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Stakes and Challenges Regarding the Financial Auditor's Activity in the Blockchain Era

Univ. Prof. Nicoleta FARCANE, Ph. D.,
Faculty of Economics and Business Administration, West University of Timişoara, Romania, financial auditor, e-mail: nicoleta.farcane@e-uvt.ro

Research & Teaching Assistant Delia DELIU, Ph. D.,
Faculty of Economics and Business Administration, West University of Timişoara, Romania, financial auditor, e-mail: delia.deliu@e-uvt.ro

Abstract

The relevance of the audit profession (in general) and the quality of the audit (in particular) in a rapidly changing business world, determines that practitioners, regulating authorities and academics should be informed about the recent technological developments that have the potential to disrupt the business ecosystems and, consequently, the audit ecosystem.

The present paper strives to formulate an objective perception of reality in a rational, structured and positivist manner, trying to examine the current debates regarding the new digital age, to identify both the advantages and the weaknesses or the fundamental deficiencies of the elements of the Blockchain technology and, therefore, to provide a critical observation on how these changes would affect the soundness and effectiveness of audit reporting.

Audit profession needs to embrace and "lean" toward both the opportunities and challenges generated by a large-scale adoption of Blockchain. Auditors are encouraged to monitor the evolution of Blockchain technology because they have the opportunity to evolve, learn and capitalize on the proven ability to adapt to the needs of a rapidly changing business world.

Moving towards a 4.0/continuous audit/hybrid audit model that includes the Blockchain-type, intelligent Smart Audit Procedures will be able to improve the quality of audit, responding much better to the informational needs of the stakeholders.

Key words: *4.0 financial audit; hybrid audit; digitalization; Blockchain; Big Data; Smart Audit Procedures; Smart Contracts; modified professional behaviours*

JEL Classification: *M42, D21, M48, G39*

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1. Introduction

Today, ***digitalization*** reaches all sectors up to the level of daily activities. In this regard, ***voluntary standardization*** plays an essential role in relation to the interoperability aspects of technology and networks, mass data management (Big Data), security (cyber security, personal data protection), as well as confidentiality. Thus, digital technologies (including artificial intelligence) represent a specific topic regarding the strategy, representing a social and economic challenge of great importance.

We believe that the participants at the economic level need to adapt and anticipate these developments, and, implicitly, their impact on the modes of production and consumption.

As a result, professions and competencies are changing, subsequently, standardization providing answers to several issues related to digitalization: the interoperability, the development of the internet of connected objects (Internet of Things), the blockchains (and their applications), the mega data, the working conditions, the cyber security and data protection of personal data, the support for new regulations (for example, GDPR – Payment Services Directive), operating in sequential modules, or the impact of digitalization on the environment.

Blockchain was "invented" by a person (or a group of people) using the name Satoshi Nakamoto, in 2008, to serve as the public trading record of a bitcoin cryptocurrency, the identity of this Satoshi Nakamoto being unknown. The introduction of the Blockchain for bitcoin has made it the first digital currency, in order to solve the double spending problem, without the need of a trusted authority or a central server, the design of bitcoin also inspiring other applications; the "blocks" can be read by the public being widely used on the basis of encryption.

The Blockchain is, therefore, *a technology, an algorithm that allows the encryption of transactions with public keys, accessing them with private keys and the public distribution of the entire resulting journal*, which is a decentralized journal that cannot be altered and does not depend on a central entity.

Thus, we can say that Blockchain is itself a public, decentralized digital registry that cannot be destroyed, being distributed and used to record transactions on multiple computers, so that any registration that is initiated cannot be changed retroactively without changing all subsequent "blocks". This allows the participants to independently check and audit transactions at no significant cost.

The Blockchain database is managed independently using a peer-to-peer network and a distributed server of signatures, which are authenticated through extended group collaboration based on collective interests. Such a design facilitates a robust workflow in which the participants' uncertainty regarding data security is marginal. On the other hand, the use of a chain of "blocks" eliminates the characteristic of infinite reproduction of a digital material, confirming that each unit of value was transferred only once, and, implicitly, solving the long-term problem of double sending (duplicate expenses). The "blockchain" chain is, therefore, described as a value exchange protocol, a Blockchain being able to maintain its ownership rights (because, when properly configured to detail the exchange agreement, it provides a record that obliges the offer and acceptance).

We are, therefore, dealing with a growing range of records (called "blocks") that are linked by cryptography, each "block" containing a cryptographic sign of the previous "block", a time and transaction data mark, generally represented as a tree. Thus, by design, a "block" shows resistance regarding the modification of the data, being a kind of open, distributed register that can record transactions between two parties in an efficient manner and in a verifiable and permanent way. In order to be used as a distributed registry, the Blockchain is routinely administered by a peer-to-peer network, collectively adhering to a protocol for node communication and validation of new "blocks". Once recorded, the data in a given "block" cannot be modified retroactively without changing all subsequent "blocks", which requires the consent of most networks. Although the "block" records are not unchangeable, the "blocks" can be considered secure by design and they exemplify a high tolerance distributed computer system. It offers an incorruptible register of identities, transactions, documents, assets, etc., thus offering a new way of recording, storing and sharing data of any kind.

We consider that the evolution of the bitcoin, and even more widely, of the distributed registers, was initially seen as having the potential to destroy, in the context of massive industries. In all possible scenarios, significant

variations of the Blockchain architecture have been suggested. Bitcoin, the most widespread user of the Blockchain, has proven to be extraordinarily valuable as a network for transparency and security on a large scale, where public participation and visibility are essential. At the opposite end, private solutions have emerged that have common features with the Blockchain, but have greater flexibility in terms of data security and authorized access.

Across the spectrum (from public to private) there is a solution to many of the world's centralized data problems, including the financial reporting and audit reporting. Although we do not claim to have the solution, we are confident that such a solution, that will slowly change the audit industry for the better, will emerge.

In this regard, the approach of our case study is a tertiary one, finding its correspondent in the following three considerations:

i. The potential of the Blockchain technology in the field of the financial services and its increased use

Companies operating in the financial services field have realized the innovative potential of the Blockchain technology in decentralizing and streamlining their operations. The advantages offered by the implementation of the Blockchain technology in the field of the financial services, such as: complete traceability of transactions, validation of transactions in very short time (maximum few minutes), elimination of intermediaries in settlements and minimization of costs for validating transactions, allow the creation of secure and sophisticated financial products at low costs. Thus, the Blockchain technology is used for various applications in the field of financial services: making payments (remittances, settlement mechanisms), auditing financial services, digital identity (storing "know-your-customer" (K.Y.C.) information on Blockchain), score lending, implementation of loyalty programs, etc.

ii. Lack of a legal framework for the Blockchain technology – early regulatory attempts in Europe

Currently, there is no integrated regulation of the Blockchain technology at the E.U. level. In the last two to three years, several European states (e.g. Switzerland, Malta, Italy, Estonia, France, Germany) have begun to make efforts to regulate the Blockchain technology and cryptocurrencies, but the few regulations that have emerged remain incomplete, isolated and inconsistent.

iii. The pitfalls of the lack of regulation – the potential application by analogy of the existing regulations

In the absence of specific regulations, it appears that crypto-assets can be used freely, without the legal constraints that other types of assets are commonly subject to. However, we note that as the use of cryptocurrencies intensifies and the market interest increases, the regulatory authorities take into account the risks involved and tend to extend the scope of the existing regulations and apply them by analogy to cryptocurrencies. As a result, there is a need for the issuers and those using cryptocurrencies to analyse in detail their characteristics, to ensure that they comply with the regulations that may become incidental by analogy, even if they do not specifically refer to cryptocurrencies.

Thus, we consider that the digital transformations and the prevalence of large volumes of data have forced the economic entities to try to adapt to an "electronic" world and to change their business practices (**IAASB, 2016**; **PCAOB, 2016**).

In this context, *disruptive technologies*, such as deep learning, together with Big Data (**Vasarhelyi et al., 2015**) are increasingly changing the type of information collected, respectively the way in which this information is analysed and disseminated. For example, the deep learning models that incorporate textual data from social media posts can help predict the reputation risk (**Forbes, 2016**) and the financial industry business practices.

With its cryptographic and consensual mechanisms that ensure the integrity of transactions, Blockchain technology demonstrates great potential, being itself an impermeable audit trail. Merged with the *Smart Contracts* (**Szabo, 1994**; **Szabo, 1997**) – which are computer programs that perform a task on behalf of a human user – Blockchain can significantly change the existing business practices. In essence, Smart Contracts, in conjunction with Blockchain, can generate agile supply chains by automatically monitoring and executing the conditions of delivery invoices and financial derivatives (**Mainelli & Smith, 2015**; **Vaziri, 2016**; **Yermack, 2017**).

Given these recent digital transformations, it is important for the auditing profession to consider the impact of the Blockchain, as well as of the Blockchain-based Smart Contracts.

Therefore, a natural research question that arises is ***the extent to which the auditor profession will be disrupted by these technologies***. In particular, this research study seeks to examine whether the Blockchain-enabled Smart Contracts have the potential to help the auditors deliver enhanced audit missions.

Economic entities have been proactive in terms of exponential changes in technology. However, the same premise does not apply to the external audit profession. Pressed by the ever-changing (and fast!) business practices, the financial audit practitioners, the regulatory and standardization authorities, but also the academic environment created initiatives to examine the ***impact of sophisticated audit analytics on the financial audit engagement*** ; these initiatives include the **Data Analytics Working Group** (**IAASB, 2017**) [1] and the **Rutgers AICPA Data Analytics Research Initiative** (**AICPA, 2017**) [2].

Although the external audit paradigm underwent significant changes over the last three decades (**Matthews, 2006**; **PCAOB, 2017**), with the recent requirement to report the critical audit issues ("Key Audit Matters" – KAM) as its last major transformation, *it is clear that the external audit profession is still substantially behind in technological innovation* .The increased volume, speed and variety of data, but also the technologies that have a rapid evolution – raise the issue regarding the *relevance and applicability of the traditional audit model* (**Appelbaum et al., 2017**; **Badertscher et al., 2017**).

This research study has several important contributions. Firstly, it contributes to the emerging literature, *proposing a* ***new generation of analytical audit tools – Smart Audit Procedures*** – activated by the Blockchain technology. Secondly, this study presents a discussion on the ***effect of Smart Audit Procedures on audit quality and public interest***, thus contributing to the debate on the ***role of the emerging technologies in the audit process***. Last but not least, this study contributes to the literature by providing *directions for future research on the* ***evolution of the external audit paradigm***.

2. Research methodology

The topic chosen for this paper finds its correspondent in the *challenges and perspectives of using the Blockchain technology*, with a special emphasis on the *factors that influence the quality of the audit report and the (proactive!) role of the financial auditor*.

