Artificial Intelligence and Blockchain in Audit and Accounting: Literature Review

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Abstract: - The aim of this paper is to introduce use of artificial intelligence in audit and accounting, with an emphasis on currently trending blockchain technology. Due to its innovative character, this field is constantly changing, with the biggest companies investing enormous amounts of capital to achieve wide use of artificial intelligence in audit and accounting. The main goal of the paper is to provide an analysis of audit tasks benefiting from artificial intelligence implementation, including risk assessment. Another goal is to analyse blockchain technology and its implications in audit. A great part of the paper focuses on smart contracts and smart audit procedures, working on the basis of blockchain technology. The most practical purpose of the paper is to evaluate the current applications and audit tools developed by Big4 companies, the four leading consulting companies in audit and accounting. The main results of the paper include overview of essential audit tasks proving the significance of artificial intelligence in audit, as well as main implications of using blockchain in audit, especially increased efficiency and integrity and reduced probability of errors, but also creating a new generation of auditing, based on continuous assurance. Finally, the practical result of this paper is a summary of the Big4 latest developed artificial intelligence tools and innovations.

Key-Words: - Artificial Intelligence, Accounting, Audit, Expert Systems, Audit Tasks, Audit Risk, Big4 Companies, Blockchain, Smart Contracts

1 Introduction – Artificial Intelligence

Artificial intelligence currently represents one of the fastest growing fields. According to the 2019 CIO Survey conducted by Gartner, Inc., one of the leading research and advisory companies, the percentage of enterprises implementing artificial intelligence grew 270 percent in the past four years. What is more, it tripled in the past year, rising from 25 percent in 2018 to 37 percent in 2019 [1]. To be more exact, global spending on artificial intelligence in 2019 will be $37.5 billion and is expected to reach $97.9 billion in 2023 [2].

The origins of the field of artificial intelligence date back to 1956 and are related to Dartmouth Conference on Artificial Intelligence, precisely to the proposal for this conference, where the term "artificial intelligence" was used for the first time. John McCarthy, Marvin Minsky, Claude Shannon and Nathaniel Rochester initiated a study on artificial intelligence which was based on the assumption that *"every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it"* [3]. The Dartmouth Conference focused on different aspects of artificial intelligence, such as automation, computers using a language and their ability to self-improve [3].

Even though artificial intelligence is currently defined in various ways by various sources, the above-mentioned assumption might have provided one of the first ones, therefore leaving a crucial mark in the history of this field. Haenlein and Kaplan [4] state an ESCP Europe Business School definition of artificial intelligence: *"a system's liability to interpret external data correctly, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation"*.

Some authors link the beginnings of the field of artificial intelligence even deeper into history, to Alan Turing and his 1950 paper on computing machinery and intelligence, concentrating on whether machines can think. Over the years, most of Turing's visions were fulfilled, mostly due to computers expansion, including distinguishing patterns of user behavior [5].

Another important step in artificial intelligence development was linked to deep learning, a machine learning method currently widely used in most algorithms working on the basis of artificial neural networks [4]. This and other methods made it possible to incorporate artificial intelligence not only into companies as a part of decision-making process but also into countless everyday activities of individuals.

Bhatia and Singh [6] recently analyzed the current situation in the field and mention the use of artificial intelligence in various cases, including driverless cars development by the biggest automotive industry producers, robots replacing human workers in food industry, particularly fast food business, robots and drones in logistics and warehouses or even therapeutic sessions.

The paper is divided into six sections. The first section introduces artificial intelligence origins as well as its definitions, further development of its methods and the current innovations in the field.

The second section follows, focusing on artificial intelligence in audit and accounting, explaining why these disciplines are so suitable for artificial intelligence implementation. The section further provides brief overview of history of artificial intelligence in audit and accounting. Then, seven essential audit tasks that benefit from artificial intelligence are outlined and analyzed, namely internal control evaluation, risk assessment, analytical review procedures, classification, materiality assessments, decisions regarding going concern principle and bankruptcy prediction. Furthermore, the section includes summary of technologies usually used while implementing artificial intelligence: genetic algorithms and programming, fuzzy systems, neural networks and hybrid systems, the combination of the aforementioned technologies, with the synthesis of expert systems and neural networks proven to be the most successful.

