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Handbook of Big Data and Analytics in Accounting and Auditing

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ISBN 978-981-19-4459-8 ISBN 978-981-19-4460-4 (eBook)
https://doi.org/10.1007/978-981-19-4460-4

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Dedicates this book to his late father-in-law Eng. Siddique Ali Miah, who passed away in April 2022, always encouraged his academic endeavors, and loved him unconditionally. He also acknowledges parents Kabir Ahmed & Ranuara Begum, wife Afsana, and boys Sabir & Jabir for their endless love, support, and patience throughout his academic career.

Tarek Rana

Dedicates this book to his children Esmeralda and Alvar, to his wife Katinka and his father-in-law Jan Svanberg Sr. for their love and support.

Jan Svanberg

Dedicates this book first and foremost to his mother Marianne who has turned 93 and always been supportive, in good times and bad. He also dedicates the book to his research fellows in Sweden end elsewhere.

Peter Öhman

Dedicates this book to all those budding accounting, management, and information systems academics who may find interest and build on this collection of contributions. Research is about sharing ideas and building community. We all need support and encouragement in this activity. It has never been more important to join with others in creating research knowledge.

Alan Lowe

Preface

There is a massive proliferation of data from largely unstructured and non-traditional sources. Not only do they contain very rich information but are updated much more frequently than traditional data sources, thus providing faster access to the latest information and developments. However, relatively little is known as to how accountants' and auditors can deal with the big data and utilize such information by using emerging technologies of analytics to enhance the decision-making capacity of traditional accounting information. Due to the proliferation of big data, a variety of rich and frequently updated information has become available. Accounting academics and practitioners are yet to delve deeply into utilizing this information. While there has been considerable research in exploring the role of big data, data analytics, and textual analytics in accounting and auditing, we still lack evidence on what kinds of best practices academics, practitioners, and organizations can implement and use.

This handbook focuses on both conventional and contemporary issues facing academics, practitioners, and organizations particularly when technology and business environments are changing faster than ever. The book project thus provides various approaches for accounting and auditing academics and practitioners to venture into the age of big data and analytics technologies and their usage. Moreover, the accounting literature lacks empirical evidence on how analytics, machine learning, artificial technologies enhance financial reporting, auditing, management control systems, performance management, and risk management by accessing such big data from multiple sources. Furthermore, accountants and auditors need to learn about the challenges and opportunities of big data and how this will change their professional roles in the digital age.

This book collects the most up-to-date scholarship, knowledge, and new developments of big data and analytics in accounting and auditing by bringing together many strands of contextual and interdisciplinary research. The handbook is interdisciplinary although it is grounded in the disciplines of accounting and auditing but utilizes expertise in management, marketing, information technology, computer science, human resource management, and supply chain disciplines. The chapters provide both retrospective and contemporary views and commentaries by leading and knowledgeable scholars in the field, who offer unique insights on the changing

role of accounting and auditing in today's data and analytics driven environment. All chapters address gaps in the literature and provide information about various technologies that are available for analytics, established and emerging models, and applications of practical tools by heavily drawing on conceptual, analytical, literature review, and case-based insights. This enriches future direction for research on accounting and auditing analytics.

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Melbourne, Australia — Alan Lowe

Acknowledgments

The authors of the chapters and the editors are equal partners in producing this volume. The editors are extremely grateful to the authors for their contribution whose chapters are published in this volume. We cannot thank enough the authors for their hard work in writing chapters during Covid-19 pandemic and patiently waiting for the compilation of the volume during this difficult time (which has caused many changes and delays by the impact of Covid-19 pandemic). Special thanks to the reviewers for their constructive comments and suggestion for improvement on the chapters included in this book. The editors greatly acknowledge the support from Daniela Argento, Timur Uman, Ling Mei Cong, and Jeanette Ng Po Tin in managing chapters for procuring the book. The editors would also like to thank Lucie Bartonek, Mokshika Gaur, Kavitha Sathish, Jacob Arun Raj, and Parasuraman Aiya Subramani of Springer Nature for their excellent support during this project.

