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Auditors' Training and Proficiency in Information Systems: A Research Synthesis

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ABSTRACT: This paper presents a review of extant literature examining issues relating to auditors' knowledge of and training in information systems. This review is important due to the rapidly increasing use of technology in business, recent changes in U.S. auditing standards on information technology and internal control, and signals of interest by regulators in possible future standards on auditors' information systems (IS) knowledge. We review prior research both to provide information on the current status of our literature, and to identify specific questions about which there is insufficient research. Our review covers three broad areas. First, we review the current environment of IS in financial reporting and assurance, and summarize related auditing standards. Second, we consider prior research on how financial statement ("generalist") auditors acquire and use IS knowledge. Third, we discuss research on the interaction between generalist and IS auditors. Each section concludes with suggestions for future research.

Keywords: information systems; auditing; information technology; audit expertise.

I. INTRODUCTION

This paper summarizes research in the auditing and accounting information systems literatures on auditors' knowledge and skills relevant to performing audits of the financial statement information provided by today's complex, technology-enabled information systems (IS). This research synthesis was initially motivated by discussions of the Public Company Accounting Oversight Board's (PCAOB) Standing Advisory Group (SAG) about whether auditing standards for public companies should specifically consider auditors' knowledge of IS (PCAOB 2004). Our literature review, initiated to address the

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SAG's questions, revealed many research questions of potential interest to the academic research community.

Current U.S. auditing standards and the interim quality control standards adopted by the PCAOB in 2003 have limited requirements regarding auditor competency. For example, Section 210 of the General Standards (adopted by the PCAOB from prior standards of the Auditing Standards Board) states broadly that auditors should have "adequate technical training and proficiency as an auditor" (PCAOB 2003). Quality Control Standard No. 40, also adopted by the PCAOB, notes that partners in charge of audit engagements should have "an understanding of how the organization is dependent on or enabled by information technologies; and the manner in which information systems are used to record and maintain financial information."[1] However, detailed guidance is not provided for individual auditors or firms on what constitutes the required knowledge base to competently perform these tasks. Conceptually, existing audit standards are broadly stated to allow the profession to adapt and change with the business environment and with technological advances.

However, the PCAOB has recently noted that future auditors of issuers will likely need to develop and maintain even higher levels of competence with respect to understanding and evaluating information systems and internal controls, preventing and detecting fraud, and evaluating the fair value of assets and liabilities. The complexity of IS and the increasingly important role of IS in business have no doubt motivated the PCAOB to consider whether more guidance should be provided, which would represent a shift from the general guidance in U.S. auditing standards toward a more prescriptive approach. Such a shift would have far-reaching implications for the auditing profession (e.g., regarding continuing professional education) and educational institutions. The goal of this paper is to bring together disparate lines of research around this topic, and to motivate further research attention toward it. This paper contributes by noting gaps in this literature, and making specific recommendations for future research.[2]

This literature synthesis proceeds as follows. First, we discuss the role of IS in financial reporting and assurance, including recent environmental changes related to IS in business, and changes in auditing standards and practice related to IS. We next review research on the need for and development of IS expertise by "generalist" financial statement auditors. We then discuss research related to IS auditors,[3] the differences in knowledge between generalists and IS auditors, and the interaction between them. Because these issues have significant implications for accounting curricula, we end with a call for research on IS in the context of accounting and auditing education. Within each main section of our review, we summarize the relevant research and pose research questions to address instances in

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[1] Similarly, the new Statement on Quality Control Standards No. 7 (AICPA 2007b), applicable after January 1, 2009, notes (in Section 45) in general terms that engagement partners should have "(a) sufficient understanding of how the organization is dependent on or enabled by information technologies and the manner in which the information systems are used to record and maintain financial information, to determine when involvement of an IT professional is necessary for an audit engagement."

[2] This paper is among a series of research syntheses supported by the Auditing Section of the American Accounting Association (AAA), to facilitate the development of auditing standards and to inform the PCAOB of insights from the academic literature. The views expressed in this paper are those of the authors and do not reflect an official position of the AAA or its Auditing Section. In addition, the paper does not purport to reflect the views of the PCAOB or its staff, and the author team was not selected or managed by the PCAOB.

[3] This specialty audit field has had many names over the years. In its infancy, IS Audit was called "EDP Audit." The names Information Systems (IS) Audit and Information Technology (IT) Audit may be used interchangeably now, although some would argue that IT Auditors deal with more technical issues, such as general controls over computers, while IS Auditors evaluate application system controls and perform Computer-Aided Audit Techniques (CAATs) in support of general auditors. This article will use the term IS Audit to refer to all of these functions discussed in the accounting literature, past and present.

which future research appears warranted. The paper closes with a summary of implications for research, practice and standard-setting.