Third section is dedicated to current trends and opportunities of artificial intelligence in audit, first focusing on robotic process automation (RPA), including literature review of RPA projects in audit, and then analyzing the current Big4 companies' trends and cognitive audit applications. The research suggests Deloitte is the most advanced in artificial intelligence development efforts, with tools called Argus and Guided Risk Assessment Personal Assistant (GRAPA). EY has been very active in the blockchain industry, developing a tool named EY Blockchain Analyzer. Extremely important tool of EY, EY Helix General Ledger Anomaly Detector (EY Helix GLAD) is then focused on fraudulent journal entries detection. Tools of PwC, GL.ai and Cash.ai, were also analyzed. Lastly, KPMG with their portfolio of artificial intelligence solutions, KMPG Ignite, is introduced, as well as their pursuit to integrate artificial intelligence into Microsoft products.

Fourth section is dedicated to blockchain, currently trending artificial intelligence technology in audit. The history of blockchain technology development is outlined, as well as its advantages and challenges. Smart audit procedures and smart contracts are further analysed and evaluated.

Fifth section provides possible threats of artificial intelligence implementation in the whole economy, such as regulatory environment problems, limitations regarding personal and financial data collection, transmission and storage, the whole issue of algorithms in audit or jeopardizing financial safety.

Finally, the conclusion follows, proving the importance of artificial intelligence in audit and accounting. However, the possible risks of financial and reputational damages are explained, with decision process of investors based on biased algorithms contradicting the main principle and aim of accounting and audit, ensuring financial statements provide true and fair view of the reality.

2 Artificial Intelligence in Audit and Accounting

Some of the accounting activities and tasks are of a repetitive and mechanic nature. However, information resulting from these are later incredibly important as an accounting output in terms of the bigger picture when evaluating the company's financial position and performance. The audit and assurance profession also highly rely on the accounting information.

All these characteristics make the field of accounting extremely suitable for artificial intelligence application. Artificial intelligence helps eliminate the human error during primary entries booking and, as a result, reliability of accounting information increases.

Audit tasks require, among other activities, decision making and sample selection and evaluation. Applying artificial intelligence during the audit procedure may therefore increase efficiency and, again, eliminate the human error. Generally, artificial intelligence may be beneficial in phases of audit that require performance of rules-based tasks, especially the time-consuming ones.

As for the history of artificial intelligence in accounting and auditing, the first attempts date back to 1980s. Abdolmohammadi [7] identified the areas of application of various computer-based support systems in auditing, particularly decision support systems and knowledge-based expert systems, both increasing the effectiveness of audit decision making.

The expert systems also formed the basis of a paper of Borthick and West from 1987 [8]. In terms of auditing, the authors believed expert systems improve the effectiveness and efficiency of auditing as auditors could use them to *"plan audits, collect and evaluate evidence and form opinions"*. Artificial intelligence in its first stages of application could suggest a level of materiality, evaluate the level of internal control quality or assess the adequacy of reserves or provisions amounts.

The main motivation for developing and using the first expert systems in 1980s was connected to increasing competition and specialization in the field of auditing, lower audit fees and efforts of the companies to increase the efficiency without compromising effectiveness [9]. However, Baldwin-Morgan's study [9] concluded that rather than efficiency impacts, expert systems are more likely to cause effectiveness, expertise and education impacts.

The significance of expert systems might be proved by further research. Brown and Murphy [10] analyzed expert systems from the point of view of the "big six" accounting companies using expert systems in their auditing practices. They recognized three areas of audit related expert systems in which artificial intelligence was used: audit work program development, internal control evaluation and risk analysis, and technical assistance. All these tasks require qualitative analysis and some expertise, and, to some extent, also might be repetitive.

Brown and Murphy's paper [10] also conducted a survey among the big accounting companies and detected multiple benefits from using audit expert systems, such as increased auditor efficiency, improved decision consensus, the ability to deal effectively with large amounts of information and the ability to communicate relationships as well as facts.

2.1 Artificial Intelligence in Audit Tasks

Baldwin, Brown and Trinkle [11] outline further audit tasks, besides the already mentioned internal control evaluation and risk assessment, that might benefit from artificial intelligence:

• **Analytical review procedures,** undertaken for the purpose of obtaining audit evidence.

• **Classification,** or deciding what a specific accounting unit or item represents, solved by generic algorithms.

• **Materiality assessments,** a different type of classification.

