The Potential Impact of Blockchain Technology on Audit Practice

Nathalie Brender
HES-SO University of Applied Sciences and Arts Western Switzerland

Marion Gauthier
HES-SO University of Applied Sciences and Arts Western Switzerland

Jean-Henry Morin
University of Geneva

Arbër Salihi
University of Geneva

In today's debate on the potential disruptive effects of blockchain, audit and control professions are rarely in the spotlight although applications such as smart contracts and distributed ledgers could significantly impact them. We conducted a study based on the grounded theory to understand how auditors in Switzerland anticipate the impacts of blockchain on their activities. Based on our findings, three hypotheses have emerged. First, the potential effect of blockchain on the profession is not fully anticipated. Second, the profession will go through a paradigm shift in two ways: become more IT oriented and forward looking. Finally, the profile of the auditors will change.

INTRODUCTION

The disruptive effect of Blockchain is now widely recognized in the financial sector, while the level of awareness in other sectors and their professions remains low. Elimination of intermediary activities (disintermediation) or transformations of these activities are expected to occur in all sectors of the economy (Von Gunten and Mainelli, 2014; Schatsky and Muraskin, 2015; Swan, 2015). This is particularly well illustrated in the audit and control professions. Indeed, current technical developments, process and service innovation, applications such as smart contracts and publicly-held registers, combined have the potential to radically change audit and control activities. The transparency, traceability, immutability and integration of rules and procedures embedded into the technology itself may enrich processes and information production in such a way that control and audit procedures may be changed significantly, or even become obsolete in some cases. At the same time, it offers opportunities for auditors to redesign best practices, update rules and procedures, define new standards of the profession that could be encoded within transactions or even innovate with new value-added services.

While the "disruptive" potential of blockchain has been extensively debated, scientific studies about the impact on business processes and professional practices remain scarce (Weber, et al., 2016) and the development of business models remain primarily associated to the financial sector (e.g. for the first semester of 2018 the global investment in fintech companies – across venture capital, private equity and mergers and acquisitions - hits $57.9 billion which is well above 2017's total investment results (KPMG, 2018)). Thus, the academic and professional literature mainly presents two kinds of contributions about blockchain:

i) advantages and pitfalls of blockchain technology both from a technical and business perspective; and
ii) business applications mainly focusing on cryptocurrencies, smart contracts, and traceability at large.

In this context, compliance, control, and audit activities have been neglected in the academic and scientific community in analyzing their developments or proposing new business processes and services.

The purpose of this study is to explore the perception of financial auditors and Information Systems (IS) auditors working in audit firms of different size in Switzerland on how the use of blockchain technology could impact practices in the audit profession.

The innovative point of this study can be tied to the focus on the audit profession and more specifically on the view of professionals in practice regarding the potential impacts of blockchain technology on their daily work and profession as this sector is currently under-researched despite the significant disruptive potential.

The next section reviews the literature and related work. Section two describes the research methodology. The research results and discussion are presented in section three. Section four concludes the paper with current and future work.

LITERATURE REVIEW

Blockchain technology is a distributed data structure, or ledger, in which transactions are recorded in append-only mode and verified through consensus algorithms (Erbguth and Morin, 2016). In other words, it is "a distributed general ledger recording that a transaction happened, when it happened and that it happened correctly, without exposing any confidential details about the subject or the parties' involved" and consists of a software protocol of its own (Kehoe, et al., 2015). These systems keep records of ownership and transaction timestamps, eliminating the possibility of digital copying and, thus, double-spending (Farell, 2015; Tsilidou and Foroglou, 2015; Lee Kuo Chuen, Guo and Wang, 2016).

Blockchain technology also offers users the feature to make transactions irrevocable (immutability) thus increasing accuracy and trustworthiness of records (Lemieux, 2016; Wespra, 2016) while at the same time simplifying back office processes. Blockchain makes it possible to tie a set of rules or procedures to specific transactions to standardize process activities. The features of this technology, in particular its transparency and distributed consensus approach (Silverberg, et al., 2015) are expected to fundamentally change current business models, practices, and professions to achieve a "sharing economy and distributed trust" according to the World Economic Forum (Brechlbuhl, 2015).

From a conceptual perspective, blockchain technology provides a series of features, which can revolutionize some of the existing architectures in the digital business world. This transparent distributed database records each network's user intervention and allows encoding rules and procedures within the platform at the transaction level. It allows business enterprises to create and run applications as well as conduct business without a central authority or server as a control point (Trusted Third Parties). In this regard, blockchain technology helps businesses craft applications and conduct transactions, which can be self-executing and autonomous at the same time (DuPont and Maurer, 2015). The autonomous, decentralized and secured capabilities characterizing blockchain technology can help in redefining the foundational patterns of business applications (Schatsky and Muraskin, 2015; Swan, 2015; Mahajan et al., 2018). The trusted third parties could even become useless and be replaced by blockchain based distributed trust (Swan, 2015, Pitter 2018, The Economist 2015) which could lead to the transformation or

elimination of intermediary activities (disintermediation) in several sectors such as finance, art, health, and literacy (Swan, 2015), personal insurance (Von Gunten and Mainelli, 2014), corporate audits and accounting (Schatsky and Muraskin, 2015; Smith 2018).

In today's business ecosystem, financial auditors are the trusted professionals who guarantee the existence of transactions, attest of their evidence, accuracy, and completeness as well as the presentation of related information in financial statements (Hayes et al., 2014). In order to fulfill these objectives, the auditors need a good understanding of the client business, IT infrastructure and IT systems relevant to financial reporting and controls in place. In order to do so, the International Standards on Auditing (IAS) allows them to team up with IS auditors to gather and interpret evidence (Axelsen, et al., 2017; IAS 220, 2009).

More specifically, IS auditors collect and examine data from database, software programs and information management systems to ensure that they allow to safeguard assets, maintain data integrity, achieve organizational objectives, and consume resources effectively (Axelsen et al., 2017). In other words, IS auditors evaluate the design and effectiveness of an organization's IT systems and internal controls against policies and regulations.

Audit and control functions have been mainly established to provide assurance to shareholders, regulators, governments and other stakeholders. All types of audits (financial, operational, compliance, governance, etc.) share the same characteristics and consist of systematic processes "of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between these assertions and established criteria, and communicating the results to interested users." (Hayes et al., 2014). An audit ultimately aims at providing trust among its intended public. For example, the purpose of a financial audit is to enhance the degree of confidence of financial statements readers (IFAC 2400 revised, 2012). Spoke M., a senior consultant at Deloitte Canada, stresses that an audit is an opinion provided on the financial statements of companies based on pre-determined accounting guidelines.

