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Initial Implementation of Data Analytics and Audit Process Management

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Abstract: To answer the call for more evidence on the adoption and effectiveness of Big Data Analytics in auditing, this study investigates auditors' use of data analytic tools in audit-process management, including audit planning, testing, and conclusions. The analysis, which is performed as a qualitative study, is based on twenty-eight semi-structured interviews with Big 4 and non-Big 4 audit professionals in Thailand to gain insights into their experience implementing audit data analytic tools in the initial stage. Findings suggest that auditors primarily use data analytic tools in audit planning and substantive testing. Nevertheless, auditors do not perceive a need to use these tools to test internal controls and conclude audit opinions. In addition, we find that auditors tend to apply audit data analytic tools for anomaly detection and testing management assertions. Overall, auditors perceive the benefits of audit data analytic tools in improving their audit process management. Findings present practical implications for audit firms and audit professionals, including how to initially implement data analytic tools effectively in auditing and as guidelines for regulators on how to develop auditing standards that govern the use of Big Data and data analytic tools. We note some limitations in this study, such as the generalizability of the results, auditors' personal biases, and the different tools and techniques used by each audit firm.

Keywords: data analytics; audit; audit process; process management; technology

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1. Introduction

As emerging technologies are advancing and progressing quickly, one of the technology trends that has received attention in the business field is Big Data [1]. Generally, Big Data refers to a large volume of complex data generated through the advancement of technologies [2]. Due to the volume and speed of data generation, traditional data storage and analyses cannot handle Big Data and thus present a challenge for businesses to consider adopting advanced data analytic approaches to resolve these issues.

In the accounting and auditing context, audit firms must consider and use proper data analytic techniques to obtain reliable evidence to maximize the benefits of Big Data and provide accurate audit opinions. To properly use Big Data in auditing, audit firms in Thailand must consider the relevant Thai Standards on Auditing (TSAs) issued by the Federation of Accounting Professions (TFAC). For example, Section 230 details audit documentation, Section 315 discusses the identifying and assessing the risks of material misstatement through understanding the entity and its environment, Section 500 explains the audit evidence, Section 520 discusses the analytical procedures, and Section 530 specifies audit sampling techniques [3]. Therefore, audit evidence from Big Data and data analytic tools should be used in accordance with the prescribed standards to attain high-quality audits.

As the newly adopted technologies enable information to flow quickly in various forms, organizations have begun to utilize Big Data to gain a competitive advantage. Specifically, modern audit engagements often involve the examination of clients that are using Big Data, and most client systems are integrated with the cloud and external data sources such as social media [4,5]. The large volume and variety of cumulative transaction

data thus challenges auditors to adjust their practices accordingly while maintaining their professional goals [6]. As a result, Big 4 audit firms have begun investing in data analytic auditing tools. The adoption of data analytic tools has led to modern audit approaches, which require auditors to develop their skills and competencies to stay current in the industry [7]. In practice, using modern data analytic tools in auditing is still a challenge for audit practitioners, partly because auditors are not well-trained in using these tools, and because technologies are changing rapidly. Furthermore, prior research calls for additional research to address audit data analytic issues, such as the appropriate audit data analytic techniques for a particular audit function, the data analytic methods used to generate predictions to compare with actual accounting numbers, and more international evidence on the adoption of audit data analytics [4,8,9].

To provide insights from the direct experience of audit practitioners regarding the initial implementation of data analytic tools in auditing, our study explores the use of data analytic tools in each step of the audit process, from audit planning, audit testing, and the conclusion of audit findings. In addition, this study offers recommendations for auditors to implement data analytic tools in auditing more effectively and efficiently. Specifically, we conducted interviews with the practitioners at the assistant auditor, audit manager, senior audit manager, and audit partner levels at practicing audit firms in Thailand during the period of December 2016 to March 2017, which was the earliest phase of Big Data and data analytics application in Thailand. The results of this study are informative to audit firms and auditors on how to implement data analytic tools in auditing effectively, and to regulators as guidelines on how to develop new auditing and audit-quality-control standards. The developers of data analytic software also benefit from users' feedback to further improve their tools to tailor to user requirements.