• **Decisions regarding going concern principle,** or whether a company is in distress threatening its continuance.

• **Bankruptcy prediction.**

Internal control evaluation represents one of the audit tasks that could possibly benefit from the implementation of artificial intelligence to the greatest extent. Gal and Steinbart [12] mention the complexity of advanced information systems, requiring more advanced controls. Their paper suggests either automation of the control evaluation process, including the decision process, or embedding the evaluation into the database system, thus developing an advanced accounting database system.

Research of Changchit and Holsapple [13] states that it is attainable to use expert systems in audit to transfer internal evaluation knowledge of auditors to management. That way, managers would understand internal control process and would be able to retain the effectiveness of control system and therefore generate more reliable accounting outputs.

In terms of assessing risk, thus recognizing a pattern or deviation causing unwanted consequences for the companies, one of the first models on the basis of expert systems was Peter's cognitive computational model of risk hypothesis generation during audit planning [14]. This model was a computer program mimicking human judgment processes and decisions.

According to Murphy and Brown [15], risk analysis is the key phase of evaluating if the audit plan is reasonable, and is useful for identifying the appropriate amount of evidence that needs to be collected as well as for identifying the appropriate materiality level. A general rule may be deduced: the higher the inherent risk, the higher amount of evidence necessary and the lower the materiality percentage allowed.

Use of artificial intelligence in auditing should decrease all three types of audit risk: inherent risk, control risk and detection risk. Inherent risk, a probability that a material error is present in the financial statements before the process of internal control evaluation itself, represents the risk that is the most complicated to determine.

The above-mentioned paper of Murphy and Brown [15]gives an example of specific expert systems used by particular companies to assess audit risks. The expert systems are usually based on statistical models that enable auditors to recognize potential inherent risks and can also state the underlying variables upon which the judgment of potential risk is made. Another popular approach is questionnaire-based, with an expert system asking auditor questions and evaluating them through a matrix, calculating an overall risk score.

As for the going concern principle evaluation and bankruptcy prediction, these might require both quantitative and qualitative measures. From the quantitative point of view, changes of specific signalling variables might be of use. Qualitative analysis then could be feasible via decision models. Other technologies applicable with bankruptcy prediction models include neural networks, classification trees or genetic programming [16].

2.2 Artificial Intelligence Technologies

Artificial intelligence in audit and accounting is usually implemented through one of the four types of artificial intelligence technologies, some of which have already been mentioned above:

- **Genetic algorithms/programming,** as mentioned, are used mostly for predicting bankruptcy or similar audit tasks, decreasing risk associated with traditional bankruptcy risk models that operate only under certain model assumptions [17]. However, algorithms might be used in a broader sense, assuring the audit evaluation is economical and within time and resource constraints [18].
- **Fuzzy systems,** advantage of which is the possibility to explicitly account for qualitative factors. Rosner, Comunale and Sexton [19] point out a major utility of fuzzy logic for the purpose of assessing materiality. Fuzzy systems permit auditors to assess materiality on a continuous scale from 0 to 1 rather than by a binary decision.
- **Neural networks** are mostly associated with risk assessment, helping auditors perform risk assessment tasks more systematically and consistently, thanks to an ability of neural networks to learn, generalize and categorize data, both complete and incomplete [20]. Calderon and Cheh [21] mention further options on how to use neural networks: for preliminary information risk assessment, control risk assessment; determining errors and frauds, financial distress and bankruptcy and forming going-concern audit opinion.
- **Hybrid systems,** combination of the above-mentioned technologies, might be used when both quantitative analysis and qualitative judgement is necessary. Davis, Massey and Lovell [22] constructed a prototype hybrid system, integration of an expert system and a neural network. The expert system part ensured an efficient use of known control variable relationships, while the neural network part provided a way of recognizing patterns in the large number of control variable relationships, some of which are impossible to express as a set of rules.

3 Current Trends and Opportunities of Artificial Intelligence in Audit

3.1 Robotic Process Automation (RPA)

Artificial intelligence has started to be gradually implemented into the accounting and audit information systems of companies. The most common first step was RPA, Robotic Process Automation. RPA is a software running other application software and can be used to automate predefined business processes [23].

The difference between RPA and artificial intelligence is that while RPA is process-driven, automating tasks based on rules, artificial intelligence is data-driven, requiring data of high quality in order to learn the patterns and simulate the decisions of human [24]. These two terms are therefore closely related, with artificial intelligence being one step further. However, these technologies do not replace each other, rather complement each other [25].

