JOURNAL OF INFORMATION SYSTEMS
Vol. 28, No. 2
Fall 2014
pp. 1–15

American Accounting Association
DOI: 10.2308/isys-10412

EDITORIAL

AIS as a Facilitator of Accounting Change: Technology, Practice, and Education

I. INTRODUCTION

The accounting information systems (AIS) field is undergoing expansive changes, both professionally and academically. The AIS sections of the American Accounting Association (AAA) have grown, jointly enrolling close to 900 members and publishing two journals. The field has at least four other journals being published,[1] with others emerging. Research areas once traditionally part of the AIS domain (Brown, Wong, and Baldwin 2007; Chiu, Liu, and Vasarhelyi 2014) are progressively overlapping with more traditional literatures. For example, financial accounting research, especially market research, has expanded the usage of text mining (Berry 2004); traditional auditing literature has begun to address continuous auditing (Vasarhelyi and Halper 1991; Alles, Kogan, and Vasarhelyi 2004); managerial accounting literature has discussed ERP (enterprise resource planning) systems (Kuhn and Sutton 2010; O'Leary 2009); and fraud literature has discussed the use of such tools as data mining (Ravisankar, Ravi, Raghava Rao, and Bose 2011) and neural networks (Huang, Tsaih, and Lin 2012).

At the same time, accrediting bodies are pressuring schools to enhance the technological content of accounting courses across the curriculum:

- The Association to Advance Collegiate Schools of Business's (AACSB) A7 standard[2] states: "Consistent with mission, expected outcomes, and supporting strategies, accounting degree programs (**should**) include learning experiences that develop skills and knowledge related to the integration of information technology in accounting and business. Included in these learning experiences is the development of skills and knowledge related to data creation, data sharing, data analytics, data mining, data reporting, and storage within and across organizations. Accounting degree programs (**should**) integrate current and emerging accounting and business information technologies throughout the academic curricula.

The authors thank Michael Alles, Alex Kogan, and Paul Byrnes for their helpful suggestions, and Qiao Li for her assistance.

Published Online: December 2014

[1] *Journal of Emerging Technologies in Accounting, International Journal of Accounting Information Systems, International Journal of Intelligent Systems,* and *International Journal of Digital Accounting Research.*

[2] See: http://www.aacsb.edu/en/accreditation/standards/2013-accounting/Learning%20and%20Teaching%20Standards/standard7.aspx

Learning experiences may be supported by business, accounting, and other academic units." (bolded words added)

- Pathways Commission Report, Action Item 4.1.6[3] and AACSB A7 Standard language map to each other.
- Because the review process recognizes the dynamic, interdisciplinary nature of the learning experiences related to emerging information technology applications, there will be a transitional period of three years, from 2013 to 2016, related to this standard.

Given the level at which traditionally AIS-related concepts have reached the mainstream, we are forced to reassess the destiny of the AIS field of study. This editorial focuses on four key questions:

1. What is the future of AIS as an accounting subfield?
2. Who should be teaching AIS?
3. What is the role of AIS?
4. What is the role of academia in the development and adoption of new technologies and concepts?

II. WHAT IS THE FUTURE OF AIS AS AN ACCOUNTING SUBFIELD?

Most accounting curricula include at least one course in AIS, often staffed not by an AIS specialist, but by mainstream financial or managerial faculty. The AACSB's recently implemented Standard A7 advocates for an increase in IT integration within the accounting curriculum, implying that such is often not the case. Furthermore, the level of AIS content in the CPA exam remains low.[4] Anecdotal evidence indicates that although there is a perceived need for more technical and analytic methods in the audit profession, the CPA exam does not cover these issues as test takers are likely left unprepared after completing a largely technology-averse accounting curriculum.

AIS journals have been prescient in many areas of research that eventually have progressed to the mainstream, as discussed above. Research streams on increasingly commonplace areas such as text mining, ERPs, and continuous audit have tended to appear earlier in AIS journals than in mainstream literature. At a conceptual level, the future of AIS will not be very different from its present state. Technologies and concepts that have not yet been integrated into other elements of the accounting curriculum have their home in AIS. There are no spreadsheet courses in the curriculum, not because spreadsheets offer no value, but because their use is so commonplace as to be expected within a standard financial or managerial accounting course. In the same vein, tax software may be integrated into a tax class, not treated separately.

AIS is and will continue to be a home for those principles, concepts, and tools that have not yet reached this mainstream level of integration. Past elements that are now in the mainstream include statistical sampling, ERPs, and spreadsheets. While there may be debate on how long a given technique or concept should remain in AIS, its necessity as the genesis for many now-vital technologies cannot be denied or cast aside. Accounting's unique position at the intersection of manmade rules and unstoppable technological progress creates a space for the continued existence

[3] Pathways Commission subcommittee members are Faye Borthick, Ingrid Fisher, Guido Geerts, Allan Graham, and Brigitte Muehlmann.

[4] Current American Institute of Certified Public Accountants (AICPA) standards mandate that Information Systems and Communication occupy no more than 19 percent of the Business Environment and Concepts portion of the CPA exam.

of a course designed to speak to the future state of the art. However, as important as the content of AIS courses is the level of qualification of AIS professors.

III. WHO SHOULD BE TEACHING AIS?

Demand for qualified AIS professors stems naturally from demand for its course content. This demand can be driven by four main forces: faculty advocacy, CPA exam content, student interest, and employer needs. These four elements are interrelated, and all currently serve to limit the potential pool of qualified AIS professors.

