IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Received April 21, 2020, accepted May 12, 2020, date of publication June 8, 2020, date of current version June 25, 2020.

Digital Object Identifier 10.1109/ACCESS.2020.3000505

The Impact of Artificial Intelligence and Blockchain on the Accounting Profession

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This work was supported in part by the National Natural Science Foundation of China under Grant 71790602 and Grant 71702160, in part by the Chinese Ministry of Education under Grant 16JJD790034, and in part by the Chinese Fundamental Research Funds for Central Universities under Grant 20720201020 and Grant 20720201011.

ABSTRACT Recent developments in technology have introduced dramatic changes to the practice of the accounting profession. This paper provides a comprehensive review of current developments in big data, machine learning, artificial intelligence, and blockchain utilized in general business practice and by specialized practitioners in the accounting profession worldwide. This paper explores the evolution of the accounting profession following these recent technological developments and assesses the impact of future developments. Inherent challenges and opportunities posed by these new technologies pertaining to accounting professionals and accounting educators are also examined, including an increased demand for IT professionals with accounting experience as opposed to accounting major graduates. Considering the dramatic changes and developments of AI applications in accounting, this paper reflects how all these technologies and the associated requirements of job candidates will affect the desired capabilities of accounting graduates and provides further discussion regarding what higher institutions and their accounting graduates can do to adopt such changes.

INDEX TERMS Accounting profession, artificial intelligence, big data, blockchain, machine learning.

I. INTRODUCTION

As the ''language of business'', accounting was first established by Luca Pacioli in 1494 [1]. Its main functions are to measure an organization's economic activities and communicate such information to related stakeholders, such as corporate managers, creditors, consumers, and regulators [2]. Recent developments in intelligent automation have introduced dramatic changes to the practice of many traditional professions, including accounting. According to a study performed by the BBC, accountants rank 21st of a total of 366 occupations that are likely to be eliminated due to the introduction of artificial intelligence (AI), with an elimination rate of 96% [3].

Surveys of more than 120 internal auditors from the 2016 and 2017 KPMG IT Internal Audit conferences reveal that nearly half of the representatives confirmed the use of AI by their organizations, at least to a limited extent. However, these surveys also demonstrate that 80% had no confidence in the governance around the use of these technologies, and 70% admitted that they did not know how their auditing methods would be affected [4].

The Big Four accounting firms have recently launched their own financial robots that are capable of automatically recognizing data, entering invoices, and generating financial reports. These financial robots are likely to replace basic accounting clerks, allowing business managers with zero accounting knowledge to make informed business decisions based on basic accounting information [5]. Therefore, it is necessary to investigate the current development of AI applications in the accounting profession. The increased prevalence of AI within the accounting profession is likely to transform current accounting practices and inform the education development of future accountants. AI technologies are widely used in financial distress, financial fraud, stock market forecasting, and auditing [6]. The improvement of accounting

The associate editor coordinating the review of this manuscript and approving it for publication was Nizam Uddin Ahamed.

technical and data analysis skills has received attention from accounting firms [7] and is required in accounting education courses [8], [9].

The main objective of this article is to explore, present, and discuss the applications of AI and blockchain technology in the accounting field, especially the opportunities and challenges of current applications of these emerging technologies in the accounting field, particularly in the development of and education for the accounting profession. The article reviews five AI technologies, including natural language processing, machine and deep learning, artificial neural networks (ANNs), social robotics (human-computer interaction), and computer vision; eleven applications, including Nuance, Cortana Alexa, AlphaSense, TensorFlow, Kensho, Microsoft Cognitive Services, Skymind, IBM Watson, Accenture myWizard, and Clarifai; fifteen financial scenarios, including voice recognition, conversation AI services, phone fraud detection, real-time demand and behaviour analysis, intelligent voice banking assistants, intelligent financial search engines, stock index predictions, public sentiment information management systems, statistical analysis, identification of the withdrawal customer on ATMs, bank fraud detection, tax preparation, intelligent automation strategy, pattern recognition in images, and retailer inventory management; and the underlying framework of blockchain technology and the construction of a blockchain auditing application platform.

The rest of this paper is presented as follows: Section 2 provides a brief introduction of the technologies of big data, machine learning (ML), and AI, as well as their applications in the business (accounting) fields; Section 3 provides a further discussion of the current use of AI by Big Four accounting firms worldwide; Section 4 reviews the concept of blockchain and its current application in the accounting field; Section 5 reflects how all these technologies and the associated requirements of job candidates will affect the desired capabilities of accounting graduates.

II. AN INTRODUCTION TO BIG DATA, MACHINE LEARNING, AND ARTIFICIAL INTELLIGENCE TECHNOLOGIES AND THEIR APPLICATIONS IN THE BUSINESS (ACCOUNTING) FIELD

A. BIG DATA

Big data incorporate four key characteristics: large volume, high speed, huge variety, and uncertain veracity [10], [11]. The term ''big data'' comprises both enormous amounts of data and the data analytic techniques (algorithms) used to analyse these data [12], [13]. Following recent improvements in data storage and analytic capacity, companies are now able to extract business value from data to better understand their business environment, consumers, and competitors. For better accounting, big data are valuable as a source of financial data to support business decision-making.

Big data demonstrably improve decision-making and prediction accuracy [14]. For example, it is now possible to examine unstructured data such as e-mail, telephone, and audit committee meeting materials [15]. Previous literature identifies the use of the wisdom of crowds on social media platforms to detect corporate fraud [16]. In addition, data visualization software can transform massive amounts of data into information that can enhance decision-making processes [17].

Following the widespread adoption of big data, data security has become a serious issue prompting new regulations in many countries. For example, the European Union (EU)'s ''General Data Protection Regulations'' (GDPR) came into effect on May 25, 2018, specifying corporate requirements in protecting users' data, including business use and sharing. Within the EU, the Payment Service Directive 2 (PSD2) addresses concerns about consumer protection, the promotion of innovation, and the improvement of the security of payment services. The UK Competition and Markets Authority is currently implementing a program known as Open Banking, which enables customers to share data securely with other banks and third parties via application program interfaces (APIs) [18].