The results of the study indicate that auditors use data analytic tools in audit planning and substantive testing only. However, auditors do not use the tools to test internal controls and finalize the audit findings. To be specific, auditors prefer using data analytic tools to identify anomalies in accounting transactions and to examine the management assertations regarding the accuracy of financial-statement disclosure. Furthermore, the interviewees discussed that data analytic tools improved their audit process management and confidence in concluding the audit findings and audit opinions, resulting in increased accuracy and client satisfaction. To ensure the use of data analytic tools in auditing more effectively, audit firms, audit practitioners, and relevant stakeholders must be involved in developing work procedures to minimize limitations in using the audit data analytic tools.

2. Literature Review

This section reviews the related accounting and auditing literature to identify pertinent issues related to Big Data and data analytics and to understand the definitions of Big Data and data analytics, data analytic tools for auditing, and the adoption of audit data analytic tools.

2.1. Big Data and Data Analytic Techniques

Big Data refers to a large volume of complex data—machine-generated or human-generated—in various forms and at an unprecedented speed. Due to these characteristics, traditional data analyses cannot handle Big Data; therefore, more advanced analysis tools are required [10,11]. In addition to the data analytic tools, which include software and technology that can help process Big Data, data scientists play an essential role in the process because they have well-rounded knowledge and skills regarding data, relationships among variables, and tools; they therefore have expertise in processing and analyzing Big Data.

Big Data can be classified into two categories based on its forms [12]. Structured data refers to numeric data in traditional databases. For example, point-of-sale transaction data, internet usage logs, online banking transactions, and financial stock-market exchanges. Unstructured data cannot be stored in a traditional database, such as text documents, e-

mails, videos, audio, and social media data from Facebook or Twitter. In addition, Big Data can also be categorized as public or private. Specifically, public data is readily available and accessible by the public, while private data is held and available to the companies that have the data. However, private data can be transferred to third parties if users have given permission or if the data has been anonymized, whereby the identifying information has been removed [13].

Data analytics is one discipline used to manage data to achieve business objectives by gathering relevant data and transforming data for data analytics with tools, or by developing a model to analyze data for business use [7]. Data analytics are divided into four categories. First, descriptive analytics is the most basic data analytic approach. This technique focuses on explaining what has happened or what is happening, such as sales forecast reports and financial outcomes. Second, diagnostic analytics aims to explain why things happen by examining the relationships among variables; for instance, the relationship between sales and marketing campaigns—for more informed decisions. Third, predictive analytics is a more advanced technique that predicts what will happen using historical data, statistical models, and other sophisticated techniques such as machine learning and data mining. Examples of predictive analytics are sales forecasting models and credit-rating score models. Fourth, prescriptive analytics is the most sophisticated technique because it relies on advanced algorithms. It extends the predictive models to simulate different scenarios with predicted outcomes to recommend alternatives to users [14].

2.2. Big Data and Data Analytics in Auditing Literature

Big Data is a large data warehouse that provides knowledge and useful information in various forms [15]. Therefore, these characteristics could be viewed as both opportunities and threats to organizations, depending on the organizations' abilities to adapt their organizational structures to keep up with technological change. For the auditing profession, Big Data involves business transactions recorded in general and subsidiary ledgers, trial balances, financial statements, annual reports, industry and competitors' data, and social media data. Large audit firms with the necessary hardware, software, and personnel expertise can adopt data analytic approaches to analyze data in auditing to meet the demands of their clients. By contrast, small audit firms have limited investment budgets, know-how, and experience in data analytics; thus, these firms may consider outsourcing audit data analytic tools from software vendors or professional data-analytic consulting firms in the market. Audit professional firms and practitioners must be prepared to engage in data analytics, which may involve testing all the business transactions using data analytic tools.

Several TSAs are related to Big Data and data analytics. For example, in TSA Section 520, the analytical procedures include an analysis of the relationship between financial and non-financial data and an analysis of data fluctuations and misstatements [3]. Examples are data comparisons across different periods, auditors' estimations of financial statement line items, comparative financial ratio analyses of firms and industry competitors, and relationships among financial variables. Audit data analytics (ADA) explores and analyzes data to identify anomalies, categorizes and filters relevant data, and predicts financial and non-financial data trends to generate useful information for risk assessment, audit planning, and substantive tests [16–18]. According to Kend and Nguyen [19], the usage of ADA has a positive impact on auditing because it diverts auditors' attention away from manual activities and allows them to focus on more important tasks such as assessment and judgment.