However, after scandals such as Enron in 2001 among the most notable, the global audit industry has lost its principal asset; public trust (Spoke, 2015). This is highlighted by the literature which shows that trust in audit has been undermined due to scandals and is still in a recovery process within the public (Mueller, Carter and Whittle, 2015; Fearnley, Beattie and Brandt 2005; Zabihollah, 2004).

As a response to rebuild this trust, new regulations as well as accounting and auditing standards have been imposed, adding complexity, and increasing the cost of control activities and reporting for companies. Today, blockchain technology allows business enterprises to make digital interactions or record transactions in a way that is transparent, secure, auditable, efficient, and highly resistant to interruptions (Schatsky and Muraskin, 2015). Those features could not only decrease the accounting, auditing and compliance costs but also transform and facilitate the work of auditors (Spoke, 2015). It is clear that such technology can enable more efficient access to data and completion of financial audit. Indeed, the fact that any asset or document can be codified and referenced or encapsulated by a ledger entry helps simplify the work of auditors and accounting professionals (Schatsky and Muraskin, 2015), and reduce the manual work (Drane, 2016) while at the same time help to ensure complete transaction traceability.

Large international audit firms themselves foresee that the cost and time necessary to conduct an audit would decline considerably (Allison, 2015; Tysiac, 2017). It seems therefore reasonable to expect a significant increase in the commoditization of financial audit services (Anderson, 2017) and a decrease of audit costs. Those firms, and more particularly the Big Four (the four largest audit firms being Deloitte, EY (Ernst & Young), KPMG, and PwC (PricewaterhouseCoopers) are currently working on blockchain technology (Allison, 2015): EY, for example, announced the launch of EY Ops Chain, a set of applications and services to help firms leverage blockchain technology to enhance operation and drive growth (Alarcon, 2018). KPMG LLP and Microsoft reported a partnership to create a series of innovation workspaces and other initiatives dedicated to developing use cases and applications of blockchain technology (Alarcon, 2018). Deloitte declared a blockchain team of 800 professionals in 20 countries (Alarcon, 2018) with the EMEA blockchain lab based in Dublin, and in particular, the Rubix Project

being an example of work performed on interoperability, scalability, performance and security in the audit field (Keogh, 2017; Spoke, 2015). And PwC also created its global Blockchain team and set up a Blockchain Experience Lab that works in co-creation with industry experts.

Blockchain is also expected to reduce reliance on auditing for testing financial transactions providing an "automated third-party verification" (Spoke, 2015). This could ultimately lead to the elimination of control and audit activities or at the least to a profound redefinition of those professions. For example, access could be granted to auditors and regulators, providing a "single source of the truth" (Roberts, 2017) and allow for real time audit (MacManus, 2017). Another example is the confirmation process that could be eliminated from the auditors' review process; especially confirmation of outstanding receivable and payable balances. Indeed, once data has been uploaded and approved by the blockchain, confirmation of transactional information and details are broadcasted to the entire network, providing real time verification of the transfer of funds from one counterparty to another, making the auditor's confirmation no longer necessary (Smith, 2018; Borthick, 2017).

However, even though blockchain technology offers many different features and seems to be secured, there are several existing challenges that need to be addressed. One major issue is interoperability. Interoperability is defined by the Francophone Association of Free Software Users as "a characteristic of a product or system, whose interfaces are completely understood, to work with other products or systems, present or future, in either implementation or access, without any restrictions". As of today, even though multiple blockchain projects have been set up and some of them are even well established, such as Bitcoin and Ethereum, there are still interoperability issues among blockchain infrastructures. Moreover, the compatibility issue of blockchain with enterprise information systems (e.g., ERP) which often include a variety of functional modules such as accounting, controlling, procurement, logistics, warehousing, manufacturing, project management, quality management, etc. are currently being addressed by several ERP vendors and technology companies (Kacina, et al., 2017). These systems are widely used across all industries nowadays. Lastly, blockchain's benefits are best realized when different industry participants come together to create a shared platform which increases interoperability challenges at two levels (PwC, 2018), first at the technical level as each participant's systems need to be compatible with the shared blockchain and second at the blockchain governance level as each participant needs to agree on the shared network rules.

Another key issue is the blockchain scalability. Scalability is the ability for a system to continue to function well when it changes in size or volume - typically, to a larger size or volume (Rouse, 2006). In the blockchain context, the scalability issue arises when the number of participants increases over time. Scalability has several components: latency, which is the "time for a transaction to confirm" (Croman, 2016). As of today, latency takes at least 10 minutes with the blockchain Bitcoin, and 14 seconds for Ethereum, which is significantly more than current payment processing systems. Moreover, 13 % of transactions on public blockchains exceed 20 minutes, and 25 percent can exceed an hour (Kanaracus, 2016; Harris, 2018).

Size and storage are other important scalability components that need to be worked on. Indeed, by design, the ledger of a blockchain contains all the transactions since the genesis block. Thus, as the number of users and transactions grow, the size of the ledger also grows.

Bandwidth is also important as transactions need to be relayed through the network prior to being validated through consensus algorithm. Indeed, when the number of users increases and consequently the number of transaction increases, a better network connectivity is necessary. Good network connectivity and large storage capacity require effective record management leading to centralization, increased costs (Harris, 2018), and more energy consumption.

The last component of scalability is throughput referring to the maximal rate at which the network can work properly (i.e. transmit, receive and validate transactions). Because of the design of the blockchain infrastructure, the number of transactions being transmitted, received and validated over the network is small in regard to other existing, centralized, infrastructures. With Bitcoin, for example, the maximal rate is of approximately 7 transactions per second. This issue mainly concerns public

blockchains and is already managed for private blockchains for which some infrastructures can already handle thousands of transactions per second.

There are other important types of risks. For example, credentials can be compromised or stolen, and there are concerns that it might be vulnerable to programming errors (such as in the Decentralized Autonomous Organization or DAO platform, which lost $50 million in 2016) or systems weaknesses (such as the vulnerabilies behind the scandal of the Bitcoin exchange, Mt. Gox, in 2014). This is also true for smart contracts. They are stand-alone programs that, once started, automatically execute pre-defined conditions encoded within the blockchain. They work just like any conditional statement of the "if - then" type (if such a condition is satisfied, then such a consequence runs). No form or human intervention is needed to process those transactions. A study recently revealed that 3% of all smart contracts are fatally flawed (Nikolic et al., 2018). Another analysis performed by a blockchain security company showed that among projects that have collectively raised $1 billion, more than one quarter of them had critical vulnerabilities (De Havilland, 2018).

In addition to these technical challenges, the biggest barrier to blockchain adoption today as reported by PwC and Deloitte in their reports (PwC, 2018; Deloitte, 2018) is the regulatory uncertainty. Indeed even though many territories have begun studying and discussing the issues (PwC, 2018), particularly as they relate to financial services, the regulatory environment remains unsettled. Overall, there are currently insufficient standards and controls in place to ensure that the systems are functioning as intended (Alarcon, 2018). For example, in the European Union it is unclear how any blockchain project can meet the General Data Protection Regulation (GDPR) privacy standards (PwC, 2018).