B. MACHINE LEARNING

Broadly speaking, ML is the science of computers running without being explicitly programmed [19]. It applies a series of statistical techniques, such as mathematical modelling, data visualization, and pattern recognition, to conduct self-learning activities with input data to predict and understand data trends and patterns [20], [21]. Recent applications of ML include corporate revenue forecast analysis and investment decision-making. For example, Two Sigma Investments LP, a New York City-based international hedge fund, works with vast sets of big data from over a thousand diverse sources and uses ML to build powerful investment predictive models [22]. Other applications of ML in the business world include the prediction of consumers' purchase intentions, as widely used by Amazon and Taobao [23].

In the practice of management accounting, ML could assist in transaction classification with the scope of the control function, such as in financial planning and analysis (FP&A). The use of an application of ML technology allows the prediction of transaction classification based on the analysis of historical transactions. However, prediction quality relies on the quality and inherent bias of the dataset being utilized [12]. An example of transaction classification is an e-mail communication tool that classifies marketing and promotion to consumers as ''advertising expenditure'' and employee communication as ''IT or communication cost''. ML technology can be trained to recognize the difference and clarify each category with a pre-set algorithm. In the practice of tax administration, the Guangdong Provincial Taxation Bureau adopts ML approaches to identify suspected fraudulent tax practices [24].

C. ARTIFICIAL INTELLIGENCE AND SUPPORTING TECHNOLOGIES

AI is the outcome of successful applications of big data and ML technologies to understand the past and predict the future based on enormous data [19]. Table 1 records selected applications of AI, followed by a further discussion of AI applications.

The **Nuance** security suite filters every call and compares voice characteristics, including tone, rhythm and accent, to a voice digital library associated with bank fraud. The software can quickly flag suspicious calls and alert agents in call centres to a possible fraudulent attempt [25].

Cortana is Microsoft's personal intelligence assistant. It can connect with users in real time to analyse their needs and behaviours in order to help them manage assets efficiently and conveniently [26].

Alexa is Amazon's personal intelligence assistant that can activate the user's workplace and application via voice. It also provides guests with easy access to the service via voice. Amazon has teamed up with banks to give users voice access to their bank accounts [27].

AlphaSense is an intelligent financial search engine that helps professionals who need to cope with large amounts of data solve the problem of information overload. It provides access to proprietary research databases and includes semantic knowledge of the financial language and correlation analysis to unlock valuable hidden information. AlphaSense collects millions of documents, including regulatory filings, company profiles, news, press releases, Wall Street research reports, and other uploaded files [28].

TensorFlow was developed and is maintained by Google Artificial Intelligence Team Google Brain, a symbolic mathematical system based on dataflow programming that is widely used in the programming implementation of various ML algorithms. TensorFlow can be applied in stock index prediction [29] and public sentiment information management systems [30].

Kensho is a leading real-time statistical computing system and scalable analytical architecture dedicated to providing market transparency to financial institutions through advanced technology. Kensho leverages massively parallel statistical computing, user-friendly visual interfaces, and breakthrough technologies in predictive analytics to provide investment professionals with the next generation of analytics platforms [31].

Microsoft Cognitive Services gives every developer access to AI without the need for ML expertise. With just one API call, it can analyse the contents of images, customize image recognition to meet business needs, and detect and identify people and emotions in images [32].

Skymind uses AI technology to automatically adapt to new behaviour, using untapped data sources to detect fraud cases. Skymind builds and trains a neural network that uses historical transaction data to score new transactions based on their likelihood of fraud. Human analysts are used to review risky trades, and the results are fed back to the neural network to improve detection efficiency [33].

IBM Watson uses 10,634 documents and was trained by 13 tax experts on five different development models. After training, Watson suggests the correct tax treatment three out of four times. Tax professionals use Watson to improve customer service and identify deductions and deductions [34].

The **Accenture myWizard** intelligent automation platform embeds advanced analysis, insight, and automation capabilities, and enterprises combine business process-led application outsourcing services with problem management, intelligent knowledge management, and system stability routines. Enterprises reduce costs and increase productivity by implementing a comprehensive intelligent automation strategy [35].

Clarifai is used in combination with a camera system to calculate the number of items left on the shelf through item detection and identification and thereby understand the selling speed of commodities. For example, if there is too much of an item on the shelf compared to the remaining quantity of the item in stock, it is time to eliminate it, and if it is out of stock, it is time to increase the order quantity [36].

D. ROBOTIC PROCESS AUTOMATION

Robotic process automation (RPA) is a repetitive and automated process developed from AI technology [37]. It can be used to imitate human behaviour, send e-mails, complete spreadsheets, and record and re-enter data for other tasks. It functions on the basis of prescribed procedures and is incapable of discerning changes in conditions, such as the external environment. By 2020, it is estimated that more than 40% of data science tasks will be automated, resulting in increased productivity and broader usage by citizen data scientists [11]. PwC's 2017 RPA survey found that 30% of respondents have at least begun incorporating RPA into their businesses [38]. While the decision to adopt a joint or centralized operational model is a function of organizational culture, Ernst & Young (EY) suggest six key components required for most traditional RPA operational models, including vision and standard setting, identification of RPA application scenarios, performance value measurement with adjustment, raising awareness and training, and integration across the whole platform [39].

A major application of RPA in the accounting field is related to taxes. For example, following the creation of automation software, robots are configured to perform repetitive processes, such as submitting applications to a tax authority portal. Tax automation can free up corporate tax teams to focus on higher-value work, such as research, planning, and analysis. Figure 1 illustrates several RPA applications between manufacturers, retailers, and consumers [40]. For example, following the completion of transactions between manufacturers and retailers, as well as between retailers and consumers, the issue of invoice and account receivable reconciliation can be facilitated by constant updates with

TABLE 1. Selected applications based on AI technologies.