Ninety-one American universities offer Ph.D. degrees in accounting[5] and 72 offer doctorates in tax,[6] but only 16 offer a doctorate in accounting information systems.[7] This disparity leads to a lack of Ph.D.-level researchers and professors to be employed by schools looking to establish or expand an AIS curriculum. At the same time, innovative research has had difficulty penetrating the elite journals of accounting scholarship, as new paradigms do not conform to the norms and traditional bibliographic stream of the extant literature. These journals tend to be great vehicles for sustaining incremental changes, not introducing major disruptions.[8] Once a paradigm is established with a core literature (e.g., Ball and Brown 1968), changes are made with incremental research pieces, evaluated by the core established researchers in the area. Disruptive research work threatens the *status quo* by creating areas of expertise beyond those of currently established leaders in the field.[9] Systems research is the current and longstanding bastion of many such disruptions.

The lack of information systems content within A-journals deters potential Ph.D. students from pursuing AIS degrees, creating a lack of demand that hinders other schools from establishing AIS doctoral programs. Ph.D.-level research faculty simply *do not exist* in large numbers and, given the current state of accounting research, it is difficult to convince a new Ph.D. graduate that pursuing systems research is in his or her best interest. This constraint is magnified by undergraduate student concerns and priorities.

Passing the CPA exam is a priority for most accounting students regardless of their other aspirations. The exam's current limited AIS content, therefore, serves as a limitation on student demand for additional AIS content, regardless of the relevance of such content to their careers. Student demand will need to be precipitated by changes in the CPA exam. A double bind problem occurs as students are not ready for analytics as these are not covered in the CPA exam and the CPA exam does not involve these topics, although there is wide recognition of their need, because these are not in the curriculum.

The only remaining force that could potentially advocate for AIS increases is the employer. As systems knowledge and understanding become more and more necessary tools for the auditor, education will need to address this necessity. Employers and university accounting departments typically enjoy a close relationship, exemplified by accounting advisory boards staffed with CPA-credentialed alumni, guest lectures from professional accountants, and the near ubiquity of externship and internship programs for sophomore, junior, and senior-level accounting majors. Many members of the AICPA are either current or former employees of accounting firms and might, therefore, have some understanding of the looming changes in the accounting field. A concerted effort by accounting firms to encourage greater inclusion of systems in the undergraduate, graduate, and certification spheres would serve to benefit all parties involved and better prepare the

[5] See: http://www.jrhasselback.com/AtgDoct/AtgDoctProg.html
[6] See: http://www.byuaccounting.net/rankings/phdrank/rank_phd.php?qurank=Tax&sortorder=ranking66
[7] See: https://aaahq.org/infosys/aisphd/participatingschools.htm
[8] This follows Christensen's (2003) concept of the "innovator's dilemma," which notes that companies often fail by addressing customers' current needs, rather than anticipating future needs.
[9] For more on issues related to innovation, its constraints, and the threats it poses, see Christensen (2003).

accounting field for an uncertain future. This is by no means a certain thing, however; employers may choose to ignore technological developments that would provide long-term stability in favor of a greater focus on competencies that will benefit individuals in the short term. Furthermore, employers may view technological competencies as elements that can be outsourced, negating the perceived value of encouraging skills development in undergraduates.

Additional AIS Certification

One potential resolution to the problem of less qualified AIS professors is the creation of a separate body to provide A7-level certification for accounting systems professors. Akin to a Certified Information Systems Auditor (CISA) or Certified Internal Auditor (CIA) certification, but with a broader and more pedagogical focus, such a certification would offer more assurance regarding the qualifications of the instructor.

While this may seem like a natural step, it resolves a problem that is long-term in nature, and should not be implemented immediately or with haste. Lack of AIS Ph.D.s presents a more fundamental problem, and adding another layer of certification, whether optional or mandatory, will further discourage potential candidates from following this path. In addition, the effort necessary to provide such certification will hamper AIS Ph.D.-granting institutions' efforts in continuing to offer their programs, and it will certainly discourage new institutional entrants to the field. If and when a future of more plentiful AIS professors is reached, certification requirements for the AIS class may be seen in a different light; at the moment, it solves the lesser of several interrelated problems at the cost of potentially exacerbating already larger ones.

IV. WHAT IS THE ROLE OF AIS?

AIS Classes Serve as a Counter to the CPA Exam

The CPA exam has become a multiple-choice and essay-based examination of the candidate's memorization of accounting standards and ability to apply those standards. The confusion of an "accounting function" and "audit function," in which practitioners prepare for assurance work by studying accounting, has created a corps of professionals that are not properly prepared for this age of technology-based work. Accounting standards and methods often do not address the day-to-day work of professionals.[10] Furthermore, the standards themselves are often outdated and inadequate to the tasks of complex problem detection and judgment necessary for modern assurance.

Given the development of the Accounting Standards Codification and the seeming omniscience of Internet search engines, the career-relevant value of memorization may be limited to its role in the CPA exam. At best, this prioritization of memorization over analysis is an innocuous but banal use of a student's time; at worst, it runs counter to the dynamic, progressively updated set of analytical skills needed by the auditor of today and tomorrow. Assurance workers need to be able to think critically and analytically, make associations, detect anomalies, and apply conservatism; all of these skills rely mainly on understanding of processes rather than memory of specific standards. Internal accounting work requires understanding of IT system use, precision, data interpretation, and a broad level of standards recall. At no point in the accounting or assurance professional's career is extensive memorization a necessary skill, outside of the CPA exam that certifies these professionals for their careers.

[10] Modern accountants seldom make bookkeeping entries or decide on treatment under Financial Accounting Standards Board (FASB) rules, as most of these decisions are already made by the accounting/ERP software that they use. Auditors must reach a senior stage before making judgments on appropriate accounting treatment. In general, the role of the accountant is data preparation and explanation to management.

Whether the CPA exam undergoes an evolution or not, AIS professors have a duty to prepare their students for the real world. More than that of any other subject, the pedagogy of AIS revolves around a set of dynamic tools and developments that force a different manner of course preparation and conceptualization.