As discussed in Dagiliene and Kloviene [20], there are four research streams related to ADA. First, a major research stream argues that the use of data analytics is useful for ensuring audit quality by improving the efficiency and effectiveness of financial statement audits and by using Big Data as audit evidence [2,21–23]. The second stream of research focuses on competencies to ensure an effective process when using ADA [24]. The

third stream of research emphasizes the role of changes in auditing standards [4]. Lastly, the fourth research stream highlights the technological challenges for audit firms using ADA [4,25–31].

Because Big Data encompasses several data types and sources, such as business news, articles, online media, textbooks, pictures, audio, videos, and population data, firms can utilize these data to predict customers' behaviors and derive more accurate sales forecasts. Auditors also benefit from Big Data and data analytics in analyzing the association among variables to identify anomalies and potential fraud, resulting in enhanced audit quality [20]. The prior literature discusses several uses of data analytics in auditing [22]. For example, auditors can use data analytics to assess firm risks related to bankruptcy, management fraud, and misstated financial statements. Data mining is a technique that has advanced classification and prediction capabilities and can contribute to fraud detection [5,32].

In addition, O'Donnell [33] highlighted the important role of data analytics in auditing as boards of directors, management, and investors expect auditors to keep up with emerging technologies and to be able to analyze Big Data to enhance audit quality. Examples of data analytics in the revenue cycle involve examining anomalies of price and quantity differences among sales orders, shipping documents, and sales invoices. Data analytic tools can better understand clients' environments, expand substantive and internal control tests for fraud detection, and improve the overall audit quality. Furthermore, Brown-Liburd, Issa, and Lombardi [21] described that auditors must first analyze the relationships among the available Big Data and perform additional analyses to identify the root causes of anomalies while obtaining sufficient audit evidence.

To add value to the audit process, auditors must use their expertise and relevant tools to carefully review the reliability and quality of financial and non-financial data. Big Data quality is an important issue for the audit profession and requires auditors' professional judgment and expertise to validate data before data analysis. In addition to using data analytic tools, auditors may still need to exercise their judgment to review the details in each business contract for concluding the audit findings [23]. Predictive analytical tools are utilized by auditors to make projections and estimates and to enhance business intelligence. Auditors can also utilize data visualization tools and predictive analytics to uncover trends in the business process [18]. Overall, external auditing firms benefit from implementing data analytics, especially when they need to audit big companies, which have a tremendous amount of Big Data available. Therefore, data analytics tools become useful in enhancing the effectiveness and reliability of audit results [5,20].

Despite the potential benefits of Big Data in auditing, several gaps and issues must be considered [34]. First, because Big Data is obtained from various sources and in different formats, users must know how to integrate data across systems and ensure data consistency. Second, due to the large volume of Big Data, users must validate the authenticity and quality of data to ensure data integrity. Third, users should be able to identify the sources of structured and unstructured data and use proper tools to analyze the data effectively. Fourth, users must gather and collect Big Data properly to select relevant data for high-quality ADA. Fifth, data privacy and security must be protected to prevent the unauthorized disclosure of data for auditing. These issues present a challenge for ADA, such as auditing various data formats, data inconsistencies, falsified data, and incomplete data [35]. The traditional approach cannot handle the audits of Big Data and thus requires audit firms to adopt advanced technologies to enhance audit quality [36]. Lastly, a significant challenge concerning Big Data in auditing is a shortage of professionals who possess the knowledge and skills to use these demanding tools. The growing demand for such skills urges for educational institutions and new training programs to be implemented at both the undergraduate and graduate levels [5,37,38].

2.3. The Adoption of Data Analytic Tools in Audit Process Management

Two key factors motivate audit firms and practitioners to adopt data analytic tools in audit process management [25]. First, because clients have begun to adopt more advanced

tools and technologies to collect and process their Big Data for business purposes, auditors must adapt their audit process and tools to meet the clients' requirements. As a result, audit process management is expected to be improved due to more sophisticated ADA and tools, which enhance accuracy and confidence in the conclusion of audit findings and audit opinions. Despite the initial investment in audit data analytic tools, audit firms can eventually leverage economies of scale to lower operating costs while improving profits. Second, prior literature shows that audit practitioners have struggled to apply new technologies in auditing. Several traditional auditing approaches do not apply to the current business environment, which involves large volumes of complex Big Data and modern accounting information systems. These factors have incentivized audit firms to adopt and apply data analytic tools in their audit process management to stay current in the business.