II. THE CURRENT ENVIRONMENT OF IS AND ITS ROLE IN FINANCIAL REPORTING AND RELATED ASSURANCE

Information System Trends in the Business Environment

As background to our review of the literature, we consider the implications of several trends in IS that impact the financial statement audit. Businesses have invested in IS because that investment can lead to substantial economic benefits (Lim et al. 2008; Dehning et al. 2003; Im et al. 2001) and competitive advantages (Ranganathan and Brown 2006; Burg and Singleton 2005). In their synthesis of the literature on returns on investments in IS, Dehning and Richardson (2002, 8) report that numerous studies have found "positive payoffs" from these investments (e.g., Stratopoulos and Dehning 2000; Dewan and Min 1997; Brynjolfsson and Hitt 1995, 1996; Hitt and Brynjolfsson 1996). Companies are also willing to radically change the nature of their investment, such as outsourcing of IS, when such methods hold the promise of future benefits. In the following paragraphs, we discuss three implications of the changing IS environment for the audit process. First, IS are increasingly automated, such that business processes in many organizations operate without human intervention. Second, businesses are expanding their use of enterprise resource planning (ERP) systems. Third, the lure of cost savings and access to scarce resources is encouraging many companies to outsource critical IS processes.

First, the ability to capture and report the financial statement effects of economic events has evolved to the point that key business processes in many companies are entirely automated (e.g., inventory reorders and credit approval for sales on account). In complex systems, automated operations can include crucial functions such as job flow, database monitoring, detection of hardware and software problems and failures, security management, making backups, and responding to systems failure (Green et al. 2005). Accounting and financial reporting are also among the business processes increasingly performed using automated technologies. Most IS include application controls (e.g., tests of input accuracy and tests for data reasonableness) that are designed to ensure the validity of transactions. These automated controls are important to the auditor because they are a key means of reducing the likelihood of misstatements (Messier et al. 2004). Furthermore, automated controls are critically important in mitigating the risks of certain frauds (Bell et al. 1998; Collier et al. 1991). While automated controls contribute to efficiency, extensive reliance on them comes with the risk that the controls may not function as expected. For instance, automated controls may not be activated during a system implementation, or may be circumvented by technologically savvy employees. Additionally, highly automated controls may provide no audit trail, which can complicate the audit of these processes.

The second feature of recent IS investment that has implications for the financial statement audit is the emergence of ERP systems. Sutton (2006) observes that ERP systems allow entities to tightly couple the company's IS with its business and supply chain partners. Such extended enterprises pose new challenges to the auditor, since they redefine the boundaries of the entity/client to include "the myriad of inter-organizational relationships that represent upstream and downstream trading partners in the supply chain, outsourcers, and other electronically connected business partners" (Sutton 2006, 98–99). Wright and Wright (2002) provide further evidence on ERP audit matters by interviewing IS auditors in large audit firms. Their discussions confirm that ERP systems present several unique control risks. First, implementation processes have an important impact on system reliability. Second, ongoing risks differ across applications and vendors. Third, obtaining assurance on these

systems requires greater focus on testing the process rather than the output. All of these matters represent challenges for auditors.

A final trend is the outsourcing of accounting-related IS. The functionality that is outsourced can vary dramatically: from little more than connectivity services, having limited impact on an organization's internal controls, to the exporting of all IT-related functions, with a significant impact on controls (Lacity and Willcocks 1998). Among the many concerns to the organization from outsourcing are: picking an appropriate vendor, data privacy, data and intellectual property security, establishing effective service-level agreements (SLAs), business continuity planning for the vendor, change management, knowledge continuity planning, and auditability (Musaji 2005; Trivedi 2007). These concerns are exacerbated when outsourcing is also off-shore, due to country-specific risks. In most instances, an organization's auditors will not have access to the information systems housed in an outsourcing vendor's operation, and will be forced to rely on SAS No. 70 assurance regarding the adequacy of controls. Audit risks associated with SAS No. 70 reliance include overestimating the scope of assurance provided and failure to recognize gaps in controls between organizations (ISACA 2002; Mainelli 2005). For example, most outsource vendors, and their SAS No. 70 assurance, cover the data while it is within their organization's boundaries—thus, the controls over data in transit are the responsibility of the outsourcing entity.

Despite the significance of IS and technology to accounting and financial reporting processes, relatively little is known about their impact on the frequencies and types of financial misstatements. Lynch and Gomaa (2003, 296) suggest that IS may "inadvertently provide sophisticated means and opportunities for employees to perpetrate fraud." While this may be the case, frauds in complex IS also could be perpetrated by rather simple and straightforward means. Regardless of the manner in which the fraud is perpetrated, an auditor's attention to the basic principles of separation of duties may prevent or detect fraud.

An earlier study by Bell et al. (1998) found few audit differences due to failures in audit clients' IS (i.e., internal-control problems). However, a more recent study by Messier et al. (2004) found that control problems have become more common since the period of the Bell et al. study, and that control problems are more prevalent in computerized environments. Problems arise even from relatively simple technologies, such as spreadsheets. For example, the European Spreadsheet Risks Interest Group cites numerous instances of spreadsheet errors and their impact on financial reports (ESRIG 2007). Significant financial reporting implications may also arise from complex technologies such as ERPs (Sutton and Hampton 2003). For example, Hershey Foods reported a 12 percent drop in revenues in 1999 after a botched ERP implementation (Romeo 2001).

