# Formalization of Standards, Automation, Robots, and IT Governance[[1]](#footnote-1)

Miklos A. Vasarhelyi

## Introduction

The Real Time Economy has created a world of automated transaction sensing, integrated information systems, big data, and thousands of real time applications running throughout the multiple process environments of modern business systems. Accounting and audit procedures are progressively more and more anachronistic (Titera, 2013) in view of the different environments and new data quality requirements. The opaque nature of modern systems with user-configurable controls, where operations and control are not directly observed and codified rigidly, requires rethinking of the measurement and assurance processes. New approaches are needed for the assurance and data quality objectives of organizations. These new approaches to measurement and assurance have to span the areas of audit automation, continuous monitoring, and continuous assurance as well as have an overlay of solid governance. Without a responsible and coherent governance structure, even solid systems adapted or reengineered for modern circumstances are useless.

This issue contains sixteen articles including this editor’s note, the special section on IT governance, and an article from practice. Eight articles in this issue focus on the topic of IT Governance, which is defined as *“the process by which organizations seek to ensure that their investment in information technology facilitates strategic and tactical goals. IT governance is a subset of broader corporate governance, focusing on the role played by information technology within the organization.*  “(Debreceny & Gray, 2013), and is rated as one of the principal concerns in the now very popular and large governance literature. Governance methods encompass a mix of processes, organizational structures, and rules that cope with the information asymmetry created by the current form of public capital organizations, although they are also relevant to other entities like private and governmental enterprises.

This introductory article reviews the content of this edition, and attempts to set the stage for a discussion of future issues in the evolving technological environment and how auditing needs to change. Furthermore, it offers insights concerning what research must be performed to guide this evolution. Keys to these considerations are issues of formalization, automation, and robots.

The next section will describe the non-governance articles in this issue, and the following section will discuss research implications of the quest for accounting/audit automation.

## Issue content

The current issue includes a special section on IT governance edited by Professor Roger Debreceny, which is introduced in this issue by an additional “invited” editor’s note (Debreceny, 2013) and encompasses seven articles. Other articles, also edited by Prof. Debreceny, may appear in later editions, as they are still going through the editorial process. The ensuing issues will also have special sections on privacy (edited by Prof. Marilyn Prosch), enterprise ontologies (edited by Prof. Guido Geerts), virtual worlds (edited by Prof. William Dilla), social networks (edited by Prof. Roger Debreceny) and the smart audit.

Cao, Nicolaou, and Bhattacharya (2013) examine post-implementation enhancements in enterprise resource planning systems (ERPS). Past information systems research on real options suggests that large-scale information technology projects, such as ERPS, create various future options for system reconfiguration and extension. Management would decide whether to exercise an option according to future conditions. From the real options lens, the authors conduct a longitudinal examination of the determinants of post-implementation enhancement decisions for firms that have previously reported ERPS adoptions. They find that proactive ERPS adopters that employ performance-enhancing post-implementation review (PIR) practices and obtain favorable performance outcomes are more likely to make system enhancements. Overall, their findings are consistent with the logic of real options, suggesting that managers make heuristic evaluations for general conditions that allow for future contingent investments.

Davidson, Desai, and Gerard (2013) study the Effect of Continuous Auditing on the Relationship between Internal Audit Sourcing and the External Auditor’s Reliance on the Internal Audit Function. Prior research indicates that external auditors are willing to rely to a greater extent on the work of the internal audit (IA) function when it has been outsourced, or co-sourced, as opposed to maintained in-house. They address, in an experimental setting, the extent to which this relationship between IA sourcing and external auditor reliance is moderated by the use of continuous auditing. Results indicate that, when the IA function uses periodic auditing, external auditors rely more on an outsourced function than an in-house operation. Conversely, when the IA function uses continuous auditing, external auditors exhibit similar reliance on in-house and outsourced operations. The prior literature suggests that outsourcing an IA function can lead to higher levels of external auditor reliance, and, consequently, lower external audit costs. The results here suggest that maintaining the IA function in-house and employing continuous auditing may lead to similar external audit effects.