AIS Teaches Concepts First, Tools Second

One counterpoint to the argument that AIS will disappear is the continued existence of auditing, tax, financial, and managerial accounting courses. The fact that these subject areas have long since entered the mainstream has not prevented them from maintaining distinct positions in the standard accounting curriculum. Why should AIS be any different?

To say that AIS may deserve to pass out of existence is to confuse teaching of tools with teaching of concepts. A good AIS course should not "teach technology" any more than a tax class "teaches tax software." To do so would be to embrace looming obsolescence, simultaneous with the aging of the tools being taught. All respectable accounting pedagogy, like all curricula in any field of university education, should focus primarily on concepts and only secondarily on related tools. Managerial accounting, for instance, consists of a standardized, multi-course track because it contains concepts (e.g., budgeting, costing) distinct from other, equally valid subfields. What are the concepts covered by AIS? Given the diversity of approaches and elements adopted and used by various AIS professors, this is not an easy question to answer. Some adopt an internal control perspective, others an REA approach, and still others a fraud prevention angle. Two professors could design rigorous courses, each called "Introduction to Accounting Information Systems," with little to no overlapping content.

Many would see this as a problem and propose that the AICPA offer guidance regarding standardization of content. However, this ignores the fact that diversity and change are endemic to AIS itself, and standardization would likely hinder innovation more than it would make any positive contribution. Requiring that all students learn internal control on the same software would engender claims of anti-competitiveness, hamper the efforts of professors who want to try something new, and require curricular changes as frequent as the development of software updates.

While the number of tools available to an AIS professor is and should remain broad (e.g., ERP integration; use of system, program, and document flowcharting software; purpose-built audit programs; etc.), some standardization of concepts may allow for a better understanding of the distinct benefits received by AIS students. As an added benefit, if these concepts are universally understood and valued, the AICPA may feel justified in increasing the proportion of AIS content on the CPA exam. This increase will amplify students' desire to learn more about AIS concepts, creating a feed-forward effect.

V. WHAT IS THE ROLE OF ACADEMIA IN THE DEVELOPMENT AND ADOPTION OF NEW TECHNOLOGIES AND CONCEPTS?

Academic research has contributed to the development of modern accounting and assurance methods only in sparse, specific areas. For example, the original concepts underpinning audit sampling (Neter and Loebbecke 1977) and continuous auditing (Groomer and Murthy 1989; Vasarhelyi and Halper 1991) can be found in academic research. Activity-based costing (ABC) (Cooper, Kaplan, Maisel, and Morrissey 1992) and other cost accounting areas have also been influenced by research. Academic papers and, by extension, academics have otherwise been largely passive and reactive agents in preparing students to pass the mainly professionally prepared CPA exam.

The limited role that academia has taken in the development of extant accounting thought is understandable; practices are often the product of in-the-field development, strongly guided by

standards that aim to enhance comparability by standardizing applied practices (GAAP). The exceptions noted above tend to represent the adaptation of academic work in other fields, such as statistics and computer sciences, to improve practice. In a few instances, these improvements have been promulgated into GAAP and GAAS (Generally Accepted Auditing Standards).

Recent years have seen accounting and audit practice trying to keep pace with the rapid adoption of technology by business. The emergence of computers, ERPs, large sets of transactions, and automated control systems has forced the integration of analytic and information technologies into practice, but its impounding into standards has lagged. Academics trained in these fields can potentially be of value in this constant pursuit of methods to measure business and provide assurance. The increasing rate of change within accounting and auditing may necessitate greater involvement by members of the academic community.

Changing Paradigms Shift Cost/Benefit Trade-Offs

It is important to note that accounting and audit practice, due to its applied nature, is often a product of compromise and the adoption of cost/benefit trade-offs. Manual methods of transaction recording create costly storage and retrieval processes that are often destructible, changeable, and prone to errors and inconsistencies. On the other hand, they are simple, requiring little equipment, and controls can be directly observed. The ability to justify such an error- and damage-prone recording system has decreased with the introduction of cheap, user-friendly computing power, and even the smallest sole proprietorships are now hard-pressed to justify avoiding basic spreadsheet software.

Materiality standards likewise emerged from a compromise between the cost of additional verification and the benefits of increased knowledge. Manual methods are too costly to use to constantly re-verify calculations, maintain disaggregated amounts, and re-compute when changes are made. As is the case with manual recording, the entire proposition of acceptable error should be rethought with the new realities of information processing.

In areas such as these, academia can lead the way in creating new paradigms and shifting the focus of accounting practice. By proposing new methods and perspectives with rigor and sound reasoning, academia can get ahead of the curve and approach such problems without being saddled by anachronistic methods of collecting and reporting financial data.

VI. FUTURE DIRECTIONS AND CONSTRAINTS ON CHANGE

Facilitating Technological Innovation: Where Do We Go From Here?

While it is tempting to propose the development and standardization of an AIS major, there are several constraints on this eventuality. First, CPA educational requirements already create a large burden on accounting students. Many states require 30 or more hours of accounting coursework, leaving a CPA-bound student with little room for additional curricular pursuits within a four-year timeframe. While nearly all states now require 150 credit hours for licensure, many students will use the 30 additional credits to pursue a Master's degree, typically either an M.B.A., a Master's of Accountancy, or a Master's of Taxation. The near-total absence of information systems topics addressed by the CPA exam will further constrict students' interest.

Another constraint is the strain that technological change will place upon curriculum development. New technologies may require perpetually updated lesson plans, potentially hindering a professor's ability to produce published research. They may also necessitate the development of new courses, a task often slowed by one or several layers of bureaucracy and committees, taking months or years before receiving approval.

The two most likely routes for AIS instruction, as earlier discussed, would be (1) its integration in most accounting courses as proposed by A7, or (2) the expansion of its standalone offerings to increase the technological education of students. Of these, the latter is the most likely, given that it will place the least burden on an already heavily compressed accounting curriculum. In this innovation facilitation role, AIS educators must incorporate elements of computer science, statistics, economics, and artificial intelligence, and apply these fields to specific issues in accounting and auditing.