On the other hand, this research aims to add value to the multitude of the already existing research on the interdependence between the effect of Smart Audit Procedures and the quality of the audit through a series of inputs on how they contribute to bridging the gap of perceptions of the public interest regarding the financial auditor's set of responsibilities.

Most of this paper is based on ***fundamental research***, including debates on the Blockchain technology as a fundamental concept, namely its *impact on audit theories and practices*, as well as views on the *issues and vulnerabilities of an audit engagement, in the case of the exclusive use of the Blockchain-type Smart Audit Procedures* in the near future.

Our approach strives to formulate an *objective perception of reality* in a rational, structured and *positivist* manner. We try to identify the link between strategies and structures, and, at the same time, we intend to make explicit the aspects related to the uncertainty of the evolution of the business environment.

The *interpretative paradigm* to which we appeal follows the effects of a *permanent reconstruction of the modalities of exploiting the financial-accounting information*. The reality of the facts is seen as a sum of individual actions through their participation in interaction and interconnectivity.

The study will be constructed using ***qualitative research methods***, the decision to use qualitative methods to the detriment of the quantitative ones, finding its correspondent in the fact that the latter would provide neither an analysis and evaluation of the evolution of the blockchain technology and its scope nor one of its importance in the context of a financial audit engagement.

Above all, we want to provide a fundamental understanding through an in-depth analysis of the interaction between the advantages and disadvantages of using the Blockchain technology, the quality of audit reporting, the role of the external auditor, and what an

[1] Data Analytics Working Group – D.A.W.G. (IAASB, 2017): https://www.iaasb.org/projects/technology

[2] Rutgers AICPA Data Analytics Research Initiative – R.A.D.A.R. (AICPA, 2017): https://www.aicpa.org/interestareas/frc/assuranceadvisoryservices/radar.html

effective audit engagement means (or should mean) – especially in a sensitive socio-economic context.

Therefore, we examined the current debates on issues related to the new digital age, identified both the benefits and the deficiencies or the fundamental weaknesses of the elements of Blockchain technology, and offered a critical observation on how the caused changes would affect the soundness and effectiveness of the audit report.

3. Transformations and evolutions regarding accounting information, their treatment and revision

3.1. The new digital age, new challenges for the business world

At the current stage, internationally, we are witnessing the development of modern forms of commerce – such as the Internet commerce, which has almost exclusively relied on financial institutions that serve as trusted third parties in the processing of electronic payments, this method working quite well for most transactions, but without covering all the shortcomings of a model based on total trust.

Without a doubt, so far, transactions of a completely irreversible type are not really possible, as the financial institutions cannot avoid the mediating potential litigation related to them, the cost of mediation leading to an increase in the transaction costs, limiting the size of practical transactions and leading to reduce the possibility of occasional small transactions. As a result, the growing need for ***guaranteeing trust*** is emerging in the counterparty. Hence, it is inevitable to accept a certain percentage of fraud (although if the physical currency were used, these disadvantages and additional costs would disappear), but it is difficult to identify a mechanism for making payments, based on the communication channels, without proceeding with ways to guarantee trust.

Henceforth, it is necessary to have an electronic payment system based on cryptographic evidence instead of trust, allowing any two willing parties to carry out direct transactions between them without the need for a third party system that guarantees trust.

Technological progress has led to the ***development of invoicing/billing methods***, which means *revolutionizing e-invoicing power and means to access it*. The coordination of invoicing applications with other software applications and technologies has improved communication and automatic updating of data. The invoicing platforms that have been used so far have allowed carrying out of limited tasks such as editing and sending invoices, but, nowadays, the billing modalities can be integrated with other software programs that allow tracking the moment of operation, generating reports and transmission of follow-up electronic messages.

In this regard, **Vevera (2014)** shows that there are currently more mobile devices than people in the world, finding almost 2.7 billion Internet users and 1.5 billion smartphone users, pointing out that this unprecedented penetration of technology, combined with the agility and accessibility of high computing power through the cloud, changes the way data is produced and used.

Thus, we observe the manifestation of the transition towards an *information society* and the *increase of the degree of democratization* together with the *complementary evolution of the cloud*, namely that through mobile telephony and the Internet, the software infrastructure becomes accessible to a wider range of users. The consumer mind-sets and patterns are changing, globally, the e-commerce selling recording billions of dollars, while the number of companies using these new technologies to create new business models at significantly lower costs is increasing.

The **Digital Agenda for Europe 2020** elaborated by the **European Commission** presents a vision on the future of Europe in what will become "a digital single market, characterized by increased interoperability, security and trust in the Internet, a faster access, investments in research and development, digital literacy, application of information technologies to solve the various problems that society faces" [1].

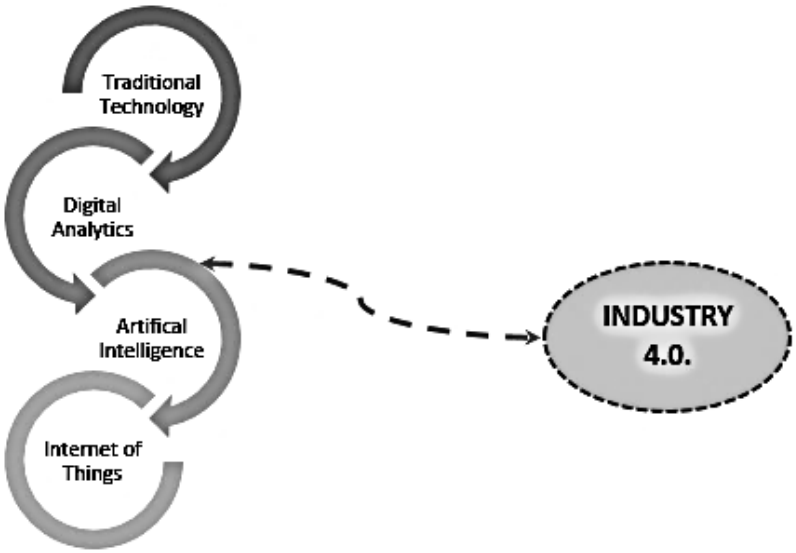
Industry 4.0 – the fourth industrial revolution – is the result of the intersection of traditional technology with digital analytics, artificial intelligence and Internet of Things[2], as shown in the ***Figure no. 1***. *Industrialization 4.0* represents, in fact, the name of the Research Council of the German Federal Government and of the draft strategy[3] regarding the future technical vision of the same government, as a consequence also being born a Research Platform of the same name.

[1] https://europa.eu/european-union/file/1525/download_ro?token=Yfra7Pmc; https://europa.eu/european-union/file/1497/download_en?token=KzfSz-CR

[2] Internet of Things (abbreviation for IoT) is a concept that involves using the Internet to connect different devices, services and automated systems, thus forming a network of objects.

[3] https://ec.europa.eu/growth/tools-databases/dem/monitor/sites/default/files/DTM_Industrie%204.0.pdf

Figure no. 1. Industry 4.0 Framework



Source: Own projection

Thus, future industrial production will develop in symbiosis with the modern information and communication technique. The technical basis for achieving this goal is the interconnected digital systems, these systems making possible in the Industrialization 4.0 of a self-organized production in which the operators, machines, installations, logistics and the product communicate and cooperate with each other directly. The *interconnection* will make a leap from the supervising a small production segment to self-organizing an entire chain to company-level. The network will have to include all phases of a product: from ideas, going through the design and production processes, including logistics and calculations, tracking the use of the product and service, to recycling.

In this regard, last year, the consulting company interviewed **Deloitte** 1.600 top executives from 19 countries to find out how prepared they were to *take advantage of the benefits offered by Industry 4.0*, for the benefit of the customers, the employees or the community[1]. The consequence of developing the concept of e-government, robot-making and automation in the industrial sectors and the transfer of services from the traditional area to the digital area, has determined the estimate that about 60% of the existing jobs in Romania could be affected by the digital economy. The questions addressed to the study participants focused on four major themes: social impact, strategy, workforce skills and technology. The results of the study indicate that although, at a conceptual level, they understand the changes that Industry 4.0 brings, the executive directors are less sure about how they should act on these changes so as to benefit as much as possible from them. In each of the four impact areas, the survey identified a degree of contradiction.

Most of the answers suggest that the fourth industrial revolution will *improve the social equity and quality of life*, as well as *stability*, considering that the influence of the business environment on shaping the future will be greater than that of governments.

The companies that put the implications of the fourth industrial revolution on the workforce at the top of the list of priorities are exploring the potential of the new roles that will enable people to highlight their strengths, as they use technology for innovative purposes and for new approaches in terms of learning and development.

In Romania there are concerns in the sense of *encouraging the involvement in technologically*

[1] Deloitte (2018) – *The Industry 4.0 Paradox – Overcoming Disconnects on the Path to Digital Transformation*. Survey: https://www2.deloitte.com/content/dam/Deloitte/mx/Documents/energy-resources/2018/Industry-4dot0-Paradox-RegionalAnalysis-Americas.pdf

modernising the activities of companies, as shown by the study carried out among the SMEs and the suppliers of IT products destined for digitalization, a study realized by **ENCORE RESEARCH SRL** for ARIES Transylvania in November 2018 [1]. The key concepts around which projects and actions are developed are *innovation* and *entrepreneurship*, *supporting companies in the technology area*, as well as in a *cross-sectoral collaboration*, by activating working groups: eHealth, Smart City, Smart Mobility, e-Learning and Open Innovation 2.0. Within the companies in an advanced phase of digitalization implementation, the main services introduced are those concerning the use of the electronic invoice (87%), mobile technology (69% of them already use it) and the use of centralized tools and equipment for access, control and security (65%). The advanced digitalization component (Cloud storage, data analytics or the use of ERP applications, SAP) is implemented only in proportions ranging from 20% to 37%. Following the digitalization, the main products/services obtained were those of digitizing the production process and those of high exposure of the company in the online environment, through the web page. The management software applications are implemented at a negligible percentage at the company level.

The study shows that at present, companies in Romania are not yet sufficiently prepared and this happens due to the obstacles in the implementation of the digitalization process, these being related to a lack of expertise, high costs or incompatibility with the field of activity. At the market level, the signals show that the customers' reluctance towards the benefits, their lack of preparation and the insignificant allocated budgets determine the manifestation of great obstacles in the sale of products destined for digitalization. In order to be able to get out of this impasse, we recommend *client educational programs* and *to devise a complex strategy* that will allow *the attraction of resources for the implementation of digitalization*. In the medium run (5 years), the number of companies that will implement digitalization is expected to increase by about 35% -40%, although in general, digitalization is known to be quite superficial. The public institutions and large companies, with turnover of over 6 million lei, are the ones who know, trust and see in the greatest proportion the high impact of digitalization in the environments in which they operate.