The main reason for integrating the RPA technologies in the first place was that too many repetitive, simple, rule-based tasks still unnecessarily occupied auditors. Examples of these tasks might include audit data preparation, file organization, integration of data from multiple files, performance of basic audit tests in Excel, copying and pasting data as well as manual annotations [26].

Rozario, Zhang and Vasarhelyi [23] formulated two examples of RPA projects in audit. The first one explores the usefulness of RPA in audit planning. Three modules were created: firstly, a Python program was used to convert original client data into a standardized and machine-readable format. The second module consisted of a series of rule-based analytical procedures interacted with auditor's professional judgment and its output was a summary spreadsheet that was able to generate a planning worksheet. Finally, the third module used the results from the summary spreadsheet and filled them in the planning worksheet. All the modules were connected by RPA software.

The second RPA project applied RPA to execute test of details on an example of revenues. First, the audit evidence was collected from several files and compiled into a standardized format. Then, the audit evidence was imported to the data analytic software. Finally, audit tests were executed, being pre-programmed to match the sales amount in the chain, from invoice details to shipping and sales orders details.

Another paper [27] on the topic of RPA in auditing then describes revenue tests in more detail. It recognizes three steps in revenue audit: reconciliation, analytical procedure and internal control and substantive testing. RPA can perform reconciliation by automatically following a predetermined process of steps:

• Logging into the file transfer protocol (FTP) server set up by the auditor and the client to share client files.

• Entering a query to search for the revenue listing and trial balance, extracting them and importing them into Excel or IDEA, auditing software.

• Calculating the total per the revenue transaction listing.

• Comparing the total per the listing to the total reported in the trial balance revenue account.

Then, when comparing the previous years balances, therefore executing analytical procedures, RPA can generate an alert if the difference between yearly balances exceeds a threshold of materiality of a chosen percentage [27].

Internal control testing and substantive testing can be accomplished by RPA via a program set up to automatically match purchase orders, invoices and shipping documents and also verify whether the price and quantity on the documents match. This test can therefore help with validating the effectiveness of preventive internal controls within the organization's computer system. What is more, also management's assertions of existence, completeness and valuation can be verified by these tests [27].

3.2 Big4 Companies Current Trends

As for the trends and news in the field of artificial intelligence in audit, latest ongoing innovation is led by the Big4 companies: Deloitte, EY, PwC and KPMG. Therefore, the analysis of artificial intelligence technologies introduced by them follows.

Deloitte formed an alliance with Kira Systems in March 2016 to bring innovation and machine learning to the workplace [28]. Based on the alliance, Deloitte then created a cognitive application called Argus, intended specifically for audit purposes. This application *"learns from human interactions and leverages advanced machine learning techniques and natural language processing to automatically identify and extract key accounting information from any type of electronic document"* [29]. For this step, the company won 2018 International Accounting Bulletin's Audit Innovation of the Year award for dedication to innovation and development of tools for transforming audit profession [30].

Another application developed by Deloitte is Guided Risk Assessment Personal Assistant, or GRAPA for short. It assists auditors in comparing their chosen strategy against other previously used risk strategies, working with a Deloitte database of 10,000 cases, with each case including around 50 risks [31]. According to Deloitte [32], the application should be considered a tool for planning and benchmarking, as the creativity and human intelligence is still needed, especially with critical consideration of processes, developments and risks.

Deloitte also plans to introduce chatbots, guiding the employees effectively through regulations, law, auditing and accounting standards and specialist literature [31]. This application will be based on algorithms and will also be gathering valuable feedback data from the users to improve the further searches and to make the application more efficient.

According to the EY Growth Barometer survey conducted in 2019, 73 % of middle-market CEO respondents are already adopting artificial intelligence, or plan to adopt it in the next two years. Two years earlier, 74 % of them said they had no strategic plans involving artificial intelligence at all [33].

Generally, EY would like to use artificial intelligence to release auditors' time and potential for the more value-added tasks. To achieve that, EY develops advanced analytics tools for analyzing larger populations of data in a shorter period of time. Also, smart automation and RPA technologies are used, automating the most time-consuming, repetitive, standardized, and, the most importantly, rule-based tasks, leaving artificial intelligence to execute tasks which are much more complex [33].