Technological Integration: The Next Waves

The technological scenario continues to evolve at a faster and faster pace. Social system change slows this process as technologies suffer from the "hype curve" phenomenon (O'Leary 2009) and need to be placed in context before they can be usefully integrated into the accounting curriculum. In this context, there is a mix of three major effects: (1) dramatic change in the electronization of education (Vasarhelyi and Greenstein 2003; Vasarhelyi and Graham 1997), (2) the progress of research, especially big data analytics, (3) the need for up-to-date methods of accounting and audit, and (4) the continual automation of accounting and auditing processes.

Electronization of Education

The increasing availability, convenience, affordability, and modularity of online education will transform the landscape of auditor competence development. Where an auditor in the early 2000s wishing to increase her technical competence would need to seek out, apply for, finance, and attend a graduate program at a separate physical location at great cost to both the individual auditor and her firm, now that same auditor can simply search for MOOCs (Massive Open Online Courses) or relevant videos on YouTube, Khan Academy, the Massachusetts Institute of Technology's (MIT) OpenCourseWare, Rutgers Accounting Web,[11] to name but a few resources. Where a lack of skill was previously a barrier to advancement, now the barrier is a lack of willingness to learn. The electronization of education has shifted the focus from experience and financial resources to adaptability and comprehension.

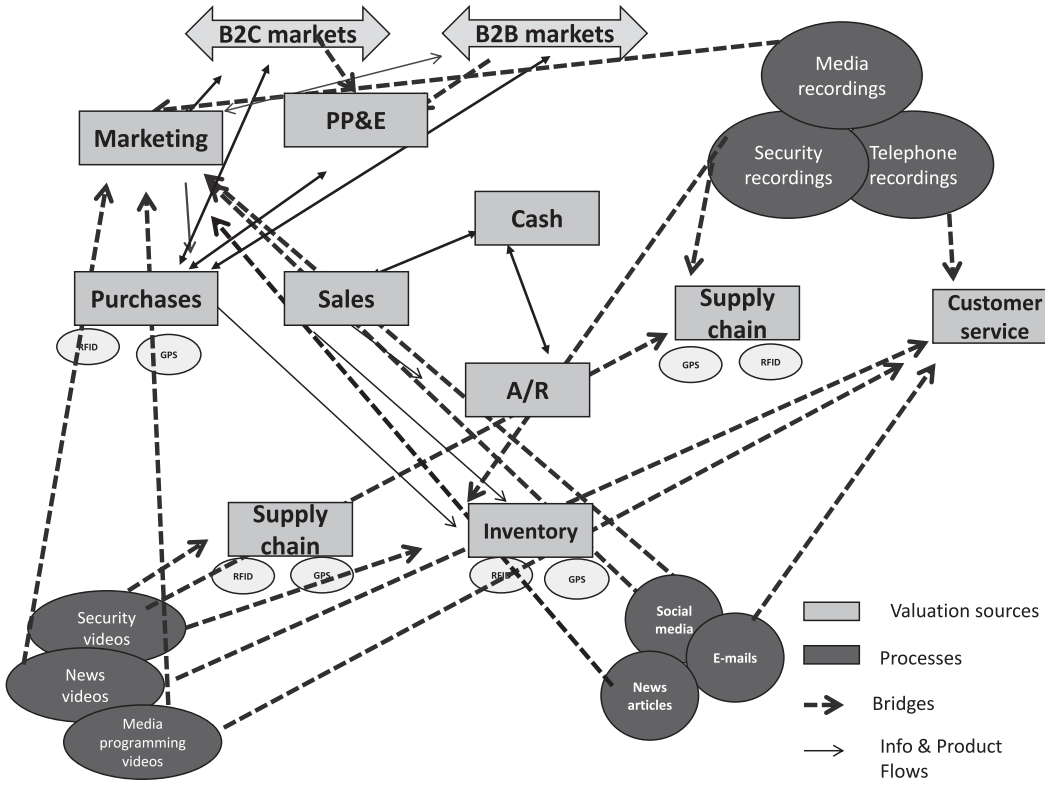
Given the availability of affordable, competency-specific course content online, AIS education must find a different path toward adding value. In brief, AIS professors must show students *how* to learn, not *what* to know. A push to promulgate an AIS curriculum based on concepts, not tools, is one step in the right direction. The understanding that education cannot end with the receipt of a diploma can no longer receive simple lip service from accounting educators and professionals; the ability to learn will be valued more highly than any preexisting knowledge. A large percentage of current students will be working in measurement and assurance functions of types of businesses that still do not exist today. Many will have to migrate to functionalities for which they have not been trained. Most will work in software environments that do not exist today. All will work in a big data environment (Vasarhelyi and Kogan 2015) where accounting and assurance methods will be drastically different.

Big Data

The expansion of data sources has been immense. Although there is a broad literature on big data, specific accounting and auditing considerations are sparse. A special issue of *Accounting Horizons* will focus on emerging audit utilization and considerations (Vasarhelyi and Kogan 2015), including a wide range of discussions on the applicability of big data analytics to accounting and

[11] See: http://raw.rutgers.edu

FIGURE 1
Big Data and Sources of Audit Evidence



Adapted from Moffitt and Vasarhelyi (2013).

auditing. Notwithstanding this emphasis, several issues must be noted: (1) data collection will increase to such a degree that most relevant data will be transitory, not stored and static; (2) automatic data generation/storage devices such as RFID and GPS can be set to collect data at preset intervals, from once a year to once a second; (3) an increasing number of bridges from large environmental datastores (Liu and Vasarhelyi 2014) will provide increasing integration between physical and virtual worlds; (4) point-in-time retroactive analysis will lose relevance and give way to a more predictive, real-time set of analytics; and (5) privacy and security issues will dramatically change in nature.