Attracting more customers, *optimal communication*, but also *productivity and efficiency* are perceived as ***major benefits of digitalization***. Companies consider that production and sales are the departments most likely to be digitized. Among the ***disadvantages*** presented are the *lack of expertise at the human resource level*, *the poor professional training* that allows it to be activated in a digital environment.

However, all these aspects allow us to see ***new ways of approaching the processing of information in the age of digitalization***. We find that the information media also undergoes significant changes, which allow operational exploitation in the age of digitalization; as a consequence, we will try to identify the ***support forms of the financial-accounting information in the business world*** and the ***innovative ways of processing them with the help of the electronic devices***.

3.2. Consequences of the evolution of forms of information support and the modification of processing methods

It is obvious that accounting professionals prefer a convenient and easy-to-use invoice application, which allows them to view a summarising financial report on a single page. It is certain that those companies that do not adapt to the online invoice system will be left behind, as more and more customers and service providers have chosen to *integrate digital invoices* and have access to *modern payment methods*.

Therefore, the accounting support documents have evolved to adapt to new technologies available, such as magnetic or electronic records, cloud or tablets. It has also evolved not only the form of accounting records that have as support the written paper, but also the registers that are presented in the form of databases (e.g. the Journal Registry, the Registry of Fixed Assets or Stock Balance), which are actually databases with their own specificities. There are types of databases accessible to the general public, but with a certain degree of confidentiality, such as access to the formulation of merchandise orders; more precisely, the customer individually completes his order directly in the system having access to the stock database on categories,

[1] ENCORE RESEARCH SRL pentru ARIES Transilvania (2018) – *Cererea şi oferta de digitalizare*, studiu realizat în rândul IMM-urilor şi furnizorilor de produse IT destinate digitalizării: https://www.itstudy.ro/media/wysiwyg/cerere-oferta-digitalizare-2018.pdf

characteristics, price. Registers, such as the General Ledger account, can be in the form of databases managed both internally, but also partially externally, serving the direct access of the shareholders or auditors.

✓ *Online invoicing – a challenge today*

There are many reasons that make digital invoicing a must for every company that wants to streamline its management process. In fact, the interested suppliers strive to provide diversified billing solutions for their customers, with innovative tools and simplified and secure processes. E-invoicing can help reduce the traditional invoicing costs by up to 80%. This way it eliminates the use of paper, envelopes, stamps and transport costs. An electronic invoice can be generated, approved, sent and paid at an interval that does not exceed one hour, proving efficiency and allowing both the customers and the service providers to instantly access invoices from anywhere and at any time. Online invoicing saves all data securely, making a recovery easier when databases are needed.

✓ *Modern technologies and invoicing methods in the future*

The growing trend of changing technologies and invoicing processes has led to the increasing use of online invoicing, notably by the large companies but also by the smaller ones. The existence of a significant number of small and medium-sized companies has increased the potential for adopting e-invoicing technology, as these companies have accessed the new online billing methods. However, although their requirements differ somewhat from the needs of the large companies, they, nevertheless, expressed their desire and sought the affordable, fast and easy-to-use digital invoicing solutions, understanding their benefits well.

There are more and more applications that meet these requirements. The difference that manifests itself is only in terms of the degree of security, data protection and integration in the company's global system (Billing.tn, Smart bill, FGO in partnership with Saga Software, Archibus, Oblio.eu). E-invoicing methods are reliable, efficient and fast applications, in order to meet the customer's billing needs, covering the areas of billing, payment, notifications, time tracking, synchronization, reporting and many other functions.

The experience of the integrated digital invoicing demonstrates that it is much easier to be able to provide a pleasant experience for the customers when they understand the important elements of the online invoicing. The digital tools help speed up the billing and payment process, allowing them to access certain information, make payments, invoice the desired items and even analyse the reports that can be generated from these built-in databases.

The synthesis of the information obtained from the introduced database ensures consistency and can assist the clients in expressing the best option. The client needs something that can give him a result on which to base their decisions. Functional awareness of the benefits of billing applications is part of a complex process, but it must be provided in the simplest way. Thus, the various applications strive to provide the customers with the best possible experience, such as creating monthly reports or accessing a summary page to find all the main information on a single page. Invoicing is certainly an evolving process that is already associated with a great deal of complexity. But, thanks to technology, the opportunity arises to benefit from the many advantages offered by the online invoicing.

Analysing several invoicing sites in our country, we noticed how different companies are promoting on different applications. To prevent delays or loss of payments from customers, a beneficial option is the online invoicing, with the possibility of sending business invoices online to customers and, therefore, the payments can be made at the same time or at the optimum time. The billing elements for the online invoice generator can help avoid a multitude of small problems related to invoicing, saving time for the work of the accountants. The integrated E-invoicing helps send the invoices directly to the customers, allowing the possibility of being paid on time, as well.

Example:

Billing.tn – is a professional online invoicing platform that offers an integrated digital invoicing experience. It has developed a complete online accounting and billing solution that connects the small businesses with the accountants, suppliers, banks and other e-commerce programs. Billing.tn opens the door to connect the customers and the suppliers directly, in order to carry out all business transactions related to billing.

✓ *And to go further... The excellence of the Blockchain technology*

Thus, we observe that, under these conditions, it is imperative to **have a form of security that will reduce the divergences or conflicts** resulting from the lack of invoices or those due to possible errors.

The **Blockchain technology**, which we will present below, will be able to enable these shortcomings to be resolved by automating all processes regarding the invoice cycle, beginning from the starting point – from the supplier to the customer, by securing the invoices and the data contained in its content, tracking real-time invoices, instant possibility to share invoices with the management representatives, shareholders or auditors. The use of this modern invoicing technology represents a significant support, and there are also payment methods that could be associated with the invoice, without implying the payment of commissions, thus, the automatic payments can be made based on Smart Contracts defined at the level of this special technology. In addition, the Blockchain technology protects against the risks of fraud by securing payments, and can, consequently, lead to improvement by reducing the number of due days in the payment made by the beneficiary to the provider.

✓ *Blockchain and the invoicing system*

The implications of the Blockchain are potentially transformative, affecting the accounting, auditing, taxation and consulting services.

The large accounting service companies already recognize the importance of the "block". In this regard, the consulting company **Deloitte** announced the involvement of a working group of 800 professionals from 20 countries which develop applications in the field of banking, cross-border payments, trade and finance. On the other hand, the consulting firm **PwC** notes that the "block" may structurally alter the common practices between customers, competitors and suppliers. **Ernst & Young** show that Blockchain will do for the business ecosystems what ERP[1] planning system has done for a single company. The Blockchain, integrating information and processes within and outside the entity, has the potential to streamline and accelerate business processes, respectively, to increase protection against the cyber security and to reduce or eliminate the role of intermediaries. Also, **KPMG** is currently working with the software companies TOMIA and the two leaders of the distributed registry industry (DLT type) – Microsoft and R3 – to solve the arising problems from the multi-party connections and 5G connectivity and to develop Blockchain solutions for the telecommunication settlements.

The Blockchain can improve the *accuracy and efficiency of the billing and payment process* because the provider, instead of sending a traditional invoice to a client, will invoice directly to the client's accounting department, in real time, on a multi-party digital book. By using Smart Contract-technology, the customer could automatically pay the invoice after the computer has confirmed the reception of the goods and the existence of sufficient funds in the bank account. Blockchain is one of the technologies that, we could say, goes beyond the technical, financial market and the regulatory challenges.

The Blockchain technology itself can be seen as an ***accounting-based technology***. Through this technology, assets, liabilities, transactions are recorded and stored, allowing the use of methods of recording cash flows and reconciling the accounts. The accounting industry has, so far, relied mainly on paper supports and, sometimes, even on cloud-based technologies to perform accounting functions and transactions and to ensure that the regulatory requirements are met.

These procedures are, of course, cumbersome, but the *auditors* – in order to provide the assurance „certificate" – request paper-supporting documents as the accounting transactions are reviewed.

4. The current attraction of the Blockchain technology in the business environment

The Blockchain technology has the potential to support entire industries, as the financial sector may undergo the largest and most disruptive changes. Although this technology has attracted the attention of many of the largest financial institutions, the cases in which it is used are still in the experimental phase.

In this context, the present paper presents the advantages of the Blockchain technology for ***specific cases of using it in the audit engagements***.

[1] Enterprise Resource Planning (ERP) is an integrated management resource for all processes and operations within a company, within a single IT platform.

4.1. The current state of the accounting technology

The digitalization of the accounting system is still at the beginning, compared to other industries, some of them being strongly affected by the advances of technology. Some of the reasons may find their correspondent in the exceptionally high regulatory requirements regarding validity and integrity. The entire accounting system is built so that counterfeiting is impossible or at least very costly. To achieve this, it relies on the mutual control and verification mechanisms, which inevitably affect the daily operations.

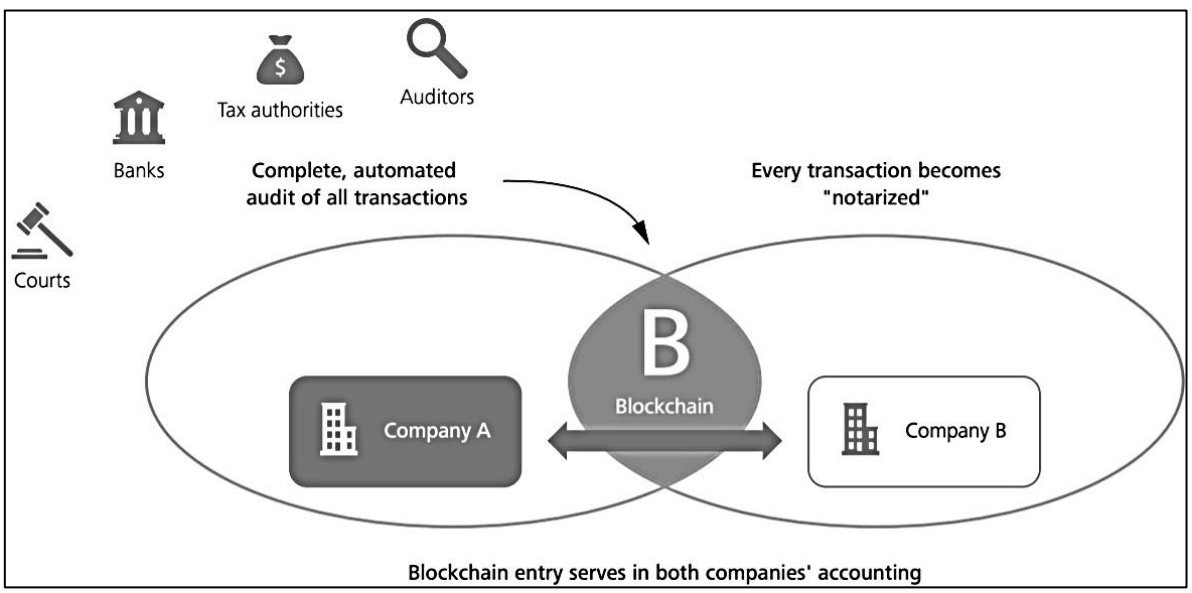
Among the disadvantages, we mention: systematic duplication of the efforts, extensive documentation and periodic checks. Most of them are manual, intensive tasks, far from being automated. So far, this has seemed to be the sacrifice of the disclosure of the accounting truth. Blockchain, a recent release, is a *distributed, trustless registry*[1], *available in an open system* and *with negligible user costs*.