Technologies	Applications	Financial Scenarios	Challenges	Opportunities
Natural language processing	Nuance	· Voice recognition · Conversation AI services · Phone fraud detection	· It has a weak ability to grasp the needs of ordinary users	· It provides basic voice technology services for enterprises
	Cortana	· Real-time demand and behaviour analysis	· People are still not accustomed to talking to their own computers; most Windows users want to get answers or prefer to type by text	· It utilizes the advantages of Windows data and resources to achieve random switching between work and life scenarios and providing users with integrated services
	Alexa	· Intelligent voice banking assistant	· Since Amazon's Alexa has not become a system-level feature of phones, it can be controlled only through applications or smart speakers, so the response to some command questions seems weak	· It can be used for ecosystems · It can be used for smart home application scenarios
	AlphaSense	· Intelligent financial search engine	· The product focuses only on financial professionals	· It searches for critical information across lots of disparate datasets
Machine and Deep Learning	TensorFlow (platform)	· Stock index prediction · Public sentiment information management system	· Distributed support is not yet mature, and the skills to implement custom code are strong	· It can be used to research, develop and iterate new ML architectures
	Kensho	· Financial decision engine	· Kensho can only verify the hypothesis of user thinking and make predictions for users based on ML algorithms. ML algorithms require input variables and tuning parameters. In this process, the algorithm is in the state of a black box, and users cannot guess the reason behind it based on the results	· It offers an underlying structured database, the middle-tier financial domain knowledge base, and the front-end Q&A technology
	Microsoft Cognitive Services	· Identification of the withdrawal customer on ATMs	· It has financial account security issues	· It is convenient
Artificial General Intelligence	Skymind	· Data analysis · Bank fraud detection	· It is currently mainly applied to small and medium enterprises (SME)	· It can store, process, and quickly analyse large amounts of data · It provides all-inclusive deep learning services for institutions
	IBM Watson	· Tax preparation	· Massive amounts of unstructured data need to be transferred into structured data	· It can be used to advise tax officials on different occupations, family economic conditions and personal circumstances · It can be used to advise taxpayers individually

TABLE 1. *(Continued.)* **Selected applications based on AI technologies.**

	Accenture myWizard	· Intelligent automation strategy	· It is focused mainly on IT consulting	· Equipped with multiple virtual specialists, it can use ML technology to collaborate with human colleagues to manage projects, use data analysis results to support business goals, provide recommendations for tasks that require judgement, and monitor the agile development process from multiple perspectives
Computer Vision	Clarifai	· Pattern recognition in images · Retailer inventory management	· Due to the complexity of the background environment, lighting conditions, angles, and occlusions of image acquisition, the recognition accuracy still needs to be improved	· When used in conjunction with a camera system to see how customers browse a physical store, it can identify the areas in the store that receive the most or least traffic, and set up your employees and promotional displays accordingly. These devices can be used to count the number of items left on the shelf to understand how fast the items are selling.

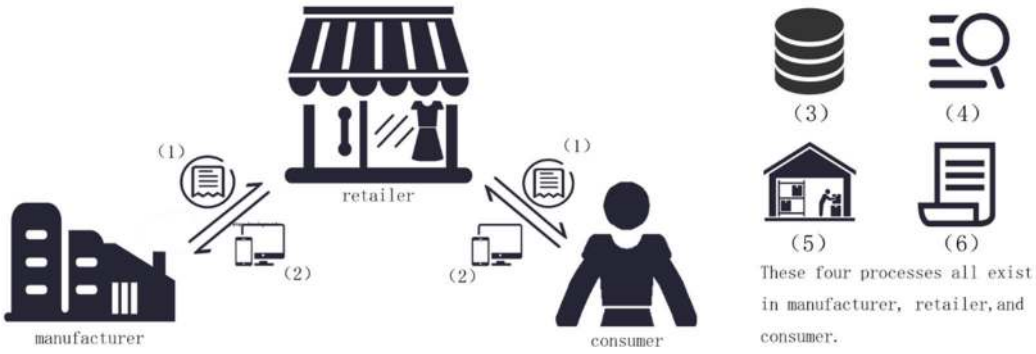

FIGURE 1. **Illustration of RPA applications.**

inventory databases and bank account systems. Certain countries, such as China, require invoice verification before the confirmation of tax benefits. Depending on the invoice format, OCR scanning technology can be used to ''read'' and ''record'' paper format invoices and store such information in real time. In addition, RPA technology can perform real-time invoice verification by constant contact with the government tax office database. The feature of RPA technology aims to provide constant verification across various databases, facilitating real-time business communications.

In the financial accounting and document approval field, SMACC has designed software called ''AI Extractor'' to extract financial information data from invoices [41]. This software is capable of automating accounting and control, payment preparation, three-way matching in procurement processing, business intelligence, and data analysis. With the assistance of ML technology, it offers superior automation compared to traditional optimal character recognition (OCR) and robotics solutions [42].

While RPA follows rules-based practices that allow the software to aggregate data, trigger responses, and initiate new actions, AI adopts new technologies such as voice and facial recognition to perform judgement-based responses, succeeding RPA's rule-based engines. When AI is integrated with RPA, it allows the automation process to begin much more quickly, creating an automation continuum.

1) RADIO FREQUENCY IDENTIFICATION

Radio frequency identification (RFID) utilizes wireless communication technology to identify information stored on objects via electromagnetic field reading. Following recent technological advances in reading and storing information,

RFID has become increasingly affordable [43]. One application of RFID is to manage inventory and curb inventory wastages, thereby reducing overall losses [44]. Developments of RFID technology contribute primarily to increased process automation, such as inventory receipts, shipments, inventory, and valuation. This facilitates increased efficiency by RPA in the preparation of transaction ledgers and financial statements. RFID provides information- sharing support for buyers in the supply chain to improve the accuracy of purchase prediction. RFID uses smart shelves to improve the flexibility of operations and reduce the cost of inventory management [45]. In 2014, Zara parent company Inditex decided to adopt RFID technology to improve the company's supply chain, eventually leading Zara toward ultrahigh efficiency in which the process of design concept to finished product could be completed in only 10 days; it also led to better sales and profit [46].

2) SPEECH RECOGNITION

Speech recognition technology converts dialogue content into computer-readable input [47]. It contributes to the further expansion of AI applications, such as consumer service inquiries and foreign language translation. For example, Alexa, the virtual assistant developed by Amazon, is capable of interacting via voice, streaming podcasts, playing back music, making to-do lists, setting alarms, and providing real-time information, such as news, weather, traffic, and sports information. Such speech recognition technology allows AI administrative assistants to coordinate and arrange meetings between team members and external parties, contributing to more efficient accounting practices [48], [49].

For example, Maycur.com is the leading domestic enterprise travel and expense management SaaS platform. It mainly adopts speech recognition, automatically converts semantics into structured information through AI training, and automatically completes the filling of the amount, time and place of the fee type. Voice accounting is similar to a dedicated intelligent reimbursement secretary. It only needs to speak in order to complete the reimbursement. It can extract the key information from one's voice, perform automatic classification, and complete the reimbursement process easily [50].