Figure 1, adapted from Moffitt and Vasarhelyi's (2013) discussion on big data, illustrates several of these impacts on accounting and auditing. For example, in accounting, the valuation of real estate and property, plant, and equipment can be performed at very low cost by simply linking B2C and B2B electronic market prices to asset or inventory codes. The focus can then move from feasibility to level and frequency of valuation, treatment of the non-valued items, valuation basis (market value, current cost, replacement value, etc.) (Sterling 1973). These issues, if examined with care, will revolutionize the nature of business measurement and require the FASB to substantially reconceptualize its mission. These are the types of issues that can be handled and informed by AIS researchers, then handed off to more mainstream researchers.

FIGURE 2
Retroactive, Predictive, and Preventive Audits

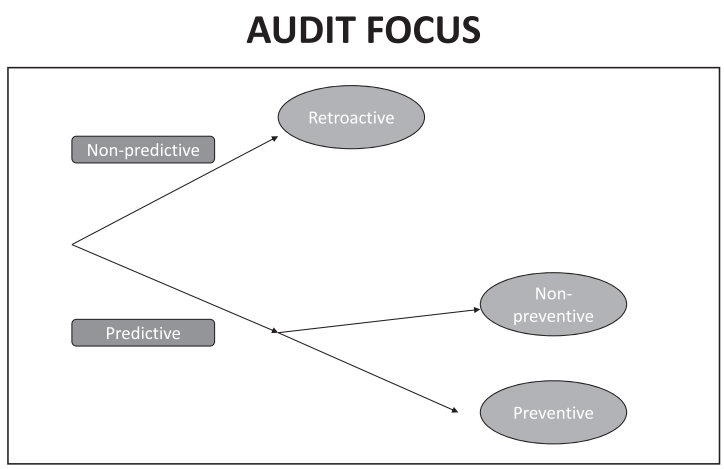


Figure 2 illustrates the alternatives related to the focus of assurance. Traditional technology only practically allowed for retroactive verification on an archival basis. Retrieval of information was cumbersome, its information processing very expensive, but the process *in loco* (Teeter 2014) was observable. Modern assurance, on the contrary, will rely on an audit ecosystem where predictions, control monitoring, and transaction prevention will interact with a live set of measurements in real time.

Continuous and Predictive Audit

The timing of the assurance function has been discussed extensively in the literature (Vasarhelyi and Halper 1991; Groomer and Murthy 1989; Brown et al. 2007; Chiu et al. 2014). With the evolution of technology, the nature of the assurance function will change, although its overarching structure of rules and regulations has perversely provided a shelter of protection to anachronistic procedures that make little sense in the current information environment. Small samples, physical document evaluation, and purely point-in-time historical value assessment do not provide much value for either the business or investors. A new form of the measurement and assurance functions that is mainly automatic, forward-looking, complementary to business controls and, in many instances, preventive needs to emerge. Developing the base for this new form of practice is also the role of AIS research before the more traditional area embraces it.

Figure 2 illustrates that auditing can be both reactive and predictive (Kuenkaikaew 2013). When predictive, the auditor, *a la* continuous audit (Vasarhelyi and Halper 1991; Vasarhelyi, Alles, and Williams 2010), will rely on models (standards) to predict results (performance) in an account (transaction) (Kogan, Alles, Vasarhelyi, and Wu 2014). This prediction is compared with actuals in near-real time to detect substantive variances in monitored processes. These variances are treated either as an alert to the management/audit function or, if the system has reliable filters, to prevent faults from progressing toward execution. Modern systems combine management action and assurance. Much conceptual work is needed, possibly by AIS scholars, in the redefinition of concepts such as auditor skepticism, independence, materiality, auditor role, audit objectives, etc.

Many of these needs are motivated by the ever-increasing level of automation in corporate business systems and the correspondingly automated nature of tools used by individuals.

Automation

Provision of and requests for information will become progressively more automated. The advent of computer systems and ERPs and the outsourcing of many processes have created a lack of direct observability that changes the structure of information processing, supervision, and controls. Accounting and auditing are concurrently changing to require more than simple adjustments to basic processes.

Accounting

The processes of business measurement have evolved substantially. Where businesses of past decades were able to share the maximum available level of data with outsiders and insiders equally, today there is substantive asymmetry and discrepancy. Internal management information is frequent, disaggregated, and diverse. External reporting is infrequent, aggregated, and static. With the evolution of technology, a more diverse society, and improved information processing, customers of corporate information provisioning have developed more complex needs that are not being acknowledged by statement preparers. While external reporting has retained a paper focus, internal reporting has evolved to very frequent, granular, and digital information structures. The information technology environment now has an internal element (with ERPs, legacy systems, etc.), a cooperative data environment (with outsourced processes, downstreams from suppliers and clients, etc.), and a progressive set of connectors to the exogenous data environment (Moffitt and Vasarhelyi 2013) (see Figure 3).