Using the Blockchain for accounting is extremely promising – from *simplifying compliance with regulatory requirements* and *improving double entry accounting*, anything is imaginable, including the ***triple record***, respectively the *auditor's intervention*.

4.2. The huge leap: how Blockchain can improve today's accounting practices

Modern financial accounting is based on a dual entry system, this type of accounting record revolutionizing the field of financial accounting during the Renaissance and solving the problem of managers who began to trust their own accounting records. However, to gain the trust of all stakeholders, the independent external auditors also verify the financial information of the company (***Figure no. 2***).

Figure no. 2. The attribute of Blockchain technology to enable complete and conclusive verification

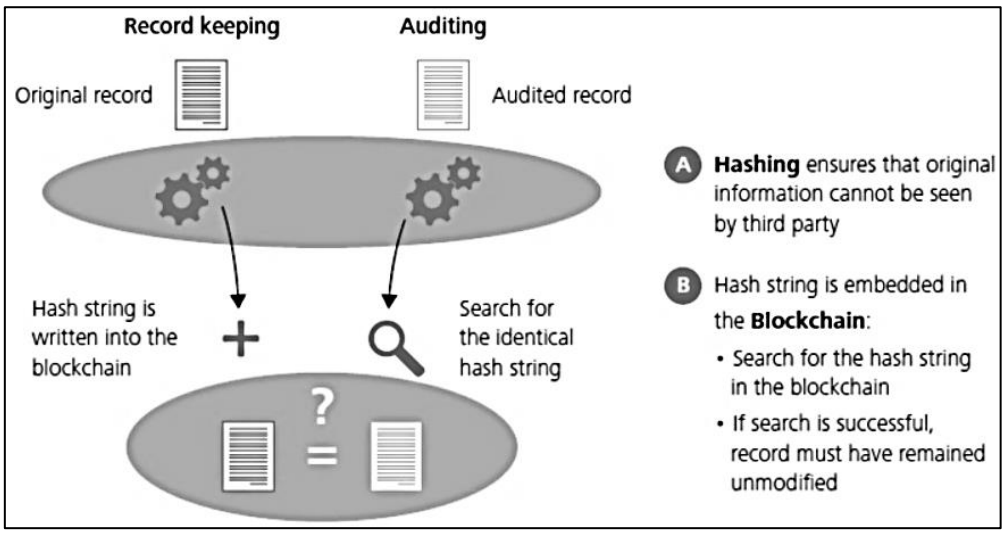


Source: Deloitte (2016)

Blockchain technology can be the next step in accounting (***Figure no. 3***).

[1] Blockchain does not actually eliminate trust. What it does, however, is to minimize the amount of trust needed by every single actor in the system. This is achieved by distributing the trust between various actors in the system through an economic game that stimulates the actors to cooperate with the rules defined by the protocol. Perhaps a more accurate way of describing Blockchains is not "trustless", but built on ***distributed trust***: *"we trust everyone in the aggregate"*.

Figure no. 3. Verifying the integrity of the accounting records through Blockchain



Source: Deloitte (2016)

Thus, instead of keeping separate records based on supporting documents, companies can record their transactions and operations directly in a *common register*, creating a *system for interlocking long-term accounting records*. Because all entries are distributed and sealed cryptographically, falsifying or destroying them to hide the activity is virtually impossible. It is similar to the transaction verified by a notary – only electronically.

Companies would benefit from several points of view:

- ✓ *standardization* would allow *auditors* to *automatically* verify much of the most important data behind the financial statements;
- ✓ the *cost* and *time* required to carry out an audit engagement would be significantly reduced;
- ✓ the auditors could allocate the *saved time* to *areas* where they can create *added value* (e.g. very complex transactions or internal control mechanisms).

These advantages will be addressed to in the following.

4.3. The first steps to the Blockchain-based accounting

It is not necessary to start with a common register for all accounting records. Blockchain, as a reliable source, can also be extremely useful in today's accounting structures, and can be gradually integrated with the typical accounting procedures: from ensuring record integrity, to completely follow-up audit trails. At the end of the road, the fully automated audits could become a reality. The result is a wide range of organizational, technological and procedural orders. All the preventive measures must be documented conclusively for third parties. Surprisingly, although aware of the many benefits, many companies are extremely reluctant to introduce a holistic electronic filing system.

Using the Blockchain makes it easy to prove the integrity of the electronic files. One approach is to generate a ***"hash"*** string of the file, which, in fact, represents the *fingerprint of that file*. Next, the fingerprint is immutable/timestamped with the help of a transaction on the Blockchain. At any given time, the integrity of that file can be proven by generating the fingerprint again and comparing it with the fingerprint stored on the Blockchain. If the fingerprints are the same, the document has remained unchanged since the first writing of the hash on the Blockchain.

Timestamping can be carried out at any point in the life cycle of documents and makes any subsequent organizational, technological and procedural provisions to be exceeded. Preferably, the fingerprint should be chronologically marked immediately after the electronic

document is created, even before the document is sent from the issuer to the recipient, thus being able to exclude the risk of modifying the document throughout its life cycle. For archiving the document, regular data repositories/ archives can be used, as integrity can be easily proven.

To extend this concept, the life cycle of each accounting event, including all the relevant documents, can be represented on the Blockchain. Whole business processes that span multiple departments or companies, thus, become easy to follow. Finally, the Blockchain technology allows for ***Smart Contracts***, that is, computer programs that can be executed under certain conditions (e.g. an invoice that "pays itself" after verification that the delivered goods have been received as specified and that sufficient funds are available in the bank account of the company).

The Blockchain technology has the ***potential to model the nature of the current accounting***, and can be a way to largely automate the accounting processes in accordance with regulatory requirements. As described above, there are many starting points for using the Blockchain technology. There will probably be a cascade of new applications, which are built on top of each other, leading to new, unprecedented services.

Beyond the changes in the accounting techniques and information systems, the *inevitable consequences of the Blockchain on the accounting and financial functions in business* (**Iansiti & Lakhani, 2017**), respectively *on transactions and external auditors* (**Dai & Vasarhelyi, 2017**), have been examined, which should lead us to reflect on the ***skills of the professionals*** who carry out these activities. Blockchain can be expanded extensively by attacking areas other than the area of receivables and payables accounts. Thus, **Dai & Vasarhelyi (2017)** discuss how the "block" of links, together with the Smart Contract-technology, could be used to automatically initiate the performance-based compensation based on predefined criteria. They also analyse how the "block" of links could be used to automate the revenue recognition based on algorithms and data from specific activities recorded in the "block-chain" system.

The Blockchain operations are marked with time data and are immutable, so the *auditors would benefit from track records and automatic transaction authentication*.

Deloitte notes that the standardization created by the Blockchain could allow the auditors to automatically check the large number of transactions underlying the financial statements. For example, if the complete inventory activity data are recorded in a "block" system, the auditors could determine the balance of the remote and real-time stocks.

As a result, auditing would evolve significantly, allowing the auditors to spend more time on the ***value-added analysis*** sessions, such as *predictive analysis*, *foreseeing internal control improvements*, and *other areas that require human reasoning and complex problem-solving*.

Thus, if the Blockchain as it is, does not allow the reduction of accounting operations, the implementation of Smart Contracts could allow this, especially if they are related to connected objects. Indeed, the recurring transactions with suppliers and customers could be easily managed by this technology. The simple validation of the logistics service, for example, could allow cascading of these Smart Contracts. The automation of these tasks could continue to allow valuable time and work to be avoided within the accounting services: errors in the invoice numbers, transfers of the amounts that do not correspond to the invoiced amounts, and so on.

The nature of the "block" will ultimately allow an evaluation in continuous financial documents (**Degos, 2017**). This should be profound, affecting the activity of the accountant and corporate financier, both in its tasks and in its annual planning.

Transactions that are impractical to reverse would *protect the sellers from fraud* and the *routine escrow mechanisms* could be easily implemented to *protect the buyers*. Therefore, we pay attention to the aspect of *double spending* by using a time-distributed platform as a time server to generate a computational proof of the chronological order of the transactions.

The system is safe as long as the honest nodes are group-controlled, allowing more power for the accounting professionals than any other cooperating group of attack nodes, i.e. PayPal.

The skills of the accountant and of the auditor *will also have to be extended both at the application level but also in relation to adaptability*. The students and the accounting professionals will have to adopt the perception that technology will permanently change their skills and redefine their new roles.

When the frequent paradigm shifts become the norm, education and research will need to change at the same

time with them, the current trends including progress on ***Big Data***, ***progress on the automatic data capture*** and the apparition of ***on-going auditing/continuous audit***. All this allows more informed decisions to be made, but managing and analysing these data will require increased statistical skills and an ability to understand the business processes, both of which can be developed and taught at the academic level. Although the automatic data capture offers several advantages – speed, accuracy, width and accessibility – ***without a human ability to generate adequate rules for reporting exceptions, aggregation and other important decisions***, the benefits of automation will be lost.

The continuous audit, which can be seen as an evolution of the two trends mentioned above, can lead to increased assurance, but only if it is managed by the auditors who add benefits through their analytical skills, not through a capacity to perform sampling labour-intensive manual and the activity of collecting data from the old auditors.

The potential impact of the fourth industrial revolution on the level of the auditor profession, determines us to appreciate that today's audit could undergo significant changes due to the new technologies promoted by this revolution, which could be manifested in the form of an *audit evidence collection, valid in real time (just-in-time)*, and could allow *permanent monitoring of all transactions*.

4.4. Databases, ERP and Blockchain

Since 2009, Blockchain has served as a major disruptive piece of information, the technology it relies on being prized as revolutionary as the Internet (**Swan, 2015**). Initially it was developed as a methodology for recording the crypto-currency transactions, its functionality being taken over by a large number of applications, such as banking services.