3) NATURAL LANGUAGE PROCESSING

Natural language processing (NLP) focuses on understanding unstructured data (from human sources) as an application of AI. Examples of NLP include text mining, manual text analysis, and readability analysis [51], [52]. NLP is used to find evidence for strategy-making based on the market environment and consumer activities.

Different from traditional internal auditing, NLP technology can automatically process unstructured text information, systematically and automatically retrieve and review the main points of review so that internal auditors are free from heavy reading and review work. At the same time, the language model can identify high-risk cases that do not meet the target terms and issues and conduct preliminary screening for internal auditors so that they can focus on high-risk cases and conduct in-depth tracking to achieve efficient internal audit work [53].

Notes:

(1) Invoice Issue – Sales data gathered from database;
(2) Accounts Receivable Reconciliation and Receipt Verification – Access bank information;
(3) Invoice Verification – Access government database; Invoice Processing – OCR scanning;
(4) Expense Reimbursement – Verification of invoice with logical query check;
(5) Inventory Measurement – Real-time, based on transaction records;
(6) Process Payment – Utility bills, etc.

4) ARTIFICIAL NEURAL NETWORKS

ANNs attempt to simulate human neuron networks so that computers can learn things and make decisions in a human-like way. ANNs are created by programming conventional computers as if they were interconnected brain cells [54], [55].

The artificial brain function of the ANN tool is at a much more advanced level than traditional computer linear logic, which is able to establish a stable network connection weight between the business data input and the accounting element record. Following the establishment of a case library based on the learning of historical economic transactions, the accounting information configuration of future economic matters can be automatically realized and integrated into the enterprise reporting system [56].

III. APPLICATION OF NEW TECHNOLOGIES BY THE BIG FOUR ACCOUNTING FIRMS

A. DELOITTE

Deloitte has developed several applications based on advanced technologies. For example, Deloitte developed an insight-driven organization (IDO) framework to help organizations achieve strategic goals. IDO embeds daily analysis, data, and reasoning into the decision-making process, which facilitates the scaling of projects across the organization to drive greater business impact by translating growing data volumes into measurable business value and creating long-term competitive advantage from existing data assets. IDO can also help to improve the speed and quality of decision-making while reducing decision cost, transforming clairvoyant-like decision-making from a solely executive pursuit to one achievable by all employees [57].

Based on deep learning technology, Deloitte has also developed a voice analysis platform called the Behaviour and Emotion Analytics Tool (BEAT) to monitor and analyse voice interactions. BEAT has three key functions. First, it monitors the voice interactions of customers. Second, it is capable of identifying high-risk interactions through NLP. The language model algorithm is used to judge the preliminary

TABLE 2. An example of high-risk contract identification by Deloitte's NLP.

Steps	Contents
1	Internal information extraction from contracts;
2	External information extraction such as business licenses and scopes;
3	Use of a language model algorithm to judge the preliminary data and then determine the regulatory compliance of the signed contracts;
4	Identification of high-risk contracts.

data extracted from internal and external information and then determine the regulatory compliance of the signed contracts (see Table 2 for an illustration of this approach) [58]. Third, it can alert users to interactions that may have negative outcomes (e.g., complaints or behavioural problems) and provide detailed information about the reasons for their occurrence [56]. BEAT is able to analyse over 30 different languages and 30 different behavioural indicators and can be customized to meet specific risk and user requirements [59].

Through NLP innovations, Deloitte has developed an automated document review platform using cognitive technologies that can read and automatically identify relevant information in a set of documents. The platform has broad advantages that enable Deloitte teams to process all types of unstructured information quickly and accurately [60]. Natural language generation (NLG), as a type of NLP, is used by Deloitte to obtain computer-generated text for tax purposes. The company processes upwards of 50,000 tax returns annually for clients' employees who have expat status or other complicated financial situations. Using NLG, Deloitte provides in-house individual tax services for over 50,000 employees and creates detailed narrative reports of individual tax returns. Its tax professionals rely on these reports to provide more targeted financial advice to clients during consultations [61].

B. PRICEWATERHOUSECOOPERS

PricewaterhouseCoopers (PwC) has a diverse portfolio of industry-specific and cross-industry data and analytics solutions. For example, PwC uses RPA technology to collect data and determine the filing status of all entities, review trial balance sheets, and convert data into tax bases. These procedures facilitate the preparation and revision of tax returns, tax payment submission, and responses to related parties' enquiries [62].

For auditing purposes, PwC has its own AI audit lab to improve audit quality, automation levels, and operational efficiency and maximize the capability of AI technology to collect comprehensive information and data for rapid and accurate analysis. In collaboration with H2O.ai, a company in Silicon Valley, PwC has integrated AI technology into accounting practice through the creation of the GL.ai robot. Building on the training algorithm, GL.ai adopts ML technology to absorb PwC's global knowledge and experience to stimulate the thinking process and make decisions similarly to an experienced auditor. GL.ai is programmed to check every uploaded transaction in milliseconds and to identify anomalies and suspicious transactions in the general ledger. It has therefore become an essential competitive advantage of PwC and has increased the company's corporate value [63].

PwC has also been successful in leveraging NLG. By implementing Narrative Science's AI power engine ''Quill'', PwC has been able to work with global financial institutions to automate customer understanding (KYC) reporting, a previously time- and resource-intensive task. Using Quill, PwC has been able to help clients reduce reporting time by approximately 25%, saving more than $1 million per year. In partnership with Narrative Science, PwC has also developed automated narratives for anti-bribery and anti-corruption (ABAC) reporting. ABAC reports traditionally require experienced compliance professionals to mine vast amounts of data to identify and record violations. PwC uses Quill to develop automated narratives that highlight potential misconduct based on risk models and data, reducing the time required to produce a report from a few hours to a few minutes and improving overall report consistency and quality [64].

C. ERNST & YOUNG

EY is committed to building a portfolio of industry solutions based on injection and innovation and has publicly set six industry priorities: financial services, life sciences, retail and consumer goods, health, electricity and utilities, the public sector, and the government. For each of these target industries, EY is currently developing a range of accelerators, assets, and products supported by its big data platform [65].