In the XBRL Mandate article, Du, Vasarhelyi, and Zheng (2013) examine XBRL filing errors. Since the mandate by the U.S. Securities and Exchange Commission (SEC) to begin interactive data reporting in June 2009, more than 4,000 filing errors have been identified. The researchers examine the overall changing pattern of the errors to understand whether the large number of mistakes may hamper the transition to interactive data reporting. Using a sample of 4,532 filings that contain 4,260 errors, the authors document that the XBRL filers are facing a significant learning curve. Specifically, the researchers find that the number of errors per filing is significantly decreasing in the number of filings, suggesting that the filing company or agents progressively learn from their experiences such that future filings show improvement. This provides evidence to encourage the regulatory body, filers, and XBRL technology-supporting community to embrace the new disclosure requirement in financial reporting. The significantly decreased error pattern also helps address the information users’ concerns regarding the data quality of XBRL filings.

Gailly and Geerts (2013) examine ontology-driven business rule specifications. Discovering business rules is a complex task for which many approaches have been proposed, including analysis, extraction from code, and data mining. In this paper, a novel approach is presented in which business rules for an enterprise model are generated based upon the semantics of domain ontology. Starting from an enterprise model for which the business rules need to be defined, the approach consists of four steps: (1) classification of the enterprise model in terms of the domain ontology (semantic annotation), (2) matching of the enterprise model constructs with ontology-based Enterprise Model Configurations (EMCs), (3) determination of Business Rule Patterns (BRPs) associated with the EMCs, and (4) use of the semantic annotations to instantiate the business rule patterns; that is, to specify the actual business rules. The success of this approach depends on two factors: (1) the existence of a semantically rich domain ontology, and (2) the strength of the knowledge base consisting of EMC-BRP associations. The focus of this paper is on defining and illustrating the new business rule discovery approach: Ontology- Driven Business Rule Specification (ODBRS). The domain of interest is enterprise systems, and an extended version of the Resource-Event-Agent Enterprise Ontology (REA-EO) is used as the domain ontology. A small set of EMC-BRP associations—i.e., an example knowledge base—is developed for illustration purposes. In addition, the new approach is demonstrated with an example.

Teqarden, Schaupp, and Dull, (2013) Identify ontological modifications to the resource-event-agent (REA) enterprise ontology using a Bunge-Wand-Weber (BWW) ontological evaluation approach. A BWW ontological evaluation emphasizes two criteria (completeness and clarity) and two independent mappings (representation and interpretation). The results of the evaluation confirm that the majority of the REA constructs correspond with a subset of the BWW constructs. Based on the results of this study, there are recommended modifications to the REA enterprise ontology including extensions associated with state, event, and system related constructs, as well as other clarifications.

In the “Practice Articles” section, Titera (2013), from the practitioner point of view, examines the anachronism of current Audit Standards and the enablement of audit data analysis. The article highlights the emerging role of data analysis on the financial statement audit and its value throughout the audit process, particularly in providing audit evidence. In addition, it raises the issue of needed revisions to the Audit Standards, whether for public or private company audits, and illustrates how certain of the current Audit Standards inhibit the external auditors’ use of enhanced data analysis and continuous auditing techniques. While this whitepaper identifies a few audit standards that could be revised in light of current technological capabilities, it does not purport to address all needed revisions. Rather it recommends that a more in-depth analysis be undertaken to develop needed guidance, as well as a list of recommended changes to the standards.

## Evolving Business Measurement and Data Quality (Assurance)

Both business measurement (accounting) and the assurance of reporting / information quality (auditing) are becoming progressively automated. These now socio-technical systems are increasingly incorporating automation driven by a set of different forces.

* The traditional accounting process, incorporating the double entry paradigm, is manually oriented, and, consequently, is prone to a high level of errors and extremely labor intensive. Furthermore, modern business, with a large number of transactions and non-financial processes, would be strangled if processes remained manual. The history of computerization of business processes signals the major initial driver of automation to be labor replacement. The automation of processes has brought many collateral benefits, such as:
  + substantive improvement in data quality (consistency), and
  + the emergence of “reports” with very low marginal cost of creation
* Computerization of processes has not been restricted to accounting systems, but evolved to impact many other areas. Traditional computer systems were “file oriented” (Nolan, 1973), whereby each process had its independent implementation causing substantive data inconsistency and redundancy.
  + Although ERPs have been fully implemented in business, the “file oriented”/ separate process view still permeates accounting and audit. The logical interconnections between the production world and the accounting world (Vasarhelyi et al, 2012a; Alles et al., 2008) have not been explored or incorporated into practice.
  + The links between manufacturing, inventory purchase, marketing, etc. and the associated financial measurements have not been incorporated into the financial model
  + These links have not been explored in the audit model as suggested by Kogan et al. (2013b)
* The inherent opacity of machine-based processes can be substantially eased by investment in computer-based mechanisms to create transparency. The operational costs of data manipulation and storage are now marginal, although the development costs of these mechanisms is still high. The net benefits of opacity reduction (internal and external) do not substantively drive their progress. Organizations have historically been resistant to reveal business information as the modern organizational form motivates agents to restrict information flow.
  + The reporting schemata is highly asymmetric with internal information overwhelming external information, and this fails to create the inter-process connections mentioned above
  + The assurance process, although using some of the large internal information that exists, also does not make these inter-process connections