Comparing the Blockchain with the existing approaches could help us illustrate the benefits of this emerging technology. Databases are the most explored and the most widely used in the context of registration and organization of the applications on a large-scale. The distributed databases are especially comparable to the Blockchain, as both systems rely on multiple computers for the operating and maintenance procedures. **Peters & Panayi (2015)** emphasized that Blockchain helps to avoid conflicts that occur when multiple changes are made simultaneously by different computers in the distribution in the database system.

In our opinion, the **advantages** include the ability to create self-execution contracts, but also to ensure the security, confidentiality and integrity of data stored in these registers.

ERP systems are among the most important innovations in the use of corporate databases, an ERP system representing pre-equipped business software that offers an integrated solution for the organization's information processing needs. ERPs are usually built on basic relational databases.

Blockchain is considered a new type of database that has the potential to play the role of the accounting module in an ERP or to be used in conjunction with the existing accounting information system. Unlike a regular ERP, which is usually organized in a centralized architecture, the Blockchain distributes the power of the verification, storage and organization transaction to a group of computers.

We believe that smart factories will use a completely new approach to production, in which the intelligent products are identifiable and can be tracked with the capacity for self-awareness and optimization, and all manufacturing systems are connected vertically with other business processes and horizontally with the affiliated parties outside the factory.

Industry 4.0, as we highlighted above, is, in itself, a concept that encompasses the technologies and concepts of **organizing the value chain**. Within the modularly structured smart factories, the physical processes are monitored, a virtual copy of the physical world is created and decentralized decisions are made. In addition to IoT, the cyber processes and systems communicate and cooperate with each other and people in real time. Through **IoS** (**Internet of Services**), both the internal and the cross-border organizational services are offered and used by the participants in the value chain.

The fusion between the physical world and the virtual world is possible on the basis of the cyber physical systems that represent integrations of computing processes and physical processes. The embedded computers and networks monitor and control the physical processes, usually with feedback loops where the physical processes affect the calculations and vice versa. The first generation of cyber physical systems

includes identification technologies such as labels that allow unique identification.

Storage and analysis should be provided as a centralized service. The second generation of cyber physical systems are equipped with sensors and actuators with a limited range of functions, and the third generation can store and analyse data, being equipped with several sensors and actuators and being compatible with the network.

Example:

An example of a cybernetic physical system is ***Würth's Intelligent Basket (iBin)***, which contains a built-in infrared camera module for managing parts and which determines the quantity of iBin parts. If the quantity falls below the safety stock, iBin automatically orders new parts. This allows the management of parts based on real-time consumption (**Günthner et al., 2014**).

Industry 3.0 was characterized by predefined material flows based on predefined standardized processes, the intra-logistic system being based on a centralized and complex material flow of material architectures. On the other hand, within Industry 4.0, the regulation and reconfiguration of the flow of materials imposes, at any point in the course of the materials, the existence of some decentralized control systems and taking of hybrid decisions. The intra-logistic system, in this case, consists of functional units (entities) through the cooperation of transport modules, transport units and services (software).

The challenge is the *real-time configuration, the control and decision-making based on intelligent logistics entities*.

With the increasing automation of accounting information in the modern business world, ***most accounting standards should be incorporated into software and systems*** that implement and execute the recording process, as **Krahel (2012)** has also pointed out. In this context, *Smart Contracts* could play an important role in codifying of the accounting rules and autonomously recording of the transactions that meet certain accounting standards.

Knowledge and understanding of computer systems are becoming increasingly necessary tools for the auditor and the *professional training* will have to deal intensely with this need. With the evolution of technology, ***the nature of the audit's assurance function will change***. The small samples, the evaluation of physical documents and the evaluation of punctual historical value over time do not offer much value for the company or for the investors. This regards *a new form of measurement and assurance functions, mainly automatic, perspective-based and complementary to business controls and, in many cases, highlighting the preventive* ***needs***.

Audit can be both ***reactive*** and ***predictive***, which makes us reflect on the new forms of manifestation of the audit works compared to the traditional forms.

5. Audit evolution – from a traditional audit to a "smart" audit

The current audit methodologies provide:

1) sampling of transactions and operations in order to collect audit evidence regarding the risk of material misstatement;
2) a retrospective audit approach; and
3) an annual, point in time, audit opinion.

In the modern economy, where databases store thousands of daily transactions that can be exposed to cyber security attacks, it is essential that the traditional audit model evolves, as the audits of financial statements become automatically progressive and predictive.

Therefore, it is essential for the external auditors to consider the *impact of the sophisticated audit analytics*, as well as of *other emerging technologies*, including the Smart Contracts and Blockchain, in order for them to remain relevant and continue to create added value for the public interest, by providing high quality audits in a complex ecosystem. As the economic entities continue to adopt the Smart Contracts and Blockchain and improve the efficiency of the business processes (**Tapscott & Tapscott, 2016**), it is important for the external auditors to understand the opportunities and challenges these technologies offer (**Dai & Vasarhelyi, 2017**; **Rozario & Thomas, 2017**).

Currently, the auditors have the option of developing ***in-house data analytics tools*** or purchasing data analytics tools from the audit software providers.

Additionally, the *integration of several analytical audit tools* would be needed to respond to the stakeholder requests for a more transparent, timely audit reporting (**Romero et al., 2012**; **No & Vasarhelyi, 2017**).

As a result, although these analytical audit tools could be uploaded to the cloud by the auditor and made available to the stakeholders, saving the results of the near-real-time audit procedures in the cloud could prove to be an extremely difficult task. As the audit planning requires multiple cost-benefit assessments (including the accounts that should be examined, the nature, the timing, and the extent of the audit procedures, etc.) (**Louwers et al., 2013**; **Badertscher et al., 2017**), it is very likely that moving to a reporting ecosystem for cloud-enabled analytical audit tools will not be possible from a cost-benefit point of view.

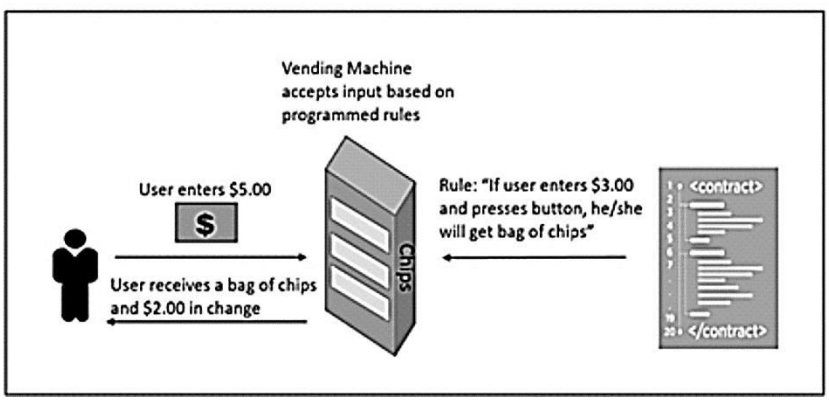
Given the inherent complex dimensions of adapting the existing technologies to reflect a more proactive and transparent audit model, it is essential to consider the implications of the *smart contract-based audit analytics* (hereinafter ***Smart Audit Procedures***). Essentially, the Smart Contracts on a Blockchain created by the external auditor can facilitate the execution of audit procedures and, at the same time, provide real-time audit reporting, but also more transparency to the stakeholders (**Rozario & Thomas, 2017**). Thus, the conceptualization of Smart Contracts is expanded to include Smart Audit Procedures to assist the external auditors in providing more efficient and effective audits.

Smart Audit Procedures are autonomous audit procedures, including *autonomous internal control tests* (hereinafter referred to as ***smart control tests***) and *autonomous analytical procedures* (hereinafter referred to as ***Smart Analytical Procedures***), which are implemented on the Blockchain of the external auditor. Conducting Smart Audit Procedures on the distributed Blockchain registry would bring close reporting in time to the stakeholders, such as the key investors, the suppliers, the audit inspectors, the SEC and the audit committee. As the Blockchain provides a platform for performing Smart Audit Procedures and near-just-in-time audit reporting, these new audit procedures have great potential to improve the audit quality, allowing the auditors to more effectively execute the audit procedures, and, as a result, to allocate more resources to the higher risk areas. Finally, since the Smart Audit Procedures would be distributed to participating nodes on the auditor's "block" of audit almost in real time, this would lead to meeting the needs of more transparency and timelier, just-in-time audit reporting.

5.1. The relevance of the Smart Contracts and Smart Audit Procedures in the context of the Blockchain for audit

Smart Contracts were first introduced by **Szabo (1994)** as a "computerized protocol of transactions and operations that execute the terms of a contract", including the implementation, execution, verification and performance stages of the contracting process. Szabo describes Smart Contracts using the example of a vending machine to describe their efficiency in the real world, as we can see illustrated in the ***Figure no. 4***.

Figure no. 4. Illustration of a smart contract – an example of a chips vending machine



Source: Own projection, after Szabo (1994) and Rozario & Vasarhelyi (2018)

Example:

Thus, a vending machine is a Smart Contract between a customer and a seller and it is designed to accept a set of inputs (based on predefined rules) and outputs, that is through the transfer of ownership, if these rules are respected. The customer would enter a specified amount of money and select a product, respectively, in this case, the customer would enter 5.00 lei to buy a bag of chips that cost 3.00 lei. The Smart Contract will activate and look for the respective product and the related price. If the product is found and the price is equal to or lower than the monetary amount provided by the customer, the Smart Contract transfers ownership of the product by releasing it to the customer and returning the difference between the price of the product and the amount provided by the user (if the money provided by the user customer exceeds the price of the selected product). As a result, the distributor releases a bag of chips and the remaining 2.00 lei to the customer, and the transaction between the seller and the customer is settled. Obviously, if the product is not found or the money provided by the user is not sufficient to purchase the product, the transaction cannot be completed **(Szabo, 1994)**.

Although an innovation in the early 1990s, the Smart Contracts did not flourish during that period, precisely because there was a need for a trusted third party, authorized to monitor the terms and execution of coded contracts, which presents the risk that a contracting party would not fulfill the contractual obligations, as **Kiviat (2015)** also observed. However, with the help of Blockchain technology, the execution of Smart Contracts becomes possible as the supervisory responsibilities are distributed to the participating nodes (**Buterin, 2014**; **Dai & Vasarhelyi, 2017**).

Thus, we consider the ***advantages of Smart Contracts on Blockchain*** as the following:

1) *disintermediation* – because it is not necessary to pre-emptively select a trusted central authority;
2) *trust in an untrustworthy environment* – given that the information is encrypted and visible by everyone on the Blockchain;
3) *mitigating the risk of fraud or human error* – as the Smart Contracts make accurate calculations; and
4) *process efficiency* – because the Smart Contracts are self-executing.