In addition to RPA and NLP technologies, EY uses a series of new technologies, such as drones, to satisfy new business requirements. In addition to utilizing machine reading (such as QR codes and barcode labels), EY also uses drones to assist with inventory observation and real-time analysis (such as optical characteristic recognition). Drone data are transmitted directly to EY Canvas, the EY Assurance global audit digital platform that seamlessly connects more than 80,000 auditors [66].

EY also adopts NLP technology in several of its business operations. For example, when the Internal Revenue Service (IRS) issues a new lease regulation, instead of re-examining all pre-existing lease contracts, EY uses NLP to extract information and a human-in-the-loop to validate the results [67]. The AI system is three times more consistent and twice as efficient as traditional human teams. To access potential purchasing synergies in mergers and acquisitions, EY has also adopted an intelligent classification engine to quickly compile relevant information, a significant improvement from manually building spreadsheets and pivot tables and reading lines of non-standardized accounts payable and accounts receivable data [68].

To improve professional efficiency, EY has further adopted ML technology to detect fraud. EY's Fraud Investigation and

Dispute Service (FIDS) has achieved an accuracy rate of 97% in identifying suspicious invoices using ML technology [69].

D. KLYNVELD PEAT MARWICK GOERDELER

Klynveld Peat Marwick Goerdeler (KPMG) has implemented a strong data and analysis vision within its core practices, with the Global Expert Insight Center providing complementary resources to local teams. KPMG is currently developing its data and analytics service portfolio within member companies to help customers address specific data issues, such as privacy, security, and forensics. It is also extending its current services to new markets. KPMG combines its tax, advisory, and audit credentials with its digital investments and uses its value delivery framework and trusted information to help clients transform their businesses.

In 2017, KPMG launched a team called ''KPMG Ignite'' to focus on research and exploration. It is a technical partner ecosystem that helps build and provide solutions using AI with tested open source tools and accelerates the development and delivery of AI solutions. To ensure the smooth operation of KPMG's AI technology, KPMG Ignite provides continuous testing for prototype development and innovation, as well as a framework and guidance to address employees' and customers' queries with AI applications. KPMG Ignite functions as a data analysis processor that provides unbiased estimations. To ensure its effectiveness and credibility, KPMG performs regular inspection and maintenance. In addition, KPMG has established two special departments to address Internet and data security. One department is responsible for company software design and testing network security. The other department addresses data protection and instant responses to cyber attacks [70].

KPMG has also introduced a novel means of assessing risks. KPMG's dynamic risk assessment (DRA) combines actuarial theory, complex algorithms, mathematics, and advanced data with analysis to identify, link, and visualize four-dimensional risks (severity, likelihood, interconnectedness, and velocity). Compared with traditional two-dimensional risk assessment (high likelihood and severity), DRA takes into account the risk interconnectedness and velocity with which the risk may affect business operations.

Combining the latest applied science with management insights and extensive benchmarking, DRA modelling allows audit professionals to see the spread (''contagion'') of risks that could form key clusters or trigger other risks. By identifying the expected contagion effect between global and corporate risk, KPMG can objectively measure important threats. These new insights provide a new level of risk assessment for audit professionals, help improve audit quality, and provide the organization with information about how best to address and monitor these threats [71].

Based on RPA technology, KPMG has developed ''K-analyzer'', tax analytic software that is capable of analysing thousands of transactions in a matter of minutes. K-analyzer downloads data from corporate ERP systems to reduce errors, uses automation to analyse a large amount of data, and then clearly summarizes the results. This process generates a clear audit trail acceptable by tax authorities and is capable of analysing tax-sensitive data in a cost-efficient manner [72].

KPMG has also developed a robot to reduce the time required to complete FBT compliance tasks, known as the FBT Automator. This tool is capable of performing line project and ledger data analysis, including interactions with business systems such as SAP and Oracle to access back-end data, and preparing FBT for return to work files using numerical coding and fuzzy word matching without manual line-by-line review. KPMG has also introduced the Payroll Tax Automator tool, which automatically fills in the payroll code and allocates wage codes to the correct the type of payroll tax wage. It can also run data analysis across monthly payroll tax returns and annual payroll tax adjustments to ensure compliance with the initial submission and generate a central storage facility for payroll taxes that functions as a data collection room [73].

The KPMG Automatic Exchange of Information (AEOI) reporting tool aims to streamline the reporting process by using hundreds of data validation checks to create and embed the required XML files for submission. KPMG offers licensing solutions and hosting services to translate system data into relevant reporting formats, such as the Foreign Account Tax Compliance Act (FATCA) and Common Reporting Standard (CRS) [74].

Examinations of the use of BG, ML, and AI technologies by the Big Four accounting firms reveal two common trends. First, the accounting profession is increasingly investing in AI and its integration into core business; second, the Big Four claim that AI is a key factor for future success in the accounting field. The following section outlines predictions for future development in these areas.

IV. BEYOND ARTIFICIAL INTELLIGENCE – BLOCKCHAIN

A. BLOCKCHAIN TECHNOLOGY

Blockchain can be described as a series of blocks used to establish or record ownership of assets between parties [75]. Blockchain does not need an arbiter [76] and can therefore facilitate direct trading in the private sector [77]. It improves the efficiency of transactions that require multiple validations and validations via more rapid checking between parties [78]. Table 3 records some of these examples.

It can be seen from the table that the impact of the blockchain on auditing is reflected mainly in the following aspects:

a. Nontamperable features provide a reliable source of data to support the auditing business while ensuring the unique sources of accounting data. Once the data for the audited entity are entered into the blockchain network, they are difficult to tamper with [79].
b. Distributed ledgers improve the authenticity and reliability of audit data, significantly reducing the risk of data being attacked by the audited unit [80]. Traditional audit data are

TABLE 3. The impact of blockchain on accounting and auditing.