Introduction

In recent years, the demands for accountants, auditors, business analysts, and financial consultants to extend their analysis and interpretation of big data for planning, control, and strategic decision-making are increasing. The academics and practitioners are increasingly interested in helping organizations to rapidly develop and contextualize the analytics means by which to incorporate big data, machine learning, artificial intelligence technologies, and capabilities that will allow them to make sense out of the exponentially growing data captured within and outside organizational domains from structured and unstructured sources. Increased competition for revenues, market share, sustainability, technological advancement, proliferating government regulations, and increased social and community expectations for greater transparency and accountability have introduced more challenges and pressures on business and professional organizations to develop capability to leverage the benefit of big data through appropriate innovation and diffusion of analytics capability.

To this end, the academic and professional community as a whole will greatly benefit as we learn more about data analytics and how organizations successfully innovate and use such systems in the age of big data. The emerging importance and significance of big data and data analytics suggests that organizations need to get a handle on how to use this data earlier rather than later. There are limited documented instances on how organizations could use these large data warehouses to gain competitive advantage but lacks a comprehensive coverage. In a rapidly changing business environment which is increasingly volatile, this handbook can help academics, professionals and organizations to develop capabilities to explore further into the realms of big data with a focus not only on managing threats of declining revenues, but on identifying opportunities to increase revenue and improve customer satisfaction by adding value across the whole supply chain of the business.

The handbook's content will be highly desirable and accessible to accounting and non-accounting audiences across the globe. Aimed at academics, practitioners, students and consultants in the areas of accounting, auditing, management, and other business disciplines, the handbook provides high-level insight into the design, implementation, and working of big data and analytics theories and practices for all types

of organizations worldwide. The scholars from interdisciplinary fields provide theoretical perspectives, critical evaluations, and practical guidance on big data and data analytics by illustrating issues related to various sectors such as public, private, not-for-profits, and social enterprises.

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Review Process

This book is a collection of peer-reviewed chapters. Springer Nature is one of the leading scientific and commercial publishers in the world for edited books and major reference works. Springer Nature is an interdisciplinary publisher of research books and monographs. This book is a part of Springer Nature's research handbook series that seeks to advance new and scholarly knowledge and debate by providing leading edge and contemporary research outputs. To maintain the high quality of publishing, peer-review is an essential and integral process and fundamental element of Springer Nature's publication process for research books like this one. For each chapter, reviewers and editors have provided anonymous review comments on the content, quality, and contribution. The book has an International Standard Book Number (ISBN), and each chapter has a unique Digital Object Identifier (DOI). The authors and the editors share responsibility for the entire book.

Contents

Editors and Contributors

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Alan Lowe is an Honorary Professor of Management Accounting at RMIT University, Melbourne, Australia. He served as a joint Editor of the *British Accounting Review*. His research interest has included management controls, ERP, technologies, and internet reporting using case studies and interpretive methodology. Recent projects include ethical identity and financial innovation in Islamic financial institutions, ICT service provision in health care sector, and governing climate change.

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Chapter 1
Introduction: Analytics in Accounting and Auditing

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Abstract Big data and analytics offer new opportunities and challenges for academics and practitioners in all business disciplines including accounting and auditing. In the backdrop of increasing growth of emerging technologies, the organizations in public, private and not-for-profit sectors are embracing digital economy and the fourth industrial revolution journey. This requires knowledge of better practice examples, lessons learned and future directions in addressing the new challenges and seizing new opportunities. In this chapter, we discuss the implications of data analytics, artificial intelligence and machine learning on the accounting and auditing practices. We focus on the technological, social, political, economic, institutional, and behavioral aspects of these technologies in the public, private, non-governmental and hybrid contexts. We present state-of-the-art research directions on philosophical, theoretical, methodological, and practical issues, new developments and innovations of big data, analytics, artificial intelligence, machine learning, blockchain, cryptocurrencies and other emerging technologies related to accounting and auditing.

