Public Accountants (http://www.pcaobus.org/standards/interim_standards/auditing_standards/au_319.html).

Ballou, D. P., and Pazer, H. L. 1995. "Designing Information Systems to Optimize the Accuracy-Timeliness Tradeoff," *Information Systems Research* (6:1), pp. 51-73.

Baginski, S. P., and Hassell, J. M. 1990. "The Market Interpretation of Management Earnings Forecasts as a Predictor of Subsequent Financial Analyst Forecast Revision," *The Accounting Review* (65:1), pp. 175-190.

Chengalur-Smith, I., and Pazer, H. 1999. "The Impact of Data Quality Information on Decision Making: An Exploratory Analysis," *IEEE Transactions on Knowledge and Data Engineering* (11:6), pp. 853-864

COSO. 1992. *Internal Control-Integrated Framework*, Committee of Sponsoring Organizations of the Treadway Commission, Jersey City, NJ: AICPA.

DeFond, M., Raghunandan, K., Subramanyam, K. R. 2002. "Do Non-audit Service Fees Impair Auditor Independence? Evidence from Going Concern Audit Opinions," *Journal of Accounting Research* (40), pp. 1247-1274.

DeLone, W. H., and McLean, E. R. 1992. "Information Systems Success: The Quest for the Dependent Variable," *Informatin Systems Research* (3:1), pp. 60-95.

Doyle, J., Ge, W., and McVay, S. 2007. "Determinants of Weaknesses in Internal Control over Financial Reporting," *Journal of Accounting and Economics* (44:1/2), pp. 193-223.

Feng, M., Li, C., and McVay, S. 2009. "Internal Control and Management Guidance," *Journal of Accounting and Economics* (48:2/3), pp. 190-209.

FASB. 1980. *Qualitative Characteristics of Accounting Information*, Statement of Financial Accounting Concepts No. 1, Financial Accounting Standards Board, Norwalk, CT: FASB.

Fisher, C. W., Chengalur-Smith, I., and Ballou, D. P. 2003. "The Impact of Experience and Time on the Use of Data Quality Information in Decision Making," *Information Systems Research* (14:2), pp. 170-188.

Grant Thornton. 2006. "Getting Business Benefits from 404 Compliance," Grant Thornton CorporateGovernor Series, February.

Hausman, A. 1978. "Specification Tests in Econometrics," *Econometrica* (46), pp. 1251-1271.

Hausman, A. 1983. "Specification and Estimation of Simultaneous Equations Models," in *Handbook of Econometrics, Volume I*, Z. Griliches and M. D. Intriligator (eds.), Amsterdam: North-Holland, pp. 391-448.

Healy, P. M., and Palepu, K. G. 2001. "Information Asymmetry, Corporate Disclosure, and the Capital Markets: A Review of the Empirical Disclosure Literature," *Journal of Accounting & Economics* (31:1-3), pp. 405-440.

ITGI. 2004. "IT Control Objectives for Sarbanes–Oxley: The Importance of IT in the Design, Implementation and Sustainability of Internal Control over Disclosure and Financial Reporting," IT Governance Institute, Rolling Meadows, IL (http://www.scribd.com/doc/6893609/IT-Control-Objectives-for-SarbanesOxley).

ITGI. 2007. "COBIT® 4.1," IT Governance Institute, Rolling Meadows, IL (http://www.isaca.org/Knowledge-Center/cobit/Pages/Downloads.aspx).

ITGI. 2006. "IT Control Objectives for Sarbanes–Oxley: The Role of IT in the Design and Implementation of Internal Control over Financial Reporting," IT Governance Institute, Rolling Meadows, IL.

Klamm, B. K., Kobelsky, K., and Watson, M. W. 2011. "An Evaluation of Future Internal Control Effectiveness," Working Paper, North Dakota State University, Baylor University, and Mississippi State University.

Klamm, B. K., and Watson, M. W. 2009. "SOX 404 Reported Internal Control Weaknesses: A Test of COSO Framework Components and Information Technology," *Journal of Information Systems* (23:2), pp. 1-23.

Krishnan, R., Peters, J., Padman, R., and Kaplan, D. 2005. "On Data Reliability Assessment in Accounting Information Systems," *Information Systems Research* (16:3), pp. 307-326.