Blockchain Characteristics	Goals	Potential Impact on Accounting	Potential Impact on Auditing
Non-tamperable (Public Key Encryption) [79]	Prove ownership	The only source of accounting data is guaranteed, and the accounting data cannot be falsified [86]	The only source of auditing data is guaranteed, and the audit data cannot be falsified [87]
Distributed ledger (Decentralized) [80]	Enhance transaction transparency	Improvement in the transparency of accounting information [81]	Improvement in the authenticity and reliability of audit data [82]
Timestamp [83]	Clear transaction order	Improvement in the difficulty of changing data and retain permanent accounting records [80]	Improvement in the reliability and timeliness of audit data, and lay a solid foundation for continuous audit and real-time audit [84]
Network consensus [85]	Verify transaction legality	Improvement in accounting efficiency; provision of real-time transaction clearing or settlement [88]	Improvement in the authenticity, reliability and timeliness of audit data, and lay a solid foundation for continuous audit and real-time audit [89]
Programmable [90]	None	Intelligentization of accounting business processing through programmability, setting accounting algorithms or accounting business processing rules [80]	Intelligentization of audit work through programmability, setting audit algorithms or auditing business processing rules [91]

stored on a centralized cloud server and are highly vulnerable to hackers, resulting in file loss or data tampering. The blockchain stores data in a distributed manner and uses multiple nodes to back up data [81]. Even if a single node is attacked by a hacker, it will not affect the consensus state of the data in the network as a whole [82].

c. The timestamp feature increases the difficulty of tampering with the data for the audited unit and provides a stable audit trail for the development of the auditing business [80], [83].

False transactions and accounting fraud are the main sources of material misstatement risk. The existence of the timestamp feature requires that the data for the audited unit be revised to reach consensus with multiple participants. This greatly increases the difficulty of providing fraudulent financial data and improves the authenticity and reliability of the data for the audited unit, thereby reducing the cost of false financial information verification [84].

d. Network consensus has improved the authenticity, reliability and timeliness of the data for the audited entity, laying a solid foundation for continuous audit and real-time audit work [85]. On the one hand, it is more convenient to obtain audit request information through the blockchain network, and audit requests can achieve minute-level or even second-level responses, which can save information collection and finishing time, thereby improving audit work efficiency [88]. On the other hand, the consensus mechanism for blockchain enables all data to be jointly confirmed the first time, which can guarantee the timeliness and accuracy of the data. Greatly improving the authenticity and integrity of the data saves many inquiry and correspondence procedures, thereby improving the efficiency of audit work and saving labour costs [89].

e. The programmable feature enables auditors to write audit algorithms and audit business processing rules according to different audit application scenarios, laying a solid foundation for the automation of audit work [90].

In summary, the impact of blockchain on auditing mainly includes the following two aspects:

a. The non-tamperable, distributed ledger, time stamp and network consensus features of blockchain will enhance the authenticity and reliability of the data for the audited unit and reduce the verification cost of the data for the audited unit [79]. For data for the audited entity in a detrusted environment, auditors may use electronic credit procedures or reduce procedures such as inquiries and letters, depending on the circumstances, thereby reducing audit costs. At the same time, the improvement of the authenticity and reliability of the data for the audited unit may also reduce the need for third-party verification information, such as auditing [92].

b. In the blockchain programmable environment, auditors can write audit algorithms or audit business processing rules according to specific audit scenarios and promote the intelligent implementation of audit work [91].

Blockchain technology can simplify the transfer of any value (data, assets, currency, and information) in real time in a secure and cost-effective manner. It is extremely useful to conduct transactions that require multiple validations and validations, contracts, and any type of record validation. This technology can also make it easier to detect fraud and errors by providing clear and transparent information about transactions, as no one can modify records once they are uploaded. Blockchain can be described as a series of blocks used to establish or record ownership of assets between parties. Blockchain does not need an arbiter [76] and therefore facilitates direct trading in the private sector.

B. APPLICATIONS OF BLOCKCHAIN BY THE BIG FOUR ACCOUNTING FIRMS

1) DELOITTE

Deloitte has Blockchain laboratories in New York, Dublin and Hong Kong, comprising more than 800 professionals. These laboratories work with international organizations seeking blockchain solutions, such as food suppliers that wish to track products from farm to table, banks and insurance companies seeking fraud detection, and car manufacturing and leasing companies [93]. Deloitte has developed more than 30 blockchain-related models for purposes such as digital identity, digital banking, cross-border payments, trade finance, and loyalty and reward solutions, as well as unique work in investment management and insurance [94].

2) PricewaterhouseCoopers

PwC has developed the Blockchain Validation Solution, which combines a risk framework with proprietary continuous audit software. This tool is used to discover long-term indicator patterns that are not obvious to humans, both direct and predictive, and provide objective results. PwC keeps a log of transactions with customers who are currently experimenting with blockchain technology and applying controls and testing standards to its applications, including major stock exchanges and digital wallet providers that allow users to monitor, view, and test transactions in real time [95].

3) ERNST & YOUNG

EY has developed Blockchain Analyzer, a blockchain-based auditing technology that enables in-depth reviews of cryptocurrency transactions and supports the auditing of companies that use cryptocurrencies. It is a foundational tool for auditing blockchain assets, liabilities, equity, and smart contracts [96]. Blockchain Analyzer is developed in conjunction with Guardtime (an enterprise blockchain company) and Microsoft's Azure Blockchain team. The platform is used to create marine insurance contracts, digitize trading rules and automate the entire process by using smart contracts to reduce paperwork. Insurance companies can update their information online and check the location of ships around the world anytime and anywhere. The platform makes the collective database available to all interested parties in real time by connecting their core capabilities [97].

4) KLYNVELD PEAT MARWICK GOERDELER

KPMG has partnered with Microsoft to create the KPMG and Microsoft Blockchain Nodes, an innovative workspace that combines KPMG's industry and blockchain application knowledge with Microsoft's technical expertise. Blockchain nodes are used to build a close relationship with start-ups and developer communities, demonstrating the utility of blockchain technology for a range of businesses, such as healthcare and the public sector [98]. Furthermore, the KPMG Digital Ledger Services is a tool that helps financial services companies apply blockchain technology, streamline automated back-office operations, deliver faster and more secure transactions, and reduce costs [99].

C. THE IMPACTS AND FUTURE DEVELOPMENT OF BLOCKCHAIN FOR AUDITING

When all transaction details are stored on blockchain, it becomes impossible to change information because all stakeholders have the same information and all changes are recorded (with real-time updates). Therefore, blockchain naturally eliminates any abnormal records (which no one dares to do) and makes reliable real-time auditing possible. It is likely to significantly improve audit quality and efficiency.