EY also focuses on using artificial intelligence to detect frauds. It developed a tool called EY Helix GL Anomaly Detector, or EY Helix GLAD for short. Its algorithm can uncover fraudulent journal entries and provide reasons for their detection [34]. Extremely interesting seems to be the use of drones for physical inventory purposes [35].

PwC won both 2017 and 2019 International Accounting Bulletin's Audit Innovation of the Year award. The 2017 award was connected to its technology GL.ai, developed in cooperation with H20.ai, a Silicon Valley company, developing an artificial intelligence enabled system capable of analyzing documents and preparing reports [36]. GL.ai is able to replicate thinking and decision-making of auditors and examines all the transactions, users, amounts and accounts to detect unusual transactions in the general ledger [37].

The 2019 award was obtained for another technology, Cash.ai, which automates the audit of cash, including cash balances, bank reconciliations, bank confirmation letters, foreign exchange and the financial condition of the bank [38].

KMPG perceives artificial intelligence as a whole ecosystem and created a concept of KPMG Ignite, portfolio of artificial intelligence solutions and capabilities [39]. KPMG cooperates with Microsoft, providing integrated innovation to their clients. These solutions include Intelligent Underwriting Engine [40], tool for risk profile and premium calculation or Sales Intelligence Engine [41], sales cycle optimization tool.

Particularly interesting for audit is Strategic Profitability Insights [42], a platform that helps extract key financial data and deliver insights into the value of a deal. KPMG also mentions Digital Solution Hub, based on Microsoft Azure cloud services, connecting it with artificial intelligence tools [43]. However, no direct links to artificial intelligence in audit are publicly presented.

4 Blockchain in Audit

One of the currently trending artificial intelligence technologies used in audit is blockchain. This technology will possibly have an enormous impact on the whole audit profession; thus, a whole section is dedicated to its analysis.

Blockchain is defined as an open, distributed ledger which "*records and verifies transactions without any trusted central authority*" [44]. To be more specific, blockchain is a file that is able to maintain a list of ordered records, called blocks. Each of the blocks contains a timestamp and a link to previous block. Therefore, the blocks are resistant to any data modification, both in real time and retroactively.

The blockchain transactions are conducted among various entities, known as nodes, within a network. All nodes connected to the network at a specific time validate a requested transaction via a consensus algorithm by following a set of instructions to ensure transaction verification [45]. As soon as the consensus is reached, the transaction is permanently included in all copies of the ledger, without a possibility to modify or delete it.

According to Mahbod and Hinton [45], blockchain has four important characteristics: almost real-time settlement of transactions, distributed ledger, irreversibility and censorship resistance. Distribution is secured as every node contains a complete copy of each transaction. Possible censorship would require all, or majority, of nodes to be complicit, which is improbable.

The following benefits of implementing blockchain technologies in general are mostly presented: securing information, reducing errors, fostering reliability and improving effectiveness and integrity [46].

Blockchain technology was first officially formulated in 2008 by Nakamoto [47]. The chain of blocks was used to create a secure digital currency system, named Bitcoin, which enabled peer-to-peer digital currency trading.

Since then, blockchain has evolved from blockchain 1.0 to 3.0. Blockchain 1.0 is focused on the currency itself and the deployment of cryptocurrencies in applications related to cash, such as currency transfer, remittance or digital payment systems. Blockchain 2.0 covers similar trading, however, with financial applications in areas much more extensive than simple cash transactions. Examples of these applications include stocks, bonds, futures, loans, mortgages, digital asset ownership, smart property or smart contracts, which will be analysed further. Blockchain 3.0 is represented by applications beyond currency, finance and markets, mainly in the areas of government, health, science, culture and many more [48].

Even though blockchain has been mostly associated with digital currencies such as Bitcoin, its impact in audit might be significant. Blockchain is extremely suitable in areas where transferring value of assets between parties is complicated and expensive, requiring various central intermediaries [45]. Therefore, financial services, including audit, might benefit from blockchain transactions the most.

Baron [44] lists some possible applications of blockchain in audit, some of which will be analyzed further in the following subsections: traceable audit trails, automated audit process, authentication of transactions, tracking ownership of assets, development of "smart contracts" and registry and inventory system for assets, ranging from raw materials to intellectual property.