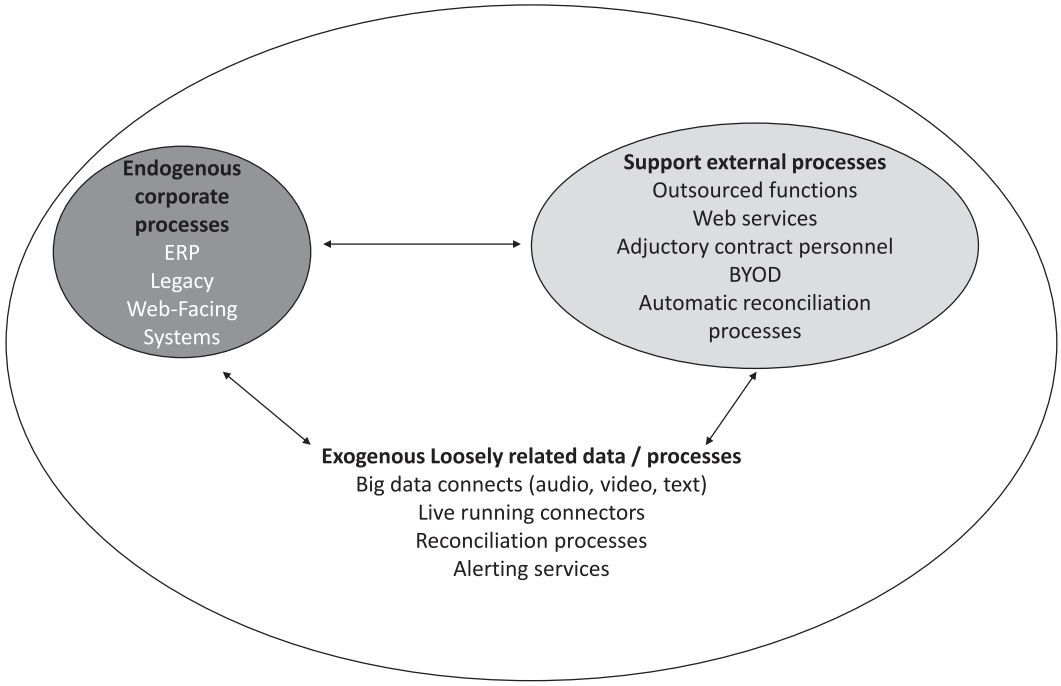
Three main effects interact to affect process automation: economics, errors and discrepancies, and relationships between accounts.

Automation has changed the *economics* of providing external information. With modern relational databases and the wide scope of information collected for internal purposes, the incremental cost of providing additional information for stakeholders is dramatically reduced. Once a report is developed, repeated production cost is small (Krahel 2012). Management's focus has turned to identifying available information in thousands of preprogrammed reports, rather than manually creating an *ad hoc* set of information. The accountant's job is subsequently evolving from poster and preparer of information to retriever and explainer, with wide consequences to AIS education and research. Bookkeeping entries and minutiae about accounting standards are to be replaced by systemic understanding and concerns about data quality and security. The advent of BYOD (Bring Your Own Device; Loraas, Crossler, Long, and Trinkle 2014) expanded the scope of tools used by the accountant in many useful and potentially worrisome ways.

The AIS student-turned-corporate worker is used to the power of smart handheld devices for information search, personal connectivity, and computation. While security-conscious organizations often block access to many Internet functions and applications on company-owned property, personal devices regularly bridge functionality gaps, generating security concerns.

ERP structures and the wider set of big data connections described in Figure 3 multiply the issue of *errors/inaccuracies/structural changes* over time in data, encouraging a redefinition of concerns. The bridges to the big data environment tend to be more probabilistic than deterministic. For example, a face identification algorithm may return a 94 percent probability of a company employee being the person on a Facebook post, or a news piece being 61 percent likely to be adverse to the company. Consequently, automation dramatically changes the nature of data and multiplies discrepancy concerns, raising the detection and management functions of the AIS worker.

FIGURE 3
Internal, Cooperating, and Big Data Sources



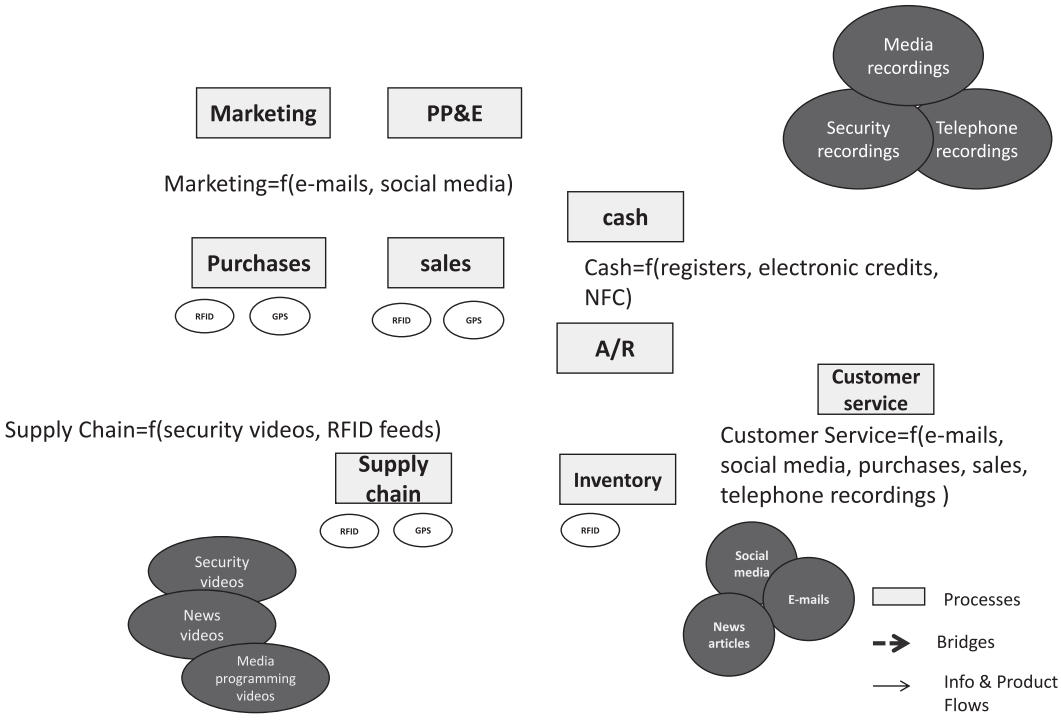
The expansion of capabilities propagated by automation also brings about the potential for analytic exploration of the *relationships between business processes* (Figure 4). Although probabilistic, this relationship can add much to corporate analytic understanding. The business cycle is rich in real relationships that are not explored in current accounting analysis. The modern AIS field must develop these analyses, often bridging between disciplines, to provide a less "siloed" and more comprehensive measurement of the firms, and a more realistic external reporting story.

