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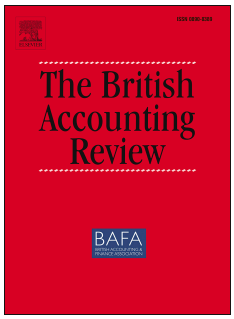

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The Role of Internet-Related Technologies in Shaping the Work of Accountants: New Directions for Accounting Research

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Abstract

This paper reviews the accounting literature that focuses on four Internet-related technologies that have the potential to dramatically change and disrupt the playing field for accountants and accounting researchers in the near future. These include cloud, big data, blockchain, and artificial intelligence (AI). For instance, access to distributed ledgers (blockchain) and big data supported by cloud-based analytics tools and AI will automate decision making to a large extent. These technologies may significantly improve financial visibility and allow more timely intervention due to the perpetual nature of accounting. However, given the number of tasks of which technology has relieved accountants, these technologies may also lead to concerns about the profession's legitimacy and the role of accountants. The findings suggest that scholars have not given sufficient attention to these technologies and how these technologies affect the everyday work of accountants. Research is urgently needed to understand the new kinds of accounting required to manage firms in the changing digital economy and to determine the new skills and competencies accountants may need to master to remain relevant and add value. The paper outlines a set of questions to guide future research.

Keywords: accounting profession; cloud; big data; blockchain; artificial intelligence

1. Introduction

The Internet and related information technologies such as cloud services, blockchain, data analytics ("big data"), and artificial intelligence (AI), combined with web-based business models, such as platforms, are rapidly transforming the digital economy and industry (now in its fourth revolution – Industry 4.0) and have raised concern about the future of the accounting profession. Some questions being asked are: how can those working in the profession continue to add value to organisations; where can accountants work; and what data do they have to work with (Bhimani and Willcocks, 2014). For instance, Krumwiede (2017) recently reported that a survey of 161 Institute of Management Accountants (IMA) members revealed that 5% of respondents were extremely worried and 42% were somewhat worried that emerging technologies such as AI and automation would make them irrelevant in the workplace. IMA President Jeffrey Thomson (2018, p. 8) observed that "These changes [AI, machine learning, robotic process automation, etc.] are redefining and expanding the role of accountants and making our cultivation of skills such as data analytics, data visualisation, storytelling and strategic management more important than ever before…".

The main goal of this paper is to take stock of the accounting and information systems literature that is focused on understanding how innovations in the Internet and related information technologies are transforming the everyday work of accountants.[1] The analysis of the literature was guided by the broader research question:

How are the Internet and related information technologies affecting the work of accountants?

Some potentially interesting questions that researchers have overlooked or have given insufficient attention to are considered to deepen the understanding of how accounting and accountants are entangled within the broader changes in business brought about by these digital technologies.

The paper adopts Christensen's (2016, p. xiii) definition of "technology" as "the processes by which an organisation transforms labour, capital, materials and information into products and services of greater value". The technologies reviewed in this paper include cloud, big data, blockchain, and AI. These technologies have the potential to dramatically change and disrupt the playing field for accountants and accounting researchers in the near future (see, for instance, Cooper, 2017). Several of these technologies underpin the next generation manufacturing systems known as Industry 4.0 where 'smart' machines increasingly take control of production and maintenance decisions (Penas, Plateaux, Patalano, and Hammadi, 2017).

[1] The scope of this paper is limited to Internet-related technologies but the authors are aware that other factors may also contribute to the changing role of the profession and to how the profession is looking to add new competencies.

To provide some depth to the review, the paper focuses on three specific areas of accounting: management accounting, financial accounting and auditing. Hence, the review does not include all of the six capitals (i.e., financial, human, social and relational, manufactured, intellectual and natural) that drive the thinking behind integrated reporting (De Villiers, Rinaldi, and Unerman, 2014).

The paper is structured as follows. Section 2 describes the method and scope of the paper. In Section 3, the literature on cloud, big data, blockchain, and AI in relation to management accounting, financial accounting and auditing is reviewed. Section 4 identifies research gaps and research questions evident from the literature review. Section 5 includes a discussion and summary of research questions identified for future research. The final section of the paper concludes the study.

2. Method and Scope of Review

In selecting the technologies to review for this paper, articles and reports from professional accounting bodies[2] such as the Chartered Institute of Management Accountants (CIMA), the Institute of Management Accountants (IMA), the Association of Chartered Certified Accountants (ACCA), and Chartered Accountants Australia and New Zealand were relied upon, as well as articles published by professional services firms (PSF) such as the Big 4. These organisations are important for the accounting profession from a professionalization standpoint (Cooper and Robson, 2006), and innovation and disruption serve PSFs' commercial agenda (Spence, Zhu, Endo, and Matsubara, 2017). In particular, PSFs play a critical role in the diffusion of new practices and technologies (Hogan, Soutar, McColl-Kennedy, and Sweeney, 2011).

The review identified four technologies (cloud, big data, blockchain, and AI) as particularly relevant to accountants, although the number of technologies reviewed was not exhaustive. Given the number of technologies reviewed in the paper and the required depth for the review, the paper focuses on three accounting areas: management accounting, financial accounting and auditing. This somewhat narrow focus leaves opportunities for future research in areas such as natural capital (e.g., sustainability, carbon, or water) or tax. These areas and other potential research questions are discussed in Section 5.

Moreover, since the accounting profession encompasses research, practice, and policy (c.f. Laughlin, 2011), the research questions that are developed in the later sections of the paper highlight issues likely to be of interest to these three groups. The topics covered in the review are presented in Figure 1.

INSERT Figure 1

[2] Although the commentaries were sourced from professional accounting bodies originating in North America, the UK and Australia, many of these organisations are global, similar to the Big 4.

The following full-text databases were searched for relevant papers: JSTOR Arts and Sciences IV, Wiley Online Library, EBSCOhost Business Source Premier, ProQuest, Elsevier ScienceDirect, Emerald Insight, Springer Standard Collection, Proquest ABI/INFORM Global, Sage Journals Management and Organization Studies Collection Full Text Collection, ACM Digital Library, and Allen Press American Accounting Association. The review was not limited to the 'top journals' due to arguments that these journals may be biased against specific topics or methodologies. For instance, Summers and Wood (2017) discovered that in the past 25 years, fewer than 2% of articles published in the top journals focus on Accounting Information Systems (AIS). Similarly, a study by Barrick, Mecham, Summers and Wood (2017) discovered that the most cited work for topical areas such as AIS and Management Accounting Research was not published in the journals characterised as being in the top 3, namely, Journal of Accounting and Economics, Journal of Accounting Research, and The Accounting Review.

The search terms that guided the review included each of the technologies (cloud, big data, blockchain, and Artificial Intelligence) combined with the following terms: accounting, management accounting, financial accounting and audit. To identify relevant studies, paper titles, keywords and abstracts were searched for these terms. The review was not limited to a particular timeframe or journal list, but attention was paid to papers published in leading accounting journals cited in the Association of Business Schools Academic Journal Guide 2018[3] and previous research (Lowe and Locke, 2005). This approach also ensured that accounting and information system journals were included in the search. When a relevant paper was identified, the reference list was examined to ensure that other key contributions were not missed. The search identified a total of 38 published peer-reviewed papers. An overview of the academic literature investigating Internet-related technologies and accounting is provided in Table 1.

INSERT TABLE 1

In addition, practitioner-based articles published in professional magazines (Strategic Finance, Harvard Business Review, etc.) were reviewed, as well as C-suite equivalent reports for studies funded by professional accounting bodies such as the Chartered Institute of Management Accountants (CIMA) and the Association of Chartered Certified Accountants (ACCA). The method for the literature review was similar to that of Grabski, Leech and Schmidt (2011).

The following section introduces the four technologies and reviews the relevant literature as illustrated in Figure 1.

3. Internet-related technologies: What the literature shows

[3] There are a range of journal ranking indexes.

This section is divided into four subsections, with each subsection providing an overview of the reviewed technology and the relevant accounting literature (see Figure 1). While the main content draws on the 38 peer-reviewed papers identified in the literature search, for completeness, some articles and reports from the business press were also included.

3.1 Cloud

Cloud-based solutions or services are available in a range of key functions that are recognised as part of the accountant's role, for example, accounting, analytics, compliance, control, monitoring, and reporting and data governance. There are four possible cloud deployment models, including private cloud, public cloud, community cloud and hybrid cloud (Mullholland, Pyke, and Fingar, 2010). To date, firms have shown the most interest in cloud services provided on a public server, and it has received the most investment, thus it is the main focus of this section (Babcock, 2010). For a detailed review of the kinds of cloud see Mullholland et al. (2010).