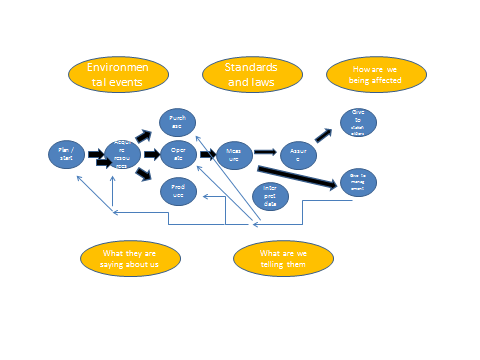


Figure 1: A larger focus for reporting and assurance

Figure 1 illustrates a wider view of the reporting and assurance processes that places some of the above discussion into context. Further discussion is needed of the emerging role of automation in these financial processes, in particular, the cooperation of man and machine (Vasarhelyi, 1973). Parasuraman et al. (2000) examine levels of automation in the context of human versus machine activities -) and the degree that automation takes over the entire process. The original Parasuraman et al (2000) table has been enhanced -by adding an additional column -that hypothetically describes the various levels of interaction in an audit context.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **Man x machine Interaction** |  | | **Interaction in the audit Context** | |
|  |  |  |  | |  | |
| High | 10 | the computer decides everything, acts autonomously, ignoring the human. |  | | The computer does the entire audit and  signs the opinion; no human auditor involvement | |
|  | 9 | informs the human only if it, the computer, decides to |  | | There is selective human monitoring in the audit whereby  automation limits the boundaries of human auditor  action; computer decides when to inform | |
|  | 8 | informs the human only if asked, or |  | | There is selective human monitoring in the audit whereby  human auditor decides what elements to be informed of | |
|  | 7 | executes automatically, then necessarily informs the human, and |  | | Computer conducts audit, but auditor is provided with all  resulting audit information as a default rule | |
|  | 6 | allows the human a restricted time to veto before automatic execution, or |  | | Automation enabled but subject to selective human  intervention; human auditor has final decision power, but  only within a given time window | |
|  | 5 | executes that suggestion if the human approves, or |  | | Human controlled automation whereby human auditor  approves or rejects computer-provided suggestions | |
|  | 4 | suggests one alternative | |  | | Suggestive model with decision function; Human auditor  maintains control over audit activities |
|  | 3 | narrows the selection down to a few, or | |  | | Automated screening; system provides suggestions, but  human auditor controls the audit and makes decisions |
|  | 2 | the computer offers a complete set of decision/action alternatives, or | |  | | Wide suggestive model whereby human auditor  conducts the audit, but computer facilitates the process  by offering alternatives; decision support based audit |
| Low | 1 | the computer offers no assistance: human must take all decisions and actions. | |  | | The manual audit |

Table 1: levels of automation of decision and action selection (adapted from Parasuramaran et all,2000)

Parasuraman et al. (2000) also divide human information processing into four stages: 1) information acquisition, 2) information analysis, 3) decision -selection, and 4) action implementation. Table 2 presents potential tools / approaches relevant to audit as aids in these dimensions.

|  |  |
| --- | --- |
| Information acquisition | SQL queries  Computer vision  Automatic sensing  E-Commerce |
| Information analysis | Ratio analysis  Descriptive statistics  Visualization  Machine learning  Many forms of audit analytics |
| Decision selection | Knowledge engineering  Deterministic and stochastic models  Optimization |
| Action Implementation | Process reengineering  Typically manual methods |

