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Auditors' Perceptions of and Competencies in Big Data and Data Analytics: An Empirical Investigation

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This study presents evidence on practicing auditors' perceptions of and competencies in applying big data and data analytics to audit engagements. An electronic questionnaire distributed to accountants shows that auditors have good information technology skills and are well-acquainted with big data and data analytics. However, they lack relevant technical skills and are unfamiliar with related data analysis tools, excluding Excel. The results reveal 64.71% of accountants have not attended any training on big data and data analytics, while 31.37% plan to enhance related knowledge. Auditors need to obtain training on substantive audit risk assessments using big data and data analytics.

KEYWORDS

big data, data analytics, auditors, perception, competence, Saudi Arabia

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1 | INTRODUCTION

A credible financial reporting system must recognize in real time all events or transactions that affect the value of a company's net assets and thus, common shareowners' wealth (Chartered Financial Analysts Institute, 2007). Financial statement disclosures should provide information that allows stockholders to understand how the reported figures were generated, including details of models used to produce them (Nikolai, Bazley, & Jones, 2009). In addition, disclosures must explain all risk exposures and the possible effects of future events on investors' wealth (Chartered Financial Analysts Institute, 2007).

Accounting can be viewed as a craft because it comprises techniques designed to serve certain practical ends, and the instruments of the craft are generally subject to a system that leads to a gradual evolution (Yamey, 1947). During the course of its development, accounting has always responded to business needs with technological inventions (Al-Adeem, 2017). For instance, double-entry bookkeeping, a written manifestation of merchants' affairs (Pacioli, 1494 as cited in Gleeson-White, 2011), was developed in response to business needs (Yamey, 1947). Accounting strives to offer financial investment information, both internally and externally, from the recording of financial transactions to the presentation of financial reports (KPMG, 2013). The process of information disclosure includes sharing relevant data that aid users in evaluating an enterprise's performance and accordingly, in rationalizing their decision to invest in such entities. Accounting and data have a strong interdependency, which is a consequence of ongoing business transactions (Alles, 2015), and auditing has witnessed progressive opportunities and challenges owing to rapidly changing technology. Auditors may earnestly embrace big data as a method to increase the effectiveness and reliability of their tasks (Alles, 2015).

The development of information technology (IT) has influenced auditing, thus creating a contemporary phenomenon in the field (Vasarhelyi & Halper, 2018). In practice, based on sampling testing accompanied by inferences derived from their professional judgement, auditors determine whether further testing needs to be performed to obtain both process and compliance-based outcomes. In addition to possessing the skills needed to gather and objectively evaluate audit evidence and the diligence to perform tasks with integrity (Kueppers & Sullivan, 2010), auditors apply specialized knowledge and thus, societies perceive them as trustworthy (West, 2003). Current trends in technological advancements that incorporate the use of big data for auditing practices have simultaneously created opportunities and challenges for the profession. Auditors must understand the impacts and risks of big data and strive to acquire the requisite professional skills to remain relevant to their societies in general and their clients in particular.

In today's economy, rapid IT movements have enhanced the ability of businesses to collect, store, retrieve, and utilize data. In fact, an increasing number of companies are becoming better and more efficient at structuring data and thus, are able to incorporate information into more complex models and algorithms (Gordon & Shankaranarayanan, 2015). Belkaoui (2017a), a contemporary accounting professor, strongly urged professional accountants to recognize emerging realities that institutionalize them and their profession. Professional auditors with a good understanding of computer-assisted audit techniques (CAATs) have the means to improve audit programs or review plans during an audit using data analytics (Singleton, 2013b). CAATs can be defined as computerized methods used by accountants to process data (Braun & Davis, 2003). Big data necessitate the creation of representative analytics and delivery platforms to track and display data stored on a large scale (Pedrosa & Costa, 2014); "Big data is going to get bigger and faster" (Singleton, 2013b, p. 1).

Saudi Arabia is one of the world's fastest-growing countries, with per-capita income expected to rise from USD 25,000 in 2012 to USD 33,500 by 2020.[1] Mukthar and Sultan (2017) predicted that the value of implementing data analytics in the Saudi Arabian market will grow from USD 920 million in 2013 to USD 1.85 billion in 2018.[2] As businesses, particularly corporations, attempt to tap into these opportunities, investors become more aware and thus demand greater financial information to avert risks associated with their hard-earned capital. In addition, with the recent adoption of the International Financial Reporting Standards (IFRS) and the shift toward a more robust open economy, Saudi Arabia is witnessing considerable economic growth and technological advancements. It is conceivable that the country's decision on IFRS convergence is aimed at strengthening its goal of rapid economic development and progress (Al-Mousa & Al-Adeem, 2017).

With big data becoming a reality, using related data and analytics for audit tasks has become a necessity for accounting professionals to create more value. In general, real-time corporate activities could cause a shift from auditors "providing assurances about numbers to assurances about real-time systems" (Gepp, Linnenluecke, O'Neill, & Smith, 2018, p. 109). In the same vein, with companies using more complex computerized financial data in their transactions, knowledge about and expertise in big data have become a more genuine need for external auditors in audit assignments. IT plays a fundamental role in the efficiency and integration of operations in modern organizations, thus requiring audit professionals to maintain up-to-date knowledge on IT and data management (Silltow, 2003). This creates both challenges and growth opportunities for preparers and reviewers of financial information. It is pertinent to explain the extent to which auditors can tackle the challenges of this shift—that is, the need for new skills, creating opportunities, and questioning relevance—given its impact on auditing. Thus, a major challenge is using the vast amount of data created and stored by organizations to reduce risks and improve the proportion of IT in audit functions (Dzuranin & Malaescu, 2016). Given the above discussion, auditors' perception toward and competence in applying big data and data analytics to audit assignments is an appropriate research topic to explore. This study, thus, empirically examines auditors' awareness and practical knowledge of big data and data analytics in creating more value in audit activities.