Services provided on a public cloud are sold to multiple tenants on a pay-as-you-go (i.e., subscription) basis (Du and Cong, 2010; Garvey, 2012; Mullholland et al., 2010). There are several benefits attributed to the public cloud model. First, it allows firms to be billed according to their usage of cloud services, and this permits them to monitor and control their resource usage better and to scale quickly when services are required (Babcock, 2010; Du and Cong, 2010; Howell, 2015; Mullholland et al., 2010; Shim, Siegal, and Shim, 2012). Second, cloud services often operate based on multi-tenancy agreements, thus making services such as data analytics more cost-effective for a broader range of organisations (Babcock, 2010; Bhimani and Willcocks, 2014; Mullholland et al., 2010). Third, compared with an on-premise system, the time required to roll out cloud apps across organisations that operate with subsidiaries in multiple jurisdictions is significantly reduced (Gill, 2011). Fourth, in the past, many firms allowed each of their subsidiaries to customise the Enterprise Resource Planning (ERP) system. The result was that only those using the system were familiar with how it worked, making it difficult to integrate and reconcile the accounts (Gill, 2011). In contrast, the pre-packaged nature of much of the software available for purchase in cloud can help avoid such problems. Fifth, the provider rather than the user of cloud services is responsible for the equipment and its maintenance (Du and Cong, 2010; Mullholland et al., 2010). This means that specialised IT support is not required and that management can reduce their capital investment in IT infrastructure (i.e., computers and servers) and allocate resources towards their core competencies (Alali and Chia-Lun, 2012; Du and Cong, 2010; Shim, 2012; Shim et al., 2012). For instance, organisations previously had to invest heavily in information systems capable of coping with expected peak capacity. However, using cloud means that organisations pay only for usage, leaving more funding for other initiatives (Gill, 2011; Mullholland et al., 2010). Sixth, all client systems benefit from improvements to software or security (Mullholland et al. 2010; Shim et al., 2012). Seventh, unlike an on-premise ERP system, cloud delivery should allow accountants to spend less time backing up their data. Eighth, many organisations benefit from providing their employees access to information in real time using apps that they can download on smart devices (Chandler, 2012). This change is particularly beneficial for those working in virtual environments since the cloud allows them to update data and view it more quickly (Bhimani and Willcocks, 2014; Chandler, 2012; Strauss, Kristandl, and Quinn, 2015). For example,

Cohen (2015, p. 32) explains that cloud providers are developing mobile apps that "enable managers to review and approve invoices no matter where they are." Finally, cloud can benefit relations with suppliers by providing work space to share information (Mullholland et al., 2010).

In addition, the variety, availability, and multitude of cloud applications, platforms, and infrastructures on the market allow for a multi-cloud deployment strategy, which provides organisations the opportunity to exploit the strengths of each cloud solution and thereby optimise performance and costs (Ferry, Rossini, Chauvel, Morin, and Solberg, 2013). While there are distinct advantages to a multi-cloud strategy, interoperability between applications is likely to be low (Ferry et al., 2013). Furthermore, monitoring a multi-cloud environment to which multiple vendors provide cloud services is complex from both a technological (e.g., security and performance) (Slawik et al., 2015) and a contractual/compliance point of view.

The benefits make cloud a particularly attractive solution to small and medium-sized enterprises (SME) that previously did not have resources to allocate to many of these functions (Du and Cong, 2010; Strauss et al., 2015). For instance, Nixon (2015) suggests that at least 5% of small and medium-sized businesses in the US have abandoned desktop accounting software in favour of cloud-based accounting software. In other countries such as New Zealand, the SME adoption rate is thought to be as high as 30% (Nixon, 2015). In the UK, a survey (see Smith, 2017a) commissioned by Xero indicated that more than four in five UK organisations use at least one cloud-based service. The survey also revealed that approximately 65% of UK accountancy practices are already using or are planning to use cloud accounting software (Smith, 2017a).

The benefits of cloud are perhaps best summed up by Wolf (2015, p. 24):

> "Cloud-based tools are levelling the playing field for smaller companies to deploy sophisticated functionality quickly and at relatively low cost. Cloud-based planning systems include communication and collaboration tools and mobile and analytic applications. All these tools help companies better adapt to an increasingly volatile and global marketplace."

Despite the reported benefits of cloud, few empirical studies have investigated the technology, leading some researchers such as Clinton and White (2012, p. 43) to conclude that cloud is "not yet proven or well understood" (see also Grabski et al., 2011). One exception is a study by Alali and Yeh (2012) that examined the risk characteristics (client business risk, audit risk and auditor related risk) of companies that provide cloud services to others. Based on a hand-collected sample of 370 firm-year observations during 2006-2009 including 118 in the pre-cloud period, 185 in the post-cloud period, and 185 non-cloud, Alali and Yeh found that cloud providers tend to be "highly leveraged, less liquid, and more likely to have internal control material weaknesses" (p. 15).

Strauss, Kristandl and Quinn (2015) undertook a study funded by CIMA that investigated the impact of cloud technology on (management) accounting. Their research involved a survey of a subset of the Controller Panel at Germany's WHU Otto Beisheim School of

Management. Based on 139 responses the authors concluded that cloud offered SMEs benefits such as improved decision making and cost-effectiveness. However, the survey also revealed limited use for finance transactions and that security concerns were preventing widespread adoption of cloud technology.

Overall, accounting in the cloud provides real-time access to financial data from any (mobile) device. Add-ons to standard cloud accounting software available from firms such as Xero also allow enhanced functionality such as forecasting and external benchmarking (Xero, 2018). Such features not only enable better planning and control but also improve financial reporting by automating and streamlining tasks associated with statutory reporting requirements.

Cloud accounting may improve internal and external audits as well (Liu and Vasarhelyi, 2014). For instance, access to and analysis of data in near real-time may enable timely detection of anomalies (Vasarhelyi, 2013), although maintaining an audit trail in the cloud environment may be more problematic than traditional in-house systems (Weir, Aßmuth, Whittington, and Duncan, 2017). While many of the benefits of cloud-based systems are likely to be similar to those of conventional ERP systems (e.g., Chapman and Kihn, 2009; Velcu, 2007), the cloud offers unprecedented data sharing abilities and mobility. Hence, cloud-based systems benefit accountants by enabling them to track business performance without having to contact the client, leaving the client to focus on other value-added activities (KPMG, 2012, p. 4).

3.2 Big data

Big data is defined by Gartner (2012) as "high-volume, high velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making and process automation." The data may be structured and unstructured; some researchers suggest that as much as 90% is unstructured, comprising information sourced from social media, videos, wireless machine sensors, etc. (Warren, Moffitt, and Byrnes, 2015). For instance, websites such as Amazon often use cookies to track the products and services customers consider for purchase, which provides a wealth of new unstructured information about individual customer preferences (Bhimani and Willcocks, 2014). Additionally, in recent years, the proliferation of sensing technologies enabled by wireless networks to measure and gather environmental indicators – the Internet of Things (IoT) – has dramatically contributed to the big data phenomenon (Gubbi, Buyya, Marusic, and Palaniswami, 2013). Self-sensing and self-acting devices used in smart factories, logistics, transportation (e.g., autonomous vehicles), military, law enforcement, medicine and households (e.g., appliances, wearables) (Lindqvist and Neumann, 2017) generate vast amounts of data. The unstructured nature of much of this information and the need to integrate it with structured data requires new forms of management and analysis (Huerta and Jensen, 2017).

A survey of more than 2000 Chief Financial Officers (CFO) and finance executives by the Chartered Global Management Accountant (2013) indicates that approximately 87% view big data as likely to transform the way business occurs in the next ten years. Currently, big

data is used mainly by large companies, including Internet and retail (ICAEW IT Faculty, 2014). However, big data has much to offer SMEs. According to the ICAEW, external big data and analytical providers allow SMEs "to access technical resources required without investing in substantial hardware themselves" (ICAEW IT Faculty, p. 8).

Since 2012, NewVantage Partners has completed several surveys of firms to gauge the shift to big data. The latest survey[4] indicates that 97.2% of companies are undertaking big data or AI initiatives; however, for most firms, the investment remains relatively small. Of the firms involved in the study, 73.2% suggest they have measurable results from these initiatives. The largest benefit reported is improvements in decision making, but firms also cite better customer service and reduced cost. Approximately 43.8% of the firms surveyed say that big data and AI initiatives improved innovation. Despite the importance of these insights for understanding how widespread big data adoption has been, little is known about how these firms measure the success of such initiatives, how they integrate different kinds of data, and how they analyse big data to increase innovation.

Those working in academe have largely ignored the impact of most digital technologies on the work of accountants; big data appears to be an exception as demonstrated by the recent publication of Special Issues by the Accounting, Auditing and Accountability Journal (AAAJ) (on Social Media and Big Data, see Vol. 30 (4)), and Accounting Horizons (on Big Data, see Vol. 29 (2)).

In the AAAJ Special Issue, Arnaboldi, Busco and Cuganesan (2017) outline an agenda for those inspired to research the interplay between accounting and big data. Issues deemed worthy of further research include: how performance metrics that appear in social media such as Twitter and Facebook are used inside organisations; the implications of predictive analytics for organisational decision making; how numbers, narratives and visuals can communicate big data performance indicators; the frame used to evaluate the representativeness of big data; the role of accountants inside the organisation in using big data, including with whom they should work to use the data more effectively and which new skills they may need to acquire to add value to big data processes; and the role of big data in providing persuasive evidence that can complement accounting to convince others of a particular course of action.