More recently, auditor reports issued under Sarbanes-Oxley Act (SOX) Section 404 have highlighted the implications of IS and related technologies for financial reporting and internal controls over financial reporting.[4] For example, Ge and McVay (2005) report that IS-related problems led a number of companies to disclose material weaknesses as required by Section 404 of SOX. Also, Canada et al. (2006) find that about 24 percent of companies with material weaknesses in their first Section 404 report had some issue with information

[4] The following examples illustrate the relation of IS to internal control. In developing an understanding of the client's internal controls, the auditor should trace transactions through the information system relevant to financial reporting. In addition, when determining whether an account assertion is relevant to the auditor's consideration of internal control, the auditor should consider the nature and complexity of the systems, including the use of information technology by which the company processes and controls information supporting the assertion.

technology reported in their filings. This implies that a substantial number of entities have enough difficulty with technological applications related to financial reporting to cause concern among their auditors about the risk of material misstatements. Bedard and Graham (2008) report that about 21 percent of all deficiencies, detected in a sample of companies by auditors and clients in the Section 404 testing process, relate to problems with information technology controls. However, relatively few of those problems rise to the level of a material weakness. This implies that while the vast majority of systems problems are not visible in Section 404 reports, companies subject to Section 404 are identifying many such issues. Canada et al. (2006) also find higher audit fees associated with clients that disclose IS-based material weaknesses, relative to companies with no reported material weaknesses or companies with material weaknesses not related to IS. They conjecture that some of the increased audit cost is likely due to greater use of IS auditors in these audits.[5]

Taken together, the research cited in this section provides evidence that the use of IS in business is increasing and changing in its basic nature, and that automated controls are intended to produce more reliable financial statement information. However, research on initial SOX Section 404 reports indicate that this goal may not be achieved in a substantial number of public companies. There are several implications for auditing in this environment. First, the pervasiveness of IS and rapid pace of change in the business environment mean that auditors without extensive systems knowledge may have difficulty understanding the complex technology supporting the business processes of their clients. Second, as we discuss in the next section, auditing standards over the last decade have recognized the growing use of automated business processes and controls by expanding the need for auditors to incorporate IS into planning and obtaining evidential matter.

Auditing Standards and Audit Practice Relevant to IS and Internal Control

In this section, we review features of auditing standards and audit practice related to the role of IS in the financial statement audit. Over the past decade, auditing standards have placed increasingly more emphasis on the client's internal-control systems and on the auditor's role in understanding those systems in order to perform an effective audit. Prior to recent changes in standards, auditors often chose not to rely on a company's internal controls in completing an audit, as allowed by auditing standards, gaining assurance from substantive tests (i.e., tests of account balances and transaction amounts) instead. Thus on those engagements, auditors avoided the need to evaluate and test controls.[6] As noted by Briggs (2008), this audit strategy was associated with a "prevalent gap in many external audits—a lack of understanding of IT and its role in a company's finances." Effective in 2001, SAS No. 94 was designed to "raise the bar" by requiring auditors to consider IT as a part of the entity's control environment (Tucker 2001). SAS No. 94 requires that an auditor planning to perform only substantive tests on an engagement must be satisfied that such an approach will be effective. For those audit clients for whom a significant amount of evidential matter is in electronic form, SAS No. 94 warns that it may not be possible to

[5] The causality between the reporting of IS-related material weaknesses and the use of IS auditors is not discussed by Canada et al. (2006). Thus, it is not possible to determine whether the detection of IS-related weaknesses was due to the presence of more IS specialists on those engagements, or whether IS auditors were called in after significant IS-related weaknesses were discovered. Either scenario is possible. It might be assumed that the increased audit costs after discovery of material misstatements signal greater use of IS auditors, who typically bill at higher hourly fees than generalist auditors.

[6] One study based on Norwegian data suggests that auditors use more tests of details rather than attention-directing procedures on audits because they believe that "it is more effective and efficient to conduct such tests than to rely on controls" (Messier et al. 2004). This study reinforces the historical evidence from the U.S. that unless auditing standards prescribe control testing, auditors are more likely to use a substantive approach.

limit detection risk to an acceptable level using a purely substantive strategy. For those clients, the design and effectiveness of controls must be assessed.

The Auditing Standards Board's (ASB) Statement on Auditing Standards (SAS) No. 109 (effective in 2006) further increases the need for auditors to consider the effectiveness of the client's internal controls, which in turn increases the need to evaluate automated as well as manual controls. SAS No. 109 requires that the auditor document the understanding of the control environment, evaluate control design, and determine whether the identified controls have been implemented. Consequently, SAS No. 109 eliminates the option for auditors to "arbitrarily default to maximum control risk and avoid documenting that decision" (McConnell and Schweiger 2007, 23). Under this standard, a strategy of not relying on controls (and thus not testing them) is unlikely to be effective if audit evidence is the result of highly automated processes and is obtained in electronic form. SAS No. 109 also increases the auditor's responsibility to understand the client's IS environment with respect to its effect on the risk of material misstatement. As noted by Kiel (2008, 42), implementation of this standard has been challenging. He notes that firms are recognizing that their staff members need "a higher level of technical competency" and that they must provide more training in both entity-level and activity-level controls. This effect of the standard is seconded by Carney (2008, 44) who says that loss of the option to default to maximum control risk has caused a "huge cultural shift, especially as it relates to documenting and testing internal control."