The remainder of this paper is organized as follows. Section 2 reviews the literature on big data and data analytics. Section 3 presents the method used to address this research question as well as the scale developed and employed in the instrument used to collect data. Section 4 discusses the results, while Section 5 concludes with limitations and suggestions for future research.

2 | LITERATURE REVIEW

This section analyzes the literature on big data and data analytics as phenomena in the auditing profession and the reasons for using big data in related practices. In addition, it highlights the opportunities and challenges that big data create in the auditing profession. Finally, the section poses the following question: how do auditors perceive their competence in the application of big data and data analytics?

[1] See Doing Business in Saudi Arabia's guide on "Why Saudi Arabia?" http://www.saudiarabia.doingbusinessguide.co.uk/the-guide/opportunities-in-saudi-arabia [Last Accessed February 13, 2018].

[2] See MicroMarketMonitor's report. See Computer Weekly's article (2016) on "Saudi Arabia turns to Big Data to boost business innovation": https://www.computerweekly.com/news/450402173/Saudi-Arabia-turns-to-big-data-to-boost-business-innovation; (Last Accessed February 13, 2018)

2.1 | *Overview of IT in Auditing*

The auditing profession is currently in a critical phase, particularly with the world concurrently witnessing greater advancements in technology and real-time methods of business transactions, resulting in a call for change in the auditing profession (American Institute of Certified Public Accountants [AICPA], 2012). Traditional audit tools were effective in dealing with limited data. These practices proved feasible for auditors for a reasonable period; however, with increasing data volume, the use of CAATs has become essential for dealing with expanding data and the accelerated speed of data transformation and recall. Conventional audit approaches have evolved into utilization of technology such as electronic spreadsheets, electronic working papers, generalized audit software, embedded audit modules, SQL database search and retrieval, parallel simulation software, and test data (Rosli, Yeow, & Eu-Gene, 2013). In addition, "automated decision-making has played a vital role for quite some time" in the financial sector (Frey & Osborne, 2017, p. 260). The integrated and real-time nature of digital businesses requires collaboration among historically independent organizational units, where data analytics programs are at the core of enhancing decision-making processes (Gartner, 2017). In its report on audit data analytics, the Centre for Financial Reporting Reform (CFRR, 2017) asserts that rapid growth in technology combined with stakeholder demands drives "the need for auditors to innovate and transform their approaches in order to keep pace with demand" (p.1).

The application of CAATs to audit procedures has been tested, including the potential for improvements in audit engagement productivity (Curtis & Payne, 2008). In fact, the audit profession has the opportunity to collect audit evidence from the entire data population rather than simply relying on sampling techniques. Persistent growth in technology and software applications has allowed auditors to anticipate steps in their auditing processes (CFRR, 2017). Undoubtedly, "present and future users of accounting and auditing services have an increasing need for relevant, reliable, and timely information and IT provides the means to meet them" (Elliott, 2002, p. 139, as quoted in Curtis & Payne, 2008, p. 3). Compared to traditional manual auditing, CAATs have played a more vital role in the application of innovative processes (AICPA, 2012). Further, with the growing global expectations of capital owners and relevant parties, the adoption of modern technology in audit programs is rapidly evolving (International Federation of Accountants-IFAC, 2017).

The fundamental purpose of accounting has been to process and communicate financial information to both internal and external decision makers (Janvrin & Watson, 2017). The accounting profession, through the prudent use of financial data, has long contributed to organizations' key objectives and decision-making processes (Richins, Stapleton, Stratopoulos, & Wong, 2017). Auditors must analyze financial statement data and significant data related to financial statements to enhance decision-makers' confidence. A rapidly increasing number of corporate strategies are accounting for the use of IT to provide adequate relevant information and maintain reasonable compliance with related regulations and laws (Rikhardsson & Dull, 2016). Janvrin and Watson (2017) contend that accountants have a tendency to expand their expertise to new data. For example, in the 1990s, many practicing accountants extended their traditional auditing services to assurance services, symbolizing modern methods of improving sources of data for financial accounting (Janvrin & Watson, 2017). Data-based decision making has been considered a tool for achieving enhanced productivity and profitability, but this perception has not been developed without experience (Alles, 2015; Waller & Faucett, 2013).

2.2 | *Big Data and Data Analytics as Phenomena*

Understanding the nature of big data can broaden knowledge about the techniques, impacts, and conditions necessitating its adoption. "Big Data is a relatively recent phenomenon," where records of every significant aspect can be captured, measured, and eventually converted into meaningful data (Cao, Chychyla, & Stewart, 2015, p. 1). Gartner (2016) defines big data as high-volume, high-velocity, and/or high-variety information assets that demand cost-effective, innovative forms of information processing, enabling enhanced insight, decision-making, and process automation. "Big data is no mere buzzword—big data is here to stay" (Hammer, Kostroch, & Quiros, 2017, p. 6). From a technical perspective, Gepp, Linnenluecke, O'Neill, & Smith (2018) describe big data as certain techniques and technologies used to deduce results from a pool of events characterized by both structured and unstructured datasets representing the four Vs: volume, variety, velocity, and veracity. In sum, big data are "large volume unstructured data which cannot be handled by standard database management systems like DBMS, RDBMS or ORDBMS" (Mukthar & Sultan, 2017, p. 258).