As a result, Smart Contracts are simply *software agents that automatically execute tasks on the Blockchain based on predefined conditions that mimic the actions of a human user* (**Nwana & Ndumu, 1999**; **Vasarhelyi & Hoitash, 2005**). Research on software agents preceded research on Smart Contracts and Blockchain, as they emerged in the 1980s (**Nwana & Ndumu, 1999**) in order to develop computer programs that assist the human user in monitoring events or performing tasks (**Maes, 1994**).

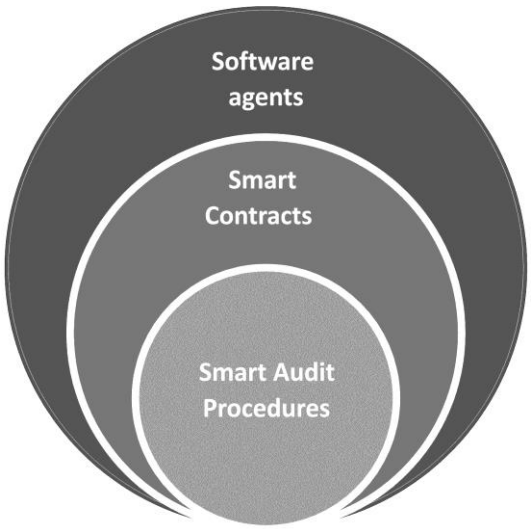
Therefore, it is natural to expand the definition of the Smart Contracts to represent a variety of computer programs that contain predefined rules and perform tasks, based on these rules.

Although there are general applications for Blockchain Smart Contracts, including the automatic settlement of financial derivatives and the secure transfer of securities (**DeCovny, 2015; Fanning & Centers, 2016**), *the applications for the audit domain remain unexplored*. Applied to the field of the external audit, *the definition of the Blockchain Smart Contracts is expanded to include the* ***Smart Audit Procedures*** (e.g., the analysis of audit evidence) that are performed independently on behalf of the auditor in order to improve efficiency, effectiveness and satisfaction in relation to the informational needs of the stakeholders regarding more transparent and timely audit reports. The ***Figure no. 5*** shows the aforementioned links between software agents, Smart Contracts and Smart Audit Procedures.

Each year, PCAOB releases information on the current year's inspections that highlight the audit areas in which audit firms were deficient, these areas including: the internal control over financial reporting, the validation of fair value estimates and the response to significant risks of misstatement (**PCAOB, 2017**).

Applied to audit, the ***benefits of the Smart Audit Procedures*** are imminent, as they can help reduce the gap in the expectations that currently exist between the procedures that auditors already perform and the procedures that audit quality inspectors and regulatory authorities expect them to carry out.

Figure no. 5. The intercorrelation relationship „software agents – Smart Audit Procedures"



Source: Rozario & Vasarhelyi (2018)

On the external auditor 's Blockchain, Smart Audit Procedures can be developed based on the audit procedures that are agreed with the audit inspector. Essentially, these Smart Audit Procedures would be analysed by the inspector to reduce the waiting time gap, while allowing proactive audit inspections, given the fact that both the auditors and the regulators have the opportunity to proactively address precisely those areas where the audit firms have deficiencies. Once a consensus is reached, the Smart Audit Procedures would be uploaded to the Blockchain, and the external auditor would invoke these procedures, submitting relevant audit evidence. Smart Audit Procedures and their results would be visible to the external auditor, as the owner of the audit blockchain, but also to the audit inspector.

Just as important, the stakeholders, including the SEC, the key investors and the audit committee, could have limited access to review the aggregate results of the Smart Audit Procedures, with an emphasis on all error messages (a.k.a. „red flags"), which can be indicators for notable elements (**Alles et al., 2006**; **Issa & Kogan, 2014**); therefore, the expectation difference between the auditors and the users of financial statements will be reduced in a fast and modern economy. Additionally, reviewing the results of the Smart Audit Procedures would allow the SEC to follow a proactive approach by monitoring the audit clients who may require inspection or by identifying the potential indicators that may signal an economic crisis. Collectively, conducting Smart Audit Procedures on the Blockchain has the potential to improve audit quality and to respond to the stakeholders' requirements.

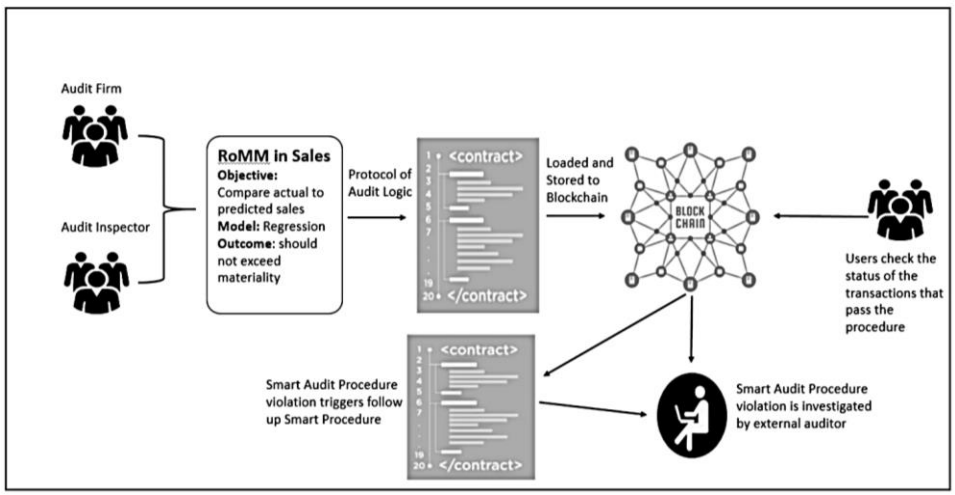
For example, the external auditor and the inspector would agree to the predefined audit procedures in order to address the risk that the shipped goods would not be accurately recorded. These predefined procedures would be broken down into "IF-THEN" rules by the audit firm, for example, and be incorporated into a Smart Analytical Procedure that is uploaded to the external auditor 's Blockchain and is pre-approved by both the audit firm and the inspector (**Rozario & Thomas, 2017**).

In this regard, the description of a Smart Analytical Procedure to address this risk is presented in the ***Figure no. 6*** and would consist of:

1. *a rule to predict the current weekly sales* based on a trained *multivariate regression model* that incorporates financial and non-financial parameters (including weekly sales, location and previous week temperatures); the multivariate regression model will be re-trained and re-tested, as more data would be collected each time the auditor approaches the smart procedure;

2. *the expected sales* from the multivariate regression can then be used as *a reference or a benchmark* to compare current sales (**Yoon, 2016**). The "IF-THEN" logics can express that, if the current sales are equal to/lower/greater than/up to 5% of the total value, then no other audit procedures are required and the auditor is able to quantify the risk of material misstatement for revenues. If the entry (i.e. current sales) does not meet the scheduled rules, an error message will be displayed indicating that further investigation is required.

Figure no. 6. Example of a Smart Audit Procedure – Solving the risk of material misstatement in Sales



Source: Rozario & Vasarhelyi (2018)

On one hand, the external auditor can then propose alternatives for processing these error messages. The first alternative involves generating a Smart Follow-up Audit Procedure that interacts with the aforementioned Smart Analytical Procedure. The rules programmed in this smart follow-up audit test would include rules that reflect risk filters which segregate transactions with errors that would require the auditor's attention. An "IF-THEN" condition that indicates if sales increased as a result of the season, for example, would discriminate against those sales transactions that increased for legitimate reasons compared to those transactions that increased for unverifiable and potentially fraudulent or misleading reasons, which would, of course, require investigations by the external auditor.

On the other hand, error message processing is not required to be autonomous; therefore, the external auditor may choose to manually check those transactions that have been signalled by the Smart Analytical Procedure, although this may lead to the problem of "exceptional exceptions", which may already be evident due to the more sophisticated analytical tools that are executed outside the Blockchain (**Issa & Kogan, 2014**). On the external auditor's Blockchain, the audit inspector has the ability to proactively inspect the results of the Smart Analytical Procedure, because he can access the procedure and the status of the transactions that are subject of the procedure almost in real time. In addition, the SEC, the key investors and the audit committee may view the results of this procedure and make a revenue valuation (if no additional procedures are required) or may make a preliminary assessment in the scenario in which error messages need to be processed.

An illustration of a Smart Analytical Procedure has been described above, however, it is important to mention that simpler, but also new, Smart Audit Procedures can be developed further on. For example, since Blockchain allows the secure tracking and monitoring of different Internet of Things (IoT) devices, the audit firm can design an internal control test to verify the actual location of the goods and compare it with the expected

location of the goods (**Dai & Vasarhelyi, 2017**; **Rozario & Thomas, 2017**) to assess the risk of the goods being shipped to the wrong location. As economic entities have begun to explore the Blockchain and IoT synergies (**IBM, 2017**), it is reasonable to infer that auditors should design *new audit procedures to help them assess the risk of the material misstatement* in *more precise manner*.

5.2. The processing reasoning – a new form of audit evidence

Processing Reasoning is a promising tool that is useful at different stages of the audit process, especially for the internal control tests.

The data stored in the event logs provide the auditors with abundant information that could serve as additional audit evidence when conducting control tests or other audit procedures. Additionally, the event logs are automatically logged into the IT system when business activities or processes take place and are, therefore, less likely to be modified or distorted.

It is worth noting that the use of reasoning applied to processes in the case of the audit procedures is still in its infancy and there are many challenges for both the auditors and the management. For example, not all companies are willing to keep records of the entire event log for each business cycle, because storing the event logs could use a large amount of disk space and slow down the IT system. In this case, if the company does not record a part of the event log for an economic cycle, then the information extracted is incomplete and cannot be used by the auditors. Therefore, the auditors must ensure that the information they use for the process analysis is complete and accurate.

The tool would, thus, facilitate payments, information exchange, introduction of business partners and banks, as **Coyne & McMickle (2017)** point out, in a new degree of partnership using the connected accounting, using the Smart Contracts to constitute what is designated as a ***true digitized accounting ecosystem***.

The concept of ***Smart Accounting*** refers to the *Smart Contracts*, computer programs used by the "smart" companies that take full advantage of opportunities such as Blockchain technologies. These programs are qualified as "intelligent", as we pointed out at the beginning of our research, because they are capable of operating autonomously in order to check the conditions of their accomplishment and to trigger them as appropriate. The recent development of this technology allows the decentralization and the assurance of these Smart Contracts – an impossible task to do until that date – making their use possible in the professional activity.