Other papers in the AAAJ Special Issue focus on how big data has created centres of calculation in organisations for accumulating knowledge about customers (Agostino and Sidorova, 2017); how social media can undermine attempts to manage corporate reputation (Brivot, Gendron, and Guénin, 2017); the reluctance of accountants to see social media as a useful source of information for business development (Arnaboldi, Azzone, and Sidorova, 2017); the extent to which accountants should be involved in data analytics and in the interpretation and storytelling behind big data to reduce the likelihood of misinterpretation (Al-Htaybat and von Alberti-Alhtaybat, 2017); and the effectiveness of Facebook when used by philanthropic foundations as a dialogic accounting instrument (Bellucci and Manetti, 2017).

[4] See http://newvantage.com/wp-content/uploads/2018/01/Big-Data-Executive-Survey-2018-Findings.pdf. Please note that the survey considers the use of Big Data and Artificial Intelligence in Fortune 1000 companies.

The papers published in the Accounting Horizons Special Issue present commentaries or conceptual models regarding potential uses of big data in accounting. The majority of papers focus on how big data may complement auditing (Vasarhelyi, Kogan, and Tuttle, 2015; Yoon, Hoogduin, and Zhang, 2015) and continuous auditing (Zhang, Yang, and Appelbaum, 2015) or discuss some of the drivers and challenges of using big data in auditing at both the organisational and individual level (Alles, 2015; Brown-Liburd, Issa, and Lombardi, 2015).

The role of accountants in using big data has been the focus of several other papers, but these papers tend not to be supported by empirical data. Huerta and Jensen (2017), for instance, argue that the profession is in transition because of big data and they argue more research is needed to understand how cognitive biases can be overcome in the interpretation of data analysis. Richins, Stapleton, Stratopoulos, and Wong (2017) provide a roadmap for the accounting profession in a big data era. These authors argue that big data may lead to transitions in the accountant's role. However, they also state that many of the accountant's tasks are not easily automatable and therefore will not be replaced by big data. These authors suggest that, to remain relevant, accountants will need to develop expertise in interpreting and utilising data analytics. In particular, they claim that accountants' skills in problem-driven analysis of structured data position them to work with non-structured data and to integrate it with structured data so actionable strategies can be developed and accomplished. For instance, those using big data need to be wary that the results from big data generally suggest correlation, not causation (Davenport, 2013). Similar to Richins et al. (2017), Bhimani and Willcocks (2014) claim that the daily work of accountants—including the content that they work with—is likely to undergo substantial change because of the availability of big data. These authors also suggest that to understand big data, one needs to consider the "full-circuited knowledge system in place," which includes both the manager's tacit knowledge and the information system.

For financial accountants, big data may change their ability to understand the company assets features and conditions and, therefore, support fair value accounting (Warren et al., 2015). For instance, Warren et al. (2015) explain that multimedia records (i.e., videos) of each asset may provide a more accurate picture of the asset. Big data may also provide new forms of valuation of intangible assets, including those that firms are not required to report on the balance sheet, such as customer base, human resources, commitments, and vendor base. Metrics valuing such off-balance sheet items can be tracked over time and disseminated to stakeholders to enhance disclosure. Computer programs searching the Internet over an extended period may also lead to improvements in the valuation of hard-to-value assets (Warren et al., 2015). Considering IoT, new sources of data obtained through sensors embedded in property, machinery, etc. can complement financial accounting tasks. For instance, sensory data measuring the health of an asset may be utilised to select a more appropriate depreciation method.

For management accountants, big data is likely to have far reaching implications for tasks such as internal financial reporting, analysis and decision making (Bhimani and Willcocks, 2014). Bhimani and Willcocks (2014) explain that much information that was cast aside in the past because it was not linked to an economic transaction can provide further insight to

a customer's preferences and how they make purchase decisions. In addition to helping an organisation to understand changes and trends in customer preferences, the information can be used in new product development, and it can help organisations to customise their marketing strategies (Bhimani and Willcocks, 2014, p. 476). As a consequence, Bhimani and Willcocks (2014) argue that management accountants may need to rethink how information is collected and processed; in particular, how can they capture and use real-time data and entire data sets. Appelbaum, Kogan, Vasarhelyi and Yan (2017) make a similar observation; they argue that management accountants' focus remains to a large extent on descriptive analytics. They develop a Managerial Accounting Data Analytics framework based on the balanced scorecard to help management accountants understand how data analytics may be used to provide information that is descriptive, predictive, and prescriptive.

The use of big data in auditing raises challenges concerning auditors' judgement and decision making. While auditors are accustomed to using computer-assisted auditing tools to analyse structured data (Dowling and Leech, 2007), their current skills are inadequate for more advanced statistical techniques to mine non-financial data. Information overload, data relevancy, and the ability to recognise patterns are some of the challenges facing auditors. These may be overcome by designing effective decision support systems (Brown-Liburd et al., 2015).

Traditionally, audit studies have used text-mining techniques to analyse company disclosures and conference call transcripts to estimate the probability of misstatement (Humpherys, Moffitt, Burns, Burgoon, and Felix, 2011; Larcker and Zakolyukina, 2012), but other opportunities arise as more data becomes available. For instance, data from radio frequency identification chips can be used to verify inventory, and data from news articles, product discussion forums, and social networks may be useful to evaluate sales (Vasarhelyi et al., 2015; Yoon et al., 2015). Furthermore, there is some evidence to suggest that big data visualisation may impact the audit process. For instance, an experimental study by Rose, Rose, Sanderson and Thibodeau (2017) that included 127 auditors from two Big 4 companies discovered that auditors found it difficult to identify patterns from big data visualisations if they had not first viewed traditional audit evidence.

Finally, some scholars are interested not in understanding how big data is being used inside organisations to improve decision making, but in how it is created by professional organisations to change client perceptions of the profession. For instance, Suddaby, Saxton and Gunz (2015) studied how social media (i.e., Facebook, LinkedIn and Twitter) and social media experts are being used by professional organisations such as KPMG and Ernst and Young to reconstitute accounting through a process involving boundary work, rhetorical work and the construction of the embedded actor. Surprisingly, accountants seem to give social media experts significant freedom in negotiating their new professional identity.

3.3 Blockchain

Blockchain received a great deal of coverage in the business press as the enabling technology for cryptocurrencies such as Bitcoin and Ethereum, which have been widely

speculated upon in the market. For instance, the value of Bitcoin rose to over $19,000 from approximately $17 in less than five years (Bitcoin, 2018) (see Figure 2). Blockchain is a type of distributed ledger technology where multiple copies of the same ledger are shared among the members (nodes) of a large network. The technology is considered to be highly 'promising' by many organisations. For example, the Australia Securities Exchange recently adopted blockchain technology for trade settlements (ASX, 2018) and the Bank of England is examining the implications of a Central Bank-issued Digital Currency (Cleland, 2017). According to the Gartner Hype Cycle, blockchain has at least ten years before it becomes 'mainstream' (Panetta, 2017).

INSERT Figure 2

The main advantage of blockchain technology is that once a transaction is approved by the nodes in the network, it cannot be reversed or re-sequenced. This inability to modify a transaction is essential for the integrity of blockchain and ensures that all parties have accurate and identical records. Because blockchain is a distributed system, all changes to a ledger are transparent to all the members of a network (Treleaven, Brown, and Yang, 2017).

Blockchain technology provides a mechanism to create 'trust' among unknown members of a network without the need for a trusted third party (a central authority), such as an organisation (e.g., bank) or intermediary (e.g., notary). Commentaries on blockchain suggest that the technology will transform many industries, including banking, insurance, media, energy, and public services by using automation to lower the cost of transacting (e.g., Grewall-Carr and Marshall, 2016; Scull, 2017).

Treleaven et al. (2017, p. 15) succinctly explain the attributes of the technology:

> "In simple terms, the technology handles blocks—uniquely identified, linked transaction records—in a chain. A blockchain is a continuously growing, distributed, shared ledger of such blocks, which are sealed cryptographically with a digital fingerprint generated by a hashing function."

Cryptocurrency mining is used to add a new block to the chain. This process involves solving a mathematical 'puzzle' that requires extensive computations until a target value is found. Essentially, the mining process is similar to finding the correct combination to a safe by trial and error. Participants in the network compete to add the next block to the chain by attempting to solve the puzzle first; when successful, they are rewarded in new cryptocurrency. This process simultaneously validates the transactions within each block and serves as an input for the next block. 'Puzzles' are intentionally incorporated into blockchain technology to delay the verification process (approximately 10 minutes for Bitcoin), to control the supply of new cryptocurrency and to reach a secure, tamper-resistant consensus (Flint, 2014). The process of mining becomes more difficult over time to offset growing processor and hardware power and to keep the time to solve each 'puzzle' stable.