Keywords Big data · Analytics · Artificial intelligence · Machine learning · Digital economy · Accounting · Auditing

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T. Rana et al. (eds.), *Handbook of Big Data and Analytics in Accounting and Auditing*,
https://doi.org/10.1007/978-981-19-4460-4_1

1 Point of Departure

The change to accounting and auditing that is caused by the emerging use of autonomous decision support systems has been described as if this change would concern only the simple repetitive and labor-intensive tasks and not at all the complex judgement-based work accountants and auditors do in the upper end of the value chain. In accounting that would be the work performed by bookkeepers or a stock inventory, and in auditing that would be to perform substantive testing by digging through thousands of items in a ledger. The pervasive arguments are that the effects of artificial intelligence (AI) are likely to be highest on such tasks that have already been computerized because they can be defined in a computer-friendly manner. Typical tasks suitable for computerization are the verification of mathematical accuracy of supporting schedules, tracing the cash receipts journal and cash disbursement journal to general ledger postings and bank statements.

The expected AI revolution of accounting and auditing happens in conjunction with the technological breakthroughs such as robotics, blockchains, mobile applications, and collaboration platforms. The Big 4 audit firms are involved in AI-projects aimed at developing methods to improve efficiency and effectiveness of their services. However, so far the impact of AI in audits is pronounced only in the area of data acquisition. This means that there is AI-enabled methods to locate information for example by extracting it from documents with the purpose of providing information to human auditors. This type of application liberates the accountants' and auditors' time for high level judgment tasks. As long as the use of AI is limited to this non-judgment type of task neither accounting nor auditing needs to feel any threat because such analytics are tools under the user's control. We find, however, that the picture painted in previous literature is based on a layman's perspective on AI and that the real potential is much broader and deeper than automation of hands-on tasks. Analytics using software capable of learning on its own can be used much like statistical methods to make multidimensional decisions concerning the most complex tasks. As any investor or medical practitioner knows, this type of multi-criteria decision-making is the hardest because the human mind does not seem fit to weigh many factors against each other and make accurate predictions on such data.

The many significant contributions to the accounting and auditing analytics literature presented in this volume should be seen in the light of the fact the previous analytics literature has underestimated the capacity of analytics in accounting and auditing. Big audit firms unconstrained by the beliefs and predictions of the academic literature are beginning to make progress towards fully autonomous decision support systems based on AI. For example, KPMG runs a cooperation with IBM about a large AI implementation to experimentally improve the audit process. The precise topics which this system is proposed to address is not yet publicly known but it is obvious that a system like IBM's Watson is capable of doing more than just scraping up pieces

of information and presenting them in accessible graphs to auditors. The real potential lies in enhancing the limitations of human judgment when confronted with the most complex and fuzzy problems in accounting and auditing. Information extraction is just a starting point.

2 Part I: Emerging Technologies, and Accounting and Auditing Challenges

The adoption of emerging technologies in accounting and auditing is obviously not without challenges. Challenges relate to the clash between autonomous software and current standards and to how accountants and auditors make sense of the emerging technologies and their properties (Salijeni et al., 2021). Most academic contributions exploring the rise of big data and analytics in accounting and auditing offer a normative perspective on how technologies may better equip accountants and auditors to analyze client data and the practical challenges (Vasarhelyi et al., 2015), while underlying adoption issues are seldom analysed. Adoption issues which are not directly a matter of how to most effectively employ analytics include security, privacy, too much or too little reliance on a system, ownership, and training. For example, auditors may integrate data from multiple sources (Issa & Kogan, 2014) but when doing so auditors need to comprehend the appropriateness of their collected data for the decision they are about to make and that requires knowledge of the inner logic of the analytics tools they are using. Sometimes this is straightforward but there are cases when the manner in which questions are asked through the use of AI-methodology to deal with a measurement problem in business calls for conceptual development. New ways of viewing measures lead to new understandings of the problem and what it means to solve it.