Rozario and Thomas [49] provide characteristics of blockchain in the specific conditions of audit. One of them is decentralization, related to the already mentioned distributed ledger. Together with immutability, or preventing retroactive changes of the ledger, auditors are provided with a tamper-resistant audit trail. Accountability then enables auditors to verify the originator of a transaction thanks to the digital signature of the user. Collectively, these attributes make blockchain technology incredibly suitable for audit as it provides a *"secure set of records, near real-time reporting, a robust audit trail, and transparency"* [49].

The most complex version of blockchain use in audit is presented by blockchain ecosystem, a multitude of blockchains formed by various business entities, including auditors, with all of them being interlinked [49]. The data recorded in the blockchain ecosystem contain companies' financial data, non-financial information from business processes or from outside information resources, life-logs of physical objects such as inventory or buildings, and system logs recording real business processes [50].

4.1 Implications of Blockchain Use in Audit

One of the main arguments in favor of implementing blockchain into audit processes is its possible ability to improve the reliability of audit evidence. This aspect is closely related to the existence of Big Data environment.

Due to the Big Data business environment, the type of evidence auditors examine has changed dramatically. The traditional form of audit evidence, evidence generated by company or based on external documents, has been evolving into electronically transmitted, processed, maintained or accessed information [51].

According to Brown-Liburd and Vasarhelyi [51], audit evidence should be sufficient (quantity dimension) and appropriate (quality dimension). The sufficiency point of view is not problematic, even in Big Data environment, as new technologies enable auditors to extract and test the full accounting data, with no need to sample.

However, the quality aspect, mostly connected to relevance and reliability, is a key issue. Relevance is likely to be evaluated by auditor's judgment, in the same way as with the traditional audit evidence when auditors evaluate if the audit evidence fulfils audit objectives. Due to automated data extraction, the reliability of this process is much higher than collecting data manually. Furthermore, blockchain has the potential to enhance the evidence integrity. Thanks to blockchain's ability to store the audit evidence from various sources, aggregating information will no longer be required [49].

Another phase of audit process that has been changed by blockchain is sampling. Due to use of data analytics, complete sets of data are tested, rather than just samples chosen by auditors [52]. Borthick and Pennington [53] even mention that the change of sampling mentality to data analytics is now becoming a competitive necessity, with large investments of companies into staff training and creating new analytic methodologies.

Rozario and Thomas [49] also mention locational data from GPS devices and temperature data stored on the blockchain. Using these creative means of information might improve the accuracy of audit estimates and valuation.

A frequently used tool of audit, confirmations of outstanding receivables and payables, chosen both randomly and by materiality, will most likely be eliminated in the near future due to the previously analysed character of blockchain technology, providing real-time verification of all transactions.

All these aspects have contributed to creating a new generation of auditing, based on the continuous assurance. The data are constantly being shared, creating an effective and efficient internal control environment. The audit process is gradually acquiring a preventive nature rather than being used for testing and examinations.

The role of auditors has evolved from an assurance entity to a strategic partner and advisor, thanks to all the artificial intelligence tools and data analytics, including blockchain [54].

4.2 Smart Contracts and Smart Audit Procedures

During the second generation of blockchain, smart contracts have been introduced. This concept was first proposed in 1994 by Szabo who noted that the execution and monitoring of most of the contracts relies on a central authority [50]. Therefore, smart contracts decentralize the power of central authority to each of the nodes, embedding the contractual rights and obligations onto the network.

A smart contract might be defined as *"a software program that performs actions on behalf of the user based on pre-defined conditions"* [49]. The complete process of engaging contractual agreements is covered by smart contracts, from enforcement and verification to performance of the contractual terms.

Dai and Vasarhelyi [50] describe smart contracts application on an example of loan covenants. After covenant agreement between bank and client is concluded, it is encoded into a smart contract and deployed into a blockchain. The conditions and activities of the company are monitored by nodes, being compared with conditions outlined in the agreement. If the conditions are violated, blockchain will automatically activate the sanction resulting from the agreement, such as immediate repayment of the loan, interest rate increase or issuance of a warning. Auditors and bank management can also participate in the surveillance.

The main benefits associated with smart contracts include the above-described automatic execution of contracts. Internally, it results in lowered costs and enhanced efficiency of payments, allowing management to focus less on compliance and more on strategic planning.