Blockchain impact on audit and control professions remains an under-researched area. In a context where blockchain developments flourish, our general hypothesis is that blockchain technologies have the potential to significantly disrupt and transform the audit and control work.

RESEARCH METHODOLOGY

This section describes the methods used in developing the research, collecting and analyzing data. The grounded theory approach was used for this research. Strauss and Corbin have defined grounded theory as “theory that was derived from data, systematically gathered and analyzed through the research process”, and Charmaz and Bryant as a method of qualitative inquiry in which researchers develop inductive theoretical analyses from their collected data. Grounded theory was the selected research approach as it stresses the importance of allowing theoretical ideas to emerge from data (Bryman, 2016) and provides a methodological framework to develop “emergent” theories that particularly fit exploratory studies such as this one where theoretical concepts have not yet been developed. Research based on grounded theory “involves using multiple stages of data collection and the refinement and interrelationship of categories of information” (Creswell, 2014). The initial phase of the study consisted in semi-structured interviews analyzed using a research software for qualitative data analysis, ATLAS.ti, allowing the formulation of the hypotheses presented in this paper. Those hypotheses are to be tested in the next research phase in order to generate a theory on the impact of blockchain on the audit and control profession.

A guide for semi-structured interview was developed and consisted in 17 questions classified in 5 categories: Global knowledge, Business Processes, Audit Work, Opportunities and Challenges, and Last Questions; to explore each interviewee’s observation on blockchain and its potential impact on the audit profession. This approach allowed each participant to discuss in depth their understanding and concerns on the technology, as well as the foreseen changes in their profession in relation to the deployment of blockchain technology. The interview guide is reported in Appendix A – Interview Guide.

On average interviews lasted 50 minutes. Interviews happened either in French or in English depending on interviewees’ proficiency. Based on the interviewees’ request answers were either recorded or transcribed through notes in preparation for analysis and coding within ATLAS.ti.

The sample selection was based on the theoretical sampling process where two researchers jointly collected, coded and analyzed the data in order to identify major categories. Theoretical saturation where

nothing new emerged was reached after 32 interviews of Financial and IS auditors from 23 audit firms with different level of responsibility ranging from manager to partner, all located in Switzerland, except one auditor who was covering the Swiss market from Paris at the time of the interview. There were two occasions where two auditors were interviewed at the same time, therefore a total of 34 auditors were interviewed from December 2016 to November 2017.

The anonymized list of interviewees including the interviewee job title, expertise, whether or not the interviewee works for one of the Big Four, the date of the interview, and the way the interview was conducted is presented in Appendix B – Interview Details. Table 1 below presents the categorization of the population:

TABLE 1
CATEGORIZATION OF THE AUDITORS INTERVIEWED

Specialists / categorization	% of interviewees
Partner	38%
Non-Partner (manager and above)	62%
IT (Audit, security)	25%
Financial Audit	65%
Advisory / Risk	9%
Standards Specialist	1%
Big Four	35%
Non Big Four	65%

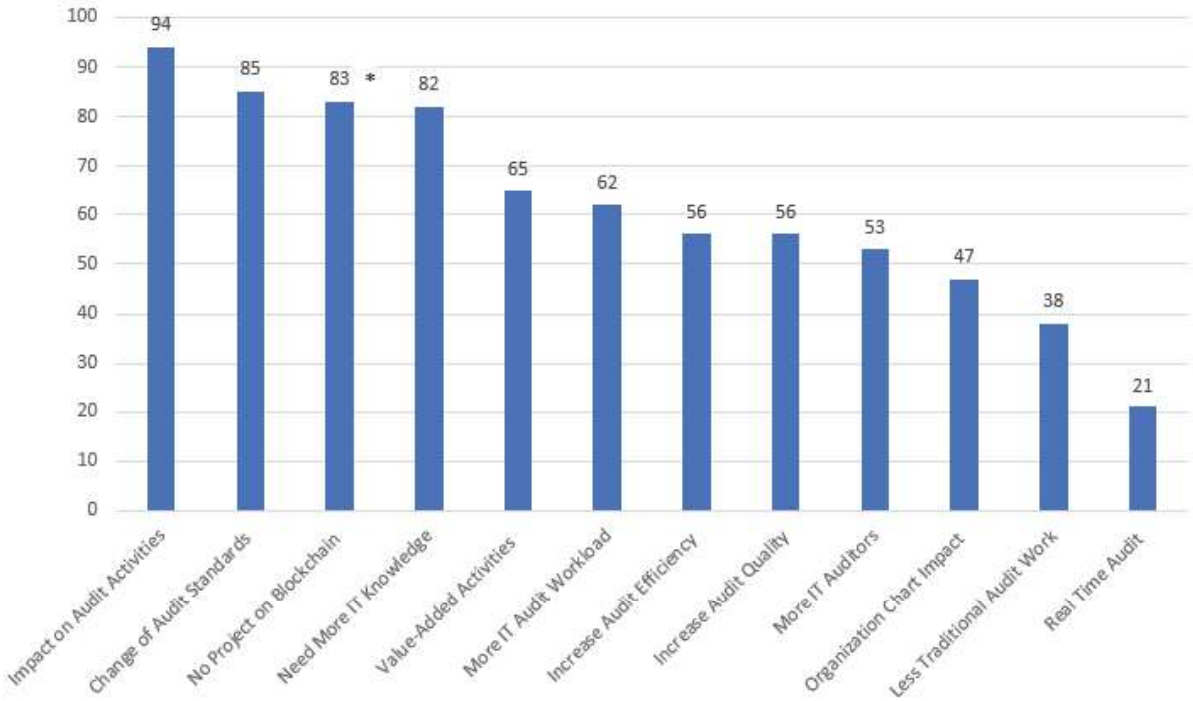
The analysis of the data was performed by two researchers. Each of them defined the codes as the interviews were performed. They then compared their codes and agreed on their definition. Thus, sixty-nine codes were created and categorized into twelve code groups. The codes and their definitions as well as the code groups are provided in Appendix C – Codes.

Subsequently, one of the researchers coded the interview transcripts using the qualitative data analysis and research software, ATLAS.ti. Once theoretical saturation was reached, the two researchers, as a result of initial coding, were able to carry out focus coding; they worked jointly to identify the most significant initial codes to classify the data into more elaborate categories, which resulted into twelve potential impacts. Then, one of the researchers identified the interviewees whose responses supported each one of the identified potential impacts. And for each potential impact, the percentage of auditors who agreed with it was calculated. The results of the analysis and the related percentage computation are presented in Appendix D – Categories.