As has been discussed in the prior literature, global stakeholders have expressed interest in increasing the use of data analytics throughout the audit process. While data analytics offers great opportunities in identifying insight information, auditors may not use this information to its full potential, resulting in a missed opportunity for possible improvements to audit quality [39,40]. Data analytics can be viewed as an extension of analytical procedures, but auditors do not always use analytical procedures effectively [4,40–42]. Another challenge in the implementation of data analytics is that international auditing standard setters, such as the PCAOB, do not require the use of data analytics [40]. In addition, auditors prefer simple analytics, including comparing current-year balances to prior-year balances, and thus may be reluctant to use more sophisticated analytics [43]. Nevertheless, the international auditing standard setters encourage the use of these tools to improve the audit process and audit quality [40]. As discussed by Koreff [39], auditors have a greater cognitive fit with data analytics if they use analyses that they are familiar with because cognitive fit increases with experience. These findings indicate the importance for audit firms to train their employees on the use of data analytics to enhance cognitive fit and facilitate uniform decision making.

An exploratory study of the use of ADA in Norway presents several interesting findings from one developed country that can be compared with evidence from Thailand [9]. Overall, the attitudes of the audit interviewees toward ADA usefulness were positive. An analysis of the audit engagements suggests that the use of ADA is relatively limited, and the use of advanced ADA is rare. More ADA tools are used for clients with integrated ERP/IT systems and for new audit engagements. In the audit planning phase, ADA tools are used for the overall assessment of the client's operations and performance, identifying and assessing key risks, and mapping business processes. In the substantive testing phase, ADA tools are used for journal-entry testing, calculating sample size, and selecting random samples. In the completion phase of the audit, ADA tools are used for reconciliation and control between final accounts and underlying ledgers, analytical procedures, and the review of financial statements [9]. Similar evidence was documented for audit firms in the Middle East [8]. Auditors in this region rely on big data technology to a moderate extent. Specifically, ADA has an impact on the audit process at every stage. For example, ADA is used to understand the audit client's internal and external environment before accepting or continuing the audit assignment. ADA is also used to perform analytical procedures, analyze client risks, and understand and evaluate internal control systems [8].

3. Research Methodology

This study used a qualitative method of in-person interviews for data collection. Specifically, the target group of interview participants consisted of incumbent audit practitioners with direct experience using data analytic tools in auditing during the initial stage, including the audit assistants, audit managers, senior audit managers, and audit partners. These participants worked for Big 4 and non-Big 4 audit firms in Thailand. The main reason for choosing an interview method was to obtain the primary source of data from personal insights and specific responses from audit professionals within the scope of the study. The

primary purpose of the interviews was to study how auditors applied data analytic tools in audit process management.

To ensure the quality of the in-depth interviews and interview questions, we reviewed the related literature and documentation, such as research publications, academic articles, practitioners' articles, and auditing standards, before developing interview questions. Semi-structured interviews with open-ended questions were used for data collection to allow the interviewees to discuss personal experiences more openly. Before starting the interviews with participants, pilot interviews were held with two senior audit managers regarding the draft interview questions to confirm their validity, clarity, and relevance. At the beginning of each interview, we started by introducing our study. Confidentiality and anonymity were assured to all interviewees. Interviewees were then asked to express their opinions regarding each question in the list. Interviews were conducted flexibly to enable participants freedom to respond to the themes or questions raised. Furthermore, we were also open to additional discussions, comments, and responses from the participants for comprehensive analyses.

Based on the research method and data collection process described above, the interview questions were divided into two sections. Section One comprised the personal information of the interviewees. Section Two included open-ended questions about the use of data analytics in each step of the audit process. The list of questions used is available in Appendix A. We obtained the participants' perceptions towards using data analytics in auditing during December 2016 to March 2017, which was the initial implementation period of Big Data and data analytics in Thailand.