For public companies subject to SOX Section 404 integrated audits, the current governing standard is the PCAOB's Auditing Standard (AS) No. 5.[7] While anecdotal evidence indicates that the extent of SOX 404 internal-control testing performed by auditors is less than under its predecessor standard (AS No. 2), AS No. 5 still requires auditors to test controls that are considered important in preventing or detecting future material misstatements (or to supervise client testing of those controls). Briggs (2008) notes that while SAS No. 94 was intended to address the gap in auditors' understanding of IS, this understanding among auditors was "sorely lacking" in audit engagements before SOX Section 404 brought effective enforcement to the process.

There is some evidence that reliance on internal control in the financial statement audit is increasing. Janvrin et al. (2008a) report that in 42 percent of a sample of companies with complex IS, auditors relied on controls to some degree. Bedard and Graham (2008) show that in a sample of 2004–2005 audits of clients subject to Section 404, average control reliance was between "some" and "significant" reliance. Another study shows that the adoption of "business risk" audit approaches by some firms in the 1990s might have increased testing of controls. Bierstaker and Wright (2004) investigate the effects of a large international audit firm's adoption of a business-risk audit approach in 1997 on the auditor's choice of a control documentation method and format (i.e., questionnaire, narrative, flowchart, matrices), as well as the extent of tests of controls. Surveying senior auditors before and after the change in audit approach, they find a shift toward predominant use of the

[7] This standard implements the internal control requirements of Section 404 of the Sarbanes-Oxley Act of 2002 (SOX), prescribing that the auditor must understand the "accounts, disclosures, and assertions that present a reasonable possibility of material misstatement to the financial statements and related disclosures" (PCAOB 2006, paragraph 21). Regarding testing of controls, paragraph 39 requires that the auditor "test those controls that are important to the auditor's conclusion about whether the company's controls sufficiently address the assessed risk of misstatement to each relevant assertion." If from these procedures the auditor becomes aware of any internal control deficiencies that have a reasonable possibility of causing a future material misstatement in financial reports (and this deficiency cannot be remediated by the balance sheet date), the auditor must issue an adverse opinion on internal controls.

narrative format, use of fewer documentation methods and formats, and more tests of controls. Bierstaker and Wright (2004) conclude that the emergence of business-risk approaches in auditing resulted in greater reliance on internal controls. However, this does not necessarily mean that reliance on *computerized* controls has increased. Moreover, by using a single format to document internal controls, the auditor is less likely to identify internal control weaknesses than when multiple formats are used (Bierstaker and Wright 2004, 73). This issue is likely exacerbated by complex IS such as ERPs and the outsourcing of various IS functions (Sutton and Hampton 2003).

The recent changes in auditing standards outlined above imply that professional requirements around internal controls have become more extensive. Research conducted within the past decade provides varying results on the extent to which auditors have incorporated testing of controls into engagements. Both academic and practice literatures note a formerly widespread tendency not to rely on internal controls during the financial statement audit (e.g., Waller 1993; Briggs 2008). This tendency likely reduced auditors' familiarity with control testing, but there is some evidence that this pattern is changing. In the following section, we consider auditing standards and audit practice relating to interaction between generalist and IS auditors on financial statement audit engagements.

Auditing Standards Regarding Use of IS Auditors on the Engagement

Current auditing standards recognize that auditors may need to request the assistance of IS auditors to supplement their auditing expertise for some tasks, including evaluating the design and effectiveness of the company's IS controls. SAS No. 94 notes that an auditor might need specialized skills to assess the effect of IS on the audit, to understand the client's controls, and to perform control and substantive tests (Tucker 2001). Factors that suggest the need for specialists include: system complexity and usage, system changes or implementations, the extent of data sharing, the extent of the client's involvement in e-commerce, the client's use of emerging technologies, and the extent to which audit evidence is only available in electronic form (AICPA 2006b). Further, the new suite of risk-assessment auditing standards (e.g., SAS Nos. 108, 109, and 110) also consider the involvement of IS auditors during audit engagements (AICPA 2006a, 2006b, 2006c). For example, SAS No. 108 provides that the auditor should consider whether specialized skills are needed to understand the complexity of a company's systems and IS controls, changes to existing systems or implementations of new ones, or evidence that is available in electronic form only (AICPA 2006a). If specialized skills are needed in the IS area, engagement teams are directed to seek the assistance of a professional possessing IS skills (PCAOB 2004). Thus, the engagement partner's decision to incorporate a systems expert (from inside or outside the firm) into the team is a judgment based on matching the skills of the team members with the characteristics of the client and its business.

IS auditors are considered to be members of the audit-engagement team who require the same supervision as any other member of the team (e.g., Tucker 2001). Supervision of IS auditors involves directing their efforts toward accomplishing the objectives of the audit and determining whether those objectives were accomplished. Supervision requirements include informing team members of their responsibilities and the objectives of procedures to be performed; informing them of accounting and auditing questions raised during the audit so they may assess their significance; reviewing the work performed to determine whether it was adequately performed and whether results are consistent with the conclusions in the auditor's report; and resolving any differences of opinion concerning accounting and auditing issues arising among team members. To perform these duties adequately, the supervisor must have sufficient IS knowledge to communicate the objectives of the IS

auditor's work, evaluate whether the planned procedures will meet the audit objectives, and evaluate the results of the procedures applied as they relate to other planned audit procedures.