Lee, Y. W., Strong, D. M., Kahn, B. K., and Wang, R. Y. 2002. "AIMQ: A Methodology for Information Quality Assessment," *Information & Management* (40), pp. 133-146.

Lundholm, R., and Sloan, R. 2006. *Equity Valuation and Analysis*, New York: McGraw-Hill.

Miller J., and Doyle, B. A. 1987. "Measuring the Effectiveness of Computer-Based Information Systems in the Financial Services Sector," *MIS Quarterly* (11:1), pp. 107-124.

Nelson, F., and Olson, L. 1978. "Specification and Estimation of A Simultaneous-Equation Model with Limited Dependent Variables," *International Economic Review* (19:3), pp. 695-709.

Nelson, R. R., Todd, P. A., and Wixom, B. H. 2005. "Antecedents of Information and System Quality: An Empirical Examination Within the Context of Data Warehousing," *Journal of Management Information Systems* Spring (21:4), pp. 199-235.

Patell, J. M. 1976. "Corporate Forecasts of Earnings per Share and Stock Price Behavior: Empirical Tests," *Journal of Accounting Research* (14:2), pp. 246-276.

PCAOB. 2007. *Auditing Standard No. 5: An Audit of Internal Control over Financial Reporting That Is Integrated with an Audit of Financial Statements*, Public Company Auditing Oversight Board, New York (http://pcaobus.org/Standards/Auditing/Pages/Auditing_Standard_5.aspx).

PCAOB. 2003. *Section 3. Professional Standards: Rule 3200T. Interim Auditing Standards*, Public Company Auditing Oversight Board, New York (http://pcaobus.org/Rules/PCAOBRules/Pages/Section_3.aspx).

Penman, S. B. 1980. "An Empirical Investigation of the Voluntary Disclosure of Corporate Earnings Forecasts," *Journal of Accounting Research* (18:1), pp. 132-160.

Petersen, M. 2009. "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches," *Review of Financial Studies* (22:1), pp. 435-480.

Pierce, E. M. 2004. "Assessing Data Quality with Control Matrices," *Communications of the ACM* (47:2), pp. 82-86.

Pipino, L. L., Lee, Y. W., and Wang, R. Y. 2002. "Data Quality Assessment." *Communications of the ACM* (45:4), pp. 211-218.

Pownall, G., and Waymire, G. 1989. "Voluntary Disclosure Credibility and Security Prices: Evidence from Management Earnings Forecasts, 1969–73," *Journal of Accounting Research* (27:2), pp. 227-245.

Raghunathan, S. 1999. "Impact of Information Quality and Decision-Maker Quality on Decision Quality: A Theoretical Model and Simulation Analysis," *Decision Support Systems* (26), pp. 275-286.

Redman, T. C. 1998. "The Impact of Poor Data Quality on the Typical Enterprise," *Communications of the ACM* (41:2), pp. 79-82.

SEC. 2003. *Final Rule: Management's Reports on Internal Control Over Financial Reporting and Certification of Disclosure in Exchange Act Periodic Reports*, Securities and Exchange Commission, Washington, DC (http://www.sec.gov/rules/final/33-8238.htm)/

Siponen M. T., and Oinas-Kukkonen, H. 2007. "A Review of Information Security Issues and Respective Research Contributions," *ACM SIGMIS Database*, (38:1), pp. 60-80.

Stratton, W. O. 1981. "Accounting Systems: The Reliability Approach to Internal Control Evaluation," *Decision Sciences* (12:1), pp. 51-67.

Strong, D. M., Lee, Y. W., and Wang, R. Y. 1997. "Data Quality in Context," *Communications of the ACM* (40:5), pp. 103-110.

Wang, R. Y. 1998. "A Product Perspective on Total Data Quality Management," *Communications of the ACM* (41:2), pp. 58-65.

Wang, R. Y., and Strong, D. 1996. "Beyond Accuracy: What Data Quality Means to Data Consumers," *Journal of Management Information Systems* (12), pp. 5-34.

Wang, R. Y., Storey, V. C., and Firth, C. P. 1995. "A Framework for Analysis of Data Quality Research," *IEEE Transactions on Knowledge and Data Engineering* (7:4), pp. 623-640.