RESULTS AND DISCUSSION

This section presents the results obtained from the research and data analysis, with a discussion of the major findings and a presentation of the categories that have emerged as shown in Figure 1 below. The percentages presented in the graph below are for our population of 34 auditors.

FIGURE 1
POTENTIAL IMPACTS OF BLOCKCHAIN ON AUDITING PROFESSION



*of audit firms included in the panel, excluding Big Four

Findings show that 94% of the interviewees regardless of their function (financial or IS) think that the audit activity will change in the mid-term. More specifically 62% anticipate the function to be more and more IT oriented. Indeed, they think that the scope of the audit will not be primarily to ensure that financial statements are free from material misstatement as it is the case today but rather to focus on IS audit which has been defined by Weber as "the process of collecting and evaluating evidences to determine whether a computer system safeguards assets, maintains data integrity, allows organizational goals to be achieved effectively and uses resources efficiently" (Weber, 1999). As controls can be embedded into the technology, some auditors think that audit and accountancy firms will have to ensure that the technology is properly deployed and set-up and that automated controls are proper. As such, some of the interviewees hypothesized that auditors will be primarily "IT engineer auditors" with specific IT skills such as programming and not financial auditors as it is the case today, some even mentioned "blockchain auditors" whose function will be to certify blockchain.

53% of the interviewees anticipate that auditing firms will hire more IS auditors in the very near future instead of financial auditors. More importantly, they expect that auditing firms will hire new profiles such as analytics specialists, data scientists and statisticians. This is reinforced by the fact that today, in most cases, when the IT environment is not complex, even though financial auditors are not IT experts and have no training in IS audit, they perform themselves IS audit work by following a predetermined audit program to complete this part of the engagement (Axelsen et al., 2017) as confirmed by the interviewees. However, blockchain technology is complex and not well understood by most financial auditors and even by many IS auditors as demonstrated by the answers obtained. None of them has had hands-on experience with it and none of them knows how to audit such a technology. Besides, they usually mention blockchain and other technologies such as data analytics, process automation, digitalization, robotization, Artificial Intelligence (AI) together, regardless of each technology characteristics and its potential impacts on the profession even though they are different. We noticed that

the two major auditing standards bodies, the International Auditing and Assurance Standards Board (IAASB), and the Public Company Accounting Oversight Board (PCAOB) do not dissociates technologies from one another and have both set up working groups to investigate "new technologies", which include among other data analytics and blockchain.

The interviewees also highlight the fact that there is currently no blockchain-specific auditing standard and report a lack of personal experience with this technology, suggesting the need for the audit firms to integrate new skills. However, as demonstrated by Bagranoff and Vendrzyk, the value of the IS auditor role in the audit is often poorly communicated and indirect (Axelsen et al., 2017), and in practice as reported by Janvrin, the level of engagement between financial and IS auditors is low whereas IT environments are increasingly more sophisticated and complex (Axelsen et al., 2017). As the scope of the audit is expected to shift, and as audit firms are expected to hire people with a wider range of skills, better interaction and better communication among financial and IS auditors, and other specialists will be necessary for the audits to be as efficient, effective and of higher quality as anticipated by the use of new technologies.

At the same time, 38% of the interviewees foresee that the traditional auditing workload will decrease. Indeed, some of the tedious and labor-intensive processes traditionally associated with an audit (Raphae, 2017), especially the ones that do not require experience and technical knowledge such as data collection, data cleansing and sorting, and tick and tie activities will be eliminated or automatized (Martindale, 2016; Smith, 2018). 56% hypothesize that the use of blockchain coupled with the use of other new technologies such as workflow automation, digitalization, data mining, robotization, and the use of artificial intelligence will increase audit efficiency and effectiveness, thus leaving more time for auditors to use their professional judgment, experience, knowledge of an industry and of competitors performance to get a better understanding of their clients and therefore provide deeper analysis on business issues, controls, and risks. This trend appears to be in line with the literature that foresees efficiency gains as a result of the use of new technologies in auditing (Raphae, 2017; Sheehan, 2017; Smith 2018). Thus 65% of the interviewees think that auditors will therefore be able to focus on value added activities and provide better insights to their audit clients based on their professional judgment. This is aligned with current literature explaining that the traditional role of data verification responsibilities will change and evolve over time, but the need for data interpretation and integration into strategy are positioned to grow and change moving forward (Smith, 2018).

Some auditors also predict that they will be able to perform real time audit, as also mentioned in the literature. Indeed, if operational and financial information is uploaded into the blockchain network on a continuous basis, and if auditors have continuous access to the blockchain used by their clients, then they will be able to analyze this information in a real time manner (Banham 2017). Real time review will also contribute to providing better insights to audit clients, thus not only increasing the value of the audit but also bringing audit quality to a new level as exceptions will be detected earlier and corrected by clients on a timely basis.

Findings have some other implications for the audit firms. Indeed 'the future is characterized by unparalleled organizational and informational complexity, with corporate and business reporting evolving rapidly' (Axelsen, et al., 2017). If the auditors and the audit firms are to keep up with these changes and the IT current development, accounting firms should think about what the audit of the future will look like and whether their audit teams have the required skills (MacManus, 2017). As of today, the Big Four have already invested in the use of new technologies such as data analytics software, and AI programs and started proof-of-concept projects on blockchain. All interviewees are anticipating a "people challenge" at two levels. First, auditors need to stay up to date on new auditing and accounting standards and latest developments, and more importantly increase their IS skills. Indeed 82% of the interviewees think that auditors, financial and IS, in place and in training need deeper IT skills. To address those requirements, the Big Four continuously invest to 're-train' and 're-skill' their employees and keep them informed on "hot topics". However, it seems that smaller auditing firms are not investing as much as larger auditing firm in training their employees on new technologies including blockchain and therefore are not as prepared for the changes to come as our study shows. Indeed 83% of the audit firms surveyed that are not

among the Big Four have not started investigating the subject matter. They are in a "wait and see" mode and hope that they will be able to catch up with any new developments when time comes, but this might be too late. The second challenge comes from the fact that the tedious and manual audit processes and tests that are currently performed by junior auditors will be automated, therefore, auditing firms will not need as many juniors as they need today. Instead they will need more specialists and more experienced professionals who will be able to use their professional judgment to solve complex problem, analyze data, identify control improvements and provide value-added insights to their clients. This will affect the audit pyramidal organization and the way auditing firms manage their workforce careers, which is partially based on a high turnover rate especially at the junior and senior auditor positions.