4. Results

Based on the interviews of Big 4 and non-Big 4 audit practitioners, we summarize key findings according to the two sections of the interview questions as described below.

4.1. Participants' Demographic Information and Related Experience

Our sample group of interview participants consists of twenty-four auditors from Big 4 audit firms and four from non-Big 4 audit firms. Auditors with direct experience using data analytics tools in auditing during the initial stage of implementation. Demographic information related to the interviewees broken down by their job titles, years of work experience, gender, and audit firm types is summarized in Table 1. Most of our participants are at the manager and senior auditor levels from the Big 4 audit firms, which illustrates the perceptions of more experienced practitioners who have engaged in the audits of medium to large organizations.

Table 1. Summary of Auditors' Demographic Information.

Job Title	Years of Work Experience	Gender		Big 4 Auditors (No. of Person)	Non-Big 4 Auditors (No. of Person)	
		Male	Female		Non-Big 4 Auditors in Overseas Offices (No. of Person)	Non-Big 4 Auditors in Local Offices (No. ofPerson)
Audit Partner	25 or more	1	1	2	-	-
Senior Manager	12–25	3	2	5	-	-
Manager	6–12	5	6	9	1	1
Senior Auditor	3–6	2	4	5	1	-
Assistant Auditor	1–3	-	4	3	-	1
Total		11	17	24	2	2

Table 2 summarizes the years of auditors' experience using data analytic tools for auditing by the types of data analytic tools and the types of auditors. Specifically, Microsoft Excel is considered a basic tool for traditional analytical procedures, while other audit data analytic tools are used to analyze Big Data and perform more sophisticated analyses. As shown in Table 2, Big 4 and non-Big 4 auditors use Microsoft Excel in auditing as expected. However, only the Big 4 auditors in our sample have experience using advanced data analytic tools, and most of these auditors have experience between one to three years using the tools during the sample period. Therefore, these findings provide preliminary evidence from auditors of the international Big 4 audit firms when they adopt advanced ADA in their audit process. This prompts us to examine further how these auditors use data analytic tools in the initial stage of audit process management, as discussed in the following section.

Table 2. Summary of Auditors' Experience Using Data Analytic Tools in Auditing.

Years of Experience Using Data Analytic Tools in Auditing	Data Analytic Tools Used in Auditing					
	Basic Microsoft Excel Tool			Audit Data Analytic Tools		
	Big 4 Auditors (No. of Person)	Non-Big 4 Auditors (No. of Person)		Big 4 Auditors (No. of Person)	Non-Big 4 Auditors (No. of Person)	
		Non-Big 4 Auditors in Overseas Offices (No. of Person)	Non-Big 4 Auditors in Local Offices (No. of Person)		Non-Big 4 Auditors in Overseas Offices (No. of Person)	Non-Big 4 Auditors in Local Offices (No. of Person)
More than 15	1	-	-	-	-	-
9–15	3	-	-	-	-	-
6–9	8	1	1	3	-	-
3–6	5	1	-	4	1	-
1–3	3	-	1	13	1	-
Total	20	2	2	20	2	-

4.2. Auditors' Adoption of Data Analytic Tools in the Audit Process Management

The overall results indicate that auditors only use data analytic tools in the audit planning and substantive testing. At the time of the interview, auditors have not used the tools to test internal controls and conclude audit findings. Key findings and insights of each step regarding using ADA tools in each audit process are described below.

4.2.1. Data Analytic Tools for Audit Planning

According to the interviews, only two Big 4 participants use ADA tools for audit planning. Specifically, the ADA tools are used to understand the client's entity and environment, identify risks that may affect financial statements, and specify the nature, scope, methods, and period for auditing. For example, auditors use the tools to perform analytical procedures of current- and prior-period expenses, detect abnormal transactions that have changed significantly over the two periods, and identify high-risk accounts for further examination. In addition, auditors use the tools to analyze trends in accounting data by creating a report showing relationships between sales and costs of sales and a report showing trends of sales and gross margin. These reports would then be used as inputs for the forecasting model or for setting the expected account values. However, the interviewees suggested that the adopted data analytic tools could not perform the forecasting analyses or set the expected values for auditors. Other remaining interviewees never experience using ADA tools for audit planning. The Big 4 audit partner added to the discussion that ADA tools could be utilized in consideration of a new or repeated audit engagement to understand the client's business and assess risks. Nevertheless, the

Big 4 audit partner never uses the tools in a new engagement acceptance process because new clients are unlikely to disclose their large volume of transaction data to prospective auditors for analyses using ADA tools. For recurring audit engagements, the Big 4 audit partner revealed that the audit firm could rely on their audited financial statements in the prior period and additional information from the current period from the management to consider accepting the audit of existing clients. Therefore, it is not common for auditors to use ADA tools in audit planning.