Table 2: Automation tools in audit - human information processing

The topic of audit automation has been often in the literature (Janvrin et al, 2008; Keenoy, 1958; Vasarhelyi 2004, 1985, 1984,1983) over the last few decades. Audit automation capabilities were initially manifested in CAAT programs, were subsequently offered within PCs in the practice context, and, more recently, -have appeared in a plethora of decision support tools (Carson and Dowling, 2012; Dowling and Leech, 2007). The next generation of audit automation will have to be -an essentially integral component of business processes due to the current nature of business systems which have morphed into being un-auditable by traditional methods and certainly traditional standards (Titera, 2013). Many of these systems:

* Incorporate enormous quantities of both endogenous and exogenous data
* Encompass many real time or close to real time processes that are customer visible and sensitive
* Integrate gracefully with external (outsourced) systems
* Have some degree of automatic decision making built into the systems
* Are not directly observable neither in terms of data nor in terms of controls
* Incorporate a range of different technologies / vendors with modified ERPs adapted to the organization’s business processes
* Sit on common cloud environments
* Are part of a product ecosystem (e.g. Amazon’s Kindle, Apple Music, etc)

This “traditional method un-auditability” (**TMU**) is reflected by a series of technical, procedural, and environmental considerations such as the following-:

* Data is so large that sampling has very little value
* Data is so large that it is not practical to perform a large number of full population tests
* Analytic technology is now such that forensic preventive models can be developed to filter out transactions that would have been ex-post facto reviewed
* Traditional confirmations add very little evidence; new methods of third party validation [e.g. confirmatory extranets; (Vasarhelyi, 2008)] must be put in place
* Relationship between non-financial and financial processes can be developed to monitor and confirm processes
* Business processes are so rapid that firms may fail or processes collapse before management notices and auditors verify
* Etc, etc, etc

In view of these factors, an evolutionary approach for audit improvement may not be appropriate, but a full reengineering (Hammer, 1990) is necessary. One of the problems, as denoted by Christensen, is that organizations will tend to fail rather than cope with disruptive technology, and the reengineered audit is such a disruptive process as it violates many of the axioms of the traditional audit method (**TAM**). Furthermore, there is business being performed and it relies on assurances (although with little but psychological value) to be continued. Byrnes et al (2013) discuss the needs of future audit and the problem with short term palliative measures that actually fail to improve the long term quality of the audit process.

The core concept in dealing with the TMU issues is that rapid, progressive, reengineered assurance and its implementation involves disruptive technology. US manufacturing that one time occupied about 40percent of the workforce has gone down to very low numbers and currently is experiencing substantive[[2]](#footnote-2) economic rebound without a corresponding increase in the labor force. This is being prompted / facilitated by a second generation of automation in the factories primarily entailing the adoption of robots as replacements for human beings. The aforementioned work by Brynjolfsson and McAfee; 2011, 2012) makes a series of points that must be considered and adapted to the examination of accounting and assurance. It must however be remembered that these processes are bitable (Vasarhelyi and Greenstein, 2003), which makes them a better candidate for automation. The associated robotics by and large will not be physical entities, but will be mainly software. These issues are discussed next.

### Automation and Robots in Accounting and Auditing

Vasarhelyi, Alles and Williams (2010) discuss the real time economy, and its key motivation which is the reduction of latency for the purpose of reducing the occupation of capital. Essential to the reduction of latency is the replacement of human work for automation. Automation is dimensionally faster and more precise than human work, although unstructured decision making and decision implementation, even with extant AI technology, are not readily implementable. Figure 2 lays out the real-time economy stages that are subject to automation.