A blockchain platform called Ethereum introduced a concept known as 'smart contracts' that defines the terms of a contract (rules and penalties) between parties using computer code. The contract is automatically executed when the conditions of the contract are met (Omohundro, 2014). A smart contract is a computer program that performs tasks as simple as returning a text message (e.g., "Hello World") when called (Ethereum, 2018) or executes more complex tasks such as facilitating the exchange of cryptocurrency (as in Bitcoin), property or shares (IBM, 2018a). As with other blockchain technology, the terms of the contract are transparent to all the nodes within the network.

Smart contracts are expected to disrupt many industries by lowering the costs of contracting between parties. For instance, the insurance industry has already made significant investments in blockchain technology to automate the lifecycle of claim management. The insurance industry expects to reduce the costs of processing, negotiation and adjudication (Maguire, Adler, de Vries, and Reinmueller, 2017) by automating identity and contract verification, as well as payment. Similar disruptions are envisioned for the finance industry since many back-office processes require negotiated contracts with numerous lawyers and contacts between parties to complete transactions such as syndicated loans (Fanning and Centers, 2016). In a nutshell, blockchain is helping customers to do what they were already doing (i.e., recording transactions) more easily.

Blockchain is also expected to disrupt the accounting profession (Kokina, Mancha, and Pachamanova, 2017), with specific implications for the design of accounting information systems, auditing and assurance (Brandon, 2016; Dai and Vasarhelyi, 2017; Rozairo and Vasarhelyi, 2018). First, Blockchain permits triple entry bookkeeping, where every transaction leads to three entries to record the debit, the credit, and the cryptographic signature to verify a transactions' validity (Brandon, 2016; Wiatt, 2019). In their paper, Dai and Vasarhelyi (2017) present how a self-assuring accounting ecosystem based on blockchain, smart contracts and IoT can work. They also discuss the implications of blockchain on auditing if audit-related documents such as electronic records of inventory items, invoices, bills of lading, letters of credit, receipts, etc., are made available as part of the blockchain and provide a complete audit trail (Dai and Vasarhelyi, 2017).

While many share the view that blockchain technology will have an enormous impact on economic and social systems, Iansiti and Lakhani (2017) consider blockchain to be a "foundational technology" with a slow but steady uptake rather than one that is sudden and disruptive. Iansiti and Lakhani (2017) compare blockchain technology to TCI/IP, the key underlying protocol for the World Wide Web that significantly reduced the cost of electronic communication. Initially conceived in 1972, TCP/IP made circuit switching and dedicated lines/infrastructure between parties in an exchange redundant. The TCP/IP protocol suite digitises information and divides it into smaller data packages that can take the most efficient route to the recipient.

With the advent of the Internet, new industries, markets, and services emerged, including technology companies (e.g., Google), platform organisations (e.g., Airbnb), cloud-based software vendors (e.g., Xero), and online businesses contributing to e-commerce. Thus, TCP/IP's full use did not materialise until 30 years after its invention, but it served as the

"foundation" for the development that followed. Iansiti and Lakhani (2017) suggest that blockchain technology will significantly reduce the cost of transactions and that its impact on the economy will be comparable to that of TCP/IP as new use cases are gradually developed and adopted.

Similar to all computer systems, distributed ledger technology has risks attributable to both the technology and its users. For instance, strategies and attacks are known to allow double spending where the same Bitcoin is used for two payments. Although improvements in blockchain security are underway, many known and unknown vulnerabilities still exist (Li, Jiang, Chen, Luo, and Wen, 2017). Because private keys are used to show ownership and sign transactions, their loss or compromise can result in Bitcoin being lost or stolen (Berke, 2017). In a recent incident, 4,736 Bitcoins (worth more than $60m at the time) were stolen by hackers using social engineering (Gibbs, 2017). Blockchain technology is also associated with criminal activity because some cryptocurrencies provide anonymity and are used to trade illegally, launder funds and fund acts of terror (Turner and Irwin, 2017).

3.4 Artificial Intelligence

The discussion of AI is last because the technology may leverage and overlay the others identified and discussed in this paper. AI includes innovations, such as machine learning and natural language processing, as well as statistical techniques that have been known for decades, such as classification and clustering (Sutton, Holt, and Arnold, 2016).

Traditionally, the rules and instructions for an 'intelligent' or expert computer system were programmed by specialists and programmers to support and automate repetitive tasks (Brynjolfsson and Mcafee, 2017). In contrast, in machine learning or cognitive computing, the system learns by example without any human intervention. Machine learning uses a probabilistic framework to infer plausible models to explain observed data (Ghahramani, 2015). Once the system selects the model that best fits the data, it can be used to make predictions about future data. Machine learning better approximates human intelligence as it evolves and captures tacit knowledge that is inherently difficult to program (Brynjolfsson and Mcafee, 2017). Challenges to machine learning include measurement noise and model choice (e.g., linear regression or neural network), which can be overcome by increasing the flexibility of the system (Ghahramani, 2015).

While various techniques associated with AI have been in use since the 1950s, machine learning is viewed as a disruptive force, and its commercialisation is gaining momentum. According to Gartner, cognitive computing will become mainstream in fewer than ten years (Panetta, 2017). Software vendors and PSFs are eager to embrace AI because of its potential (Zhou, 2017). Arguably, the best known AI platform is IBM Watson, which competed on the game show "Jeopardy" in 2011 and won against the best players (Markoff, 2011). IBM Watson learns by processing vast amounts of structured and unstructured data (big data) and has a Star Trek-like voice command interface. The IBM Watson platform provides

conventional decision support through analytics and data visualisation as well as 'true' AI using questions posed in natural language (IBM, 2018b).

AI is used by many practitioners and organisations such as Ernst and Young and Deloitte to detect fraudulent invoices and to assist with tax returns, reducing processing time from months to days (Zhou, 2017). However, some professionals such as those working in management accounting have suggested that their skills are inadequate for addressing AI requirements. Krumweide (2017), for instance, reports from a survey of management accountants that many feel they have a broad understanding of AI but lack the skills to add value to work in this area.

Many studies from different disciplines report on the use of AI. In accounting, Baldwin et al. (2006) and Sutton et al. (2016) provide reviews of AI research, while Omoteso (2012) specifically focuses on the use of AI in auditing for tasks such as classifying collectable debts versus bad debts or evaluating internal control risks. Many of these studies involve knowledge-based systems such as rule-based expert systems or intelligent agents rather than machine learning (Sutton et al., 2016).

Sutton et al. (2016) report that AI research in accounting has grown over the years, although much of that research has not been published in accounting journals. The few studies published in accounting journals use AI techniques such as neural networks. As early as the 1990s, studies were published predicting the use of inventory valuation methods (Liang, Chandler, Han, Roan, 1992). For example, a study by Koh and Tan (1999) utilises neural networks to predict the going concern status of firms. Other research applies machine learning techniques to study, for example, the predictability of future earnings from the tone of forward-looking-statements (Li, 2010) and to detect financial statement fraud (Perols, 2011). There is also a significant body of research using various techniques associated with AI in journals such as the Journal of Emerging Technologies in Accounting and Intelligent Systems in Accounting, Finance and Management.

The literature highlights many advantages and disadvantages associated with AI (Gray, Chiu, Liu, and Li, 2014; Sutton et al., 2016). Many examples and use cases are also provided by the business press. While evidence suggests that AI is 'useful', earlier research on expert and decision support systems suggests that system recommendations contradicting the opinions of end-users are often discounted (Jensen, Lowry, Burgoon, and Nunamaker, 2010).

Furthermore, such systems can bias decisions depending on the attributes of the system (Chen and Koufaris, 2015; Seow, 2011) and the level of user experience/expertise (Jensen et al., 2010). Seow (2011) conducted an experiment involving 94 participants that considered whether structurally restrictive decision aids could bias decision making. The study found that participants using structurally restrictive decision aids considered fewer non-prompted items than those with no decision aid which is suggestive that organisations need to pay greater attention to how the design of decision aids influences the decision quality. In addition, while AI may offer significant cost savings by automating and accelerating decision making, machine learning introduces new risks. Because AI learns from existing data, the learning process is influenced by the inherent biases and prejudices in the data that humans

generate and capture to train the system (Knight, 2017). Thus, if users do not understand the technology and adopt a black-box approach, biases will creep into decision making and potentially contaminate future data. The ICAEW underscores the need to stay involved in the process of developing and using algorithms to understand how they work and what assumptions have been made as new data unfolds (ICAEW IT Faculty, 2014).

The next section presents future research opportunities for each of the reviewed technologies from the perspective of management accounting, financial accounting and auditing. Consistent with the previous section, each of the four technologies has its own subsection.