Lastly as reported by 85% of the interviewees, the auditing standards will have to be updated to include more IT related guidance. Indeed, as of today there is no auditing standard describing how to perform an audit on blockchain. The extent and the pace to which international rules will be modified in relation to the growth of blockchain use and other new technologies such as data analytics and AI remain unknown at this stage. We can say that the IAASB initiated an awareness process that can be illustrated both with the presentation of blockchain done by Chuck Landes, Chair of the IAASB Innovation Working Group, and the feedback statement by the Data Analytics Working Group (DAWG) on "Exploring the growing use of the technology in the audit, with a focus on data analytics". The feedback statement reports that the respondents to their request for input from the audit professionals emphasized the need for the IAASB to 'reflect the digital era in application guidance' and recommended that the DAWG members 'consider other technologies whose impact on auditing deserves further consideration such as blockchain technology'(IASB, 2018). Also, the PCAOB announced in December 2017 the plan to form a new task force on data and technology to explore whether there is a need for guidance, changes to PCAOB standards, or other regulatory actions in light of the increased use of data analytics and of other new and emerging technology-based tools (PCAOB, 2018).

To the best of our knowledge, the Swiss transmitter of the National Auditing Standards, EXPERTsuisse, has not yet set up such a working group to assess the impact of blockchain on the audit profession. In the meantime, Swiss financial auditors already face the challenge to audit companies active on blockchain or companies that have implemented blockchain platforms to run some of their business processes. This situation requires them to use their professional judgement when auditing standards are silent or not adequate. The evolution of norms or the development of new standards may follow and draw on the evolution of this professional practice.

Over all, the findings suggest that the profession is at a turning point and three major hypotheses have emerged:

H.1: *The potential disruptive effect of the technology on the profession is not fully anticipated and smaller auditing firms are not tooling up to face the changes to come.*

The impact of blockchain on the audit profession would be different if audit clients adopt it as part of their business process, or if it is used by auditing firms as an audit tool.

Even though both venues are possible, none of the auditors interviewed, even the auditors working for the Big Four mentioned blockchain as a possible audit tool on its own. All of them only considered the potential impacts blockchain would have on their profession if their clients use it, how this would have an effect on the relationship with their clients, how they would access clients' data, and how they would audit the new system in place. Furthermore, on the one hand, the Big Four have launched projects, training programs, and communicate actively on blockchain technology, which allows their auditors to better understand the technology, provide support to and advise their clients. Those companies, at the strategic level, are developing the knowledge and the resources to not only anticipate but also influence the deployment and usage of blockchain by their clients, and the audit of the technology by audit professionals. On the other hand, smaller auditing firms have not started to invest and to investigate the technology, as they do not have the financial and human capacity. They also believe that their client type (smaller firms) will not embrace the technology at the same pace as larger firms and therefore they can

wait to develop their capacities and capabilities. However, as blockchain offer many interesting characteristics and as the technology is based on "shared and distributed" features, we can anticipate that once it will start to root into the business ecosystem, its adoption will most probably be rapid and general. Indeed, PwC recently reported that in the 15 countries where they surveyed leaders, 84% of them explain that their company is already engaged into a project related to blockchain (PwC 2018). Another survey from Deloitte led in 7 countries reported that 41% of the 1053 senior executives working in companies with annual revenues over $500 million think that their company will adopt the technology within the next 12 months (Deloitte, 2018). We can thus infer that most smaller audit firms as they do not have sufficient current knowledge and understanding of the technology are not anticipating the impact of the technology on their profession and sooner than later might not be able to answer their clients' emerging needs on the technology.

***H.2**: The profession will change its paradigm to become more IT oriented and more forward-looking.*

First, blockchain allows controls to be embedded into the technology, therefore some processes and transactions will be automated. Moreover, records of all transactions will be instantly available to the auditors and will be automatically validated by the technology itself. We can then induce that the main focus of the auditors will not be to guarantee the existence of transactions, attest of their evidence, accuracy, and completeness as those checks are going to be performed by the technology itself but to attest that blockchain is working as intended. IS auditors will have to not only understand the technology but also the underlying code, they will have to assess the related risks and the emerging issues that could impact their clients. Indeed, as demonstrated by Kinney, businesses place a great reliance upon IS as part of their business strategy and operations (Axelsen, et al., 2017), which will be reinforced by the use of blockchain. The change in the profession paradigm will also be accelerated by the fact that not only the audit clients but also the audit firms use more and more different kinds of technologies to perform their audit work. For example, KPMG has partnered with IBM Watson to begin automating and streamlining audit and tax processes (Smith, 2018), other type of artificial intelligence systems can also be used to reconcile data, while drones can help with inventory counts.

Second, audit has always been a "back-looking" activity whose purpose is to obtain reasonable assurance that the financial statements of an audited entity are free from material misstatement (ISA 200, 2011) to provide an audit opinion for an ended period (ISA 705, 2011). Thanks to the use of blockchain and data-driven analysis, auditors will be able to provide new insights to their clients. We can then construe that the profession will move from checking past data to providing new types of analysis and therefore become "forward-looking". Even though none of the 34 auditors interviewed already provides forward-looking information to their audit clients, we expect this move to happen sooner than later. Indeed, audit clients will probably urge their auditors to provide them with advisory as it would bring them additional value. However, auditors are currently restricted in the type of services they can provide to their audit clients for independence reasons, which might represent an ethical challenge that the profession will have to tackle.

***H.3**: Profile of Auditors will change.*

The hypothesis 2 suggests that the audit paradigm will change as it will be more IT and advisory driven. Even though today's financial auditors and IS auditors are well educated - indeed many financial auditors are also CPAs, IS auditors CISA and both financial and IS auditors have graduated with a bachelor or a master degree - we can induce that to address the changes brought by the paradigm shift, profile of auditors will have to change in several ways.

As demonstrated by Curtis, Dowling and Leech, technologies at the auditees are increasingly more sophisticated (Axelsen, et al., 2017), and blockchain with its main technical features, such as asymmetric cryptography and distributed systems, is a good example of a sophisticated technology. If the role of auditors is less and less to audit the financial data but to audit the blockchain and certify that it is properly

implemented, then auditors will have to be able to thoroughly understand those features. They will have to widen their technical skillset to master coding, hashing, cryptography and also work on their soft skills. Indeed, if auditees use smart contracts that execute automatically predefined conditions within the blockchain (if such condition is satisfied then such consequence runs), auditors will have to first understand the underlying code and second will have to be able to communicate clearly with lawyers to ensure that those contracts are legally valid. Moreover, the literature review shows that the audit profession will also be impacted by the use of other technologies such as data analytics (Tysiac, 2017; Anderson, 2017; MacManus, 2017; Raphae, 2017; and Sheehan, 2017; IASB, 2018) which is confirmed by the interviewees. Indeed, all the auditors interviewed who work for a Big Four mentioned that they already use data analytics as an audit tool, which is, however, not yet the case in smaller CPA firms, as only a few interviewees working for this type of firm already use it. Therefore, audit firms will have to hire data scientists or train their auditors in order to drill down large volumes of data. Those data scientists will team up with experienced auditors or field specialists (tax, finance, valuation) to interpret data and provide the insights and advice auditees will expect to receive from their auditors. As such audit firms will need more experienced professionals instead of juniors and, instead of hiring juniors who gain experience over the years and climb the hierarchy, will directly hire experienced people. Today auditors leave audit firms to work in the industry, in the future the other way around might prove to be true. Professionals might leave the industry and work for audit firms directly as managers or directors, which will deeply impact audit firms' organizational chart.