From the point of view of auditing, smart contracts avert the need to review agreements for the purpose of identifying subsequent events or unrecorded liabilities that might be of material nature [54].

Besides smart contracts, auditors might benefit from blockchain also in the form of smart audit procedures, *"autonomous software programs that allow auditors to execute audit procedures based on pre-defined parameters"* [49]. Smart audit procedures might cover simple rule-based systems, checking that the sales order, shipping documents, and sales invoice match and are issued in the correct order. However, more complicated smart analytical procedures might be implemented, including the ones assessing risks of material misstatements.

In case of any differences, additional testing might be executed, possibly using follow-up smart audit procedures, pre-programmed to solve the discrepancies discovered during the initial phase of audit.

Using blockchain for smart audit procedures might result in improved audit quality, via increased reliability of both financial and non-financial information. The auditor judgment might be enhanced too as risk can be assessed through innovative tools such as previously mentioned GPS devices, especially for evaluating risk of non-financial data.

Another interesting perspective on smart audit procedures is through Audit Data Analytics (ADA). As with blockchain itself, ADA has evolved through various phases. ADA 1.0 is represented by trends or ratio analysis, ADA 2.0 introduced algorithms and machine learning models. ADA 3.0 is then associated with smart audit procedures and smart contracts [55].

The advantages of smart contracts include accuracy, clear communication and transparency, speed and efficiency, security and cost reduction [56]. Most of these aspects have been analysed above, with the exception of security. To shortly outline blockchain security, study of Apostalaki, Zohar and Vanbever [57] discovered that smart contracts use highly efficient security measures.

Challenges, arising from using smart contracts and generally blockchain, are analysed in the following subsection.

4.3 Challenges of Blockchain in Audit

Some of the further mentioned challenges prevent blockchain and smart contracts to be used in the real-life scenarios.

The fact that blockchain cannot be modified easily is usually considered to be an advantage. However, sometimes the blockchain immutability can cause problems, especially in case of short-term smart contracts when it becomes problematic to alter the changing contract terms. Further challenges arise with contractual secrecy, as nodes have access to the ledger and all transactions are visible.

Brender [58] states another practical problem of blockchain, its compatibility with enterprise resources systems, specifically the various modules such as accounting, controlling, project management, manufacturing, logistics and warehousing. Each of the nodes needs to be compatible with the shared blockchain and is required to agree on the shared network rules.

Another key issue seems to be blockchain scalability, the ability of a system to continue to function when it increases the size or volume.

The problem arises when the number of nodes increases over time.

Scalability has various components, the first one being latency, time for a transaction to confirm. Brender [58] states that as at today, latency takes more than 10 minutes with Bitcoin and 14 seconds with Ethereum, which is significantly more than the current payment processing systems.

Size and storage are another important component. Storing the ledger with all the transactions that is gradually becoming more robust might be challenging. Another component of scalability is bandwidth as the transactions need to be relayed through the network prior to being validated through consensus algorithm. As the number of nodes increases, the number of transactions increases too, and a better network connectivity is necessary [58].

The last component of scalability is the maximal rate at which the network can work properly, including transmitting, receiving and validating transactions. Brender [58] suggests Bitcoin's maximal rate is approximately 7 transactions per second. This issue mainly relates to public blockchains, some private blockchains are able to process thousands of transactions per second.

Another practical problem arises with exposure to programming errors or system weaknesses. Nikolic's research [59] revealed that 3 % of smart contracts are fatally flawed.

Allam [56] mentions legal enforceability of the smart contracts, issue that is still not established in the current contract law. This topic is broadly discussed even among the leading companies in the field of auditing.

4.4 Practical Blockchain Applications

As mentioned above with the artificial intelligence application in audit and accounting in general, even the blockchain innovation revolves around the Big4 Companies.

In April 2019, EY introduced Blockchain Analyzer, a blockchain analytics tool, which is supposed to increase transparency on blockchain transactions. The first generation of this tool was designed to facilitate EY audit teams in gathering data from multiple blockchain ledgers, to reconcile data to EY client books and records and to perform advanced analytics, including trend analytics [60].

The technology supports testing of multiple cryptocurrencies, including BitCoin, Ether, BitCoin Cash or LiteCoin [61].

The second generation of EY Blockchain Analyzer is available also as a business application for both EY teams and external clients, enabling financial reporting, forensic investigations, transactions monitoring and tax calculations [60].