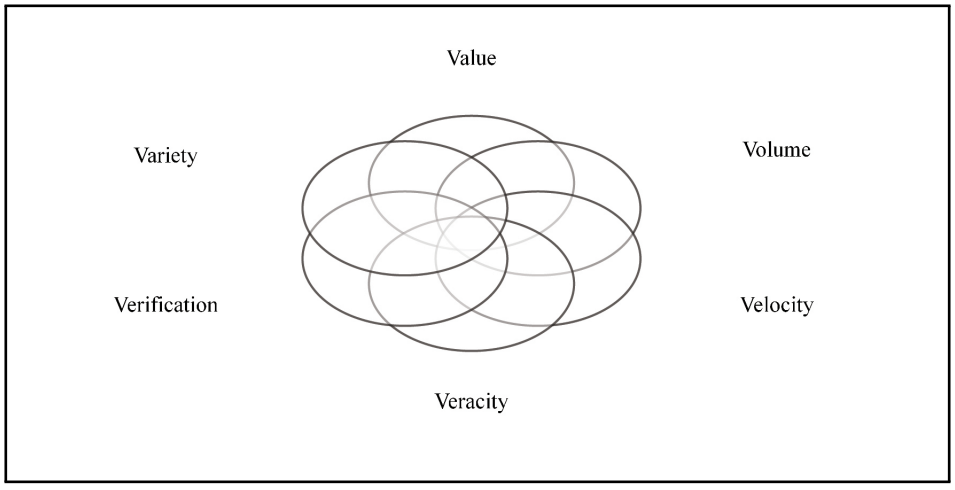

FIGURE 1 6Vs of Big Data

In practice, auditors are more concerned with the efficient use of big data to obtain substantial and reliable audit evidence (Appelbaum, Kogan, & Vasarhelyi, 2017; Brown-Liburd & Vasarhelyi, 2015). As for organizations, data alone may not meet business needs; that is, data may be of limited value unless further efforts are made to analyze them for rational decision making, thus highlighting the need for analytics. Data analytics techniques and methods allow audit teams to both analyze client data and identify areas that need further investigation early on in the audit process. This way, audit teams can tailor audit approaches to deliver substantial results by adapting their audit plans (IFAC, 2017). Data analytics address the communication of complex data to arrive at cogent decisions. Data analytics as a field identifies whether data deviate based on comparative industry data and the current situation (Yeo & Carter, 2017). This communication entails descriptive, diagnostic, predictive and prescriptive procedures and techniques. Such techniques determine causal factors that help predict likely outcomes and prescribe appropriate actions and strategies accordingly. That is, they offer insights into important business events using visualization and data diagnosis. Further, to reflect value, data remain more meaningful when analytics and technology are used for complex data needs (KPMG, 2018).

2.3 | *Reasons for Using Big Data in Auditing Practice*

Auditing is about attesting to the integrity of financial statements prepared by managers. Oversight in this simple assertion may raise doubt about the accounting profession's capabilities and thus, could diminish the level of public confidence in the profession (Edelman & Nicholson, 2011; see also Al-Adeem, 2015; Bayou & Reinstein, 2001; Belkaoui, 2017b; Berton, 1985; Previts, 1992). Using big data, new information can be extracted online, sieved, and generated, creating new knowledge (Kim, 2000). With business operations expanding globally, the role of the audit profession has become more prominent, and the greater amount of captured data has resulted in massive transaction volumes. The real-time capture of transaction data, including location, time, amount, and medium, can ease the process of gathering substantive evidence for development of an audit opinion. Littley (2012) posits that part of big data's achievable benefits is providing auditors with internal and external tools to better forecast estimates, concerns, fraud, and other audit matters (Alles, 2015). Marr (2015) suggests that certain large-scale companies have witnessed more growth in recent times by using big data to improve their business processes. A prominent example is Amazon's use of big data analytics to strengthen their retail experience (Marr, 2015). Walmart also applies big data analytics to identify current trends in social media to monitor buying habits among consumers of substitute products (Cao, Chychyla, & Stewart, 2015; Marr, 2015), thereby tracking their competitors' advances in real time (Marr, 2015)

2.4 | *Opportunities and Challenges of Big Data in Professional Auditing*

Corporations, for-profit or non-profit organizations, and medium-scale businesses that integrate, secure, and create value with big data are likely to outperform their counterparts (Deloitte, 2018; Ghobakhloo, Morteza, Sabouri, Hong, & Zulkifli, 2011). Big data is revolutionizing numerous fields at an increasing rate and it is only a matter of time before the auditing profession adopts similar analytical methods (Cao, Chychyla, & Stewart, 2015). Big data analytics can augment accountants' data skills and knowledge through their prior familiarity with structured datasets (Richins, Stapleton, Stratopoulos, & Wong, 2017). Thus, it is necessary for financial accountants, particularly auditors, to take a dominant position in the course of strategic decision making. Big data enables auditors to analyze processes that generate data, including full population testing, which adds value to the auditing and accounting profession and consequently, to their clients (Gepp, Linnenluecke, O'Neill, & Smith, 2018). Consequently, to effectively exploit the inexhaustible opportunities and value of big data, professionals must develop an understanding of business strategy fundamentals and be able to draw inferences from pools of available data.

In 2012, the AICPA made a statement regarding changes from the historical paradigm toward a proactive approach, emphasizing the need for auditors to keep pace with such changes more quickly than other professionals. However, evidence from the literature reveals that data remain underutilized in modern audit engagements (Alles, 2015; Brown-Liburd, Issa, & Lombardi, 2015; Cao, Chychyla, & Stewart, 2015). For example, Gepp, Linnenluecke, O'Neill, & Smith (2018) claim that "academic literature has lamented the slow integration of Big Data into auditing" (p. 110).

2.5 | *Auditors' Perceived Big Data Competencies*

The accounting and audit professions have not been isolated from growth through modern-day technological advancements. In the current era, auditing might even have to upskill and break new ground. Future professional auditors will

have to be competent in three sensitive areas: analytical skills, development of new metrics, and generation of a visual language for data (Yeo & Carter, 2017). At a panel discussion held on November 27, 2017, Roger O'Donnell, a partner at KPMG, stressed the need for auditors to remain relevant in the recent big data phenomenon:[3]

> We need a combination of different skills in audit teams. We need data specialists—people who extract data, understand the systems, who can bring all the data available to us. We also need analysts—people who have critical thinking skills; those people who are not only able to look at a single transaction, but also are able to analyze the entire population, the entire system. That is a transformative exercise for the audit profession.

