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Organizational and environmental influences in the adoption of computer-assisted audit tools and techniques (CAATTs) by audit firms in Malaysia

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Despite the usefulness of computer-assisted audit tools and techniques (CAATTs) in increasing audit productivity and reducing costs, their adoption by audit firms is low in developing countries. The aim of this study is to investigate whether organizational and environmental factors can help explain CAATTs adoption in less developed countries, such as Malaysia. The research framework was developed based on the Technology-Organization-Environment framework (TOE). The results reveal that for environmental factors, the complexity of clients' accounting information systems (AIS) and perceived level of support of professional accounting bodies (PABs) affect CAATTs adoption. For organizational factors, firm size, top management commitment and employee IT competency were found to be significant factors. Moreover, firm size partially moderates the influence of clients' AIS complexity on CAATTs adoption. This paper contributes to existing adoption theory by extending our understanding of the impact of factors unique to CAATTs adoption.

1. Introduction

Computer-assisted audit tools and techniques (CAATTs) include technologies such as electronic audit working papers, database applications and business intelligence audit software (Braun and Davis, 2003; Janvrin, Bierstaker & Lowe, 2009; Mahzan and Veerankutty, 2011). In spite of the importance of CAATTs in lowering audit cost and increasing audit quality and productivity (Bierstaker et al., 2001; Banker et al., 2002; Pincus et al., 2003) and their wide usage in developed countries (Lowe et al., 2017), CAATTs have not been utilized extensively in the developing world (Mahzan and Lymer, 2014; Omonuk, 2015; Widuri et al., 2016). The implications for this limited adoption of CAATTs are audits that are inefficiently performed, or worse, wanting in quality. There is a need for research to explain the lack of CAATTs adoption in this context.

Although the research on CAATTs and other technology adoptions has focused on organizational factors such as firm size, employees' information technology (IT) competency and top management commitment, as well as environmental factors such as competitive pressures, these factors do not include important environmental variables that are unique to CAATTs adoption (Curtis and Payne, 2008; Bradford and Florin, 2003; Thong, 1999; Debreceny et al., 2005b; Zhu and Kraemer, 2005).

The adoption of CAATTs differs from other technology adoption normally found in typical industries like retail and manufacturing. Indeed, there are three environmental factors which are unique to the external auditing environment. These are the complexity of clients' AIS environment, competitive pressure from other auditing firms to adopt CAATTs, and the extent to which professional accounting bodies support CAATTs adoption. Firstly, clients with complex AIS would likely appoint larger audit firms that have the capability and sufficient investments in IT resources and expertise (Axelsen et al., 2017; Lowe et al., 2017).

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Secondly, the competitive pressure to adopt CAATTs is more complex than in other industries. Audit firms face "intense pressure" to meet their budgets (Curtis and Payne, 2014) and the requirement to gather sufficient evidence and provide a "competitive audit" within their allocated costs and time (Axelsen et al., 2017). Lastly, the audit industry is regulated by professional accounting bodies (PABs) whose support plays an important role in influencing audit firms to adopt CAATTs.

Building on past research in technology adoption, the overarching objectives of this research are to investigate in a developing-country setting whether organizational and environmental factors unique to CAATTs have an influence on the adoption of CAATTs among audit firms. This study addresses the following research questions: 1) "To what extent do the unique environmental factors, namely clients' AIS complexity, competitive pressure and perceived level of PABs support for CAATTs directly influence CAATTs adoption?", 2) "To what extent do organizational factors, namely firm size, top management commitment and employee IT competency, directly affect CAATTs adoption?" and 3) "To what extent does firm size moderate the influence of clients' AIS complexity on CAATTs adoption?". The Technology-Organization-Environment (TOE) framework is used to address these research questions (Tornatzky and Fleischer, 1990).

This study makes important contributions to AIS and audit literature. Firstly, while most research on the determinants of CAATTs focuses on the United States and other developed countries, this study examines factors in a developing country i.e. Malaysia. It is unclear if the factors applicable in the context of developed countries, where CAATTs use is more prevalent, complex and pervasive, could be applied to developing countries. Secondly, it provides empirical evidence on the importance of organizational and CAATTs' unique environmental factors in adoption decisions. Our paper is the first to test the direct and moderating influences these factors have on CAATTs adoption. Understanding these factors is important to both regulatory bodies and policy makers. Lastly, this research paper also extends the existing knowledge of CAATTs adoption by looking at it from the organizational rather than individual auditor's perspective.