EY Blockchain Analyzer was not the only blockchain-related application introduced in April 2019. The other one was the second generation of EY Ops Chain, focused on industrialization of blockchain technology for enterprise users. Since its debut in April 2017, it became one of the leading blockchain business applications. Thanks to EY Ops Chain, companies are able to set up and manage networks of business partners and run shared processes across the ecosystem, including procurement, inventory, logistics, invoicing and account management [62].

Deloitte offers a whole portfolio of blockchain solutions: Bancassurance, automating labor-intensive processes through smart contracts; EduScript, designed for real-time validation and sharing of certified qualifications; or GlobalConnect, solving the challenge of the existing heterogenous networks in the global supply chain and trade finance ecosystems [63].

PwC launched Blockchain Validation Solution, software that is set up as a read-only node which monitors and logs all transactions in order to apply appropriate controls and continuous testing of all transactions [64].

5 Threats of Artificial Intelligence, particularly in Audit and Accounting

Not only opportunities and possibilities emerge with artificial intelligence application. A big volume of threats and complications connected to artificial intelligence in audit comes with regulatory environment. Deloitte [65] mentions regulation of cloud-based services, as it varies globally, with stricter restrictions in Europe. Resulting from that, companies in countries with more relaxed rules have broader possibilities for the development of artificial intelligence.

Another huge issue arises with data, both personal and financial. As for the personal data, some rules limit the collection, transmission and storage of personal data. On the other hand, individuals have higher control of businesses using their data.

As for the financial data, according to Deloitte [65], regulations in Europe require institutions to share clients' financial data with third parties, at the request of the customer. However, this is applicable only as a one-way agreement: third parties do not need to reciprocate and share their data with financial institutions. As a result, large technology companies can use financial data and have a competitive advantage in artificial intelligence technologies development.

However, there are also other risks beyond the extent of financial regulations. Deloitte [65] states just a few of them: jeopardizing financial safety resulting from even more complex connections both domestically and in a cross-border sense, a danger of polarizing communities around artificial intelligence development and causing a regional conflict or inflicting financial exclusion among segments of the population, despite its aim to democratise financial advice.

Then there are general threats of artificial intelligence, highly publicized, such as reducing the need of labour in the economy as a whole, or possible income inequality caused by a specific concentration of market power in the artificial intelligence industry.

Elon Musk, a billionaire technology entrepreneur, even stated that artificial intelligence might be more dangerous than nuclear weapons and that there needs to be a regulatory body overseeing its development [66]. Stephen Hawking, one of the leading scientists, also warned of artificial intelligence which, according to him, could even end mankind by suppressing human intelligence [67].

In audit and accounting, the danger is represented mostly by algorithms. European Union's General Data Protection Regulation, GDPR, requires organizations to be able to explain their algorithmic decisions [68]. The algorithms should also be audited, proving they are not exploitative, deceptive, internally biased or containing human logic errors or imbedded human biases.

Accounting outputs should still provide true and fair view of the reality, therefore algorithms used in accounting and audit should reflect this requirement. Decisions based on biased algorithms may cause financial and reputational damages to investors and owners of companies.

6 Conclusion

Based on the conducted research, artificial intelligence in accounting and audit has a huge potential to deliver efficiency, reduce errors and provide accountants and auditors more time to focus on more complex and value-added tasks rather than the repetitive, time-consuming and rules-based ones.

Smart audit procedures and smart contracts might represent the future of efficient automated execution of both business transactions and audit tasks.

However, there are still various topics regarding artificial intelligence to be researched, such as how to analyse costs and benefits of artificial intelligence projects, to what extent can audit judgment be automated or whether audit populations are large enough samples for deep learning [69].

Many ethical and moral issues are associated with artificial intelligence in audit and accounting. In any case, artificial intelligence is becoming a part of various business, audit and accounting processes, with companies investing more and more capital into its development.

Blockchain changes the way audit is done, eliminating the current audit tools such as sampling, confirmations and traditional way of gathering evidence. All the characteristics of blockchain contribute to creating a new generation of auditing, based on continuous assurance. However, professional audit standards are not prepared to incorporate these current trends into the traditional audit process which may cause problems with audit files and the whole audit judgment performance.

The future will, unfortunately, probably introduce new issues and dangers, but will surely bring even more innovations, possible opportunities and effective solutions.

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