Beyond simple contracts, these software programs can be coded to perform a set of operations depending on the specific conditions. These can be used, for example, as an *automatic control tool, an accounting operations supervisor according to standardized procedures*.

The program then verifies that the accounting record meets the predefined conditions and standards. They may also be scheduled to initiate specific accounting procedures when certain criteria are met. The Smart Accounting, therefore, allows the automation of the accounting operations, test of controls and secure procedures.

This path of technological use is gaining momentum in the current environment of connected objects that may resonate with these softwares.

The processing reasoning is also closely related to the ***Internet of Things (IoT)*** concept, discussed above, a recent concept that evokes the *connectivity of many physical objects within a virtual environment, the use of the RFID4 markers* (radio frequency identification), *sensors* or other elements which allow the internal connection, as observed by **Atzori et al. (2010)**.

This interconnectivity allows us to imagine a true synergy with the Smart Contracts, so that we can say that the operations related to the physical elements (sale of goods, stocks, production, etc.) are automatically integrated into the accounting and allow the initiation and execution of the accounting procedures in the Smart Contracts. Hence, we can say that *smart accounting can be connected directly to the physical environment of the organization*.

Due to the connectivity of the aforementioned physical objects and the automation of the accounting through smart accounting, we mention the ***possibility of benefiting from an accounting near a real-time update (just-in-time accounting)***.

Just-in-time accounting would allow an instant dissemination of the accounting information to the stakeholders (such as managers, but also accountants or shareholders of the economic entity). They could then manage the financial performance of the company, by

analysing the changes, in order to obtain alerts for reaching the thresholds and respecting the consequences of the specific operations.

Thus, we see the emergence of a ***Smart Connected Accounting System***, *connected to all the stakeholders of the organization*.

This type of system has been called ***Digitalized Accounting Ecosystem***, concept introduced by **Dai & Vasarhelyi (2017)**. It combines the effects of all the elements mentioned above. By combining different blockchain technologies, the Smart Contracts and the connectivity of the physical objects, it is possible to envision a *transformation of the company's accounting environment*. Accounting data is secure, automated, updated and controlled, a direct recording in the accounting of the "physical" transactions about the company being possible through the connectivity of objects and the execution of Smart Contracts. These allow carrying out of the accounting procedures according to the norms and standards in force, established by the control bodies, consequently, forming, at the same time, a register of access between managers, investors, business partners, banks, audit firms, tax departments etc.

The ***new audit model*** is the one that *continuously monitors and analyses the flow of the accounting data of an organization and the anomalies or exceptions that will trigger alarms* in order to attract the attention of the auditors.

This continuous process of audit services and ongoing monitoring can be offered as online services by the audit firms. Companies will request services on the Internet and such requests will then be correlated with the services that the audit firms can provide. Audit firms will be able to *continually relocate* their audit and permanent monitoring *services* using *models based on the cloud infrastructure*. The anomalies, as well as the related information, will be transmitted to the auditors in order to carry out further investigations and audit tests.

6. The auditor's role – what kind of changes and under what forms do changes of activities and behaviour appear?

In today's business ecosystem, the accounting professionals (in general) and the financial auditors (in particular) are trusted professionals who guarantee the existence of transactions, attest their evidence, accuracy and completeness, as well as assess related information in the set of financial statements (**Hayes et al., 2014**).

To meet these goals, especially in the context of the Blockchain technology, auditors need a good understanding of the client's activity, the IT infrastructure and the IT systems relevant to the controls, but also of the financial reporting.

6.1. Changes in the accounting profession – involvement, behaviour and role

Moving to a financial system with significant Blockchain elements will provide many opportunities for the accounting profession, as the accountants are considered professionals responsible for keeping records, applying and complying with complex regulations, but also respecting business logic and standards.

In order to truly become an integral part of the financial system, a developed, standardized and optimized Blockchain technology will have to be implemented. Thus, this process may take several years (this has already been proven since Bitcoin started functioning) and there is a lot of work still to be done. There are a lot of Blockchain applications and start-ups in this area, but there are still very few that go beyond the proof of a concept or pilot study stage.

The accounting professionals are already participating in the research, tackling the idea and playing the field, but there is so much more for the profession. Preparing the regulations and standards to cover the "blocks" will create great challenges, therefore the most important companies and accounting bodies can bring their experience in these aspects.

The accounting professionals can provide advice to companies considering joining the Blockchain technology, giving them tips on measuring the costs and the benefits of the new system.

Blockchain technology, using a digital register at which transactions are recorded chronologically and can be viewed by all who have access, is expected to affect auditing, as well as the computer security, the financial planning and analysis, but we can realize that it will represent a large and maximum security database that will have multiple uses.

Thus, the business assurance services companies are already feeling the implications for their clients, which will probably determine them in the future to adhere to the "block" implementation modalities in their enterprise

resource planning (ERP) systems, especially for tasks such as purchasing and supply chain management.

✓ *Perspectives in the accounting profession. New professional skills in the future*

The accounting activities with the assurance of transactions and the transfer of property rights can be transformed by the "blocks" and Smart Contracts, respectively through specific approaches. Reducing the time for reconciliation and managing litigation, combined with an increased certainty related to rights and obligations, about how the transactions are accounted for, will allow for an expansion of areas that can be tracked through accounting.

Thus, many elements of operational accounting can be optimized through Blockchain technology and other modern technologies such as data analysis, which will increase the efficiency and added value generated by the accounting function. As a result, we will witness a change in the area of capability of the participants in the accounting firms.

The financial managers will be forced to develop and expand their roles, as they will have to spend more time on reporting. The speed of business is high, and the finance and accounting departments have difficulty in maintaining the pace. Customer's experience will become a key offer in the service industries, and the financial controllers and directors will begin to reorient their departments from cost centres to service centres. They will increasingly take on the role of risk management. Investors will finally start paying attention to the changes in the accounting standards.

In 2018, we ascertained the obligation of the public companies to switch to dual reports. The investors need to be aware that the restatement of income will probably be lower than that previously reported for many companies. As with revenue recognition, the leasing international accounting standard will accelerate the adoption of the ERP cloud, especially as more companies are affected by the old regulations.

Consultancy activities and other added value services will expand. In order to properly control a significant transaction based on the "blocks", the focus of the auditor will change.

It will no longer be necessary to confirm the accuracy or the existence of transactions with "blocks" from external sources, but there are still a lot of issues to pay attention to if the transactions and statements are recorded and recognized in the financial accounting, as well as the statements and the way they are decided as elements of reasoning such as evaluations. In the long run, more and more regulatory authorities with access could check, in real time and with great certainty, the transactions regarding the origin of these transactions.

However, in the end, the "block" will not eliminate the audit or accounting work. Technology is still in its infancy, and until the foundation is stabilized, the benefits of its integration as a substitute for the human intelligence are removed within a time horizon.

The Blockchain technology is expected to become a key element of the modern supply chain management over the next five years, especially in terms of the safety and origin of each product that consumers want to know about.

We are facing controversy in the auditing profession. The accounting professionals (and analysts) have begun to pay more attention to the ***quality*** and ***independence issues in auditing***, and issues of *relevance* may arise. Several companies will pay attention to how the customer relationships are weighed or evaluated by the audit teams. We will pursue a much more critical discussion about what true ***agnosticism*** means in relation to that *relationship* and whether or not there will be *repercussions*.

An important issue is related to the difficulties that cannot allow a rapid adoption and use of technologies in the field of the accounting and audit practice. With the help of new technologies, audit will significantly change the auditor's profession by ***automating the current procedures, extending their scope, shortening the time and eventually improving the overall quality of provided assurance***. This section illustrates the impact of the ***4.0 audit*** on the auditing profession from four perspectives: *standards*, *principles*, *technology* and *auditors*.

On one hand, as we have shown, **Krahel (2012)** discussed the *formalization of audit standards*, arguing that most standards should be embedded and implemented directly in software, in modern computational systems. As a result, the ambiguity in the current audit standards should be replaced

by a formal representation to allow a near-real approach.

On the other hand, the assurance of working time, in the world of the Industry 4.0, will be largely dominated by the formal inter-object protocols, the technical capabilities of the "things" and the objective and functions of the interconnected objects.

The standards and rules could, therefore, be programmed into machines, production lines and products in order to enable the measurement, processing and real-time communication of the financial information. For example, inventories' evaluation would be automated by tracking the actual procurement values, the output obtained being continuously evaluated by collecting real-time data on energy consumption of the production lines and the labour costs.

Thus, many items that were allocated indirectly can now be measured directly. Additionally, the products will independently issue alerts if they are old, outdated, slow moving or damaged, so as to prevent overvaluation of inventories. Such *automation* could *reduce the auditor's time and work* related to the *actual inventory participation with physical observation* and would also *eliminate the labour of manually entering* of the current prices.

6.2. The need for advanced forms of professional training and types of activities reserved for the long-term auditor

Blockchain technology has the potential to affect all the registration processes, including how transactions are initiated, processed, authorized, recorded and reported. Changes in the business models and business processes can affect the back-office activities, such as financial reporting and tax calculations.

Also, independent auditors will need to understand this technology as it is implemented by their clients. Thus, both the role and the skill sets of the external auditors can change as new Blockchain-based techniques and procedures emerge. For example, the methods for obtaining sufficient and adequate audit evidence will have to take into account both the traditional stand-alone registries and the Blockchain registries.

Additionally, there is potential for *greater standardization and transparency in accounting and reporting*, which could allow for more efficient data extraction and analysis.

Thus, the Blockchain technology could bring *new challenges and opportunities* to the audit profession. While the traditional audit services will remain important, the approach of an external auditor may change. As the audit profession evolves today, with audit innovations in automation and data analysis, the Blockchain technology can also have a significant impact on the way the auditors conduct their audit engagements. In addition, the ***auditors may need to expand their knowledge and skill sets*** to meet the anticipated demands of the business world, as the Blockchain technology is increasingly being adopted.

All of the above-mentioned things lead us to the fact that the future of the audit should be discussed by taking into account the financial statements audit engagements that benefit from the Blockchain-type Smart Audit Procedures. Certainly, in adopting the ***4.0 / continuous audit / hybrid audit model*** various *challenges* will be encountered, such vulnerabilities referring to:

1. ***current legal requirements*** related to statutory audit, related to the annual, qualitative and aggregate audit opinion;
2. ***security and confidentiality*** of the external auditor 's blockchain and of the Smart Audit Procedures;
3. Blockchain ***scalability*** and ***flexibility*** of Smart Audit Procedures; and
4. the impact of Smart Audit Procedures on ***professional reasoning and auditor scepticism***.