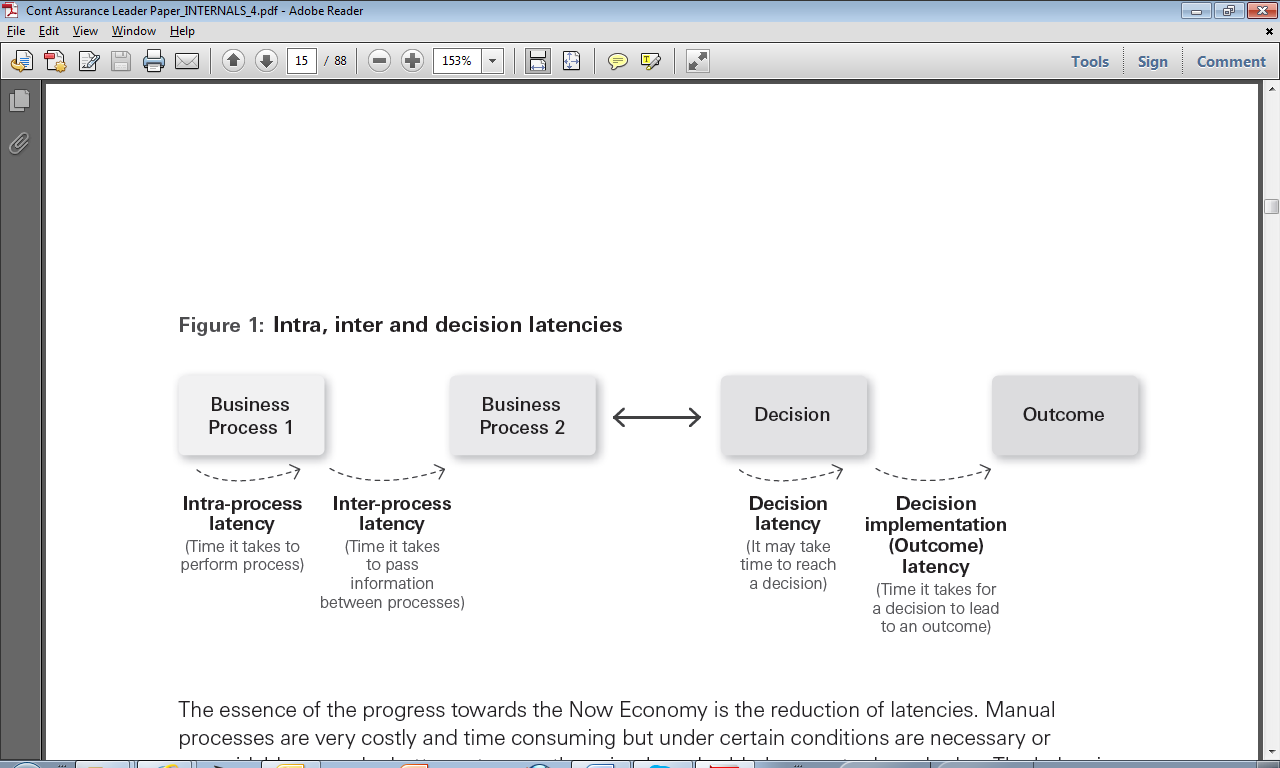


Figure 2: Business Processes and Latency (Vasarhelyi, Alles & Williams, 2010)

Brynjolfsson and McAfee (2011) prescribe that organizations should “*Create -processes that combine the speed of technology with human insight*”(p.58). Such an approach in audit automation would preserve the characteristics of professional work, and, at the same time, use the benefits of automation. The dilemma is the fact that the audit eco-system of the future will have to be by and large automated to deal with the volume of data and the speed of the process. Consequently, human collaboration with machines will have to be mainly formalized with some judgmental components concentrated in the higher level processes.

Teeter and Brenan (2008) used Siemens’ audit action sheets, that describe in detail steps to be taken in a SAP audit, to evaluate the potential methods of automation. Vasarhelyi et al (2011) create audit action sheets for the order to cash audit at P&G to evaluate and pilot key steps in the audit automation effort. These efforts provide an insight into formal processes of audit automation. The route to automation can be broken down in the steps in Figure 2 that are discussed next:

#### Automation of labor intensive tasks (intra-process latency reduction)

Analogous to the traditional implementation of computers in business processes, labor intensive processes e.g. manual billing of utilities) were the first targets of automation. Laptops and spreadsheets have already performed some of these steps, although the transfer of data into and out of these devices is often very cumbersome and time consuming. Furthermore, there is substantial lack of consistency in their usage, and, as such, many of the CPA firms and software vendors created a wide range of audit templates or supporting software.

Systems engineering research, as well as studies of time and motion (Taylor,1911), has sought to identify steps that auditors perform repetitively in the performance of their functions in an effort to reveal potential areas of systematization. On the other hand, the wide variety of types of businesses, industries, supporting IT systems, and audit objectives as well as the nature of liberal professions limits this systematization.