Another adoption issue is obviously who owns the data and the methods with which it is analyzed. As long as the company that pays for the development of a method owns its data all will be fine. When external data is needed, such as the case with ESG ratings, the problem is that the company developing the ratings can only use them within the legal limits of their rights to use the purchased data. A ground-breaking discovery that could change the world would then require costly and time-consuming investments in independent data acquisition before the method can be offered. The organization's use of certain methods may hinge on that data and analytics will be available at a certain cost in the future but ownership and distrust can obstruct a business technology adoption for strategic reasons. Some analytics must become strategic core competencies which may never be delivered from the outside. The book addresses adoption issues in Chap. 3. The chapter illustrates that some adoption issues can be specific for an institutional context while other are generic.

The implementation of new technology in accounting and auditing undoubtedly collides with the current standards at some point because the standards define tasks as performed and fully controlled by a human decision-maker. For example, audit

standards require of the signing auditor that he or she is personally responsible for the performance of the audit, including how the statistical sampling of items to control was done. If this procedure is conducted with an autonomous decision support system, which most likely will be the case very soon in many external audits, the auditor will have to be knowledgeable about the inner cognitive processing of the AI-based decision-support tool and currently there is not much discussion in the audit profession how this knot can be untied.

In this context there are some challenges that are easier to solve than others. One of them is the context-dependence of technology adoption. When new decision-support systems are developed, they cannot be used in all countries in the same manner due to country-specific regulation. Some standards relate to, for example, tax issues which are specific to the institutional context (country) and therefore make technology adoption context specific. In accounting this is clearly the case with software for small businesses' bookkeeping which is covered in Chap. 7.

A difficult challenge for accounting and auditing is the understanding and measurement of corporate social performance, or the popular terms ESG (Environment, Social, Governance). The sustainability reporting standards, most notably the GRI (Global Reporting Initiative) has made corporate social performance a new bottom line concept equivalent to what income and balance is for financial reporting. The similarities end about there, however, because while the meaning of financial income is absolutely clear, the bottom line of a sustainability report is unknown both to accountants and auditors.

ESG experts in banks and insurance companies need to deal with this uncertainty. If you ask the leading experts in a large investment banks such as Deutsche Bank or Morgan Stanley they would probably say they know what sustainability is. However, if you ask them to compare the ESG of two car manufacturers or two pharmacy companies they would stutter and eventually they would say that they prefer one because of their strong governance or their lower pollution. If you then ask on what basis they assess the trade-off between a company's governance against their pollutions, water and energy use, the number of work-place accidents and their number of female directors you would not get a straight answer. They might refer to an ESG rating from Sustainalytics or MSCI they have purchased as a state-of-the-art rating. If you press them on causes for believing that these ratings provide legitimacy (you do not ask for evidence that the ratings are valid measures of sustainable performance because you realize that the people you are talking to do not know these concepts) for their investment portfolios, their troubled faces would be painful for you to watch so when they say something about materiality or financial materiality you let them go. The problem is that there is no method to even at some modest level of objectivity measure a company's sustainable performance.

As demonstrated by the research group at Harvard Business School (Christensen et al., 2022), all investigated methods to measure the sustainable performance of companies for investment purposes lack validity, or as Chatterji et al. (2016) state it more bluntly, they are all wrong. Fortunately, a solution to what is the greatest challenge to the finance industry today is presented in the chapter on ESG and machine learning in this handbook. Chapter 4 explains the conceptual difficulty that

accountants and auditors face with the undeterminable bottom line and how machine learning can be used to develop ESG predictions, or ratings, that constitute the only ESG ratings with predictive validity and the only ratings for which there is evidence of accuracy known to the literature.

The development of a valid methodology for ESG ratings is important because it suggests a more solid basis for how institutional investors compose socially responsible investment portfolios, and it can be used as decision support in accounting and auditing. For example, the literature describes no validated method that can be used by auditors as they perform their materiality assessments in sustainability audits. On the contrary, recent evidence indicates that auditors are confused about the meaning of the bottom line of sustainable performance, and therefore they cannot assess which company features that constitute the most important sustainability items to report (Canning et al., 2018). The sustainability reporting framework GRI (Global Reporting Initiative) states that auditors should engage broad stakeholder groups in the assessment of which are the material sustainability items to report. In practice this is impossible.