Suggestions for Future Research on the Current Environment of IS and Financial Reporting Assurance

The above summary of the status of IS in businesses and the current regulatory and practice environments suggests a number of possibilities for future research. First, research tracking the nature and extent of financial misstatements associated with ERPs and other complex IS would be helpful in contributing to our understanding of where corporate controls are weak. As companies increasingly adopt these systems, their potential impact on the reliability of financial reporting grows. Such research could identify where the risks exist and how auditors address them. For example, how can auditors effectively address the risk of misstatement when a client's IS is coupled with its business and supply chain partners? Similar questions arise when critical IS is outsourced. How does an auditor obtain the necessary level of assurance on these complex systems and relationships? Such research would be helpful in SOX 404 integrated audits as well as in financial statement audits of nonpublic companies and nonprofits performed under ASB standards.

Second, little information is available about the IS experience of generalist auditors in the current audit environment. A number of researchable questions arise. For instance, how does the complexity of the client's IS affect the conduct of the audit, including: the format used to document internal controls; the number of documentation formats used; the nature, timing, and extent of internal-control tests; and the degree of reliance on internal controls? Among those companies subject to SOX Section 404, what is the nature and extent of internal-control testing on integrated audit engagements *vis-à-vis* other types of tests? Has this ratio changed as auditors have gained experience with Section 404, and does the mix of internal-control tests versus substantive tests impact audit efficiency and/or effectiveness? How effective are current audit practices in situations where automated internal controls leave no audit trail? Has the greater use of internal-control tests in integrated audits resulted in advances in control testing for clients with complex IS? For those companies with IS-related material weaknesses, are generalist auditors or IS auditors more effective at identifying the weaknesses? What are the impediments to participation of IS auditors in the financial statement audit?

Future research might also address changes in the regulatory environment that may impact generalist auditors' attention to IS. This is especially important as most relevant research on the auditor's assessment of internal-control risk and reliance on internal controls was performed prior to recent changes in auditing standards. First, AS No. 5 promotes a risk-based approach to Section 404 activities. How does the nature of a client's IS influence an auditor's risk-based decisions to increase or decrease tests of controls? Second, smaller public companies are scheduled to become subject to auditor testing requirements of Section 404 in the near future. Anecdotal evidence suggests that these companies have been preparing for Section 404 by improving IS control systems. Research could investigate the nature of these improvements and how they affect the quality of financial reporting. Third, the ASB's new suite of risk-assessment standards for nonpublic companies requires the auditor to document an understanding of the client's internal controls (including the IS environment), evaluate control design and assess implementation. As auditors implement this standard, more information will be available on the status of these environments. Research could use this information to investigate factors associated with systems quality, and

how the quality of the systems environment is associated with control reliance and other audit-planning judgments and decisions among nonpublic company engagements.

The above research questions are certainly not exhaustive, but serve as a starting point for further research on the IS/audit interface.

III. THE "GENERALIST" AUDITOR IN A COMPLEX SYSTEM ENVIRONMENT

As the business and audit environments have changed with regard to IS, the "generalist" financial statement auditor has been faced with the need to adapt. Bierstaker et al. (2001) report results of interviews with IS professionals at four large international audit firms about the impact of IS on the audit process. These professionals agree that "auditors must keep pace electronically with their clients" (Bierstaker et al. 2001, 163). In a speech given at the 2004 Auditing Section Midyear Conference, then Chief Auditor of the PCAOB, Douglas Carmichael, noted his concern regarding the IS knowledge of generalist auditors: "The reality is that there is often insufficient discussion between the computer auditors and general auditors for the general auditors to know what assurance is provided by the work being done by the computer specialists. The general auditors do not have enough knowledge to know when computer audit techniques must be used to retrieve data directly from the company's computerized accounting records" (Carmichael 2004, 132). While there is little research on auditors' judgments and decisions in technology-driven environments, a few studies support Carmichael's concern. For instance, Bedard et al. (2005) consider audit planning for client information systems. They find that auditors are less likely to adjust for system-security issues (general controls) than for information-quality issues (application controls). This study raises the issue of whether generalist auditors react appropriately to the pervasive risks associated with general controls.

An early study (Grabski et al. 1987) finds that during systems development, generalist auditors and IS auditors do not differ significantly in the identification of control weaknesses or the recommendation of control procedures. However, a more recent comparison of generalist to IS auditors suggests that generalist auditors may underestimate the overall audit risk created by systems-oriented risk factors. Hunton et al. (2004) compare risk assessments between clients with ERP and non-ERP systems and between generalist and IS auditors. They find that generalist auditors are less likely to understand the control risks presented by more complex ERP systems. The implication is that, as the complexity of systems increases along with the need for automated controls, there is an increased need for auditors to be knowledgeable in more complex IS and controls and, perhaps, an increased need for the involvement of IS specialists in the audit as well. More recently, Brazel and Agoglia (2007) find that generalist auditors' IS expertise is a significant determinant of control risk judgments in a complex computing environment. They also find that auditors with greater IS expertise are better at identifying ERP risks, and at incorporating evidence provided by IS auditors into their planned substantive testing.