Automation of staged data collection and data delivery (inter-process latency reductions)

The AICPA, through its Assurance Services Executive Committee, is issuing the Audit Data Standard (Zhang et al, 2012; AICPA, 2012) with specific guidelines on the data to be provided to external and internal auditors. This standardization can facilitate the automatic transmission of data between corporate and audit systems. Furthermore, the standard is proposing data to be tagged in XBRL/GL (Cohen, 2009) further facilitating system interoperability. This standardization could be used for repeated extractions at close time intervals, creating the possibility of a close to real time audit and, as by-products, continuous monitoring reports or dashboards.

There are substantive research needs in the audit data standard which include: composition of the standard, method of deriving the standard, potential assertions supported by the standard, apps to be developed to use the standard, consideration of the granularity necessary for the standard, what industries and cycles need specific standards, how to version and update the standard, how to promote the utilization of the standard, etc…

#### Automation of Decision making

Extensive literature on audit decision making has accumulated in the last three decades. Auditor decisions in an automated environment may be different from the types of decisions made in a manual one. Firm or statutory guidance may ultimately serve to parameterize audit decisions. The same arguments used by Krahel (2012) and Vasarhelyi et al (2011), that are based upon an examination of accounting standard setting and maintain that standards are de facto formalized regardless of the extensive literature debate of principles versus rules that emerged in the fraudulent reporting crisis of 2002/2003, are extensible to auditing standards and their automation. The argument in simple terms states that de facto all major rules that affect volumes of information in accounting are eventually negotiated with the standard setters and impounded into software allowing for no “principle based disclosure.” If auditing is to be automated to the extent that current accounting systems are, substantive formalization is necessary for putting in place automation and the necessary process changes. In addition to data processing mechanics, classification structures like taxonomies and hierarchies must be expanded to harden “soft” knowledge into computable structures (Vasarhelyi & Krahel, 2011) (Geerts & MCCarthy, 2002).

The research into the current manual processes of auditing, and the documentation of discrete steps of its performance can help to identify basic automatable decisions and meta-decisions that utilize results from different steps of audit that may require informal evaluation and intuition. Analogous to other areas of automation, progressively more and more complex decisions will be formalized and automated.

Most of the behavioral research in auditing has focused on examining auditors in different stages of the audit process, but not on breaking down decisions as automatable or not, nor providing guidance for this automation. These two areas of research could provide valuable guidance to the evolving area of audit automation.

#### Automation of Decision Implementation

Several audit decisions imply follow up action in the audit program. These potentially could be automated, or at least enhanced by progressive automation. For example, in the evaluation of confirmations, an auditor may decide to increase the sample or focus on a certain type of transactions. These follow up actions can be automated obeying general audit firm guidelines or the generic parameters of the auditee. Audit actions can be intermingled with administrative supportive processes.

The mapping of audit processes, the study of their sequences and contingencies, the study of formalization of decision implementation, and the examination of interactions of audit and administrative processes (e.g. auditor deployment and billing) are all interesting research topics

## Conclusions

The age of big data (Davenport & Harris, 2007) has arrived, and with it both the need for understanding these stores and automating many of its functions. Although many accounting processes are substantively automated, auditing is basically performed in an ad hoc manner within some generic framework constructed by laws, standards, and organization guidelines.

Many conditioning factors and objective functions created a situation where the benefits of formalized automation have not been realized in auditing. Economic factors, and the change in the technology of the auditees creates what is called here traditional method un-auditability (TMU), which will force the adoption of intelligent automation (a la robotics in production) in the assurance process. This adoption is now hampered by anachronistic rules, a conservative audit profession, and strong resistance to transparency by business entities.

The hand-crafting of audit solutions, even using computer tools, is expensive and not effective. This has to be replaced by formalized data structures, taxonomies of artifacts such as errors, controls, accounts etc., and a large number of software agents acting on behalf of the audit process in a large sea of data. Auditing is, in addition to labor intensive, a judgment rich environment. A natural path of automation is started by 1) computerization of frequently repetitive tasks and tasks that must be performed autonomously in large data receptacles, then 2) deterministic / or simple decision automation where the potential outcomes are clear, then 3) observation of human intervention to resolve higher-level ambiguities, thus allowing for the automation of progressively more and more complex decisions.