While the Blockchain technology and the Smart Contracts will both change the way the financial statement audits are conducted and delivered, the external audit profession would thrive in applying these technologies.

Several Blockchain-type Smart Audit Procedures have been proposed, but a number of relevant issues require further research (**Table no. 1**).

Table no. 1. Vulnerabilities of the Blockchain technology in case of an audit engagement

CHALLENGES GENERATED BY THE BLOCKCHAIN	
1. Current statutory requirements	• Is quality assurance relevant when the results of Smart Audit Procedures can be quantified? • Should/could audit reviews, certifications or seals of approval replace the (annual) audit opinion? • How should the legal requirements be changed in order to encourage the real-time (and transactional-level) audit reporting? • Would the concept of materiality change as companies move towards a hybrid audit model? • Could the external auditors provide assurance on the basic information that makes up the financial statements and the Blockchain-type Smart Contracts system? • What are the IT risks (and responses to them) in the Blockchain-type smart contract system that the external auditors should address to?
2. Security and confidentiality of the Blockchain-type Smart Audit Procedures	• How can you limit the access to the results of the Smart Audit Procedures in order to meet different informational needs? • What audit objectives would remain outside the Blockchain and which would not be covered by the Smart Audit Procedures? • Should the customer's confidential information be uploaded to the Blockchain?
3. Scalability and flexibility	• How should the audit firms address the wrong code in the Smart Audit Procedures? • How often should the Smart Audit Procedures be performed? • How will the non-compliance alerts (error messages) be processed in the Smart Audit Procedures? • How should the auditors handle the outdated Smart Audit Procedures? • Should the auditors store worksheets and working papers for the Smart Audit Procedures on the same or within another Blockchain?
4. The impact on the auditor's professional reasoning and scepticism	• Do Blockchain-type Smart Audit Procedures improve the auditors' professional scepticism? • Do Blockchain-type Smart Audit Procedures cause the auditors to over-access these technologies?

Source: Rozario & Vasarhelyi (2018)

In this context, in recent years there has been an intense debate about the ***nature, object and role of financial audit***, respectively of the ***expanded role of the financial auditor*** (**Deliu, 2013**) – especially in the case of using the Blockchain technology, opinions being divided. Some researchers underline the growing need of the auditors to have digital technology skills and abilities (**Raphae, 2017**), while others feel it is imperative that they should turn their attention to the less numerous but value-added activities (**MacManus, 2017**).

Because the Blockchain systems standardize transaction processing across many industries, the financial auditor may be able to provide assurance for the *technology users*, playing a potential future role precisely because of their skills set, independence, objectivity and expertise.

The list of potential new roles for a financial auditor in **Table no. 2** is illustrative and not exhaustive, precisely because of the significant regulatory and professional obstacles highlighted above, which may remain before the auditor has taken on these potential roles.

Table no. 2. Adjacent functions of the financial auditor in the context of the Blockchain technology

	AUDITOR'S POTENTIAL ROLE
i. AUDITING SMART CONTRACTS AND ORACLES function	As described above, the Smart Contracts can be incorporated into a Blockchain in order to automate the business processes. The contracting parties may wish to use the services of a professional who can provide assurance regarding the *implementation of the Smart Contracts in accordance with the appropriate business logics*. Additionally, an auditor *could check the interface between the Smart Contracts and the external data sources that trigger the business events*. Without an independent assessment, the users of the Blockchain technologies would face the risk of unidentified errors or vulnerabilities. To take on this new role, a financial auditor may need a *new set of skills*, including *understanding the technical programming language* and *the functions of a Blockchain*. ⇕ This role raises important questions for the audit profession: – What types of skill sets does the auditor need in order for the audit profession to remain relevant? – What factors would impact the audit risk? – What would the continuous responsibility and extended accountability of the financial auditor entail once a smart contract is released on a Blockchain?
ii. AUDITING CONSORTIUM'S BLOCKCHAINS function	Before launching a new application on an existing Blockchain platform or taking advantage of an existing Blockchain product, the users of the system may want an *independent assurance regarding the stability and robustness of its architecture*. Instead of each participant doing their own due diligence, it may be more efficient to turn to the services of a financial auditor in order to achieve these goals. Additionally, critical elements of the Blockchain (for example, crypto key management) should be designed to include sophisticated general IT controls that provide permanent protection for sensitive information, as well as security processing controls, availability, processing integrity and confidentiality. On an ongoing basis, an independent, trusted third party may be needed to ensure the effectiveness of controls on a private blockchain. ⇕ This type of adjacent services also raises a number of questions: – When offering insurance within a Blockchain, who is the customer? – How would a financial auditor evaluate the audit risk in case of an autonomous system? – How would the independence rules apply to the Blockchain users?
iii. ADMINISTRATION function	The solutions allowed by the Blockchain can benefit from a trusted, independent and unbiased third party to perform the functions of a *central administrator that grants access*. This function could be responsible for the *identity verification* or an additional verification process that must be completed by a participant before being granted access to a Blockchain, with the central administrator *validating the application and monitoring of the Blockchain protocols*. If this function is performed by a user/node of the Blockchain, then there could be an undue advantage and the trust among the consortium members could be weakened. As this role is designed to build trust with the Blockchain as a whole, due care will be needed in

AUDITOR'S POTENTIAL ROLE	
	order to establish its function and legal responsibilities and responsibilities. As a trusted professional, an independent financial auditor might be able to fulfil this task.  However, this role would raise new questions for the profession: – By taking on such an important role, to what extent is the one providing assurance truly independent in relation to the Blockchain participants? – Could the financial auditor perform audits of the participants' financial statements?
iv. ARBITRATION function	Business arrangements can be complex and lead to disputes even between the best-intentioned parties. For an authorized Blockchain, *an arbitration function* may be required in the future *in order to resolve disputes between participants in the Blockchain consortium*. This function is similar to the bailiff, a role usually performed by various qualified professionals. The Blockchain participants may request such a function in order to apply the contractual conditions in case the spirit of the Smart Contract departs from a legal document, contract terms or a letter. Other considerations should be examined to determine whether an arbitration function is indeed necessary.  If the financial auditor wishes to assume this role, he/she will have to answer some critical questions, such as: – What legal framework would be used in order to resolve disputes? – What skills set would a financial auditor need? – Could this role pose threats to independence?

Source: Own projection

The Blockchain technology is part of the rapid digitalization of the business processes; hence, in this context, the audit profession must consider the ***skills that will be needed in future***, so that the financial auditors can respond to the market demands in a business world where the Blockchain technology has been widely adopted.

As such, the audit profession should take into account that the pace of innovation related to this technology is relentless; new classes of digital assets are being created quickly in order to be implemented on the Blockchain. Henceforth, we believe that financial auditors – *as critical providers of professional services that support well-functioning markets* – ***should turn their attention to this subject, in order to help by identifying the risks associated with this new technology and finding ways to take advantage from its benefits***.

Conclusions

Given the recent debates about the relevance of the audit profession (in general) and the quality of the audit (in particular) in a rapidly changing business world, it is important that practitioners, regulators and academics are informed about the recent technological developments that have the potential to disrupt the business ecosystems and, consequently, the audit ecosystem.

In 2016, the **International Organization for Standardization** (ISO) of the **Technical Committee** of the "blocks" was concerned with the creation of "blocks", by developing the **ISO/TC 307 standard „Blockchain and distributed ledger technologies"**[1] . The problem no longer arises as to whether or not this technology will adapt, but rather when and in what forms it will be introduced. The certification groups at an international

[1] https://www.iso.org/committee/6266604.html

level, as well as at national level, will watch for the standardized implementation of these "blocks" and will aim to guarantee security by using these "blocks".

Numerous initiatives regarding the *impact of the new technologies on the financial statements audit* suggest that external auditors are making considerable efforts to respond continuously to a modern and digital economy.

Users of financial statements expect financial auditors to carry out an independent audit of the financial statements, using their professional judgement and scepticism. External auditors conclude if they have obtained reasonable assurance that the financial statements of an entity, taken as a whole, reflect a true image. Blockchain technology is unlikely to replace these value reasonings of the auditors. However, auditors need to monitor the evolution of the Blockchain technology, as these will affect their clients' information technology systems. Thus, external auditors will need to be familiar with the basics of the Blockchain technology and work with experts in order to verify the complex technical risks associated with it.

In addition, we believe that auditors should be aware of the opportunities to support and encourage their clients' adoption of Blockchain technology, precisely to improve the collection of evidence during the audit engagement. They should also consider whether the Blockchain technology will allow them to create automated audit routines.

Among the ***advantages*** of using the Blockchain technology by the financial auditors, we, therefore, list the following:

- ✓ streamlining accounting by reducing costs and through various automations (upon delivery confirmation, automatic payment of invoices);
- ✓ allowing automatic confirmation of transactions with third parties, without the need for their actual confirmation;
- ✓ significant cost reductions;
- ✓ some audit assertions objectives such as existence, occurrence, accuracy and completeness of operations and transactions will be checked automatically.

On the other hand, we also identify a number of ***disadvantages and risks***, which we summarize in the following:

- technology-associated risks (security, human error, overreliance);
- risks of a legal nature;
- money laundering;
- ⊗ increased importance of the internal controls;
- ⊗ higher risk of fraud;
- ⊗ outdated audit procedures.

Audit profession needs to *embrace and "lean" toward both the opportunities and challenges of large-scale adoption of Blockchain*. The auditors are encouraged to monitor the evolution of Blockchain technology because they have the opportunity to evolve, learn and capitalize on the already proven ability to adapt to the needs of a rapidly changing business world.

In our opinion, moving towards a ***4.0/continuous/hybrid audit model*** that includes the Blockchain-type Smart Audit Procedures can improve audit quality, responding much better to stakeholders' informational needs.

✓ *Future research perspectives*

Thus, we will try to conduct a study based on basic theories that will allow us to formulate perceptions about how auditors in Romania could quantify, in an estimative way, the impact of the Blockchain on their daily activities. Auditors' profile will change, and, of course there will be a potential disruptive effect of technology on the profession, being more than likely that we will witness a manifestation of resistance to change from the smaller audit firms that do not seem willing to get involved or make efforts to cope with future changes. Accounting profession will be somewhat threatened, because it will undergo a paradigm shift; it will be due to the fact that the need for the IT specialists is more emphasized than the need for accounting technicians, but the work based on professional reasoning will also imply the need for accounting professionals. This is mainly due to the fact that a prospective follow-up will be needed rather than a retrospective analysis.
With Blockchain, we will move from the trust paradigm of companies or institutions to one based on a decentralized system and dispersed community. This technology raises many issues and involves many participants, both the government and from the private sector, who will be involved in understanding, developing and exploiting this technology.

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