Other studies address this issue by comparing the knowledge, judgments, and decisions of generalist auditors to IS auditors. Several such studies confirm that IS auditors have a distinctly different way of looking at internal controls and IS than generalist auditors do (Biggs et al. 1987; Viator and Curtis 1998; Curtis and Viator 2000). This different perspective is likely developed through education and experience specific to the IS auditor's role. For example, Viator and Curtis (1998) identify significant differences in the type and extent of auditors' control reliance judgments based on education and experience. Specifically, auditors with more IS education and experience exhibited greater willingness to rely

on automated controls. Expanding on this result, Curtis and Viator (2000) find that auditors possess multiple, simultaneous knowledge structures related to internal controls—primarily organized around control objectives and transaction flows. As might be expected, the type and amount of both education and experience differentially impact the extent of each internal control knowledge-structure dimension. The extent of development in each dimension enhances performance in internal-control review. Thus, IS training and experience, which assist in the development of the transaction flow dimension, may be as important as accounting education and experience in effective internal-control evaluation.

As we note in the previous section, recently issued auditing standards have increased the requirement for engagement teams to focus on a client's systems and business processes. This increased focus is likely to cause increased knowledge development, but further research is needed. Aside from increased practice resulting from new standards, research has investigated other strategies that could be applied to help firms ensure that audit professionals are meeting the challenges of the current environment. For instance, Borthick et al. (2006) find that certain types of directed training can help compensate for lack of experience. Thus, firms employing auditors with little IS experience may discover the need to provide training in areas not previously addressed by university curricula.[8] Firms may consider assessment methods for evaluating auditors' knowledge of relevant IS issues (Brazel 2005) and identification of training necessary for continuing knowledge development as technology changes (Litecky and McEnroe 1981; Tussing and Helms 1980).

Another strategy to help auditors is the use of computer-assisted audit techniques (CAATs) software packages such as ACL and IDEA. However, while there is a developing literature demonstrating CAATs and their possible uses (e.g., Liang et al. 2001; Shaikh 2005), there is little research describing the extent of their use in audit practice and the factors associated with their use, or presenting empirical tests of their efficiency and effectiveness. One exception is Janvrin et al. (2008b), who report that auditors make extensive use of CAATs for such applications as internal control evaluation and the testing of online transactions, but the extent of technology use varies across other applications and between Big 4 and non–Big 4 firms. Additionally, two studies have explored the determinants of CAATs usage by generalist auditors (Curtis and Payne 2008; Payne and Curtis 2008). These studies find that auditor willingness to employ CAATs in the financial statement audit is impacted by auditor perceptions of the usefulness of those procedures and concerns regarding the budget impact of CAATs usage. Firms play a significant role in these perceptions through training and other resources they provide, as well as through their communication of support for CAATs usage.

Suggestions for Future Research on the Generalist Auditor in a Complex System Environment

The research cited in this section on the IS knowledge of the generalist auditor in today's environment suggests several researchable issues. For example, further research is certainly needed on how generalist auditors obtain IS knowledge in their professional roles. What training methods are used, and do these methods differ across firms? How do firms

[8] The training needs of the internal audit profession mirror those of public accounting firms. In a recent survey of chief internal audit executives world-wide, Protiviti (2006, 5) found that auditing IS is "clearly the top concern related to Audit Process Knowledge for internal audit professionals." One possible source of training is the Institute of Internal Auditors (IIA). Deloitte & Touche joined with the IIA to develop an IS audit model curriculum for practitioner training (IIA 2007). Their training curriculum includes such topics as an overview of IS audit for chief auditing executives (CAEs), information security concepts, unique auditing issues for various ERPs, and computer-aided audit techniques (CAATs).

assess whether IS training is achieving its intended results? Research could also examine whether training is as effective as work experience in acquiring knowledge of specific types of IS. Such research could be based on theories of knowledge development, and prior studies of knowledge acquisition in other auditing contexts (for a review, see Bonner 2008).

Once on engagements, what is the level of decision quality among generalist auditors with regard to performing engagements in complex systems environments? For example, to what extent does the use of an ERP system impact the ability of generalist auditors to conduct the audit? What are the implications of particular ERP features, such as those that allow for continuous monitoring, on audit planning and risk assessment? If generalist and IS auditors differ in their judgments and decisions in the systems domain, do the differences affect audit efficiency or effectiveness? When and how do auditors (at firms of differing sizes) employ CAATs, and what are the implications of using these tools on engagements? What factors influence the voluntary use of CAATs by auditors? Research addressing these questions is likely to contribute to our understanding of audit-decision quality in today's environment, and potentially to impact audit firms' practices in assisting their professionals in developing their IS knowledge. In the following section, we explore research related to the issues surrounding the interaction of the generalist auditor with IS auditors.

IV. INFORMATION SYSTEMS AUDITORS AND THEIR INTERACTION WITH GENERALIST AUDITORS

The Use of IS Auditors on Audit Engagements

As previously noted, current auditing standards provide guidance to generalist auditors in making the decision to involve IS auditors. This decision is based on a matching of skills of the engagement team, relative to the need for specialized knowledge based on demands arising from the nature of the client's business. Because computerized information systems require a specialized skill set (*c.f.*, Tucker 2001; Yang and Gaun 2004), it may be necessary to have IS auditors involved with auditing highly computerized systems to ensure that the necessary skills for such complex systems are present (Adams et al. 1975; Davis and Dykman 1993; Wright and Wright 2002).