Chapter 4 can be viewed as a proposal to solve the problem with predicting corporate social performance in several different contexts such as reporting (i.e. when companies determine the materiality of sustainability information and therefore whether it should be reported), auditing (i.e. when auditors verify the materiality assessment and thus companies' sustainability reporting focus), and investors (i.e. when composing responsible investment portfolios). When several studies have reported that current ESG ratings lack validity, the development of a valid ESG rating methodology is perhaps the greatest challenge for current research in accounting, auditing and finance.

There are other challenges related to the use of big data and analytics in accounting and auditing to solve problems with sustainable reporting, auditing and socially responsible investment. Chapter 6 describes the current status of the use of AI to collect information that is not found in annual reports but collected from other sources like the Internet by AI applications. The analysis is premised on the assumption that environmental sustainability can only be achieved when societies and economies curb negative impacts on the climate and biosphere. The biosphere refers to the Earth's ecosystems, comprised of all living things and the chapter addresses the issue of dark corners in ESG ratings by its focus on the limits to the anthropogenic pressure the planet can sustain before its ability to support our economies and societies is significantly undermined. This focus differs from the relative approach adopted in current ESG investment practices that compare companies on the basis of within-sector performance.

The growing amount of unstructured available ESG related data provides new possibilities to capture company related information of potential relevance for ESG, that can offer a more unbiased view of companies than simply relying on self-reported sustainability information delivered on an annual basis. AI technologies are invaluable tools in "reading" and analyzing these large datasets. However, until advanced analytical methods are available there are challenges with overreliance on simply collecting more information because important information about biodiversity is

not available at all. Current use of AI in ESG will capture issues that are of direct importance for absolute sustainability, while also being financially material. Many environmental issues do not lend themselves to easy capture by news headlines and therefore become dark corners. It is important for all users of ESG to recognize the existence of these dark corners of current AI-ESG approaches, and be cognizant of what this means for the capacity of ESG to measure progress towards sustainability.

Finally, the use of the blockchain technology has been described as a fundamental technology that solves many problems but few if any examples exist to show that this is in fact true. The usefulness of blockchain in key use cases across numerous business sectors is reviewed in Chap. 9, and is then examined regarding its role and function in the context of corporate tax losses, where complex rules apply. The main finding is that while in theory blockchain could enable key efficiencies in tax compliance of corporate tax losses, in practice the complexity and discretion within tax law creates real barriers for this technology's use. The chapter describes blockchain and its many possible uses and then analyses its usefulness for solving problems with tracking and accounting for carry forward tax losses in Australia. Blockchain offers an ability to track and flag resource allocation to broad, high-level elements of the corporate tax compliance and therefore offers potential for the greater digital ecosystem. Blockchain smart contracts may be established to provide the basic checks for changes in ownership, or even facilitate the carry-back refundable tax offset. However, the analysis raises significant concern over relying solely on blockchain technology to execute tax losses without holistic checks and balances. The chapter finds that blockchain does not offer a solution to the investigated corporate tax loss context in Australia but that future simplified rules can enable the use of such digital tools for rapid administration of legal rights.

3 Part II: Data Analytics and Managerial Accounting

Managerial accounting including internal control and internal auditing are the areas that have lent itself more than any other area of accounting to the use of advanced analytics. These areas differ from the environment of external audits because analytics can be tailored to the specific organization in which managerial accounting internal controls or internal auditing is conducted.