Auditing

Automation is changing the *economics* and objectives of assurance (Alles et al. 2004). First, the tendency of automated assurance processes to produce large numbers of exceptions (Issa 2013) will lead to the development of new research in *anomaly management and correction*. Error propagation remains another unexplored region of audit management. Discrepancies from early upstream processes flow progressively through downstream modules in a multiplicative manner. Intelligent preventive controls are progressively permeating the corporate IT ecosystem and personal devices. The relationships between processes that have always existed may now be explored analytically and visually for management and assurance purposes (Figure 4).

The integrated corporate environment has enabled more dynamic representations of business performance and measurement. AIS research must consider developing some of these models as more dynamic and representative replacements of the traditional financial statement. Figure 4 illustrates some relationships that are shown with a progressive usage of larger and larger and maybe more and more frequent datasets:

FIGURE 4
Formal Relationships among Processes (ERP Modules)



(A) Marketing = f(emails, social media, advertising, customer feedback, etc.)
(B) Cash = f(registers, electronic credits, NFC, etc.)
(C) Customer Service = f(emails, social media, purchases, sales, telephone recordings)
(D) Supply Chain = f(security videos, RFID feeds, POs, GPS, logistic reports, sales, warehouse reports, etc.)

The measurement and assurance function must be considered as additional layers of meta-measurement of business processes, analyzing meta-controls, meta-risks, etc. Information theory studies (Romero, Gal, Mock, and Vasarhelyi 2012; Mock 1976; Ijiri 1979) that attempt to formalize information structures and objects are needed in AIS to reconceptualize the audit issues mentioned above.

Although big data is now heavily discussed in the literature, two additional sources of Internet connection—"the Internet of Things" (Kopetz 2011) and "Wearables" (Wei 2014)—will provide further substantive data of particular value for detective and preventive assurance. Their introduction into the AIS/accounting literature warrants substantive attention.

Standard Setting

In a progressively automated world with mainly digital information, the nature of rules and regulations is clearly anachronistic (Krahel 2012), although very little in the literature proposes changes. The accounting and auditing areas, which are very heavily dependent on regulation,

require much research into the potential nature, form, and processes of automatic rule enforcement. Krahel (2012), Vasarhelyi, Chan, and Krahel (2012), and Vasarhelyi and Krahel (2011) examine the issue of formalization of standards and their *de facto* impounding into ERP systems. In addition to these practical issues, substantive behavioral and systems research is needed in the process of setting the necessary "automated standards."

VII. CONCLUSIONS

A wide variety of progressive changes are impacting the accounting field at great speed. Data needs are broadening and deepening. Information storage and retrieval processes are growing more vast, immediate, and affordable. The skills of the accountant and the auditor will likewise need to expand in both scope and adaptability. Accounting students and professionals will need to adopt the perception that technology will continually change their requisite competencies and redefine their roles. The AACSB's A7 standard places much of the burden of adapting to these changes squarely on the shoulders of academics, and AIS researchers are in a unique position to capitalize upon them, creating a more stable reporting and assurance environment in the process.

When frequent paradigm shifts become the norm, education and research must change along with them. Current trends include the advance of big data, the progress of automated data capture, and the advent of continuous auditing. Big data offers the potential for more informed decisions, but managing and analyzing such data will require increased statistical skills and an ability to understand business processes, both of which can be developed and taught at the academic level. Likewise, automated data capture offers several benefits—speed, accuracy, breadth, and affordability—but without a human ability to generate proper rules for exception reporting, aggregation, and the like, the benefits of automation will be lost. Continuous audit, which can be seen as an evolution of the aforementioned two trends, may lead to enhanced assurance, but only if it is managed by auditors who add benefit through their analytical skills, not through an ability to perform the labor-intensive manual sampling and data collection work of auditors past.

Currently, demand for this type of knowledge and ability is undermined from several exogenous sources. The CPA exam features very minimal assessment of systems understanding, and is instead content to test students' memory and application of static accounting standards. This stagnation, coupled with a widely held "gold standard" perception of CPA licensure, guides accounting students' focus away from systems and toward more traditional areas of accounting education. The lack of student demand for AIS education reduces the economic justification for top-tier research schools to create and maintain Ph.D.-level programs in AIS research, constricting the human capital available and qualified to provide systems knowledge. At this point, the only motivator for an expansion of AIS content in the curriculum and on the CPA exam is the business environment that demands qualified accounting professionals. Only when—and if—business professionals demand an increase in systems understanding from new graduates can changes to this system be reasonably expected.

AIS research has long been the incubator for several now-ubiquitous technologies and concepts, and this role will persist as long as the profession continues to exist. While the specific technologies will naturally change to keep pace with professional and industrial developments, the fundamental concepts and AIS's role in preparing the reporting and assurance spheres for them will not. Hopefully, a demand-side (i.e., business-led) push for broader systems knowledge in students will lead to changes in the CPA exam, wider student interest in systems education, and an increasing number of Ph.D.-qualified AIS researchers and research programs to meet this demand. The increasing relevance ascribed to AIS research and education may propel professors into a more prominent role in the professional realm, working in tandem with auditors in the field, integrating knowledge from other disciplines into an improved assurance framework and a refreshed reporting paradigm.

The fact that A7 is becoming a component of the AACSB's standards speaks to higher education's need to begin the process of educating a generation of continuous learners with an attitude of adaptability and an appetite for change. Fields such as big data, continuous audit, and automation are the current frontiers of this change, and AIS research does and will continue to incorporate such developments into a robust curriculum. The increasing rate of development in the business world represents an opportunity for AIS researchers to increase the value they add to the professional sphere.