Accountants who nurture themselves and stay updated on modern technological events are likely to succeed and remain relevant in the big data era. More recently, both academic and professional bodies have emphasized the relevance of and insights from using big data. In particular, the Association to Advance Collegiate Schools of Business (AACSB) has considered more dynamic approaches to advancing tools and prerequisites to create a program for data analytics.[4] According to Helen Brand, Chief Executive of the Association of Chartered Certified Accountants (ACCA), [5]

> To succeed as a professional accountant…a vastly different set of skills is required than was necessary just 10 short years ago. And in the next decade, things are likely to change even faster and more dramatically as the global economy continues to evolve at an ever-quickening pace.

Yeo and Carter's (2017) recent study in Malaysia revealed that the current generation of auditors possesses the required IT skills (e.g., systems applications and products [SAP] and enterprise resource planning [ERP]) as well as big data infrastructure and management skills (e.g., data analytics). Since auditors are more interested in applying big data to perform substantive risk assessments using control testing procedures, a reasonable level of data analysis seems pertinent.

Several scholars have emphasized the need for descriptive, diagnostic, and predictive analytical skills combined with in-depth knowledge of mathematics, statistics, business skills, and creativity to effectively use big data analytics (Davenport & Dyche, 2013; Gartner, 2016; Strengell, 2017; Yeo & Carter, 2017). In addition, descriptive, diagnostic, predictive, and prescriptive analytics help present-day business executives more effectively run their organizations (Marr, 2014). An obvious need is accounting for the current technological phenomena and auditors may have no choice but to enhance their knowledge and skills in big data techniques and analytics as an essential component of their professional dealings. Auditors perceive the need to keep pace with technological trends "not because they necessarily value the analytical power of Big Data, but because their clients do" (Alles, 2015, p. 4). Gepp, Linnenluecke, O'Neill, & Smith (2018, p.110) refute such a claim by highlighting that the early use of random sampling techniques has already set auditors ahead of their clients "regardless of whether client firms utilize Big Data or not."

Despite the countless opportunities evident from the use of big data in audit practices, little or no research has been conducted on the topic, particularly in the context of Saudi Arabia. This study examines external auditors' perception of big data and analytics application to audit tasks and the requisite professional and technical competencies.

[3] See Xing Gao's "Data, Data! Key to Auditors" on Accounting Blog. Retrieved from https://www.bna.com/data-data-key-b73014472450/.

[4] AACSB (2018). Curriculum development series, *Data Analytics Summit* held on March 19–20, 2018. Tempe, Arizona, US.

[5] See Sharron Arnold's "6 skills accountants need to survive the robot uprising" on Blackline Magazine. Retrieved from https://www.blackline.com/blog/exceptional-accountants/6-skills-exceptional-accountant/

3 | RESEARCH METHOD

3.1 | *Research Instrument for Data Collection*

This study investigates auditors' perceptions toward and competencies in the application of big data and analytics given their impact on the accounting profession. Auditors in the 21st century, including those in Saudi Arabia, should be aware of the trending boom in data, which has resulted from both internal and external business activities. In addition, it is increasingly necessary for auditors to manage data effectively and efficiently while conducting audits, that is, the readiness to adopt and adapt to technological changes since "technology will continue to change at light speed" (Arnold, 2018, p. 9).

As suggested in Morgado, Meireles, Neves, Amaral, & Ferreira (2018), a literature review is one way of developing survey items. Thus, the items included in this study's survey were developed from related literature on the essential skills (e.g., IT skills) and competencies needed by auditors to utilize big data and analytics to gather material audit evidence (Abu-Musa, 2008; Deloitte, 2017; E-Skills UK, 2013; Hammer, Kostroch, & Quiros, 2017; Rouhani, Rotbei, & Hamidi, 2017; UN Economic Commission for Europe [UNECE], 2015; Yeo & Carter, 2017).[6]

The following subsections briefly explain the research instruments and design approach for each item. The analysis considers both internal and external practicing auditors in Saudi Arabia because of the country's recent economic reforms, one of which includes granting foreign investors the opportunity to invest in the country's stock market. The survey was conducted in English as most professional auditors in Saudi Arabia are familiar with the language.

3.2 | *Scale Development*

Auditors should possess a certain level of technological skill and awareness about related improvements, particularly big data and analytics. The following skills are considered relevant to this study's objectives.

3.2.1 | ERP Skills

The most basic skills needed to benefit from big data and analytics are ERP skills. This study goes beyond end-user computing skills to include the efficient use of accounting and ERP software (integrated accounting information systems software) (Yeo & Carter, 2017), particularly when dealing with complex transactions. Such skills include knowledge of vendor-based software (e.g., Oracle, SAP, QuickBooks, and Sage).

[6] The researchers admit that while developing items solely by relying on the literature, even quality studies on the subject, may not be an ideal approach to developing scales; nevertheless, it is a suitable method for this study given its objectives and nature. The results are intended to be preliminary.

3.2.2 | Data Design and Management Skills

Data design and management skills require auditors to understand the definitions and guidelines of database concepts. In addition, auditors must know how to efficiently store, organize, use, maintain, and analyze various types of data to aid in risk assessments, analytical procedures, and insightful audit processes. Proficiency encompasses technical areas (e.g., data aggregation, mining, interpretation, and modeling), processes, and knowledge about databases. This category comprises big data analytics software such as Hadoop, Relational, and online analytical processing (OLAP) (Deloitte, 2018; E-Skills UK, 2013).

3.2.3 | Analytical and Business Intelligence Skills

Analytical skills include a good working knowledge of statistical packages employed to analyze large-scale datasets, for example, SPSS, SAS, and Excel, as well as other modern tools. In addition, they entail the ability to use analytical techniques to map business intelligence and formulate strategies, as well as creative problem-solving skills based on real data to articulate and address future events (Chen, Chiang, & Storey, 2012).

3.2.4 | Programming Skills

Programming skills are specific to computer programming and scripting area languages such as JavaScript, NoSQL, Python, and PHP (Hammer, Kostroch, & Quiros, 2017; UNECE, 2015).