4. Future Research on the Interplay Between Internet-related Technologies and the Work of Accountants

This section discusses opportunities for future research identified during the synthesis of the literature and taken from other review studies and commentaries. Table 2 provides a summary of the important directions identified and is organised according to the three broader accounting areas discussed in the method section of the paper.[5]

INSERT Table 2

4.1 Directions for Cloud

There are several potential lines of inquiry for those interested in contributing to the understanding of the interplay between accounting and the cloud. For instance, given that cloud systems are designed for multiple tenancies, there is the question of the level of customisation permitted by cloud financial applications (Gill, 2011, p. 45). Researchers pursuing this line of research may consider adopting a sociomateriality perspective (Cecez-Kecmanovic, Galliers, Henfridsson, Newell, and Vidgen, 2014; Orlikowski, 2007; in accounting, see Wagner, Moll, and Newell, 2011) to get a richer understanding of how the different interests are mediated in the systems in use.

Others may choose to build on the work that Strauss et al. (2015) undertook to understand the risks that firms encounter when migrating to the cloud. For instance, Avrane-Chopard et al. (2014) suggest that cloud providers may find it difficult to address the diverse needs of small to medium-sized businesses (SMBs). More case studies are required to understand and evaluate how cloud is being used by SMBs.

[5] In Figure 1 we suggest that the Accounting Profession Interest Groups include researchers, policy makers and practitioners. We did not specify research questions for each group in Table 2 since we believe that doing so would only serve to widen the gap between academic accounting research and professional practice. The aim of Table 2 is to outline some of the key questions as a starting point for those in the profession to work together to develop and support practices and policies that will address the challenges emerging from Internet and related information technologies.

For larger firms, a worthy line of inquiry would be to investigate how standardised systems may accommodate the *idiosyncratic* knowledge and routines of subsidiaries. Those with interest in supply chains could extend their work to gain a better understanding of how cloud modes of delivery are helping firms to manage such relationships.

Specifically, case studies are needed to better understand concerns about data confidentiality, integrity, availability (outages) (Alali and Chia-Lun, 2012), service level agreements, and data ownership (Gill, 2011). For instance, more research on service level agreements is required to understand how risk is transferred to service providers given their ability to upgrade services or add new security features without any intervention from the user. What if an upgrade leads to an outage or prevents a customer from making a purchase? A service level contract between the user and provider should include automatic penalties to the provider should service to the customer be interrupted.

New risks associated with using a single ledger instead of a dual ledger (where the accountant keeps a separate one) also require research. For instance, unauthorised changes to the ledger may become more difficult to detect. How the accountant-client relationship evolves given cloud-based systems that permit access to clients' financial data in real-time through a shared ledger is another topic worthy of investigation. For instance, are accountants servicing SMEs continuing to carry out bookkeeping roles or are they morphing into financial advisors or consultants?

How cloud models of delivery affect existing or legacy tools that may be in use in the organisation is another underexamined but important issue for management accountants. For example, how effective are tools such as the budget given that users can scale their operations up or down more easily? Have firms using cloud services had to abandon budget practices in favour of the rolling forecast since the cloud does not commit them to spend for a year or more in advance? Also, it remains unclear how firms that choose to develop hybrid cloud infrastructure manage the interfaces between clouds (i.e., cloud bursting) (Mullholland et al., 2010).

Research is also needed about how professional organisations are adapting their programmes to equip their members with the skills necessary to add value to firms moving to a cloud model of delivery. There is significant evidence that professional organisations such as the ACCA (2016) and ICAEW (2015) are interested in ensuring that their members keep abreast of the changes in technology and how it is changing the work environment, so they do not lose relevance. Understanding how organisations perceive the legitimacy of the new cloud resources and support offered by the professional bodies may affect trust in the designation and in turn membership.

Finally, firms such as KPMG and Deloitte are, for the first time, selling accountancy services to SMEs. For instance, an article in Financial Times indicated that instead of the £600+ per hour that the Big 4 has charged in the past for auditing and advising large firms on accountancy issues, the monthly fee for cloud-based services starts at £150 (FT, 2016). How smaller accountancy firms are being affected by these large firms offering cost effective services is not clear, and further research is needed to learn how the smaller accountancy firms can compete.

4.2 Directions for Big Data

The reviewed papers have provided important advances towards understanding how accountants are likely to be influenced by big data, but much more research is required. There needs to be a better understanding of how accountants and others interacting with big data derive value from it. Topics for investigation include integration of data from different sources, issues related to data quality, and the setting of data related standards (c.f. Chartered Global Management Accountant, 2013). For instance, Court (2015) reported that when McKinsey asked firms committed to big data about the cost savings they had gained from its adoption, three quarters estimated that they had saved less than one percent. Such findings raise questions about whether the benefits of big data outweigh the cost and lead to further questions about how firms are using data and whether they have been able to interpret it in ways that provide them with a competitive advantage.

One of the risks of using big data is that most firms tend not to use the data they have effectively, leading some scholars, such as Ross, Beath and Quaadgras (2013) to argue that big data is unlikely to improve performance. Similarly, Brands and Holtzblatt (2015, p. 4) observed that "Just because the data floodgate opens does not mean that business analytics will automatically add value and could lead to wasted effort. It also means that the garbage-in, garbage-out (GIGO) concept is amplified if the wrong information is analysed." The ICAEW (ICAEW IT Faculty, 2014, p. 8) suggests that "data can be overwhelming and result in paralysis. It can also stifle innovation and risk-taking". Such comments suggest that more research is needed to help firms understand how they can avoid or minimise such risks. For instance, how can accountants be involved in the interpretation and presentation of big data and ensure that information adds value to business decisions?

Big data is expected to have far-reaching consequences for existing management accounting practices, such as by influencing budgeting processes. Smith (2016, p. 62) explains that with big data "[one] can create a budget model with ten years of data, not just six months of data, used in conventional business intelligence processes." Issues such as what new data is informing budgeting processes or why ten years of data is necessary given the rapidly changing business environment remain under-examined. In addition, advocates of beyond budgeting claim that big data will influence their control systems since most of the data is externally generated (Warren et al., 2015). Yet, so far we know little about how such systems are being designed to incorporate big data. Similarly, Chartered Global Management Accountant (2013) argues that big data presents opportunities for firms to develop new or improved KPIs. More research is required to understand the new KPIs being developed and how firms are integrating new kinds of data to improve KPIs.

Research is also needed on the new visual devices that accountants are using to provide structure to their analysis of big data to communicate with other C-suite executives. Effective data visualisation is critical if big data is to provide a competitive advantage, as the Chartered Global Management Accountant (2013; see also Quattrone, 2009; Quattrone, 2011) explains. Berinato (2016, 2019) also highlights how poor data visualisation can undermine decision making in organisations.

The issue of how organisations can reduce the likelihood that big data (i.e., social media) will be used for short-term gains through promotions to customers has remained under-examined but is worthy of further investigation. Horst and Duboff (2015) explain that while promotions may increase profits in the short term, they can also have significant implications for the reputation and building of the brand. These authors argue that big data can "unwittingly expose the company to allegations of inappropriate targeting, or unfair exclusion, or using data-driven correlations that in hindsight appear discriminatory" (p. 84). Big data is also used in other spheres such as politics. For instance, the Facebook-Cambridge Analytica scandal that affected millions of users demonstrates the need to develop more strict data governance policies. Accountants may need to consider the role they can play in helping to safeguard client data (Confessore, 2018).

Research is also needed to empirically demonstrate the overlooked issue of how big data and IoT may enhance fair value accounting and disclosure (Warren et al., 2015). This work would require proof of concepts using a design science approach to develop and validate new artefacts serving financial accounting tasks (Gregor and Hevner, 2013). Furthermore, case studies may be useful to reveal whether organisations use big data such as videos and audio in financial reporting and whether such techniques are worthwhile or valued by financial analysts. Such studies may find it useful to consider the literature on valuation, and in particular, work by Mennicken and Power (2015) and Kornberger et al. (2015) focusing on the plastic nature of accounting values. Others wishing to understand the non-financial implications of valuation may consider work by Quattrone (2015) concerning how what is accounted for can help us to understand what it does.

Big data is also expected to influence the work of auditors. Richins et al. (2017) suggest that auditors likely need to familiarise themselves with how to provide assurance services for a more extensive data set (see also Borthick and Pennington, 2017). Brown-Liburd et al. (2015) identify five areas for future research that affect auditor judgement and decision making in the big data era. These include strategies and development of new mental models to effectively integrate complex data in audit engagements and issues around technology choice and auditor skill development. Yoon et al. (2015) suggest several directions for the future that include techniques to retrieve relevant audit evidence from big data, to map relevant big data sources for firms in different industries and to update auditing standards to regulate information transfer and privacy issues. Finally, big data and Industry 4.0 will enable real-time monitoring and continuous auditing; standard setters will need to develop policies to govern such practices (Unsworth, 2017).

4.3 Directions for Blockchain

Since blockchain is one of the newest technologies (Panetta, 2017) discussed in this paper, it is not surprising that the accounting literature on this topic is scarce and tends to be poorly understood in academic circles.