## References

AICPA, Assurance Service executive Committee. The Audit Data Standard. Exposure draft, 2012.

Alles, M., Kogan, A., and Vasarhelyi, M.A. 2012 Principles and Problems of Audit Automation, Rutgers Business School, Working Paper, December 17, 2012

Alles, M.G., A. Kogan, M.A. Vasarhelyi, J. Wu. 2008. *Continuous Data Level Auditing Using Continuity Equations*. Unpublished working paper, Rutgers Business School.

Brynjolfsson, E.; McAfee, A. (2012), Winning the Race with Ever-Smarter Machines, *Sloan Management Review*, Winter 2012, 53-57.

Brynjolfsson, E.; McAfee, A. (2011). Race Against The Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy (Kindle Locations 274-279). Digital Frontier Press. Kindle Edition.

Byrnes, P., Criste, T., Stewart, T., Vasarhelyi, M. A. 2013. Blue Sky Scenario: Facts and

Factoids on the Future Audit, AICPA, forthcoming.

Cao, J., Nicolaou, A., Bhattacharya, S. 2013. A Longitudinal Examination of Enterprise Resource Planning Systems Post-Implementation Enhancements. *Journal of Information Systems*, 27 (1).

Carson, E., and --Dowling, C. 2012. The competitive advantage of audit support systems: The association between extent of structure and audit pricing*. Journal of Information Systems* 26 (1). 35-49.

Christensen, C.M. 1997. The Innovator’s Dillemma: When new technologies cause great firms to fail, 1997.

Cohen, E.C. 2009. **XBRL's Global Ledger Framework: Exploring the Standardised Missing Link to ERP integration***International Journal of Disclosure and Governance*, (2009) **6,** 188–206. doi:10.105, <http://www.palgrave-journals.com/jdg/journal/v6/n3/abs/jdg20095a.html>

[Davenport](http://www.amazon.com/Thomas-H.-Davenport/e/B000APNYLC/ref=sr_ntt_srch_lnk_1?qid=1330918552&sr=1-1), T. and [Harris](http://www.amazon.com/Jeanne-G.-Harris/e/B001JS4YOK/ref=sr_ntt_srch_lnk_1?qid=1330918552&sr=1-1), J. 2007. [Competing on Analytics: The New Science of Winning](http://www.amazon.com/Competing-Analytics-The-Science-Winning/dp/1422103323/ref=sr_1_1?s=books&ie=UTF8&qid=1330918552&sr=1-1), Harvard Business School Press, 2007.

Davidson, B. I., Desai, N. K., Gerard, G. J. 2013. The Effect of Continuous Auditing on the Relationship between Internal Audit Sourcing and the External Auditor’s Reliance on the Internal Audit Function. *Journal of Information Systems,* 27 (1)

Debreceny, R., and Gray, G. 2013. IT Governance and Process Maturity: A Multinational Field Study,

Journal of Information Systems, 27, 1.

Dowling, C. and --Leech, S. 2007. Audit support systems and decision aids: Current practice and opportunities for future research. *International Journal of Accounting Information Systems,* 8, 92–116.

Du, H., Vasarhelyi, M. A., Zheng, X. 2013. XBRL Mandate: Thousands of Filing Errors and So What?. *Journal of Information Systems,* 27 (1).

Gailly, F., and Geerts, G. 2013. Ontology-Driven Business Rule Specification. *Journal of Information Systems*, 27 (1).

Geerts, G. L., McCarthy, W. E. 2002. An Ontological Analysis of the Exonomic Primitives of the Extended-REA Enterprise Information Architecture, *International Journal of Accounting Information Systems,* 3, 1, 1-16.

Hammer, M. 1990. Reengineering work: Don’t automate, obliterate. *Harvard Business Review*, July-August, 104–112.

Janvrin, D., Bierstaker, J., Lowe, D. J. 2008. An Examination of Audit Information Technology Use and Perceived Importance. *Accounting Horizons*, 22, 1, 1–21.

Keenoy, C. L. 1958. The impact of automation on the field of accounting. *The Accounting Review*, 33, 2, (April), 230–236.

Kogan, A., Alles, M.G., Vasarhelyi, M.A., and Wu, J. 2013. Design and Evaluation of a Continuous Data Level Auditing System, Rutgers Business School, Working paper, March 19, 2013[[3]](#footnote-3)\*

Krahel, J.P., Formalization of Accounting Standards, PhD Disertation, Rutgers, The State University of New Jersey, Newark. Rutgers Business School, 2012.