2. Literature review

There is a substantial stream of research which examines factors influencing CAATTs' adoption. The prior CAATTs literature summarized in Appendix 1 shows that most studies explore the adoption of CAATTs from the individual auditor's level, not among audit firms from the organizational standpoint. However, CAATTs' acceptance has to first start from an organization's decision to acquire the technology, make the initial investment and provide the facilities for adoption for the use of individual auditors. Thus, the firm's level of audit-technology investment may better represent audit-technology acceptance than the views of individual auditors (Janvrin et al., 2008).

Only a handful of studies have looked at CAATTs adoption from the organizational level. Ismail and Zainol Abidin (2009) reported descriptive analysis results pertaining to IT knowledge and the importance of audit technology among audit firms in Malaysia. Ramen et al. (2015) listed various factors that can influence CAATTs adoption, and examined the correlation and mean differences between individual- and organizational-level factors. Widuri et al. (2016) performed a qualitative study of the factors that can influence CAATTs and identified PAB support as one of them.

Lowe et al. (2017) examined auditors' perception of the importance of CAATTs and the extent of CAATTs use. They also examined how the perceived importance and extent of IT use vary by firm size and over time. They found firm size has been shown to be significant in determining CAATTs usage. Auditors from Big 4 firms were more likely than smaller firms to use IT audit applications. The study also found that the gap between IT use for Big 4 and non-Big 4 firms has been closing compared to the 2004 data. The non-Big 4 firms' CAATTs usage almost resembled that of the Big 4 firms in the Lowe et al. (2017).

Prior CAATTs studies at the individual level used the Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) theory. These theories focus on technology characteristic factors such as performance expectancy, social influence, facilitating conditions and perceived usefulness (Curtis and Payne, 2008, 2014; Huang et al., 2008; Janvrin et al., 2009b; Kim et al., 2009; Mahzan and Lymer, 2009; Bierstaker et al., 2014; Zainol et al., 2017). Most of these studies tested whether the variables in the existing UTAUT theoretical framework could be applied to CAATTs adoption in the external audit settings (Bierstaker et al., 2014; Zainol et al., 2017; Janvrin et al., 2009b).

In addition, Curtis and Payne (2008) found that the variables of budget period and auditors' risk preferences were found to significantly influence the intention to utilize CAATTs in the UTAUT model (Curtis and Payne, 2008, 2014).

Most of these studies were performed in developed countries (Ahmi and Kent, 2013; Axelsen et al., 2017; Banker et al., 2002; Bierstaker et al., 2014; Curtis and Payne, 2014; Greenstein-Prosch et al., 2008; Lowe et al., 2017), where the audit environment may be different from developing countries. For example, in the US context, audit firms are typically divided among the Big 4, regional, national and local firms (Lowe et al., 2017; Janvrin et al., 2008). However, in Malaysia, save for the Big 4 and medium-sized national and regional firms, most audit firms are either sole proprietors or have less than five locally-based partners (Audit Oversight Board, 2014). Thus, Malaysian audit firms tend to be divided into those that focus on the national (medium-sized to Big 4) or local area (small to medium-sized firms).

In addition, these prior studies are limited as they only considered technology characteristic factors, not organizational and environmental influences. To overcome these limitations, we use the TOE framework, which permits researchers to examine a broad set of technological, organizational and environmental factors (Venkatesh and Bala, 2012).

TOE is a firm-level adoption framework that was developed by Tornatzky and Fleischer (1990). TOE proposed the importance of various contextual factors in the adoption of technological innovations (Venkatesh and Bala, 2012). The TOE framework is widely employed in the IT/IS literature and has been used to determine adoption factors in various IT contexts (Zhu et al.,

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2003, 2006). The TOE framework is relevant to study CAATTs adoption because it extends beyond the technology paradigm to include organizational and environmental perspectives (McKinnie, 2016; Venkatesh and Bala, 2012).

The question therefore arises of the extent to which the variables discussed above could influence CAATTs adoption. This study proposes a CAATTs adoption model that combines the technological factors of the Diffusion of Innovation (DOI) Theory to include organizational and environmental factors. The next section will discuss how the theoretical framework influences the choice of test variables.

3. Research model and hypotheses development

The TOE framework describes three elements that have an impact on a firm's adoption of technological innovation, specifically, technological, organizational, and environmental contexts (Tornatzky and Fleischer, 1990).

3.1. Environment context

We included three unique factors i.e. complexity of clients' AIS, competitive pressure and perceived level of professional accounting body support as the environmental context variables to test whether they are influencing the adoption of CAATTs in developing countries such as Malaysia.

3.1.1. Clients AIS complexity

Clients AIS complexity is the extent to which the audit firm's clients have complex accounting systems (see Table 1). This construct is composed of the extent to which clients have highly-computerized financial reporting systems (Janvrin et al., 2008) and the level of complexity, difficulty and nature of transactions processed by the AIS in their organizations (Ahmi and Kent, 2013).