Methods such as machine learning require training on data which represents the typical behavior of the system being monitored. This is the case with systems that are tailored for a specific organization but it is not the case for an audit tool that is supposed to work on any organization an auditor is auditing. It is not surprising to find that most of the AI related analytics research has been done in the managerial accounting context. Managerial accounting is an information system, or a company navigation system intended to help managers make rational decisions in the interest of the organization. As such there is little regulation of how managerial accounting may be carried out. Thus, managers have a lot of freedom to design the information systems they would like to have and what type of information the systems should

operate on. There are many data sources that organizations could use in their management decision-making process in parallel with the traditional accounting-type of data. The new type of data offer advantages compared to traditional accounting data. For example, search trend data and social media data can be used for predicting sales with higher predictive accuracy than traditional accounting data would enable. The Chartered Institute of Management Accountants (CIMA) encourages organizations to discover how to use analytics related to financial results. In this context, machine learning is adopted to identify business drivers as means to improve financial results.

The data obviously determines the outcome of the analysis, so the choice of data is crucial to the information system managers decide to develop. Despite its importance, little is known about how managers view new data sources and whether new data sources are seen as value adding and whether managers want them in the decision-making process. Management preferences is an important concern for management accounting to improve its role of providing relevant information to managers. Due to the emergence of the machine learning technique, management accountants will increasingly become internal consultants providing business-oriented and strategic information, playing a role in the data evolution. Chapter 10 examines management perceptions of new data sources relative to longer-standing data sources, particularly how the perceptions on data sources differ by management demographics, attitudes and resource constraints. This knowledge is important for management accountants to have because they need to understand managers as users of predictive analytics. The chapter finds that the management demographics and credibility attitudes towards social media influences the preference for data sources for sales prediction. Unsurprisingly, attitudes towards social media is a key to whether such data can be trusted by managers when making decisions about their company.

The issue of trust is not only relevant for such data sources as social media. Even data that emanates from the company's internal sources may be trustworthy and seen as relevant to various extent, such as whether ESG risk data is integrated with control, i.e. incorporated into strategic and operational decision-making. ESG risk should be important because many companies have been hit by the consequences of not complying with their corporate social responsibilities and paid the consequences financially and reputationally, for example BP, Volkswagen and Wells Fargo. It is not clear even in this light that companies pay attention to ESG risks in their management practice. Chapter 12 investigates the extent that ESG risks are used for management control in large companies and finds that while companies have well developed processes and structures for integration ESG risks into reporting there is little formalized use of ESG risk data in the management decision making. The study also finds that cultural controls seem to be more important than well-developed ESG risk management processes and structures, especially in taking meaningful actions. It seems as if ESG data is not viewed as important to the large companies under study as would be expected from the public debate when it comes to organizational structures.

4 Part III: Digitalization and Accounting Education

Analytics can be used to teach and learn accounting and auditing. In the light of a vast transition over accounting and auditing into an AI supported profession with numerous autonomous decision support systems it is obviously imperative to familiarize the coming generations of accountants and auditors with the new applications the previous generations could only imagine. Some IT-based tools for teaching and learning do not in themselves target knowledge of AI decision support systems (but traditional accounting and auditing knowledge).

Chapter 16 provide insights into curriculum designs and student responses to the use of innovative assessment in accounting education. The chapter examines how digitized simulation and serious games can enhance student engagement and help to address cognitive load challenges experienced by students. It investigates how serious games and simulations can effectively reduce the extraneous and intrinsic cognitive load in education. It seems that the cognitive load can be reduced and that learning through games also contribute positively to a student's germane load enabling them to navigate the more complex topics, including debits, credits, and capital budgeting through the simulated activity. Students do not see this activity as burdensome because of the design features within the context of the simulation. Other potential benefits include reducing student attrition, whereby students may previously give up the course, potentially even the degree, based on their perceptions that accounting is difficult and inaccessible from their first encounter.

The transformation of accounting and auditing towards the use of autonomous decision support systems causes a dire need for a certain type of IT-related knowledge among accountants and auditors. The users of autonomous decision support systems that operate as AI-applications must be able to assess the validity, reliability and accuracy of decision support systems that they do not completely control (i.e. they are autonomous systems) and not fully understand the inner logic of. The replacement of mundane tasks and manual work require of accountants and auditors to have knowledge of data science tools. Professional accounting bodies address this need by emphasizing continuing professional education and developing guidelines for data analytics. At the same time, higher education institutions are taking the initiative to integrate data analytics into their accounting curricula.