4.2.2. Data Analytic Tools for Tests of Internal Controls

None of the auditors have experience using ADA tools for internal control tests. Specifically, auditors indicate that they still rely on the audit documentation and information technology audits of their clients' accounting information systems to determine whether existing internal controls are implemented and followed consistently. The main reason for continuing with this practice is that most audit partners and supervisors are still satisfied with the traditional approach of tests of internal controls. Audit practitioners also do not see the need to initiate the adoption of ADA tools for this audit process. Nevertheless, one Big 4 auditor and one non-Big 4 auditor discussed the potential use of ADA tools in performing tests of internal controls. For example, auditors could use the tools to generate reports showing the total number of recorded transactions on each account and analyze whether those reports are abnormal. ADA tools can analyze the proper segregation of duties by examining the total transactions entered by each employee daily or weekly and whether the employee has the authorization to do so. Alternatively, ADA tools can be used with other types of audit tests. For instance, using ADA tools to detect outstanding accounts receivable or accounts payable exceeding the threshold number of days and following up with clients on how they track those accounts. Another example is to use ADA tools to identify abnormal credit balances of accounts receivable or debit balances of accounts payable and follow up with clients on their existing internal controls over those accounts. Specifically, this latter method could be performed to ensure the correct valuation and disclosure of accounts receivable and accounts payable balances, and that internal controls are adequately implemented.

4.2.3. Data Analytic Tools for Substantive Tests

To perform substantive tests, auditors would begin by verifying all accounting records received from clients for completeness before loading data into relevant tools for further investigation. To test the completeness of all transactions, auditors first enter the fiscal period of interest into the ADA tool along with beginning and ending trial balances. The system will then process all input transactions and generate a report showing whether all expected transactions have been entered completely. The interview participants informed us that many substantive audit procedures can be performed by using ADA tools. For example, the cutoff testing of sales and purchases, recalculating provisions (such as allowance for doubtful accounts), amortizations (such as prepaid expenses and bonds), and inspecting (both vouching and tracing) supporting documents with accounting records. The interviewees from Big 4 and non-Big 4 firms located overseas indicated that their firms use ADA tools to examine transaction anomalies. At the same time, some auditors discuss using ADA tools to perform substantive tests.

4.2.4. Data Analytic Tools for Anomaly Detection

All interviewees use ADA tools for anomaly detection in a similar manner. To be specific, auditors would first specify criteria and parameters in the tools and execute their instructions. The program would then retrieve transactions that match the auditors' criteria and display them in the report form that auditors could use for subsequent tests. Auditors commonly execute the following instructions to detect transaction anomalies. First, auditors investigate a double-entry record of debiting assets and crediting expenses. Second, a double entry of crediting sales but debiting non-accounts receivables is included.

Third, transactions with values of "111", "222", "333", "444", "555", "666", "777", "888", or "999" in any numerical fields are included. Fourth, transactions with the explanation of "revised," "canceled," or "adjusted" are included. Fifth, transactions with the explanation of "CEO" or "CFO" are included. Sixth, transactions without any explanation are included. Seventh, transactions entered during the holidays are included. Lastly, transactions entered into by the upper-level management are included. One auditor discussed further that ADA tools could also be used to create a daily sales report to detect sales-transaction anomalies recorded during the holidays or near the fiscal year-end or abnormally high daily sales.

According to the interview, auditors shared their experience detecting anomalies or fraud using ADA tools. For example, the auditors found suspicious transactions entered during the holidays. Sales transactions were not recorded using the commonly used accounts receivable or cash account. Unauthorized users entered accounting transactions. An abnormally high number of journal vouchers were posted during one period. Further, the auditors found an abnormally high number of sales transactions posted near the end of each quarter. All these anomalies are usually explained and justified by the client management. Nonetheless, one auditor was able to identify accounting fraud using ADA tools to retrieve transactions containing the explanation of revised, canceled, or adjusted. Specifically, the audit team found that an employee of a client firm engaged in the misappropriation of assets through asset retirement.