Parasuraman, R., Sheridan, T.B. and Wickens, C.D. 2000. A Model for types and Levels of Human Interaction with Automation, *IEEE Transactions on Systems, Man and Cybernetics – Part A: Systems and Humans* - 30, -3, May 2000.

Nolan, R.L. Computer Databases: the Future is Now, *Harvard Business Review*, September – October, 1973.

Taylor, F.W. Principles of Scientific Management, 1911, Published by the Norton Library, 1967.

Teeter, R., and Brennan, G. 2008. *Aiding the Audit: Using the IT Audit as a Springboard for Continuous Controls Monitoring*, Unpublished working paper, Rutgers Business School.

Teqarden, D., Schaupp, L., Dull, R. 2013. Identifying Ontological Modifications to the Resource-Event-Agent (REA) Enterprise Ontology Using a Bunge-Wand-Weber Ontological Evaluation*. Journal of Information Systems* 27 (1).

Titera, W. 2013. Updating Audit Standards - Enabling Audit Data Analysis. *Journal of Information Systems,* 27 (1).

Vasarhelyi, M. 1985. Audit Automation: Online Technology and Auditing. *The CPA Journal*. April 1985: 10-17.

Vasarhelyi, M.[1984. Automation and Changes in the Audit Process,](http://raw.rutgers.edu/MiklosVasarhelyi/Resume%20Articles/MAJOR%20REFEREED%20ARTICLES/M08.%20automation%20and%20changes%20in%20audit%20process.pdf)*Auditing: A Journal of Practice and Theory,* 4,1, 100-106.-

Vasarhelyi, M. 1983. [A Framework for Audit Automation: Online Technology and the Audit Process."](http://raw.rutgers.edu/MiklosVasarhelyi/Resume%20Articles/PROFESSIONAL%20PAPERS/P07.%20framework%20for%20audit%20automation122.pdf) *The Accounting Forum*, March 1983, 30-44.

Vasarhelyi, M. A. 1973. Man-Machine Planning Systems: A Behavioral Examination of Interactive Decision Making, Ph.D. Dissertation, University of California.

Vasarhelyi, M. A., and Greenstein. M. 2003.Underlying Principles of the Electronization of Business: A Research Agenda.- *International Journal of Accounting Information Systems*, 4, 1, 1-25.

Vasarhelyi, M. A., and Alles, M. G. 2008. The “Now” Economy and the Traditional Accounting Reporting

Model: Opportunities and Challenges for AIS Research, *International Journal of Accounting*

*Information Systems*, 9, 4, 227-239.

Vasarhelyi, M. A., Alles, M.G. and Williams, K. T. 2010. Continuous Assurance for the Now Economy, A Monograph for the Institute of Chartered Accountants of Australia, 2010.

Vasarhelyi, M. A., and Krahel, J. P. 2011. "Digital Standard Setting: The Inevitable Paradigm." *International Journal of Economics and Accounting*.Vol. 2, No. 3, 242-254.

Vasarhelyi, M. A., Warren J. D., Jr., Teeter R., and Titera B.. (2011). Embracing the Automated Audit. Working paper, Rutgers Business School.

Vasarhelyi, M., Romero, S., Mock, T., and Gal, G. 2012. A Measurement Theory Perspective on Financial Reporting, *Journal of Emerging Technologies in Accounting*, Forthcoming 2012a.

Zhang, L., –Pawlicki A. R., McQuilken, D., and –Titera, W. R., 2012. The AICPA Assurance Services Executive Committee Emerging Assurance Technologies Task Force: The Audit Data Standards (ADS) Initiative. *Journal of Information Systems*. -26, 1, -199-205.

1. The advice and help of Prof. Michael Alles and Messrs. Paul Byrnes, Steven Kozlowski, and Stanley He Li are much appreciated. [↑](#footnote-ref-1)
2. Ibid <http://www.cbsnews.com/video/watch/?id=50138761n> [↑](#footnote-ref-2)
3. \* We thank seminar participants at the 2011 Rutgers Continuous Auditing Symposium and the European Accounting Association for helpful comments on an earlier version of this paper. [↑](#footnote-ref-3)