Given the numerous professional accreditation requirements that higher education institutions must fulfil, a big challenge remains for any institution to insert rigorous data analytics training into their existing curriculum. Following Chap. 20 which reviews the literature on digitalization in higher education, Chap. 18 describes the development of a data analytics roadmap for undergraduate accountancy education, from reviewing our academic and industry data analytics curricula and evaluating existing modules that could be integrated with relevant data analytics topics, to seeking feedback from industry partners regarding the curriculum model that is developed. The chapter also finds that while coming generations of accountants and auditors need to embrace digital transformation and be savvy about using data analytics tools there is a current shortage of data analytics talent. Even though data

analytics is increasingly gaining traction in business and industry, the supply of data analytics talent remains inadequate which means that there is a risk that accountants and auditors may not be able to play the advisory role to top management that would be possible in the emerging data driven business models.

AI can be used in the process of accounting education and strong improvements of the process through which students learn can be expected. Education methods that connect students with AI software that keeps track of and engages in the students' learning has been shown to dramatically increase the amount and depth of learning. The approach to use Learning Analytics (LA) was defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" during the First International Conference on Learning Analytics and Knowledge (LAK11) in 2011. In the same year LA was said to be "the third wave of large-scale developments in instructional technology", after the first wave where learning management system (LMS) was used in education in the 1990s, and the addition of social networking and cloud-based applications into LMS during the second wave. Developing and using such systems must be a primary goal for higher accounting education as we move towards satisfying the need for more data science aware accounting students because the use of this technology during students' time at university will automatically stimulate reflection on how autonomous learning support and decision support systems operate.

Chapter 19 addresses this potential by developing and testing an integrated telegram mobile application and a web-based portal discussion forum, to enable informal, participatory and collaborative learning beyond the classroom. The chapter analyzes student-initiated question-and-answer discussion posts where a machine learning algorithm predicts the quality of the posts, and prompts the students to improve their posts. With six in-built engagement features, the proposed system generates higher number of high-quality posts, resulting in better learning outcomes among the students. In fact, the proposed methodology provides revolutionary improvements compared to conventional teaching and student support methods such as conventional forums in which students can discuss. Being exposed to this AI-driven method at the same time as students learn data science in relation to accounting and auditing should provide the ideal platform for future generations of accountants and auditors.

A new technology that does not have any obvious practical use in accounting and auditing is virtual reality but for learning accounting and auditing where it instills a sense of reality to the learning environment. Universities provide often alienated environments by students and teachers work completely detached from the actual environment in which students' future work will be conducted. Students are not exposed to the time pressures and conflicting interests that an actual corporate environment entails. They do not learn how to prioritize between accuracy and timely deliveries that they will have to do in the future. Using virtual reality mitigates some of this difference between university and the real world so that students can put their academic learning also in a realistic perspective. Virtual reality also enables the exposure of students to technological advances that are yet not operational of today. For example, AI powered auditing tools which will be used in a couple of years as

decision support systems when graduated students are out in the real world working with tools we are only able to write about because they do not yet find practical use.

Chapter 22 offers concrete and detailed insight into how virtual reality can be used in practical teaching of accounting and auditing. The chapter examined the effects of virtual reality on learning about a taxation problem. Because virtual reality moves the students' perception to a fictive environment in which they can use their senses to capture what they are supposed to learn, students are more likely to be able to recall their visual experiences and therefore to learn. Virtual reality has the benefit of participators experiencing "presence" in their learning, putting themselves in the virtual world making it a memorable and often enjoyable experience. The results of the study include improved student understanding, strengthened learning experience, and, not least important, that students enjoyed virtual reality.