The integration of blockchain and cloud technologies allows auditors to download information on business adversaries in the private chain and directly use the opponent's information to confirm the data during the reconciliation process. The application of shared ledgers in blockchain frees auditors from repetitive transaction checking but focuses on complex transactions and internal controls, confirms the validity of the digital performance of physical assets, ensures that the contract is written in accordance with accounting standards, and changes the scope and methods of audit opinions [100].

Future research can consider establishing an auditing process based on blockchain technology. For example, a continuously working audit robot is able to complete the audit record layer, such as fetching raw data, issuing audit test result reports, and data packaging and chaining; improve the traceability of each block structure on the audit analysis layer for Interim audit testing; establish an early warning mechanism; and issue an audit inquiry list and audit abnormal item list, etc.

V. SUGGESTIONS FOR ACCOUNTING PROFESSIONALS

Based on the above review of the current developments of AI, and blockchain technologies in the accounting profession, focusing on the Big Four accounting firms, we provide suggestions regarding future developments for accounting professionals and their organizations.

With the rapid technological advances of the last few decades, accounting professionals are currently required to have programming skills and to be proficient in data

analysis. They must be capable of understanding emergent tools, interfacing with reporting techniques, and interpreting reports to answer questions from authorities [101]. A study prepared by the Association of Chartered Certified Accountants in the United Kingdom regarding the future of the accounting profession denotes the key tasks of accountants and their capabilities in this modern era[1]. For auditors, since RPA technology makes real-time and continuous audits possible, audit professionals should be flexible and adaptable regarding changing audit procedures and should be able to process real-time risk information [102]. For risk management practice, when AI accounting software is utilized to conduct a large proportion of accounting work and make decisions accordingly, professionals need to ensure that the algorithm design is correct (not intentionally manipulated or incorrectly self-developed), particularly with regard to fraud detection. This process requires consistent monitoring by experienced accounting professionals. As such, the introduction of advanced technology into the accounting profession is likely to reduce the number of employment opportunities for accountants without programming and analysis skills. It may be necessary (and desirable) for companies to provide adequate re-training for existing staff.

Accounting firms and departments may adopt several approaches in response to rapid technological developments in this area. First, companies can establish the vision of technology-driven professional practice as an overall organizational strategy, such as setting up separated centres of excellence, specific coordination with business units, or different focus units. Second, organizations may conduct a comprehensive assessment of current protocols employed in the data development and collection process, conduct a candid review of its automation and analytical capability maturity, and develop plans to implement appropriate IT support processes. Third, organizations should determine the value that the proposed technology may create and review it periodically. This process includes developing formal key performance indicators so that efforts are focused in the right direction to produce tangible results. Finally, to ensure data accuracy and security, companies can establish a governance board to define and practice enterprise-wide data governance standards. This governance board can also address the effects of potential business disruptions during cohesive technological changes within the corporation.

There is no doubt that financial robots will replace humans in performing basic accounting tasks in the future, as they are already an important component of the accounting landscape. As a financial practitioner, it is important to continuously improve one's professional knowledge and skills, including computer expertise, to complete more challenging tasks. At the same time, it is necessary for education systems to respond accordingly by incorporating a higher level of technology proficiency.

VI. A REFLECTION ON ACCOUNTING EDUCATION TRANSFORMATION (IN CHINA)

Recent media and reports from professional bodies and firms indicate the high probability of job loss within the accounting and finance profession due to developments in big data, ML, and AI [103]–[105]. Such observations present both challenges and opportunities for accounting education. On the one hand, it renews a longstanding debate regarding the goal of university education, namely, whether it should comprise liberal education or professional training. On the other hand, these technological developments can free educators from repetitive exam marking and tutorial consultations so that they can spend more time with their students. As an illustrative example, the current state of accounting education in China is examined to suggest future changes.

In 2017, more than 270,000 students graduated with an accounting degree (bachelor's level and above) in China [106]. For a high school graduate who is interested in pursuing a bachelor's degree in accounting in China, there are two options: attending either a government-funded university or a government-recognized education institute (managed by a local or international university). The most common approach is to enter a government-funded university through the Chinese college entrance exam (''Gaokao''). For accounting and finance education, there are two main types of government-funded universities in China. First, comprehensive universities such as Xiamen University, teach both accounting and finance, as well as arts, sciences, and engineering; second, universities such as the Southeast University of Finance and Economics focus on accounting, finance, and economic[2]. Students in comprehensive universities have easier access to liberal education due to accessibility to courses from other majors (such as arts and computer science). However, students in universities focused on accounting, finance, and economics are more likely to be able to access professional training related to their majors due to the large number of student enrolments in these majors. It therefore makes more sense for educators to spend time designing practical content such as ERP demonstrations for large groups of students, while small classes are ideal for the in-depth discussion of case study materials.

With the increase in AI applications in the accounting profession, the pressure for students to look for a job after graduation, and the balance of focus between teaching and research for faculty members, it is crucial to determine whether university education should be aimed towards liberal education or professional training. Although students at top universities

[1]Future accounting professionals must analyse the financial strategy and performance of the company, explain the feasibility of the investment plan, and be able to manage the expectations of different stakeholders inside and outside the company. Future financial managers must also have the following abilities: teamwork ability, language ability, and awareness of cross-cultural communication. In addition, they must be good at expression and persuasive and be able to demonstrate to people both inside and outside the financial industry.

[2]In comparison to comprehensive universities, universities with a focus on accounting, finance, and economics have much higher proportions of students in these majors due to admission guidance set by the Chinese Ministry of Education.

TABLE 4. Summary of AI applications by the big four accounting firms.