3.3 | *Protocol for Data Collection*

The survey respondents include both internal and external practicing auditors in independent financial services and other sectors. To ensure the face validity of the research instrument, two accounting professors reviewed the survey questions before it was administered to the participants. A pilot study was then conducted where five accounting graduate students responded to the survey and reported to the researchers any issues they may have faced while taking it. They were also encouraged to share comments or suggestions that could enhance the clarity and thus, the readability of the questions. While no technical issues were raised, all related and material comments were addressed and referenced to modify the instrument, thereby enhancing the quality of the survey prior to it being dispatched to the target respondents.

The questionnaire was sent to all auditors whose contact details were available on the Saudi Organization for Certified Public Accountants (SOCPA) website.[7] In addition, social media platforms,[8] such as Twitter, LinkedIn, and WhatsApp, were used to share the questionnaire with as many subjects as possible. The confidentiality of the respondents was

[7] For more details, visit http://socpa.org.sa/SOCPA/files/f6/f6a885b7-1db9-4fb6-b8d1-1263bbb826d3.html.

[8] Data collection from social media platforms was introduced as the result of a low response rate from personal emails. The researchers could not introduce a variable for respondent location because the survey was initially sent out via email before being distributed using social media. After social media platforms were utilized, subjects who had received the survey via email were still able to take the survey. The data collection was done from variety of sources simultaneously.

considered, and identities were kept anonymous. A total of 52 questionnaires were returned, of which 51 (98.08%) were usable; we excluded one owing to missing data.

The survey consisted of three parts: (i) academic and professional qualifications and active years of experience; (ii) use and perception of big data, data analytics capabilities in respondents' companies, and whether respondents plan to enroll in training courses for data analytics; and (iii) technical questions on big data and analytics competencies.

4 | RESULTS

4.1 | *Descriptive Statistics*

Table 1 and Figure 2 present averages of responses to questions on respondents' perception as well as the rate of big data analytics capabilities in an accountant's workplace. Table 2 shows the percentage of responses on auditor perceptions on big data and analytics on a five-point Likert-type scale, where 5 = "strongly agree," 4 = "agree," 3 = "don't know," 2 = "disagree," and 1 = "strongly disagree." The study classified respondents by academic discipline. A majority of the respondents studied accounting (82.35%), followed by business management (9.80%), finance (3.92%), financial risk management (1.96%), and taxes and zakat[9] (1.96%). In addition, 49% of the respondents have bachelor's degrees, 49% have master's degrees, while 2% have ACCA qualifications without a degree.

The majority of the subjects (64.71%) had no recognized professional certification/qualification, 15.69% were SOCPA certified, and 19.6% had various certifications in the field of accounting, including Certified Public Accountant (CPA; 5.88%), Certified Management Accountant (CMA; 3.92%), Certified Information Systems Auditor (CISA; 1.96%), Certified Internal Auditor (CIA; 3.92%), Certified Risk Professional (CRP; 1.96%), and Association of Chartered Certified Accountants (ACCA; 1.96%). Data further reveal that 19% of the auditors have more than 10 years of practice experience, 16% between 5–10 years and 16% less than 5 years. Figure 2 illustrates the current use of big data analytics in the respondents' companies.

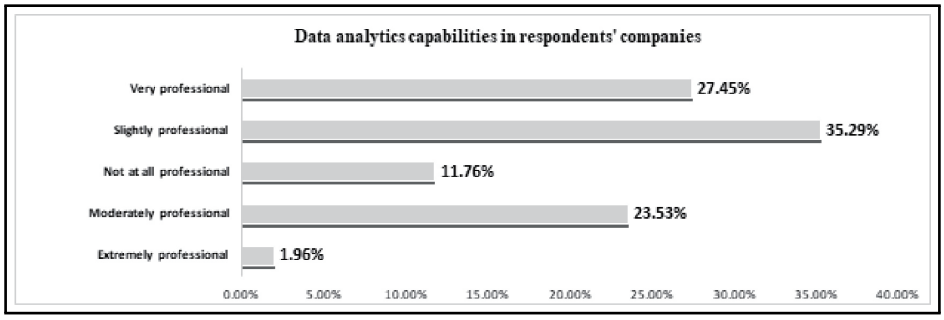

FIGURE 2 Ratio of Data Analytics Capabilities in Auditors' Companies

[9] Zakat is a form of alms-giving treated in Islam as a religious obligation or tax. It is the third pillar of Islam and a mandatory charitable contribution, the right of the poor to find relief from the rich. It is customarily 2.5% (or 1/40) of a Muslim's total savings and wealth above a minimum amount. Retrieved from https://en.wikipedia.org/wiki/Zakat

Table 1 shows that the means for each response to questions 1–6 range between 3.37 (S.D. = 0.96) and 3.90 (S.D. = 0.76). The grand mean of 3.64 is an above-average grand mean. This indicates the moderate positive perception of Saudi Arabian auditors of the benefits derived from big data and data analytics.

Table 1. Averages of Responses to Questions on Respondents' Perception

Questions	Mean	SD	Max	Min
1. Big data analytics is taking over the auditing profession.	3.37	0.96	5	1
2. The auditing profession should move toward the use of data analytics specialists in audit engagement.	3.90	0.76	5	1
3. Should CPE requirements for the profession be reformulated to reflect new big data learning?	3.80	0.83	5	1
4. I am able to effectively research and gather reliable data using IT resources in a relatively short time period.	3.53	0.88	5	1
5. I have the ability to find and detect patterns across volumes of data.	3.45	0.88	5	2
6. I have effective communication skills.	3.76	0.89	5	1
Grand Mean	3.64			

4.2 | *Responses on Auditor Perceptions*

In Table 2, about 47.06% and 5.88% of the surveyed auditors agree and strongly agree that big data analytics is taking over auditing practices. In addition, 84.32% agree to the need for data analytics specialists in audit engagements. A high rate of 68.63% and 11.76% agreed and strongly agreed that courses related to big data should be included in accountants' continuous professional educational programs. About 68.63% agreed to testing auditors' abilities to research and gather useful data using relevant IT tools, indicating their capabilities to perform such tasks. Similarly, 62.74% reported having the professional ability to find and detect patterns across volumes of data gathered from a series of client and company transactions. Finally, 80.39% auditors claimed their communication before and after audit engagements to be effective.