CONCLUSION

Indeed, blockchain is sometimes compared to automation and data analytics that will require transforming how audits are performed (Raphae, 2017). Blockchain technology has the potential not only to make the accounting and auditing rules change, but also to impact the nature of the accounting and auditing profession. Some top executives highlight the fact that blockchain is a better ledger because it allows adding entries to a ledger and to have multiple ledgers crosschecking against each other (Martindale, 2016). In addition, it provides a third validation point that did not exist before, where auditors have previously stepped in and may not have to do so anymore in a near future (Martindale, 2016). Finally, a major opportunity resides in the fact that blockchain could facilitate the audit and control work by encoding rules directly in specific processes. However, a major challenge exists in terms of potential redefinition of audit and control activities based on the properties of blockchain technology (transparency, traceability, security, persistency and immutability of transactions).

The question of the nature and scope of audit work in the case of blockchain use has been raised and not fully answered yet. Some emphasize the growing need of digital technology profiles (Raphae, 2017) while others emphasize the move towards less numerous but more value-added activities (MacManus, 2017) which is confirmed by our study.

More importantly, blockchain is an emerging technology that has the potential to cause the greatest level of disruption for the audit profession. While this potential disruption may be years away, some commentators have suggested that the potential impact on the auditing profession could be as significant as the impact of the internet on industries such as travel or retail (Sheehan, 2017). And yet, our research results highlight the fact that auditors in practice do not completely foresee the radical changes that blockchain technology could bring, potentially far more important compared to evolution of companies towards automation and increased use of data analytics.

In that sense, the audit profession could in fact be facing a paradigm change. Legal obligations to perform audits of financial statements may become useless once blockchain technologies will be mature enough and have proved their scalability. Automated and certified audits will be on blockchain and financial statements information accessible to stakeholders in real time. While auditors are foreseen to become blockchain technology experts and certifiers, it is unclear whether they will encode the rules in blockchain themselves or work together with accounting, internal control, risk management and compliances experts. Will the work be limited to assessing whether or not blockchain is working correctly

(MacManus, 2017), or go beyond that? Is the audit profession about to change its paradigm to move from being back-looking to forward-looking? Will it change its perspective and be more future-oriented? How will investors perceive this move toward less independence, especially as trust in the profession has not fully recovered yet?

We believe that because blockchain technology and the development of auditing and control standards are not envisioned in an integrated way, the potential impact of blockchain on audit and control professions has not yet been systematically and thoroughly assessed.

We think that the results of this study can be of interest to the profession and to the organizations that are in charge of training auditors. Indeed, the use of blockchain and other "new technologies" will require very different skillsets. Such skills will be more IT oriented and at the same time will require a strong business and accounting technicity; a mix of skills that is rare among the profession as well as in the current academic and professional training.

This study also contributes to both blockchain and auditing scientific literature because it describes and explores the financial and IS auditors' perceptions regarding the impact of blockchain technology on their profession. It also provides accounting and auditing firms as well as auditing continuing education institutions with insights on the required future skillset of auditors and the evolution of their scope of work.

Finally, we stress the limited nature of our study, whose purpose was to serve as an initial exploration of the impacts of blockchain on the auditing profession. We should insist on the fact that these research hypotheses need to be validated in subsequent research. Indeed, we started in March 2018 a three-year Swiss National Science Foundation research project on this specific topic covering both the management and the technical dimensions of the research question.

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APPENDICES

APPENDIX A
Interview Guide

Name		Date	
Title		Time	
Name of the company		Interviewer	
FTE		Audit type	
Turnover:		Industry	
Total balance sheet		Department	

GLOBAL KNOWLEDGE

1. What do you know about blockchain technology?
   Que savez-vous de la technologie blockchain ?
2. Are you personally involved (or will be) in a blockchain project within your company or with external stakeholders (customers, suppliers, government…)?
   Êtes-vous personnellement impliqué-e (ou serez-vous personnellement impliqué-e) dans un projet blockchain au sein de votre entreprise ou avec des parties prenantes externes (clients, fournisseurs, autorités…) ?
3. Are you aware if your company is involved in projects (or will be) related to blockchain?
   Savez-vous si votre entreprise est impliquée (ou sera impliquée) dans des projets en lien avec la blockchain ?

BUSINESS PROCESSES

4. How and where (in which activity) would you use blockchain?
   Comment et où (dans quel domaine) utiliseriez-vous la technologie blockchain ?
5. What would be the impacts of implementing blockchain technology?
   Quels seraient les impacts pour mettre en œuvre (en place) la technologie blockchain ?
6. How do you think blockchain will impact reporting?
   De quelles façons pensez-vous que la blockchain aura un impact sur le reporting d'une entreprise ?

AUDIT WORK

7. How will blockchain change the audit work?
   Comment la blockchain changera-t-elle le métier d'audit ?
8. How do you think the auditor's profile will change?
   À votre avis, comment le profil de l'auditeur va-t-il changer ?
9. How will the audit profession be impacted?
   Comment la profession (le métier) d'auditeur/trice sera-t-elle/il touché/e ?
10. Auditors are considered as trusted third parties, which is precisely what blockchain allows to instrument in a distributed and trusted way. This phenomenon is also known as disintermediation. What will happen if blockchain technology can guarantee that all these objectives are met?
    Les auditeurs/trice sont considéré-es comme des tiers de confiance, ce qui est précisément ce que la blockchain permet d'instrumenter de manière distribuée et fiable. Ce phénomène est également connu sous le nom de désintermédiation. Que se passera-t-il si la technologie blockchain peut garantir que tous ces objectifs soient atteints ?

11. How will auditing standards be adapted?
    Comment les normes d'audit seront-elles adaptées ?

OPPORTUNITIES AND CHALLENGES

12. What is your opinion regarding blockchain technology?
    Quelle est votre opinion concernant la technologie blockchain ?
13. What opportunities do you foresee around blockchain technology?
    Quelles sont les opportunités que vous imaginez autour de la technologie blockchain ?
14. What challenges do you foresee around blockchain technology?
    À votre avis, quels sont les défis que posera la technologie blockchain ?