A distributed ledger is a large integrated database and offers new opportunities for data mining and analytics similar to the opportunities provided by ERP-type systems in the past. Subject to access rights, third parties such as PSFs can analyse blockchain data to provide

business insights regarding current and future performance. Real-time access to performance data provides opportunities for management accountants to recommend immediate corrective actions. Consequently, many of the same types of research questions identified and discussed about big data in Section 4.2 are also relevant for blockchain. For example, how can management accountants use blockchain to improve planning and control? What new metrics can be developed for benchmarking and performance measurement? Any research investigating accountants' perceptions about the adoption of blockchain technology, including perceived challenges, would be highly valuable. Once the technology is in full operation, case studies reporting the benefits and costs of using blockchain would serve the profession well.

Those involved in financial reporting[6] (Kim and Zhang, 2014), corporate social responsibility (Gallhofer, Haslam, and van der Walt, 2011) and supply chain management (Agndal and Nilsson, 2010) have argued for increased transparency in transactions. Blockchain allows "transactional reporting," where aggregation and presentation choices are left to the market (Vasarhelyi, 2012). More specifically, stakeholders may access blockchain to retrieve disaggregated information about organisations to generate reports and financial statements based on their individual needs. Access to blocks could be granted at different levels, i.e., full access to regulatory bodies or partial access to investors, for example by concealing the identities of third parties. Such electronic architectures would address the inadequacy of accounting standards that fail to meet the information requirements of various stakeholders in today's digital age (Vasarhelyi, 2012). Who will be involved in establishing such architectures for organisational disclosure, and how that new information will gain legitimacy from those involved in the blockchain community, deserve further investigation. It may also be necessary to change the accounting standards to acknowledge the increasing verifiability and transparency of the accounting ecosystem (Dai and Vasarhelyi, 2017).

Start-ups, as well as established companies, are issuing their own cryptocurrencies through Initial Coin Offerings (ICO), which also helps to raise capital (Chester, 2017). For instance, Kodak announced that it would adopt KODAKCoin through an ICO to pay photographers who register and license their work on the new platform. This news is credited with increasing the value of Kodak's shares to greater than 41% (Raines, 2018). Accountants may find opportunities to support such new practices by providing both financial (e.g., valuations) and regulatory advice relevant to the technology. However, the emergence of non-bank credit intermediaries may also have implications for financial demand and those institutions regulating its use (BoE, 2018).

Professional services firms, such as Deloitte and PWC, that provide auditing services view blockchain as a game-changer (Psaila, 2017; Smith, 2017b). As transactions in blockchain have 100% integrity, these transactions do not need to be audited in a point-in-time forensic manner through sampling. Instead, the entire population of transactions can be verified, providing a higher level of assurance. With immediate access to data and another layer of technology to manage the process, transactions in blockchain can be audited continuously in near real time (Smith, 2017b). Auditors can, for example, identify high-risk financial

[6] Although there is some evidence that this may lead to mispricing (Elliott, Krische, and Peecher, 2010).

positions promptly rather than at the end of the financial year. Given these emerging capabilities, it will be necessary to research how auditors will adapt to changing audit processes and what new skills they will need to develop in the coming years (Dai and Vasarhelyi, 2017).

Real-time access to clients' data will provide new opportunities for non-audit services. Research is needed to understand whether and how this will compromise auditor independence (Frankel, Johnson, and Nelson, 2002). Furthermore, how will blockchain affect audit fees and how will firms determine them? For example, will their fees be subscription-based?

One assumption of blockchain technology is that transactions will be transparent and contain fewer errors, making it more challenging to conceal fraud. However, while increased transparency might suggest a smaller likelihood for tax avoidance, the anonymity provided by some cryptocurrencies might have the opposite effect. This area would benefit from more research.

4.4 Directions for Artificial intelligence

Big data and automation raise the question of what accountants' future role will be if AI solutions such as IBM Watson can provide answers to many business-related questions. This, in fact, might be an 'interesting' question to ask from IBM Watson. However, one task for accountants could be managing and selecting relevant data to train AI applications. This task will be necessary since many accounting-based business decisions such as "make or buy" and "vendor selection" are becoming increasingly complex and require a subject-matter expert. Accountants would be in a good position to validate, maintain, and ethically consider the quality of data sets for training AI solutions (Anderson and Anderson, 2011). This role may be comparable to that of a data curator, which involves content creation, selection, classification, transformation, validation, and preservation (Freitas and Curry, 2016).

Furthermore, the use of algorithms to make decisions raises new questions about the extent to which managers can be held accountable for the profit and loss of the business (Court, 2015). Accountants will be expected to work with AI, but given that users may see AI as a threat (Jensen et al., 2010), how and who will assure that these technologies perform as expected and can be trusted? This problem is exacerbated by the fact that machine learning techniques use very complex models such as neural networks to make predictions. While complex models may provide more accurate budgets or cost estimations, they will be less comprehensible for decision-makers. In conventional modelling, tensions between managers and modellers are overcome by abstracting the details of analytics or changing the assumptions and parameters of the model (Kowalczyk and Buxmann, 2015). Since AI learns from tacit knowledge, this will be more difficult, and research is needed to study the critical issue of how a synergistic symbiosis between AI and the processes of organisational decision making can be fostered.

Quattrone (2016) suggests that there are issues with the digital culture associated with AI, arguing that accounting numbers are "no longer there to be spoken, listened, and debated in communicative acts" (p. 120). The risks of removing accountants from organisational processes can lead to adverse outcomes for specific products or product lines. For instance, one has only to look at the history of the pricing of the book "The Making of a Fly" on Amazon. The pricing used for this book is based on algorithms. One consequence of this is that its price peaked at $23,698,655.93; days later it was listed for $100[7]. This example indicates some of the dangers of replacing pricing strategies with algorithms and suggests that another underexamined issue is whether and how accountants can continue to oversee the development and monitor the use of calculative infrastructures that support costing and pricing decisions when there appears to be so much trust in these new technologies to provide a competitive advantage.[8]

Sutton et al. (2016) suggest several neglected AI research directions, including the application of natural language processing in audits for screening high-risk employees and questions derived from the Theory of Technology Dominance (see also Arnold and Sutton, 1998). Research should also investigate the business value of AI regarding better decision making, control and organisational performance. For example, explorative studies could help uncover improvements in management accounting or internal control as well as assess markets' reactions to AI adoption announcements. Studies in ERP and business intelligence (e.g. Ajit, Donker, and Patnaik, 2014) domains adopting an event study approach could serve as an example.

The implications of AI for the future of PSFs warrants further investigation (Cooper and Robson, 2006) since there is current interest in this area (Spence et al., 2017). For example, will PSFs compete based on the superiority of their AI and big data given that compliance-related services are becoming a commodity and generating an increasingly smaller portion of their revenue (Agnew, 2015; Big4, 2015)? There is also an issue of deskilling; that is, many of the accountant's traditional tasks being automated or offshored. How will accountants gain the necessary skills and experience to advance to other roles if such positions are gradually disappearing?

Finally, when combined with other technologies such as blockchain, AI will have far-reaching consequences and implications. For instance—and this may be a bold assertion—will there be any bad debts in the future given superior predictability through AI, credit analysis, and the continuous audit (Alles, Kogan, and Vasarhelyi, 2008) of a global blockchain? This would require seamless integration between different blockchains as well as access to relevant information. This kind of assurance could be provided by a third party such as an information broker or a regulator with 'universal' access to data. However, it is unknown what governance structures may be required to manage this from both a technological and privacy/confidentiality aspect.

[7] This case was first reported on a blog by Michael Eisen (http://www.michaeleisen.org/blog/?p=358&cpage=1).

[8] Some suggest that relying on algorithms for pricing may lead unwittingly to firms engaging in price fixing (see, for instance, comments by Gilardoni, Low, and Boyd, 2017).

5. Discussion

This paper has demonstrated that empirical studies of Internet-related technologies are lacking in the accounting literature. This oversight is surprising given how interrelated these technologies are with the work of accountants.[9] The paper examines the existing literature to provide a more comprehensive understanding of current knowledge about these technologies and how they are impacting and transforming the daily work of accountants.

It is hoped that this paper will prompt additional scholarly conversation and inspire scholars to undertake further empirical research focused on firms embracing digitisation (i.e., platform start-ups and SMEs) to understand how Internet-related technologies are transforming management, accounting practices and the role of accountants. This paper focuses on the interplay of accounting and four Internet-related technologies: cloud, big data, blockchain, and AI. While each technology has its own advantages and risks—and the paper has raised many research questions for each—it is perhaps their combined use that will fundamentally change the field for accountants. At one level, a better understanding of the interplay of these technologies may be required to fully understand the changes that are being observed and to ensure that those in finance and accounting are positioned to continue to add value to organisational decision making (c.f. Frey and Osborne, 2017; Susskind and Susskind, 2015). For example, blockchain technology will further contribute to the big data phenomenon by providing access to a globally distributed ledger, including smart contracts. These data may be analysed using cloud-based analytics and AI software that will become accessible to a broader range of large and small organisations. These technologies will foster new types of automated accounting services and auditing and will be near real-time, improving performance and assurance.