Table 2. Percentage of Responses on Auditor Perceptions

No.	Question	Strongly agree	Agree	Don't know	Strongly disagree	Disagree
1	Big data analytics is taking over the auditing profession	5.88%	47.06%	31.37%	5.88%	9.80%
2	The audit profession should move toward the use of data analytics specialists in audit engagements	13.73%	70.59%	9.80%	1.96%	3.92%
3	Should CPE requirements for the profession be reformulated to reflect new big data learning?	11.76%	68.63%	9.80%	1.96%	7.84%
4	I am able to effectively research and gather reliable data using IT resources in a short time period	3.92%	64.71%	13.73%	1.96%	15.69%
5	I have the ability to find and detect patterns across volumes of data.	3.92%	58.82%	15.69%	0	21.57%
6	I have effective communication skills	9.80%	70.59%	11.67%	5.88%	1.96%

In addition, Table 2 details that 27.78% of responses were either "don't know," "strongly disagree," or "disagree," while 72.22% were "agree." This demonstrates auditors' positive perception of knowledge about and the need for big data analytics in audit practices. The results also demonstrate their elevated level of awareness about the big data phenomenon and its application to the accounting profession.

4.3 | *Competencies Related to Big Data*

In line with its objectives, this study investigates individual auditors' perceived competence in big data analytics. The required skill areas are classified into four categories, including essential skills related to big data analytics expected from a 21st-century auditor to meet the profession's technological demands.

Question 3 in the survey is based on IT skills and focuses on the ability to efficiently use accounting ERP software, particularly when dealing with complex business transactions. Questions 4 and 5 address the understanding of technical areas related to data design and management, including processes and knowledge of databases. Questions 6 and 7 focus on data analytics and business intelligence defined by auditors' use of modern statistical software and their aptitude for innovation. Question 8 addresses specific computer programming training that the respondents received prior to the study.

4.3.1 | IT Skills

Figure 3 reveals that 80.39% of auditors use various accounting ERP software (Oracle, 19.61%; QuickBooks, 3.92%; Sage, 5.88%; SAP, 23.53%; and Others, 27.45%) while 19.61% have no such skill.

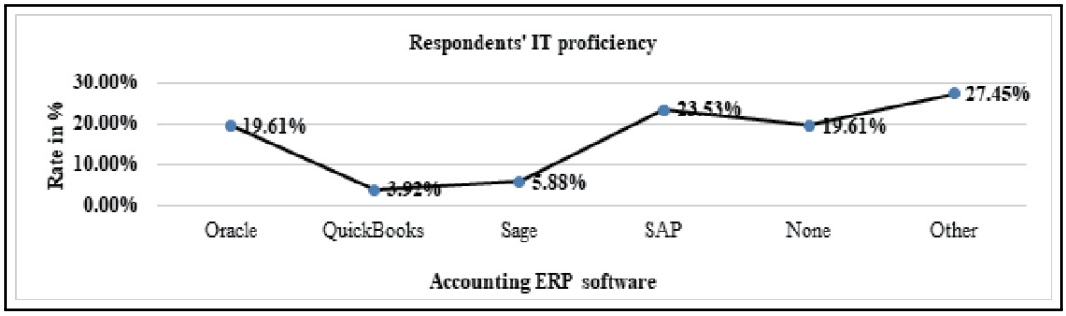

FIGURE 3 Auditors' IT Skills

4.3.2 | Data Design and Management Skills

Figures 4 and 5 reveal a majority of the surveyed accountants have received training in various areas of data design and management, with training on data modeling ranking the highest (21.57%). However, a majority (76.47%) have no practical knowledge of certain big data management tools.

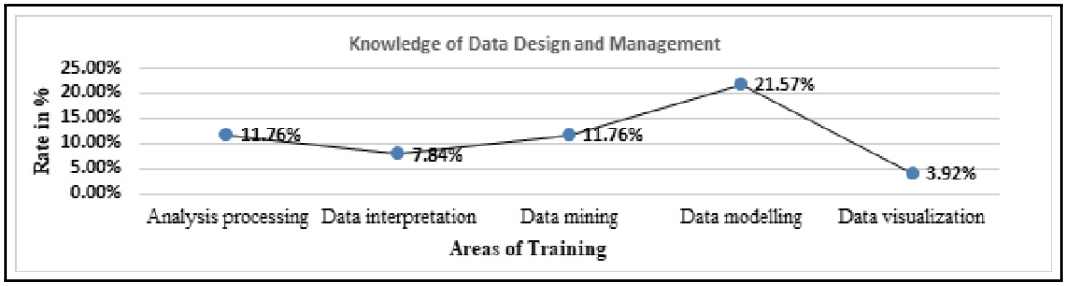

FIGURE 4 Areas of Training

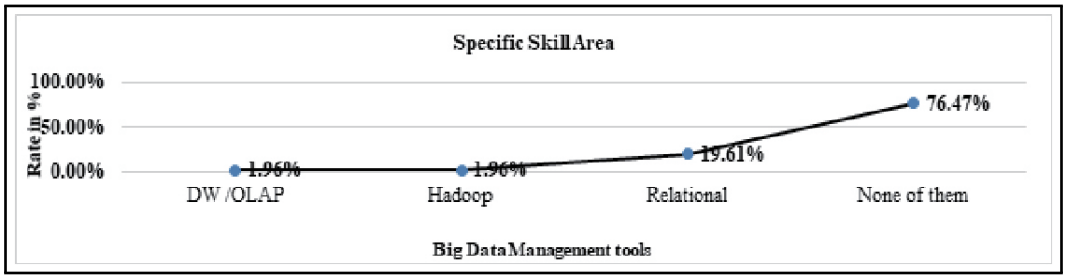

FIGURE 5 Big Data Management Tools

4.3.3 | Analytical and Business Intelligence Skills

According to Figure 6, compared to Excel (84.31%), few auditors are able to use statistical analysis software such as SAS (3.92%) and SPSS (9.80%). Meanwhile, only 1.96% of respondents use SAS, Excel, and ASL.