LAST QUESTIONS

15. Can you give the contact details for a person currently working on this technology, processes or auditor?
    Pouvez-vous nous donner les coordonnées d'une personne qui travaille actuellement sur cette technologie, sur les processus ou un auditeur ayant un projet en cours ?
16. Do you know about a "prototype" working on blockchain?
    Connaissez-vous un « prototype » fonctionnant sur la base de la blockchain ?
17. Is there anything else you want to add?
    Souhaitez-vous ajouter quelque chose ?

APPENDIX B
INTERVIEW DETAILS

#	Gender	Language	Job Title	Expertise	Country*	Location	Interview Date	Big 4	Face to Face	Recorded	Notes/ Transcript**
1	M	English	Administrator	FS/ Industry	CH	Geneva	06.12.2016	N	Y	Y	N + R
2	M	French	Manager	IT	CH	Geneva	09.12.2016	Y	Y	Y	N + R
3	M	French	Partner	IT	CH	Zurich	16.12.2016	Y	Y	Y	N + R
4	M	French	Senior Manager	IT	CH	Geneva	19.12.2016	Y	Y	Y	N + R
5	M	French	Director	IT	CH	Geneva	19.12.2016	Y	Y	Y	N + R
6	M	French	Manager	FS	CH	Geneva	16.01.2017	Y	Y	Y	N + R
7	M	English	Assistant Manager	IT	CH	Zurich	17.03.2017	Y	Y	Y	N + R
8	M	French	Head of Audit Assurance	FS	CH	Geneva	28.03.2017	N	Y	Y	N + R
9	F	French	Partner	FS	CH	Nyon	31.03.2017	N	Y	Y	N + R
10	M	French	Partner	Industry	CH	Nyon	31.03.2017	N	Y	Y	N + R
11	M	French	Manager	FS/ Risk	CH	Geneva	03.04.2017	Y	Y	Y	N + R
12	F	French	Assistant Director	FS	CH	Geneva	04.04.2017	N	Y	Y	N + R
13	M	French	CPA	Industry	CH	Geneva	05.04.2017	N	Y	Y	N + R
14	M	French	Director	Industry	CH	Geneva	27.04.2017	N	Y	Y	N + R
15	M	French	Assistant Director	Industry	CH	Monthey	01.05.2017	N	Y	Y	N + R
16	F	English	Head Business Development	FS/ previously IT	CH	Zurich	04.05.2017	N	N	N	N

#	Gender	Language	Job Title	Expertise	Country*	Location	Interview Date	Big 4	Face to Face	Recorded	Notes/ Transcript**
17	M	English	Manager	IT	CH	Zurich	04.05.2017	N	N	N	N
18	M	English	Director	FS	CH	Zurich	12.05.2017	Y	N	N	N
19	M	French	Global co-Head	FS	FR	Paris	16.05.2017	N	N	N	N
20	M	French	Partner	IT	CH	Geneva	18.05.2017	N	Y	Y	N + R
21	M	French	Partner	FS	CH	Zurich	01.06.2017	Y	N	N	N
22	M	English	Partner	IT	CH	Zurich	01.06.2017	Y	N	Y	N + R
23	M	French	Partner	IT	CH	Geneva	08.06.2017	Y	Y	Y	N + R
24	M	English	Partner	FS	CH	Lucerne	12.06.2017	N	N	N	N
25	M	English	Director	FS	CH	Zurich	15.06.2017	N	N	N	N
26	M	French	Director	FS	CH	Lausanne	03.07.2017	N	Y	Y	N + R
27	M	French	Partner	FS	CH	Neuchatel	14.08.2017	N	N	N	N
28	M	English	Partner	FS	CH	Zug	04.09.2017	N	N	N	N
29	M	French	Manager	FS	CH	Geneva	05.09.2017	N	Y	Y	N + R
30	M	French	Manager	FS	CH	Geneva	06.09.2017	N	Y	N	N
31	M	French	Member of the Board	FS	CH	Geneva	28.09.2017	N	Y	N	N
32	M	English	Manager	FS	CH	Zurich	19.09.2017	N	N	N	N
33	M	French	Partner	FS	CH	Düdingen	19.10.2017	N	N	N	N + T
34	M	English	Partner	Standards	CH	Zurich	01.11.2017	Y	Y	Y	N + R

* CH: Switzerland, FR: France

** N: notes, N+R: notes + recording, N+T: notes + direct transcription

APPENDIX C
CODES

Code Groups	Code	Definition
Customer Relationship	Access and Protection of Clients' Data	Use of blockchain will impact how and from where auditors will access clients' data. Blockchain will impact clients' data protection.
	New Services	CPA firms will have to propose new services to their clients.
	Customers' needs	Clients not only need financial data certification but also the auditor's expertise and experience.
Legal and Regulatory Requirements	Appropriateness of Current Framework	The current legal framework is sufficient for Auditors to know what to do with the use of the Blockchain.
	Disconnection Standards / Practice	There is a gap between the current legal framework and the audit practice (e.g. it is possible to analyze all the financial data and all the journal entries of a company, but the standards only require the use of samples).
	Increase IT Standards	The current legal framework needs to be updated to focus more on IT and technology usage.
	Legal Requirement	Audit will not disappear because of the use of blockchain as it is a legal requirement.
	Specific / National	Auditing Standards should be specific and national.
	Standardization / International	National Standards are influenced / inspired by International Standards and therefore are standardized.
CPA Firm Experience	Audit Proposal	The CPA firm has worked on an audit proposal for a firm using blockchain.
	Client Using Blockchain	The CPA firm already has client(s) using blockchain.
	Internal Development	The CPA firm has projects related to blockchain
	Internal Training	The auditor has learnt about blockchain through internal training.

Code Groups	Code	Definition
	No Client Using Blockchain	The CPA firm does not have clients using blockchain or planning on using blockchain.
	No Communication	The auditor's knowledge on the blockchain technology does not come from its employer but from his personal reading and interests.
	No Internal Development	The CPA firm does not have any project related to blockchain.
	Presentation	The auditor's knowledge on blockchain is through presentation from other CPA firms.
	Proof-of-Concept (POC)	The CPA firm is working on a POC (consulting services) for some clients.
	Wait and See	CPA firms will wait for other firms (Big Four) to develop blockchain audit procedures.
Future of Profession	Audit Workload	The use of blockchain will impact the audit workload in general (either increase or decrease it).
	Consulting	The audit profession will shift its work type from audit to consulting type of services.
	Financial Auditors	Impact on the need of financial auditors.
	IT Auditors	Impact on the need of IT auditors.
	IT Workload	The use of blockchain will increase the part of the work related to IT (when compared to financial / accounting data analysis).
	Juniors	Less juniors will be needed.
	Status Quo	The audit profession will not be impacted by blockchain.
	Timeframe	Time horizon of change.
	Experienced	Need for experienced professionals.
	Fees	The use of blockchain will impact the audit fees.