4.2.5. Data Analytic Tools for Analytical Procedures

Three Big 4 auditors and two non-Big 4 auditors emphasized the use of ADA tools for analytical procedures. Specifically, three interviewees discussed that ADA tools are used to analyze the reasonableness of sales, costs of sales, and expenses transactions. In addition, all of them informed that ADA tools are commonly used to analyze the relationships between sales and cost of sales, sales and accounts receivables, purchases and accounts payables, sales or purchases and changes of inventory items, and price per unit and cost per unit. During this audit process, the auditors would use ADA tools to create various visualizations to compare actual to expected values established during audit planning. For example, a report or dashboard showing an association between sales and costs of sales, an association between sales and marketing expenses, and an association between sales and gross margin broken down by region. If auditors were suspicious of any of these transactions, they could drill down to investigate the causes prior to a discussion with client management. In addition, two auditors suggested that ADA tools significantly cut down the time spent on data cleaning and preparation before the visualization process.

4.2.6. Data Analytic Tools for Tests of Management Assertions

Table 3 summarizes the auditors' use of ADA tools for testing management assertions, broken down by the information generated from the tools and the type of management assertions. While most management assertions are tested using ADA tools, none of the audit firms use ADA tools in testing the assertions of rights and obligations, classification, and understandability of disclosure. Some Big 4 interviewees expressed concern that if auditors do not consider unrecorded transactions or transactions that are not loaded into the tools, they could reach incorrect conclusions and opinions on the audited financial statements.

Table 3. Summary of Audit Data Analytic Tools for Management Assertions.

Information from Audit Data Analytic Tools	Management Assertions				
	Existence	Occurrence	Completeness	Accuracy & Valuation	Cutoff
Classification of accounts receivable, accounts payable, and a report showing detailed outstanding balances for account confirmation purposes.	X				
Reports showing an association among accounts: - Reports of an association between sales and costs of sale - Reports of an association between sales and sale promotion expenses - Reports of an association between sales and accounts receivable - Reports of an association between volume incentive rebate, purchase volume, and costs of goods purchased	X	X		X	
Reports showing an association between sales and gross profit by region	X	X		X	
Reports showing details of discounts granted for customers using hotel restaurant services	X			X	
Anomaly detection of accounting transactions	X	X		X	
Reports showing the matching outstanding payables at the end of reporting period and disbursements after the reporting period. Examples include unpaid commission and unpaid customer rebates.			X	X	
Reports of monthly deprecation expenses for reasonableness tests				X	
Comparison reports of unit cost and unit selling price of inventories on hand for the allowance for diminution in value of inventories				X	
Comparison reports of sales and costs of sales after the reporting period by product category				X	
Aging reports for an allowance for doubtful accounts				X	
Reports of monthly gross profit rate by product	X	X		X	
Graphs showing the allocated period for clearing prepaid expenses				X	
Reports of sales and purchases in the pre-and post-reporting period end					X

4.2.7. Data Analytic Tools for Audit Conclusions

All interview participants responded that they have never used ADA tools to conclude their audit findings. The interviewees explained further that, during the audit conclusion process, they would ensure that the findings of substantive tests using ADA tools in the earlier stage are aligned with their audit conclusions. Therefore, they believe that it is acceptable not to use additional advanced ADA tools in the last step of the audit process because it would not change their conclusions and audit opinions.

5. Conclusions

5.1. Discussion and Implications

This study examines the use of data analytic tools in audit process management, beginning with audit planning, testing, and conclusions. We interviewed audit professionals working for Big 4 and non-Big 4 audit firms in Thailand during 2016 and 2017, which was an early stage of adopting data analytic tools in auditing by audit practitioners in Thailand. For comprehensive analyses, our participants included auditors at the assistant auditor, manager, senior manager, and audit partner levels. Based on the literature review and in-person interviews with audit practitioners with Big Data Analytics experience, we find that audit firms adopt ADA tools in audit process management. Specifically, Big 4 auditors have received upskill training in ADA tools and techniques from their global firms. These Big 4 firms have implemented standard audit process protocols that all global offices must follow under the prescribed international and local auditing standards. Nevertheless, non-Big 4 auditors have not had much experience using ADA tools in auditing due to costs associated with ADA tools and training.