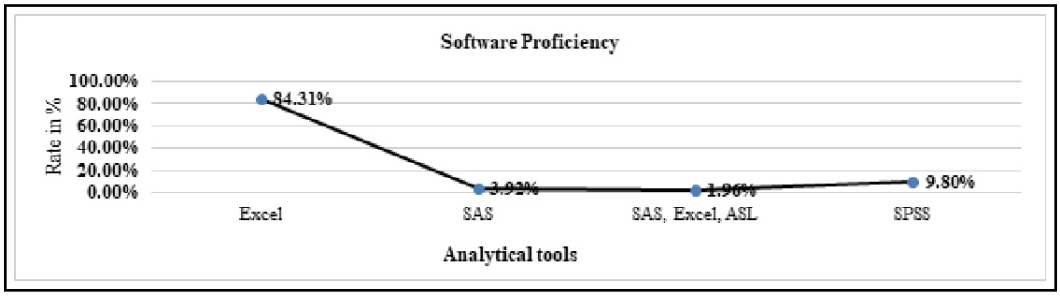

FIGURE 6 Data Analysis Proficiency

Figure (7) illustrates respondents' aptitude for innovation. When asked about how often they are able to create something new or unique, a majority of the respondents stated that they feel this drive "sometimes" (45.10%), followed by "very often" (27.45%), "always" (11.76%), "rarely" (13.73%), and "never" (1.96%). This demonstrates the low level of innovation in applying big data technologies to audit processes.

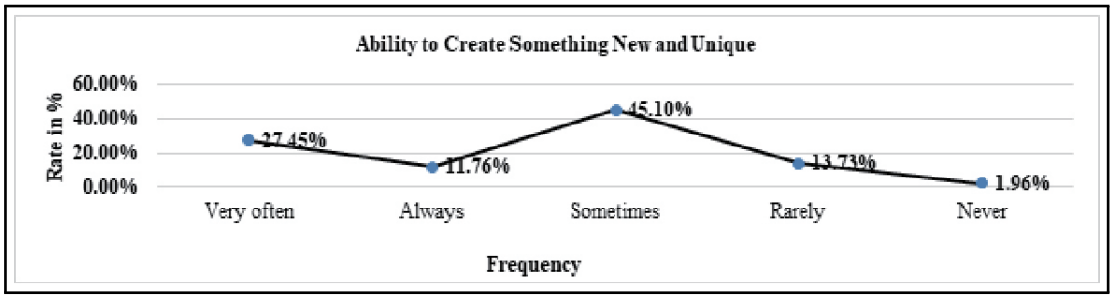

FIGURE 7 Auditors' Aptitude for Innovation

4.3.4 | Programming Skills

Figure 8 shows that most of the surveyed subjects (78.43%) have no in-depth knowledge about programming scripts or languages.

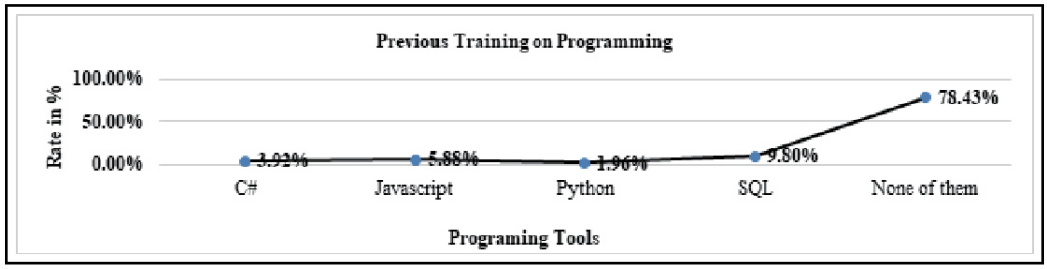

FIGURE 8 Auditors' Computer Programming Skills

In sum, figures 3–8 reveal that auditors have sufficient IT skills and reasonable knowledge about database management systems. However, apart from Excel, they are largely unfamiliar with modern data analysis tools. In addition, a large number of respondents lack big data analytics software and programming language skills.

4.3.5 | Received Training and Willingness to Receive Training on Big Data

Table 3 indicates that 35.29% of accountants have already attended different levels of training on big data and 31.37% plan to enroll in one or more courses. However, 64.71% of auditors declare that they have never attended such training, 50.98% might enroll in a course in the future, and 17.65% have no intention of doing so . Thus, a high percentage of the sampled auditors are either not trained or are open to receiving proper training.

Table 3. Received Training and Willingness to Receive Training on Big Data

Responded Auditors				
Training received on big data and analytics		Plans to receive training in the near future		
Attended	Not attended	Have plans	No plans	Maybe
35.29%	64.71%	31.37%	17.65%	50.98%

5 | CONCLUSIONS, LIMITATIONS, AND FURTHER RESEARCH

This study provides empirical evidence on auditors' perceptions toward and competencies in the application of big data and analytics to audit engagements. Using an electronically administered survey developed from the literature, the findings confirm that the surveyed auditors are well aware of the influence on and necessity of big data analytics in audit processes. In addition, they have a high level of appreciation for IT systems related to accounting (e.g., ERPs) and big data as well as their application to the auditing profession. Auditors' unfamiliarity with relevant data analysis tools, big data analytics software, and programming language skills can be attributed to their low inclination toward big data training and innovation. This may be due to the fact that the current CPA exam and most accounting programs in universities are conventionally oriented with no emphasis on such skills. The lack of requisite skills in data analytics software and programming language as well as unfamiliarity with relevant data analysis tools have important implications, particularly in the context of their counterparts in more developed nations. Auditors may have to make greater efforts to perform substantive audit risk assessments using big data analytics when faced with the complex business transaction data of their clients or companies. Thus, this study highlights the need for auditors, including those in Saudi Arabia, to receive training courses on big data analytics and techniques that can prove beneficial to their auditing practices.