Williams, P. A. 1996. "The Relation Between a Prior Earnings Forecast by Management and Analyst Response to a Current Management Forecast," *The Accounting Review* (71:1), pp. 103-115.

Wixom B. H., and Todd, P. A. 2005. "A Theoretical Integration of User Satisfaction and Technology Acceptance," *Information Systems Research* (16:1), pp. 85-102.

Zhang, I. X. 2007. "Economic Consequences of the Sarbanes–Oxley Act of 2002," *Journal of Accounting and Economics* (44:1/2), pp. 74-115.

About the Authors

Chan Li is an assistant professor at the University of Pittsburgh. She received her Ph.D. in Accounting at the University of Kansas. Her research interests include economic consequences of auditing, internal controls, and corporate governance.

Gary F. Peters is an associate professor and the Doris M. Cook Chair of Accounting at the University of Arkansas. He received his Ph.D. in Accounting at the University of Oregon. His research focuses on risk factors influencing the roles of auditors, information environments, and corporate governance.

Vernon J. Richardson is professor and the S. Robson Walton Chair of Accounting at the University of Arkansas. He received his Ph.D. in Accounting at the University of Illinois. His research focuses on the business value of information technology investments.

Marcia Weidenmier Watson is an associate professor at Mississippi State University. She received her Ph.D. in Accounting at the University of Texas at Austin. Her research interests include information technology, internal controls, business processes, and auditing.

Appendix A

SOX 404 Control Weakness Coding Examples

Firm and Year	Text from SOX 404 Report	Control Issue	Control Category
BioScrip 2005	"Inadequate system and manual controls to prevent the potential overstatement of revenue for cancelled orders and other non-standard transactions in our community pharmacies."	Inadequate system to support business processes.	Data Processing Integrity
Flowserve Corp. 2004	"not achieving operating effectiveness over controls in… software change management."	Program change controls missing or inadequate.	Data Processing Integrity
MGP Ingredients 2006	"Management has identified a programming error in the software application (CMMS) formerly utilized for processing purchasing, receiving and materials maintenance transactions at the Atchison, Kansas facility…"	Programming errors.	Data Processing Integrity
Online Resources Corporation 2007	"the Company's procedures for the supervisory review of the performance by Company personnel of manual controls associated with account analysis and the verification of the accuracy of electronic spreadsheets that support financial reporting were ineffective. This material weakness resulted in deficiencies in the operation of controls not being detected timely and in multiple errors in the Company's preliminary 2007 financial statements, including errors in revenue, interest expense, and share based compensation."	Spreadsheet(s), lack of controls over	Data Processing Integrity
Barrett Business Services Inc. 2008	"Our Company did not maintain effective controls over information technology ("IT"); specifically, general IT controls over program changes and program development were ineffectively designed and/or operating as of December 31, 2008."	Program change controls missing or inadequate Inadequate development and maintenance	Data Processing Integrity
TRC Companies 2006	"The Company did not adequately design controls to maintain appropriate segregation of duties in its manual and computer-based business processes which could affect the Company's purchasing controls, the limits on the delegation of authority for expenditures, and the proper review of manual journal entries"	Segregation of duties not implemented in system	Access and Security
Design Within Reach Inc. 2005	"We did not maintain effective controls over access to our systems, financial applications, and data."	Logical access issues.	Access and Security
Ceridian Corp. 2004	"security control deficiencies surrounding the use of certain information technology applications;"	Security issues.	Access and Security
Integra Life-sciences Holding Corporation 2007	"the Company lacked adequate internal access security policies and procedures"	Logical access and security issues.	Access and Security
Digimarc Co 2004	"Implementation of the new accounting system also was flawed because some of our accounting, finance and operations employees were not properly trained in the use of the new accounting system."	Insufficient training on system.	Structure and Usage
Online Resources Corp. 2006	"While preparing its December 31, 2006 financial statements, the Company discovered that it needed to correct errors, primarily related to the Princeton acquisition and the integration of that company's accounting system and processes."	Disparate (non-integrated) systems	Structure and Usage
Federal National Mortgage Association 2004	"We did not maintain and clearly communicate information technology policies and procedures. This weakness contributed to our inadequate internal control over financial reporting systems"	Weak Information & Communication	Structure and Usage