At another level, the increased automation, visibility and decision support might give the impression that the burden on accountants will be reduced in the future. The paper argues that, to be successful, some Internet-related technologies still need accountants to carry out conventional processes such as performance management, although even these established techniques are becoming more complex requiring new approaches be developed to ensure that information is helpful for developing strategy (see, for instance, Appelbaum et al. 2017).

Furthermore, many advanced AI applications require supervised learning; accountants may be well positioned to ensure that data used in these leading-edge developments are fit for the purpose and that human information-processing limitations are considered in the volume of data that may be produced. To effectively contribute to organisations embracing AI, accountants will have to be increasingly vigilant and critical; they will need to question the insights and suggestions provided by these new technologies and to be cautious of

[9] This may not be a surprise to some since in the past accounting researchers have tended to overlook or been non-responsive to urgent calls for research investigating the links between accounting and Information Technology such as ERP-type technologies (see, for instance, Chapman and Chua, 2003; Hopper and Bui, 2016).

others that use them in a black-box fashion and ignore the inner calculative infrastructures and the plasticity of the values being produced.

Innovative modes of governance may be needed in response to AI, particularly given the ease with which those within the organisation can blame poor decisions on the IT system, arguing that such decisions are automated and not subject to any interference on their part. Research is needed to understand practical issues such as how these governance structures are designed and how they function. The lack of empirical studies focused on this issue suggests that case studies are urgently needed to help understand the complex issues at play. Organisations seeking to improve the outcomes of automation may need to realise the importance of involving accountants in the development of such systems. Empirical research is required to understand how accountants can effectively add value in such circumstances and convince others of the legitimacy of their position. To examine how those in the profession are seeking to convince others that they possess expertise helpful for navigating Internet-related technologies, research might draw on institutional work literature aimed at understanding the "purposive action of individuals and organisations" concerning the development and maintenance of institutions (Lawrence and Suddaby, 2006, p. 215; Lawrence, Leca, and Zilber, 2013; Lawrence, Suddaby, and Leca, 2009; in accounting, see Suddaby et al., 2015).

Although many firms may be tempted to adopt the latest technology, they may not have the capacity to experiment, either because it is too costly or because they do not possess a clear understanding of the risks associated with the technology's development and installation. Case studies that focus on the very practical but neglected issue of the processes involved in developing and adopting such technologies are urgently needed to deepen the understanding of the risks attached to outsourcing and automating traditional accounting functions.

The interconnectedness and transparency enabled by the combined use of the discussed technologies will not only provide new opportunities but also intensify the vulnerabilities and risks. Along with the conventional risks associated with computer systems, such as security and confidentiality, the assumptions of the analytical model and data governance (e.g., quality and scope of information) must be considered to attain the benefits from big data analytics and AI (Neely and Cook, 2011). The skill set of accountants means they are in a good position to contribute to the evaluation, implementation and maintenance of the discussed technologies as well as the appraisal of new/affected business processes to manage the risks. However, it remains unclear how accountants will influence the shaping of such decisions to compete in the Internet-related technology space or use such technologies. Furthermore, accountants' jurisdictions (Sikka and Willmott, 1995) may increasingly be challenged by other professions, such as data scientists and technology experts. Studies involving interviews or surveys of professional accountants may be useful for addressing this underdeveloped area.

There appears to be significant scope for those in the profession to expand their skill set, particularly regarding their competence and understanding of such digital technologies. Accounting researchers (Howieson, 2003), practitioners (PWC, 2015), and professional

accounting organisations (IFAC, 2007) have long acknowledged the increasing importance of IT in accountants' work. Despite this interest, few university accounting programmes cover issues related to how accounting is interlinked with digitisation. It would serve the profession well to consider how knowledge of these new technologies can best be integrated into the university curriculum (see also Borthick and Pennington, 2017) to ensure that those intending on developing a career in accounting possess the relevant knowledge and skills. Case studies of best practices may help to resolve this issue.

This paper has some limitations in terms of the scope of the review, providing opportunities for others to help establish a research agenda. For instance, the review excluded virtual reality that may have applications in accounting. Furthermore, this paper did not focus on mobile applications, although some of the technologies reviewed, such as 'cloud' leverage mobile technologies, were deemed implicit in the coverage of topics.

Finally, while the review focused on three areas of accounting—management accounting, financial accounting and auditing—the reviewed technologies are likely to affect many, if not all, areas of accounting, such as sustainability-, tax-, and forensic accounting. Some research is already underway in areas such as sustainability in Industry 4.0 (Burritt and Christ, 2016) and detection of tax evasion through big data analytics (Tian et al., 2016).

6. Conclusion

This study focused on four influential Internet-related technologies (cloud, big data, blockchain, and AI) and their implications for the three accounting profession interest groups: researchers, policy makers and practitioners. While accountants may understandably feel threatened by technology, the technologies discussed in this study create new opportunities for accountants. Specifically, technology enables unprecedented sharing of data, access to cutting-edge hardware/software, and tools that can complement and enhance management accounting, financial accounting, and auditing tasks. However, the accounting profession may need to be vigilant in developing the required skills, and policies to effectively govern the implementation and use of these technologies in organisations.

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Table 1: Overview of academic studies in accounting and information systems journals investigating Internet-related technologies (N=38)[a]

Internet-related Technologies	Accounting Area	Total Number of Studies	%	Studies	Main Research Method
Cloud	Audit	3	8%	Alali et al. (2012)	Archival
				Liu and Vaserhelyi (2014)[b]	Commentary
	Audit			Vasarhelyi (2013)	Commentary
Big Data	MA	19	50%	Agostino and Sidorova (2017)	Interviews
	FA			Al-Htaybat and von Alberti-Alhtaybat (2017)	Interviews
	Audit			Alles (2015)	Literature Review
	MA			Appelbaum et al. (2017)	Conceptual
	MA			Arnaboldi, Azzone, Sidorova (2017)	Interviews
	MA			Arnaboldi, Busco, Cuganesan (2017)	Literature Review
	FA			Belluci and Manetti (2017)	Content Analysis
	MA			Bhimani and Wilcox (2014)	Conceptual
	MA/FA			Borthick and Pennington (2017)	Commentary
	MA			Brivot et al. (2017)	Interviews
	Audit			Brown-Liburd et al. (2015)	Literature Review
	MA/FA/Audit			Huerta and Jensen (2017)	Commentary
	MA/FA/Audit			Richins et al. (2017)	Conceptual
	Audit			Rose et al. (2017)	Experiment
	MA/FA/Audit			Suddaby et al. (2015)	Interviews
	MA/FA/Audit			Vasarhelyi et al. (2015)	Literature Review
	MA/FA			Warren et al. (2015)	Commentary
	Audit			Yoon et al. (2015)	Conceptual
	Audit			Zhang et al. (2015)	Conceptual
Blockchain	FA/Audit	5	13%	Dai and Vasarhelyi (2017)	Conceptual
	MA/FA/Audit			Fanning and Centers (2016)	Commentary
	MA/FA/Audit			Kokina et al. (2017)	Commentary

	Audit			Rozairo and Vasarhelyi (2018)	Conceptual
	FA			Vaserhelyi (2012)	Commentary
Artificial	Audit	11	29%	Baldwin et al. (2006)	Commentary
Intelligence	Audit			Dowling and Leech (2007)	Literature Review
	MA/FA/Audit			Gray et al. (2014)	Literature Review
	Audit			Koh and Tan (1999)	Archival/analytical
	FA			Li (2010)	Archival/analytical
	FA			Liang et al. (1992)	Archival/analytical
	Audit			Omoteso (2012)	Literature Review
	Audit			Perols (2011)	Archival
	MA			Quattrone (2016)	Conceptual
	Audit			Seow (2011)	Experiment
	MA/FA/Audit			Sutton et al. (2016)	Literature Review
Total		**38**	**100%**		
	MA: 16				**Commentary: 9 (24%)**
	FA: 16				**Conceptual: 8 (21%)**
	Audit: 22				**Literature Review: 8 (21%)**
					Archival/analytical: 5 (13%)
					Interviews: 5 (13%)
					Experiment: 2 (5%)
					Content Analysis: 1 (3%)

MA: Management Accounting, FA: Financial Accounting

[a] The table includes accounting information system journals such as Journal of Information Systems (American Accounting Association). It does not include practitioner journals (Strategic Finance, Management Accounting Quarterly, Harvard Business Review, MIT Technology Review etc.), books, industry papers and other non-peer reviewed publications.

[b] This paper does not refer to an accounting area.