The results of this study are consistent with a recent study in Malaysia (Yeo and Carter, 2017), who report that auditors need further training in the techniques and application of data analytics to enhance their investigative capabilities. However, research has shown that auditors in more advanced countries are now at least reasonably familiar with using big data analytics during audit investigations (Brown-Liburd & Vasarhelyi, 2015). Consequently, it was emphasized that overall technological advances (including auditor's professional competencies in this respect) in applying data analytics in audit engagements will be motivated by the advances in the US and international auditing standards (see Alles, 2015). These results have implications for practicing auditors in Saudi Arabia.

This study is not free of limitations. The main limitation is that it does not account for all specialty and skill areas in big data that a typical big data scientist might consider. In addition, the sample size is small compared to the number of practicing accountants in the case country, Saudi Arabia. Another constraint that may limit the generalizability of the research findings of the study is the use of social media in the data collection phase without including a question in the research instrument asking respondents to specify their geographic location to control for country. As indicated, utilizing social media to distribute the survey was the result of a low response rate to emailed surveys. Future research should add a variable to control for country.

Future research could also investigate the possibilities and potential effects of International Auditing Standards (IAS) pronouncements on adjusting audit engagements to foster the use of data analytics. Such an investigation could also explore key components for possible guidelines on data protection and ethical requirements in IT audits.

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Bibliography

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Dr Khalid Al-Adeem

Dr Al-Adeem attended King Saud University from 1995 to 1998 and graduated with a Bachelor of Science in Business Administration degree in accounting with honours and at the top of his class. He attended Case Western Reserve University from 2002 to 2004, earning a MAcc with an excellent GPA, and received awards from the Director of the Master of Accountancy and the Saudi Ambassador in Washington for academic excellence. Between 2004 and 2009, he earned a PhD with a published dissertation from Case Western Reserve University. Dr. Al-Adeem has taught 24 different courses. He teaches undergraduate and graduate courses at the master and doctorate levels in Arabic and English. He supervises more than 45 papers in accounting, all which were completed. Professionally, he assists the Gulf Cooperative Council Accounting and Auditing Organization and the Saudi Organization for Certified Public Accountants in its project to converge with the International Financial Reporting Standards. He is currently directing the PhD program in business with four majors(accounting/finance/marketing/management) in addition to the graduate studies in the accounting department. He is a member and a reviewer for several journals including*International Journal of Critical Accounting* (inderscience), *International Journal of Emerging Markets* (SCOPUS). He was a guest reviewer, *International Accounting Journal*.

APPENDIX

Section I - Personal Data:

Job position: *

_____

Qualification:
☐ B.Sc.
☐ Master Degree.
☐ Ph.D.
☐ Other: _____

Your discipline
☐ Accounting
☐ Business Management
☐ Other (Specify) _____

Professional Certification in Accounting:
☐ SOCPA
☐ CPA
☐ ACCA
☐ CIA
☐ CISA
☐ None
☐ Other: _____

Years of Experience:
☐ Less than 5 years
☐ From 5-10 years
☐ More than 10 years

Have you attended a training course on Big Data/Data analytics?
☐ Yes
☐ No

Does your organization work with Big Data/Data analytics?
☐ Yes
☐ No

Do you plan to get professional training in Big data analytics anytime soon?
☐ Yes
☐ No
☐ Possibly

Big data analytics is taking over the auditing profession?
☐ Strongly agree

☐ Agree
☐ Do not know
☐ Disagree
☐ Strongly disagree

The audit profession should move more toward the use of Data analytics specialists in the audit engagement?
☐ Strongly agree
☐ Agree
☐ I do not know
☐ Disagree
☐ Strongly disagree

Should the Continuing Professional Education (CPE) requirements of the profession be reformulated to reflect new Big data learning skills/requirements?
☐ Strongly agree
☐ Agree
☐ I do not know
☐ Disagree
☐ Strongly disagree

How would you rate the Data analytics capabilities in your company today?
☐ Extremely professional
☐ Very professional
☐ Somewhat Professional
☐ Not so professional)
☐ Not at all professional

Section II

1. I am able to effectively research and gather reliable data using IT resources in a relatively short time?
☐ Strongly agree
☐ Agree
☐ I do not know
☐ Disagree
☐ Strongly disagree

2. I have the ability to find and detect patterns in a volume of Data?
☐ Strongly agree
☐ Agree
☐ I do not know
☐ Disagree
☐ Strongly disagree

3. Which of these Accounting ERP software do you use proficiently?
☐ SAP
☐ Oracle
☐ Sage
☐ QuickBooks
☐ Other

☐ None

4. In which of these you previously been trained on?
☐ Data aggregation
☐ Data interpretation
☐ Analysis processing
☐ Data visualization
☐ Data mining
☐ Data modelling
☐ None of them

5. Which of the following you are skilled:
☐DW /OLAP
☐Relational
☐Hadoop
☐ None of them

6. Which of these software do you use proficiently?
☐ Excel
☐ SAS
☐ SPSS
☐ Other(Specify) _____

7. Which of these you previously been trained on?
☐ JavaScript
☐ SQL
☐ Python
☐ PHP
☐ C#
☐ None of them

8. I am an effective communicator?
☐ Strongly agree
☐ Agree
☐ I do not know
☐ Disagree
☐ Strongly disagree

9. How often do you think outside the box and create something entirely new and unique?
☐ Always
☐ Usually
☐ Sometimes
☐ Rarely
☐ Never