—J. P. Krahel
Loyola University Maryland
—Miklos A. Vasarhelyi
Rutgers, The State University of New Jersey, Newark

REFERENCES

Alles, M., A. Kogan, and M. Vasarhelyi. 2004. Principles of analytic monitoring for continuous assurance. *Journal of Emerging Technologies in Accounting* 1 (1): 1–24.

Ball, R., and P. Brown. 1968. An empirical evaluation of accounting income numbers. *Journal of Accounting Research* 6 (2): 159–178.

Berry, M. W. 2004. Survey of text mining. *Computing Reviews* 45 (9): 548.

Brown, C. E., J. A. Wong, and A. A. Baldwin. 2007. A review and analysis of the existing research streams in continuous auditing. *Journal of Emerging Technologies in Accounting* 4 (1): 1–28.

Chiu, V., Q. Liu, and M. Vasarhelyi. 2014. The development and intellectual structure of continuous auditing research. *Journal of Accounting Literature* (forthcoming).

Christensen, C. M. 2003. *The Innovator's Dilemma: The Revolutionary Book that Will Change the Way You Do Business*. Collins Business Essentials Series. New York, NY: HarperCollins Publishers.

Cooper, R., R. S. Kaplan, L. S. Maisel, and E. Morrissey. 1992. From ABC to ABM. *Management Accounting* 74: 54–54.

Groomer, S. M., and U. Murthy. 1989. Continuous auditing of database applications: An embedded audit module approach. *Journal of Information Systems* 3 (2): 53–69.

Huang, S., R. Tsaih, and W. Lin. 2012. Unsupervised neural networks approach for understanding fraudulent financial reporting. *Industrial Management and Data Systems* 112 (2): 224–44.

Ijiri, Y. 1979. A simple system of cash-flow accounting. In *Accounting for a Simplified Firm,* edited by Sterling, R. R., and A. Thomas, 57–71. Houston, TX: Scholars Book Co.

Issa, H. A. 2013. *Exceptional Exceptions*. Ph.D. dissertation, Rutgers Business School.

Kogan, A., M. Alles, M. Vasarhelyi, and J. Wu. 2014. *Design and Evaluation of a Continuous Data Level Auditing System*. Working paper, Rutgers Business School.

Kopetz, H. 2011. Internet of things. In *Real-Time Systems,* 307–323. New York, NY: Springer.

Krahel, J. 2012. *On the Formalization of Accounting Standards*. Ph.D. dissertation, Rutgers Business School.

Kuenkaikaew, S. 2013. *Predictive Audit Analytics: Evolving to a New Era*. Ph.D. dissertation, Rutgers Business School.

Kuhn, R. J., and S. G. Sutton. 2010. Continuous auditing in ERP system environments: The current state and future directions. *Journal of Information Systems* 24 (1): 91–112.

Liu, Q., and M. Vasarhelyi. 2014. Big questions in AIS research: Measurement, information processing, data analysis, and reporting. *Journal of Information Systems* 28 (1): 1–17.

Loraas, T., R. Crossler, J. Long., and B. Trinkle. 2014. Understanding compliance with BYOD (bring your own device) policies utilizing protection motivation theory: Bridging the intention-behavior gap. *Journal of Information Systems* 28 (1): 209–226.

Mock, T. J. 1976. Discussion of patterns, prototypes and predictions: An exploratory study. *Journal of Accounting Research* 14 (3): 139–144.

Moffitt, K., and M. Vasarhelyi. 2013. AIS in an age of big data. *Journal of Information Systems* 27 (2): 1–9.

Neter, J., and J. Loebbecke. 1977. On the behavior of statistical estimators when sampling accounting populations. *Journal of the American Statistical Association* 72 (359): 501–507.

O'Leary, D. 2009. The impact of Gartner's maturity curve, adoption curve, strategic technologies on information systems research, with applications to artificial intelligence, ERP, BPM, and RFID. *Journal of Emerging Technologies in Accounting* 6 (1): 45–66.

Ravisankar, P., V. Ravi, G. Raghava Rao, and I. Bose. 2011. Detection of financial statement fraud and feature selection using data mining techniques. *Decision Support Systems* 50 (2): 491–500.

Romero, S., G. Gal, T. Mock, and M. Vasarhelyi. 2012. A measurement theory perspective on business measurement. *Journal of Emerging Technologies in Accounting* 9 (1): 1–24.

Sterling, R. 1973. Accounting research, education and practice. *Journal of Accountancy* (September): 44–52.

Teeter, R. 2014. *Essays on the Enhanced Audit*. Ph.D. dissertation, Rutgers Business School.

Vasarhelyi, M., and F. B. Halper. 1991. The continuous audit of online systems. *Auditing: A Journal of Practice & Theory* 10 (1): 110–125.

Vasarhelyi, M., and L. Graham. 1997. Cybersmart: Education and the Internet. *Management Accounting* (August): 32–36.

Vasarhelyi, M., and M. Greenstein. 2003. Underlying principles of the electronization of business: A research agenda. *International Journal of Accounting Information Systems* 4 (1): 1–25.

Vasarhelyi, M., M. Alles, and K. Williams. *Continuous Assurance for the Now Economy*. A Thought Leadership Paper for the Institute of Chartered Accountants in Australia. May 2010.

Vasarhelyi, M., D. Chan, and J. Krahel. 2012. Consequences of XBRL standardization on financial statement data. *Journal of Information Systems* 26 (1): 155–167.

Vasarhelyi, M., and A. Kogan. 2015. Big data in accounting: An overview. *Accounting Horizons* (forthcoming).

Vasarhelyi, M., and J. P. Krahel. 2011. Digital standard setting: The inevitable paradigm. *International Journal of Economics and Accounting* 2 (3): 242–254.

Wei, J. 2014. How wearables intersect with the cloud and the Internet of things: Considerations for the developers of wearables. *Consumer Electronics Magazine, IEEE* 3 (3): 53–56.