Table 2: Summary of Key Research Questions for the Accounting Profession

Internet-related Technology	*Main Purpose of Internet-related Technology*	*Accounting Areas*	*Research Questions for Accounting Profession Interest Groups: Researchers, Policy Makers and Practitioners*
Cloud	Cloud computing is an Internet enabled IT model that permits real time sharing of data and exposes organisations to various risks including information security vulnerabilities.	MA	1. Given that cloud accounting systems are designed for multiple tenancies, what level of customisation do they permit? 2. How can the risks of public cloud accounting be better managed in terms of data security and service level? 3. How can accountants help to manage the interface when the accounting architecture relies on a hybrid of private and public clouds? 4. How do cloud-based accounting systems affect legacy management accounting practices including budgeting and techniques to manage supply chain relationships? 5. What new regulations are required to prevent unethical or discriminatory targeting (offers, price etc.)? 6. How are professional management accounting bodies adapting their programs to equip their members with the necessary skills to increase their relevance inside organisations? 7. How can incorporating new Internet and related technology skills and resources help professional management accounting bodies (i.e. CIMA, IMA) to maintain the legitimacy of their designation?
		FA	1. To what extent do cloud-based accounting applications meet the financial reporting requirements of large and small firms? 2. What types of new services can financial accountants offer their clients given that cloud permits real-time access to clients' books? 3. What risks do cloud-based applications pose to financial reporting because of a shared ledger as opposed to dual ledger? 4. How are professional accounting bodies adapting their programs to equip their members with the necessary skills to increase their relevance inside organisations?

			5. How can incorporating new Internet and related technology skills and resources help professional bodies (i.e. ICAEW, ACCA, CPA Australia) to maintain the legitimacy of their designation?
		Audit	1. How are cloud-based accounting services offered by accounting firms changing audit risk and fees? 2. What are the implications of cloud-based services for accounting firms?
Big Data	Big data refers to the variety and quantity of data, which can complement financial reporting, auditing and decision-making based on analytics.	MA	1. How do accountants get value from, and measure the value of big data for decision making? 2. How does big data affect management accounting techniques such as budgeting, pricing and performance measurement? 3. With more internal and external data available, what new control systems does big data afford? 4. What visual devices are accountants using to structure big data to ensure that information adds value to business decisions?
		FA	1. How can big data and IoT enhance the ability to understand and communicate the value of tangible and intangible assets? 2. How can big data and big data capabilities be valued and disclosed? 3. How can big data and IoT support fair value accounting? 4. How do analysts view the new forms of valuation made possible by big data?
		Audit	1. How can auditors select the most appropriate tools to analyse big data? 2. What big data techniques/sources do auditors use? 3. What new skills do auditors need to utilise big data? 4. How does using big data in audit affect audit fees? 5. What new policies are required to use big data in an audit without violating information privacy? 6. How will real time reporting and continuous auditing affect standard setting?

Blockchain	Blockchain enables the creation of immutable distributed ledgers.	MA	1. What new opportunities does blockchain provide to management accountants, e.g. for planning and control? 2. How can blockchain data be used for benchmarking? 3. What structures are required to govern the access and use of blockchain in terms of preserving confidentiality, integrity, accessibility, and traceability of accounting data?
		FA	1. How will blockchain affect the frequency and format of financial reporting? 2. How should accounting standards adapt to acknowledge increasing verifiability and transparency of data? 3. What new roles do ICOs create for accountants in terms of financial advice and reporting? 4. What form of regulation is required to govern the practice of raising capital through ICOs?
		Audit	1. How does blockchain affect the process of auditing and the skills required of auditors? 2. How does real-time access to client blockchain affect auditor independence and audit fees?
Artificial Intelligence (AI)	Artificial Intelligence refers to a set of computational techniques to solve problems and to complement decision-making.	MA	1. What management accounting tasks are best suited for machine learning? 2. How can AI be trained and which finance executives are well positioned to assist with this task? 3. How can accountants manage tensions arising from the use of AI inside organisations? 4. What governance mechanisms are required to ensure legitimacy and accountability of decisions supported by AI?

FA	1. How can organisations' AI be valued and disclosed? 2. How do investors react to AI adoption decisions?
Audit	1. How can AI be utilised in the audit process for screening high-risk employees? 2. What bias or risks may cognitive computing introduce to auditing?

MA: management accounting; FA: financial accounting

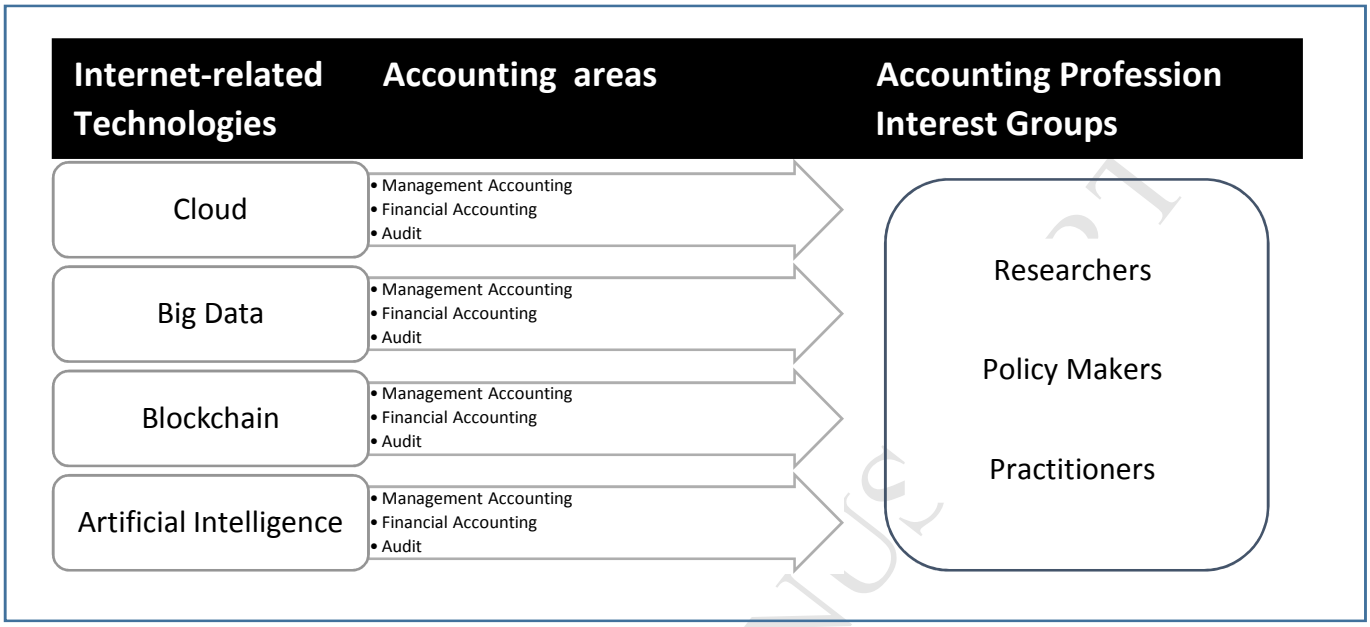

Figure 1: Topics covered in the literature review

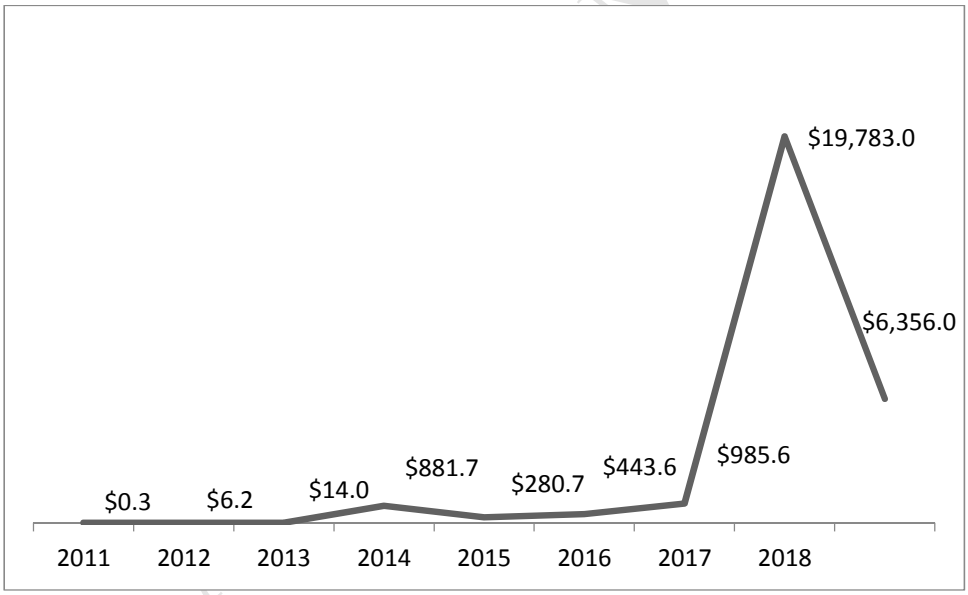

Figure 2: Bitcoin trading price in USD