Considering the increased complexity and importance of IS, there is limited relevant academic research on the involvement of IS auditors in audit engagements. In a recent study, Janvrin et al. (2008a) find that among a sample of clients from 2002–2003 (i.e., after SOX but before the effective date of Section 404) with highly computerized transaction and financial reporting systems, only 42 percent of these engagement teams relied on controls. Of those, 61 percent used IS auditors on their audits. Consequently, nearly three-fourths of the engagements in the survey did not use an IS auditor in conducting audits of highly computerized clients. Moreover, auditors from Big 4 firms tended to rely on internal controls more than those from non-Big 4 firms. Interestingly, non-Big 4 firms used IS auditors more when they relied on controls than when they did not rely on them, but there was no difference in the usage of IS auditors by the Big 4 as to whether or not they relied on controls. Because the Janvrin et al. study precedes the implementation of SOX Section 404, these findings beg the question of how firms are employing the services of IS auditors in today's environment.

While we are not aware of published evidence on how public accounting firms are using IS auditors following the implementation of SOX Section 404, conversations with engagement partners of two Big 4 firms suggest differences in the current environment. They note that in their firms, IS auditors are required to be assigned to all public company engagements. For non-public companies, these partners report that in their firms, partners of new client engagements routinely consult with the IS auditors to help understand the

client's IS and to determine whether controls are auditable. Two further trends are mentioned by these individuals. First, there are fewer hours of IS auditor participation on engagements compared with five years ago, due to improvements in controls documentation. Second, since implementation of AS No. 5 (PCAOB 2006), the firms are relying more on the client or on consultants hired by the client for controls testing; thus, the engagement team is doing a smaller proportion of its own testing. These comments on the current environment illustrate the great changes that are taking place in practice, which should be investigated through systematic research. Also, it is important to note that both partners are from Big 4 firms, and the experience at smaller firms could very well be different.

A further question relates to how the results of IS auditors' activities are used by generalist auditors. Brazel and Agoglia (2007) find that generalist auditors with greater IS expertise have more appropriate reactions to IS auditor findings. In particular, with more IS knowledge, the generalist auditor can assess the expertise of the IS auditor and appropriately adjust his or her reliance on that auditor. This may be explained, in part, by results of O'Donnell et al. (2000), who examine group decision making with internal control risk assessments in computerized environments. Their results suggest that improved decision quality does result from group decision making, such as when generalist auditors and IS auditors work together. However, they observe common information-sampling bias, in which the group focuses on information shared by most in the group, with less attention to information known by only one group member. This suggests that even with the inclusion of an IS auditor on the audit team, his or her advice and unique knowledge may be excluded from consideration by the group, if the IS auditor is the only one who possesses the knowledge.

Suggestions for Future Research on IS Auditors and Their Interactions with Generalist Auditors

Today's auditing environment and current auditing standards suggest that the use of IS auditors is a key element of effectiveness on many audit engagements, and that their role is likely to increase in importance in the future. However, there is little research related to when these professionals are used on engagements, and how they interact with generalist auditors on those engagements. There are a number of potential research questions in this area. Regarding assignment of IS auditors, further research could be directed at identifying client attributes that trigger the inclusion of IS auditors on the audit team beyond the planning stage. Do these attributes vary across audit firms, such as with firm size or culture/governance characteristics (e.g., how audit engagements are budgeted)? Do they vary according to the IS knowledge or experience of the engagement manager or partner? If so, what specific knowledge requirements are most often not met on the engagement team? In what phases of audit engagements do IS auditors participate, and how does their participation in early stages (e.g., at planning) affect subsequent stages (e.g., evidence evaluation)? Are IS auditors more likely to be included on audits after significant system changes occur? Do generalist and IS auditors reach similar conclusions on similar evidential fact patterns? If not, why do these differences occur and what are their implications for audit quality?

The interplay between generalist and IS auditors is especially important in the integrated internal control/financial statement audit under SOX Section 404. What proportion of the integrated audit is (or could be) performed by IS auditors? What are the impediments to greater use of IS auditors on an integrated audit? How is the presence of an IS auditor on the audit team related to the likelihood of reports of technology-related material weaknesses?

Other research topics relate to the ability of audit firms to develop and maintain a strong IS audit staff. For example, in regard to organizational culture, IS auditors require specialized training and skills, and may find themselves disadvantaged in firms where the primary career path results from financial audit experience (Quarles 1994a, 1994b). Anecdotal evidence suggests that some firms have implemented alternative advancement paths for IS auditors that are not CPAs. However, it is unclear whether these efforts will be successful. A number of potential research questions are relevant. How can IS auditors be recruited and retained in today's environment? Additionally, what are the career paths and reward systems for these professionals in different firms, and how does variance in career path affect retention of senior-level IS audit personnel? What are the cultural implications of firms seeking to develop a strong IS audit staff? What are optimal training methods for informing IS auditors about the audit? For example, should some portion of training be devoted to generalists and IS auditors working together? What methods work best for firms seeking to maximize information sharing between generalists and IS auditors?