5 We Look Forward

Amidst all the problems and difficulties identified in this book (and to which some solutions are provided), there are plenty of reasons to be optimistic when looking at the coming decade. Several of the greatest challenges of our society could be solved with the analytical techniques discussed in this book. However, there is good cause to be skeptical to buzzwords and phenomena which gain momentum in some applications and which are claimed by many to be the solution to a large amount of unspecified and undescribed problems.

We think of blockchain as a concept and method that might have valuable applications where information needs to be transferred and protected in ways that are not possible without packaging it in encrypted boxes. As we see it, there is no evidence in the literature that blockchain would solve any problems relevant to accounting and auditing. In contrast, AI as an umbrella concept for the many techniques to read and understand text and to analyze patterns of numbers, has unlimited capacity to solve fundamental problems in accounting and auditing. Many companies offer fully automated bookkeeping already today and several audit firms claim that they are developing and testing autonomous systems to be used as decision support in external audits. Research groups like the one lead by professor Vasarhelyi at Rutgers Business School in New Jersey have for a long time demonstrated how analytics based on machine learning can be used for the improvement of internal control and internal audits. We therefore find it most likely that internal audits and internal control will be revolutionized in the coming decade through the employment of machine learning and related techniques in AI.

Three suggested areas where big data and analytics will provide revolutionary breakthroughs in the coming few years are: (1) audits of AI-enabled automation of business processes, (2) measurement instruments for the ESG investment industry, and (3) emerging technologies for risk management. They are given space below.

AI-enabled office automation may comprise the majority of the information processing that auditors need to assess the quality of information. Robotics is widely

used for assembly of cars. Most series production is suited for automation, and automation of manufacturing is therefore only a matter of time and cost. Office automation is tricky because people in offices do interconnected tasks and the functions to be automated cannot always be defined as a copy of the tasks people say they do. Administration can be partly replaced by computers as far as the jobs can be systematically understood. Inefficient and ineffective administrative processes that fulfils primarily social purposes for the people in an organization must first be rid of its unnecessary parts before they can be described in information comprehensible to machine learning. These formalized descriptions of business processes will eventually take place and much administration will be done with interconnected machine learning algorithms. When this phase of administrative development is reached, auditors will be faced with the task of understanding the inner logic of chains of autonomous decision support systems.

Fortunately, the tools for this are here, and the major breakthrough occurred 2017 with the work of Lundberg and Lee (2017). These American data science researchers have built a generalized framework for explaining machine learning models of any kind on the discovery in economics of the Shapley values for which Shapley was awarded a Nobel prize in 2012. The so called SHAP method (SHapley Additive exPlanations) makes it possible to explain the inner thoughts of machine learning in terms of the contribution from each input feature to the output of the model as contributions of conditional probability. For an auditor who wants to understand why an individual decision was made by an administrative robot it will be possible to connect a SHAP model to the robot and obtain easily comprehensive explanations of each and every decision ever made by the robot. The level of transparency available to the auditor is far beyond what can be achieved in audits of human decision processes that often occur with a logic hidden even for the decision maker. Our estimate is that explainable AI will eventually be the most useful of all aspects of big data and analytics in accounting and auditing.

Regarding measurement instruments for the ESG investment industry, a breakthrough is not only likely but also necessary is the measurement of corporate social performance, or ESG. The need for a more solid foundation for the substantially growing socially responsible investment business in the finance sector is as obvious as sunshine at Miami Beach. Institutional investors are responsible for the allocation of the majority of the global capital, and many institutional investors are honestly motivated to mitigate the climate threat, protect biodiversity and address many social issues affected by or caused by businesses. The problem is that no one knows which direction is the right one. This is certainly the case with the ESG ratings that all aspire to be the most accurate measures of ESG but for which all scientific evidence univocally shows that they all lack validity and accuracy. The main reason for this weakness is that the ESG ratings represent each rater's subjective perceptions of good corporate behavior. The raters' inclination to adopt the 'doing good' perspective on ESG provides no support for the need to develop objective ESG ratings in the sense that they are rater independent and that they represent the preferences of society.

ESG ratings should reflect the fact that the definition of corporate social performance must come from society because it is towards society that companies have