Code Groups	Code	Definition
Education & Training	Bachelor / Master	University or University of Applied Sciences offer proper education for tomorrow profession's needs.
	CPA Exam Preparation	The training offered by EXPERTsuisse properly meets the future skills needed by the profession.
Auditor Understanding	Bitcoin	Blockchain and Bitcoin are the same.
	Dark Internet	The development of blockchain is linked to the dark internet. Perception that blockchain is « bad ».
	Governance	Auditors' understanding of blockchain governance.
	Industry	Kind of industry in which blockchain could be used.
	Risks	Risks related to the use of blockchain (New risks? Governance? Fraud...).
	Technology	Auditor's understanding of blockchain from a technological stand point (how does it work ?).
	Blockchain used by CPA	Blockchain is deployed by the CPA firm to be used as an audit tool.
	Technologies used by clients	Blockchain used by clients and audited by auditors. It can also be used by auditors to access client's data.
	Mix all technologies	Auditors consider all new technologies (blockchain, big data, IA, etc.) as a bulk. Do not dissociate each technology with its own specificities and potential usage / impact by / on the audit profession.
	Dissociate technologies	Auditor does not mix all technologies together and is aware that each technology has its own specificities (IA, BC, BD) and could impact or be used differently his / her profession.
	Usage and Capabilities	What is possible to do with blockchain technology.
Adoption of Blockchain	Cost Benefit Analysis	Before deploying a blockchain, companies will ensure that the cost benefit analysis is positive.
	Evangelization	Blockchain adoption: averse to change: evangelization of Blockchain is necessary.
	By Audit Client	Blockchain is adopted by the audit client (auditee). Auditors will access it to perform their audit (get data) and will have to audit the system itself.

Code Groups	Code	Definition
	By Audit Firm	Blockchain is adopted by the audit firm and will be used as an audit tool.
	Wide Adoption	Large adoption is necessary.
Future Skills	Data Interpretation	Future auditors will need to be able to make meaning of data (cartography of data, data analysis, big data....).
	Field Expertise	How the use of blockchain will impact the auditors' required skills.
	IT	The future skills needed by the auditors are IT based.
	Statistics and Math	Auditors will need more statistics and mathematical skills.
Reporting	Data Quality	The use of blockchain will impact the quality of financial data before the audit takes place.
	No Impact	The use of blockchain will not impact the reporting process.
	Quicker	The reporting process will be quicker.
	Real Time	Access to financial reports will be real time. Data in the financial reports will be real time data.
	Reporting Automation	The reporting process will be automatized
Audit Practice	Expand Limits	The use of blockchain will allow auditors to analyze more data and therefore to better understand and analyze their client's business.
	No Change	The use of blockchain will not impact the audit practice.
	Optimization	The use of blockchain by CPA firms will impact the audit practice: reduce length of audit work, performance gain, efficiency gain, reduce audit costs.
	Simplification	Audit will be easier to perform / simplified.
	Scope	Shift of audit scope from accounting to IT (audit of blockchain and its embedded rules e.g. integrated internal controls).
	Tests Automation	More and more audit tests will be automated.
	Traditional Tests	Impact on traditional audit tests: substantive, sample, audit figures, transactions, etc.

Code Groups	Code	Definition
	Use of Technology	Auditors will use more and more new technology to perform audit (Blockchain, drone, etc...).
Accounting Department	Number of Employees	The use of blockchain will impact how many persons work in an accounting department in the industry.
	Task Automation	More and more accounting tasks (especially low skills ones) will be automated.
Audit Quality	Professional Judgment	The use of blockchain will not replace audit as it cannot replace the professional judgment of the auditors.
	Quality	The use of blockchain will impact the quality of the audit service (more assurance, more transparency).
	Value Added	Auditors will focus on value added tasks / services.

APPENDIX D
CATEGORIES

#	Big 4	BC project*	Impact on audit activity	Change of audit standards	More IT audit workload	More IT auditors	Need more IT knowledge	Less traditional audit workload **	Real time audit	Increase audit quality	Value added activities	Organi-zation chart impact	Increase audit efficiency
1	N	N	x	x			x	+			x	x	x
2	Y	Y	x	x	x	x	x	-		x	x	x	x
3	Y	Y	x	x	x		x	-		x	x		x
4	Y	Y	x	x	x	x	x	-	x	x	x	x	x
5	Y	Y	x	x	x	x	x	-	x	x	x	x	x
6	Y	Y	x	x	x	x			x	x	x	x	
7	Y	Y	x	x	x	x	x	-	x	x	x		x
8	N	N	x	x			x	+					
9	N	N	x					-		x	x		x
10	N	N	x					-		x	x		x
11	Y	Y	x	x					x				x
12	N	Y	x	x	x	x	x				x		x
13	N	N	x	x	x		x			x	x	x	x
14	N	N	x	x		x	x		x		x		
15	N	N	x	x	x		x			x	x	x	x
16	N	Y	x	x	x		x	-					
17	N	Y		x				-				x	
18	Y	Y	x	x			x		x				
19	N	Y	x	x	x	x	x			x	x	x	
20	N	N	x	x	x	x	x			x	x	x	
21	Y	Y	x	x	x	x	x					x	x
22	Y	Y	x	x	x	x	x	-		x	x		x

#	Big 4	BC project*	Impact on audit activity	Change of audit standards	More IT audit workload	More IT auditors	Need more IT knowledge	Less traditional audit workload **	Real time audit	Increase audit quality	Value added activities	Organi-zation chart impact	Increase audit efficiency
23	Y	Y	x	x	x	x	x	-		x	x	x	x
24	N	N	x	x	x	x	x			x	x	x	
25	N	Y	x	x		x				x	x	x	
26	N	N	x	x	x		x	-		x	x	x	x
27	N	N		x			x						
28	N	N	x	x	x		x			x	x		x
29	N	N	x	x		x	x	-					x
30	N	N	x		x		x			x	x		
31	N	N	x			x	x						x
32	N	Y	x		x	x	x						
33	N	N	x	x	x		x						
34	Y	Y	x	x		x	x					x	
			32	29	21	18	28	13	7	19	22	16	19
			94%	85%	62%	53%	82%	38%	21%	56%	65%	47%	56%

* BC project: Blockchain project
**Auditors anticipated either that traditional audit workload would increase (+) or decrease (-). When they did not mention this category, we left the cell empty.

22 interviewees work in a CPA firm that is not a Big Four, which represent 18 different CPA firms (meaning that 2 interviewees at least work for the same firm). Among those 18 CPA firms, 15 have not started any project on blockchain, which represents 83% of the CPA firms that are not Big Four.