Training and Education of Generalist and IS Auditors

As the audit profession has evolved from the early days of information systems, it is difficult to determine, based on extant research, whether accounting education has kept pace. Carmichael (2004) notes that "auditing educators need to make sure their students are acutely aware of the need to obtain a thorough understanding of both the manual and computerized aspects of the accounting system." Further, both Arens and Elder (2006) and Arnold and Sutton (2007) propose several curriculum reforms they feel are necessary to meet the information systems requirements imposed on auditors in the current environment. While there was significant research on this issue during the emergence of the IS audit profession, it has received relatively little attention in recent years.

In a report in the mid-1990s, the AICPA asserted that the speed of IS development had outstripped the preparedness of various domains (e.g., educators, regulators, and audit firms) to address it (AICPA 1996). The report advised accounting educators, public accountants, and regulators on the types and extent of IS training needed of professionals in differing fields. In particular, they recommended that all students should study IS from the perspective of its usefulness, application and impact. In conjunction with this perspective, all educators should be encouraged to integrate the study of technology with the study of accounting. Additionally, a section on training in the work environment discussed a three-year plan and budget for incorporating IS training in the continuing professional education (CPE) programs of professional accountancy organizations. Following this report, the AICPA developed a Core Competency Framework, and has revised it several times since (AICPA 2006d), including the addition of a set of educational strategy and assessment resources (AICPA 2007a). Additionally, with the redesign of the Uniform CPA Examination in recent years, the AICPA is encouraging aspiring public accountants to gain IS-relevant knowledge through its emphasis in the new Business Environment and Concepts section of the exam. Other professional models include ISACA's (2006d) model curriculum (which addresses topics such as IS audit functional knowledge, fundamental auditing concepts, standards and guidelines for IS audit, internal-controls concepts knowledge, and the audit process) and a model curriculum for IS professionals developed by a consortium of IS professional organizations (ACM 2002).

Certainly, the research discussed previously in this paper supports the need for generalist auditors to have an understanding of client technology, even when, or perhaps particularly when, IS auditors participate in the audit (Brazel and Agoglia 2007; Hermanson et al. 2000; Hunton et al. 2004). However, even as numerous white papers and reports called

for increased consideration for preparing students for the technological challenges of the 21st century (*c.f.*, Bedford Committee 1986; AECC 1990; Albrecht and Sack 2000), educational research related to IS audit seems to have diminished (*c.f.*, Gallegos 1991; Litecky and McEnroe 1981; Baldwin and Kneer 1986; Vendrzyk and Bagranoff 2003; Gallegos 2004; Arens and Elder 2006). While there is a limited body of research related to the education of IS auditors, there is very little research to assess the educational preparedness of U.S. generalist auditors with regard to IS knowledge and competencies.[9] To fully address the concerns of practitioners and academics alike, a renewed investment in education research on the IS preparedness of accounting students is necessary.

V. CONCLUSIONS

In this paper, we provide an overview of the literature relevant to the question of what knowledge and skills today's auditors need to perform effective and efficient audits of the information provided by complex, technology-enabled information systems. While any literature review is necessarily limited in its scope, our goal is to review literature related to several specific areas, including auditors' information systems (IS) knowledge and the interaction of generalist auditors and IS auditors in planning and performing audits. The interest of the PCAOB, the ASB, and the International Auditing and Assurance Standards Board demonstrates that this topic area is clearly important to the accounting profession and to accounting educators. The availability of current research findings on these key topics will help accounting researchers provide empirical evidence to the profession, and potentially inform future auditing standards.

In this review, we primarily focus on the current state of the profession with regard to IS. However, new technologies will continue to change the picture of clients' IS and the auditors' tools, thus increasing knowledge demands on both generalist and IS auditors. For example, recent actions by the SEC in regard to XBRL (SEC 2008) have left the audit community scrambling to define their role in the presentation of financial statements via XBRL-tagged documents.[10] Certainly, extant research suggests that generalist auditors have difficulty with IS, and particular difficulty in adjusting to new technology. However, in this continually evolving environment, we wonder whether a "competency" standard is the appropriate approach to this issue. A highly specific standard is likely to become quickly outdated as technology evolves. As an alternative, regulators may consider encouraging public accounting firms and audit professionals to more closely adhere to the existing standard requiring adequate technical training and proficiency.

This continually evolving environment also provides considerable opportunities for researchers to investigate issues of interest to academics, regulators, and practitioners. Additionally, these recent developments present the academic community a significant opportunity to influence future regulation, as well as the evolution of educational programs to address the changing IS environment. While certainly not exhaustive, the ideas and suggestions presented here provide a starting point for filling the expanding need for research on the interaction of the financial statement auditor and information systems. We encourage members of the auditing profession and regulators to remain abreast of the academic literature as researchers examine the many questions in this area.

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[9] A notable exception to this is Daigle et al.'s (2007) methodology for assessing learning outcomes in an introductory AIS course using the AICPA Core Competency Framework. They demonstrate how this framework can be mapped to all functional competencies addressed by undergraduate accounting curricula.

[10] The most recent guidance from the PCAOB dates to 2005 (PCAOB 2005), although XBRL is on their current list of priorities (PCAOB 2007).

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