As is evidenced by this study, most auditors had experience using ADA tools ranging between one and three years during the interview period. Our interviews indicate that auditors use data analytic tools in audit planning and substantive testing only. They do not use the tools to test internal controls and finalize the audit findings. Auditors prefer using data analytic tools to identify anomalies in accounting transactions and test the management assertations. Results show that auditors commonly use ADA tools to test management assertations related to accuracy and valuation, followed by existence and occurrence, respectively. However, auditors do not use the tools to test rights and obligations, classifications, and understandability of disclosure. This is because the latter three assertions required more professional judgment and expertise than the others. As for the tests of internal controls, auditors do not see the need to use ADA tools because most tests are performed using observations, interviews, and audit evidence documentation to assess the existing internal controls. Auditor participants also do not rely on ADA tools in the audit conclusion process because the expressed audit opinions could be provided based on the substantive test results using ADA tools in the earlier stage.

Overall, the auditor participants perceived the benefits of ADA tools in improving their audit process management and confidence in concluding the audit findings and opinions. As discussed earlier, evidence from both developed and underdeveloped countries seems consistent concerning the overall positive feedback regarding the use of ADA tools in auditing clients' Big Data. However, the majority of audit practitioners still lack the required competencies to utilize more advanced ADA tools and thus prefer simple data analytics in each audit process [8,9,39,40]. The results of this study are informative to audit firms and audit professionals on how to use data analytic tools in auditing effectively, especially in the initial implementation. Moreover, regulators can use the findings of this study as a guideline on how to develop new auditing standards governing the use of Big Data and data analytic tools. The data analytic software developers also benefit from users' feedback to further improve their tools to tailor to user requirements.

5.2. Limitations and Directions of Future Research

This study investigates the auditors' use of data analytic tools in audit process management. Due to the lack of a proprietary database of all audit firms in Thailand for tackling the issue of their adoption of audit data analytic tools, we had to conduct several interviews with Big 4 and non-Big 4 auditors to gain insights into this issue. Although an interview method is considered a practical approach to gathering facts, this research method presents some limitations that future research may consider. For example, it is impossible to conduct interviews of all audit firms in Thailand. The audit practitioners that voluntarily agree to participate in our interviews are of unequal sizes in terms of their job titles and work experience, which contributes to the generalizability of the study. In addition to the facts described by the interviewees, we acknowledge the personal biases that each auditor may

have and present them through their responses. In addition, the audit data analytic tools used in each audit firm could perform different analyses for the same set of accounts or transactions. Further, we provide evidence of one developing country, which may not represent other emerging or developed markets. Future research may consider performing additional analyses, such as questionnaires or behavioral experiments in different settings to reconcile the inconclusive evidence in the literature.

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Appendix A

Appendix A.1. Interview Questions

The interview questions are divided into two sections. Section One comprises the personal information of the interviewees. Section Two includes open-ended questions about the use of data analytics in each step of the audit process. The list of questions is detailed below.

Part 1: Personal information of the interviewees

1. In which audit firms are you currently working?
2. What is your current job title or position in the audit firm?
3. How many years of work experience as an auditor?
4. How many years of experience do you use data analytic tools in auditing?

Part 2: The application of data analytic tools in auditing

5. How do data analytics and related technologies play a role in the audit process?
6. How many years has your audit firm used data analytic tools in auditing? Are these tools used for a specific audit purpose, and how?
7. Has your audit firm used data analytic tools in-house or outsourced the data analytic process to a professional service firm?
8. Have you used data analytic tools in audit planning, and how?
9. Have you used data analytic tools in tests of internal controls and substantive tests, and how?
10. Have you used data analytic tools in concluding audit findings, and how?
11. Have you used data analytic tools in which of the following financial statement assertions? Please give examples
    - Existence
    - Occurrence
    - Completeness
    - Rights and obligations
    - Accuracy and valuation

- Cutoff
- Classification
- Understandability of disclosures

12. Based on your experience, have you uncovered anomalies or fraud using data analytic tools in your audits?

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