	Deloitte	PwC	EY	KPMG
RPA	On March 10,2016, Deloitte introduced the Deloitte Robot based on cooperation with Kira Systems.	Tax analytic software, K-analyzer, uses automation to analyse a large amount of data, and then clearly summarizes the results. This process generates a clear audit trail acceptable by tax authorities and is capable of analysing tax-sensitive data in a cost-efficient manner [4, 70, 71]		In alliance with IBM Watson, KPMG has developed various tools and pilots and advance these tools in various ways. RPA tools can read thousands of pages of contracts or agreements, quickly summarize these contracts or agreements according to the requirements of customers, and continue to learn and become smarter over time.
Deep learning technology (NLP)	A voice analysis platform called BEAT was developed to monitor and analyse voice interactions.	In auditing, PwC adopts AI technology to extract, organize, and construct data, such as extracting data from client bank statements to perform the substantive tests required for cash audits	Lease contract update following the change of IRS updated regulation; An intelligent classification engine to access the potential purchasing synergies in mergers and acquisitions;	
ML/AI			To improve professional efficiency, EY adopts ML technology to detect fraud. The EY FIDS has achieved an accuracy rate of 97% in identifying suspicious invoices using ML technology	"KPMG Ignite" is a technical partner ecosystem that helps build and provide solutions using AI with tested open source tools and accelerates the development and delivery of AI solutions; It provides continuous testing for prototype development and innovation, as well as a framework and guidance to address employees' and customers' queries to AI applications; KPMG Ignite functions as a data analysis processor that provides unbiased estimations.
Automatic gathering of evidence and complex data; Capturing data from physical sensors to create sophisticated digital records	In May 2017, Deloitte announced its collaboration with McLaren Applied Technologies (MAT) to build data-driven business products. These tools are embedded with predictive analytic capabilities that can be used to evaluate the forecasts of asset valuations on the client's balance sheet	On October 21, 2016, PwC Aarata set up an AI audit lab to improve its automatic audit process, leading to greater operational efficiency and audit quality	In addition to RPA and NLP technologies, EY uses a series of new technologies such as drones to satisfy new business requirements. In addition to utilizing machine reading (such as QR codes and barcode labels), EY also uses drones to assist with inventory observation and real-time analysis (such as optical characteristic recognition). Drone data are transmitted directly to EY Canvas, the EY Assurance global audit digital platform that seamlessly connects more than 80,000 auditors [65]	KPMG has also developed other technologies, such as the Payroll Tax Automaton tool that is capable of filing and allocating payroll codes, as well as reconciliation with the tax authority. One interesting application is the Fuel Tax Credit (FTC) scheme following KPMG's investment and alliance with automation start-up Nuonic. FTC uses a GPS system to track car movements in order to calculate vehicle petrol usage for both corporate analysis and tax office compliance

achieve high marks in ''Gaokao'', this does not necessarily mean that they want to get a job in Big Four accounting firms or investment banks immediately after they graduate. Do employers prefer graduates with a liberal education?

Technology developments such as RPA and OCR have significantly reduced the workload of repetitive tasks for financial accountants. These tools can scan and enter invoices automatically, enabling real-time audits. Accountants are now expected to perform more value-added tasks such as financial management and data-driven decision-making. The future of (flat) organizational structures requires accountants to understand corporate operations and contribute to corporate governance based on their professional accounting knowledge. In our opinion, if we believe that accounting is a career more than a job, higher education institutions should continue the practice of liberal education rather than professional training. Although rapid technological developments have pushed accounting firms to restructure their professional knowledge and to reform their service approach, certain professional characteristics of accountants are unlikely to change, such as ethical and emotional intelligence [107].

Recent developments in AI can be viewed as an opportunity for educators to move one step closer to educational fairness. For example, the integration of big data and ML technologies creates an education system that can input a variety of tutorial explanation approaches for the same question that is accessible to students 24/7. Such a smart education system can facilitate a range of learning approaches, benefiting teachers and students alike.

According to Han [108], an ancient educator of the Tang Dynasty in China, a teacher should ''discuss ethics, educate profession, and clarify confusion for students''. The adoption of a smart system made possible by big data, ML, and AI to provide highly efficient tutorial consultation for students allows faculty members to spend more time in discussion with students, such as sharing their professional experience. More importantly, educators can use this extra time to design teaching cases that teach students to use their accounting knowledge to solve practical issues of financial management, corporate governance, and ethical dilemmas.

Recent technological developments have necessitated the transformation of accounting education not only in China but also around the globe. However, it is important to reiterate that the possession of adequate characteristics is essential for graduates to adapt to current and future technology changes and even create them. Therefore, educators should firmly support liberal education while also encouraging and providing opportunities for students to experience these novel technologies.

VII. CONCLUSION

The deep integration of emerging technologies such as big data, ML, AI, and blockchain in the accounting field has introduced tremendous changes to the accounting profession, such as reengineering accounting procedures, reducing accounting information errors and distortions, improving accounting efficiency, and promoting the transformation of accounting career structures.

Because this article reviews new developments in accounting, future applications of new technologies such as blockchain are also discussed in this study. For example, with the help of blockchain audit application platforms, large-scale and real-time automated audits can derived. At the same time, considering the increasing adoption of technologies in accounting, how to protect data privacy becomes an important issue. While corporations can enhance their data security structures, regulators are also expected to strengthen and implement regulations for associated crime.

The article presents extensive and profound integration between AI technology, blockchain and accounting. While the top accounting firms are embracing these new technologies and challenges, accounting professionals (practitioners, educators and students) are expected to expand their technological knowledge, creating more efficient accounting practices.

TABLE 5. Table of abbreviations.

Abbreviation	Full Name
ABAC	Anti-bribery and Anti-corruption
API	Application Program Interface
AI	Artificial Intelligence
ANN	Artificial Neural Network
AEOI	Automatic Exchange of Information
BEAT	Behaviour and Emotion Analytics Tool
BG	Big Data
CRS	Common Reporting Standard
DPoS	Delegated Proof of Stake
DRA	Dynamic Risk Assessment
EY	Ernst & Young
FATCA	Foreign Account Tax Compliance Act
FIDS	Fraud Investigation and Dispute Service
GDPR	General Data Protection Regulations
IDO	Insight Driven Organization
IRS	Internal Revenue Service
KPMG	Klynveld Peat Marwick Goerdeler
KYC	Know Your Customer
ML	Machine Learning
NLG	Natural Language Generation
NLP	Natural Language Processing
OCR	Optimal Character Recognition
P2P	Peer-to-peer
PwC	PricewaterhouseCoopers
PoS	Proof of Stake
PoW	Proof of Work
RFID	Radio Frequency Identification
RPA	Robotic Process Automation
EU	European Union
SME	Small and Medium Enterprises
FP&A	Financial Planning and Analysis
PSD2	Payment Service Directive 2

APPENDIX A

See Table 4.

APPENDIX B

See Table 5.

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