In computerized accounting systems, financial records are processed and stored in electronic form. To follow an audit trail of source documents manually is difficult with recent advances in technology such as blockchain and automation (Hall, 2011; Katamba et al., 2017; Karajovic et al., 2017).The nature of the clients' business environment and industry is another aspect of complexity of AIS. For instance, multinational-company clients in the banking industry might have complex transactions (Massetti and Zmud, 1996; Sutton and Hampton, 2003) that entail the implementation of advanced and complex AIS to process such transactions (Siriginidi, 2000).

Previous research from the perspective of individual auditors showed that clients' IT complexity influences the use of CAATTs in developed countries (Ahmi and Kent, 2013; Janvrin et al., 2009a, 2009b; Axelsen et al., 2017). The increased use of CAATTs occurs because clients' complex IT environments change the way audit procedures are conducted (Janvrin et al., 2009a) and require more controls versus substantive testing (Axelsen et al., 2017). Our first hypothesis tests whether this relationship still holds in the public-audit-firm setting in Malaysia.

H1. Clients' AIS complexity positively affects CAATTs adoption.

3.1.2. Competitive pressure

Competitive pressures may influence an organization's decision to adopt a technology (see Table 1) (Bradford and Florin, 2003; Iacovou et al., 1995; Riemenschneider and Mykytyn, 2000; Tornatzky and Fleischer, 1990; Venkatesh and Bala, 2012; Zhu et al., 2003). For example, when an organization finds that other audit firms are benefiting from a technology through improved audit quality and efficiency, it might follow suit to reap similar benefits. With the pressure from its competitors who have adopted new technology to a high extent, a firm has to adopt the same technology to improve its business processes or maintain its clients' satisfaction (Venkatesh and Bala, 2012; Oliveira and Martins, 2009, 2010). Therefore, audit firms are more likely to adopt CAATTs to make their audits more efficient (Curtis and Payne, 2014), thus allowing them to lower audit fees and exert competitive pressure on those who have not adopted CAATTs. In addition, CAATTs could also make audits more effective and improve their quality (Curtis and Payne, 2014).

Nevertheless, competitive pressure in this study setting may differ from the contexts described earlier. Competitive pressure in audit is more complex than in other industries (Curtis and Payne, 2014). Auditors need to balance between obtaining sufficient

Table 1
Measurement Items for Environmental Aspects.

Variables	Definition	Source
Environmental context		
Clients AIS Complexity	The extent to which the audit firm's clients have complex accounting systems.	Ahmi and Kent (2013); Janvrin et al., (2008); Axelsen et al., (2017)
Competitive Pressure	The degree of competition to adopt CAATTs.	Bradford and Florin (2003); Venkatesh and Bala (2012)
Perceived Level of Professional Accounting Body Support	The degree to which the perceived level of professional accounting bodies support CAATTs' usage.	Zhu and Kraemer (2005)

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audit evidence to give an opinion and meeting their costs and time budgets (Axelsen et al., 2017). Unlike in developed countries, CAATTs adoption is not as widespread in developing countries such as Malaysia (Mahzan et al., 2009; Mahzan and Lymer, 2009, 2014; Omonuk, 2015; Widuri et al., 2016) where audit firms tend to be smaller and clients have less complex accounting systems. It is not clear whether using CAATTs in these environments would result in sufficient improvements in audit efficiency or quality. Thus, we test the following hypothesis in the Malaysian setting:

H2. Competitive pressure positively affects CAATTs adoption.

3.1.3. Perceived level of professional accounting body support

PAB support refers to the degree to which standards, guidance and support by these bodies encourages audit firms to adopt CAATTs (see Table 1). PABs which regulate audit firms include the American Institute of Certified Public Accountants (AICPA), International Federation of Accountants (IFAC) and Malaysian Accounting Standards Board (MASB).

The regulatory bodies in developing countries are seen as important for creating awareness of technology innovations among audit firms. For example, the Malaysian Institute of Accountants (MIA) and IFAC have released standards such as the International Standard on Auditing (ISA) 300 and 330 as guidelines for professional members to conduct audits using CAATTs (International Federation of Accountants, 2009; Malaysian Institute of Accountants, 2003). According to Mahzan and Lymer (2009), professional body recommendations are among the criteria that auditors look for when selecting audit tools.

Apart from issuing standards, PABs also provide incentives to support their members. For example, the MIA has provided a 70% subsidy on training fees to its members, especially small and medium-sized practices (SMPs) (Malaysian Institute of Accountants, 2014). The incentives may enable the members to discuss current issues that will increase their knowledge about emerging technologies and innovations in the profession. Previous literature found a relationship between the professional association and technology adoption (Swan and Newell, 1995). The professional body plays an important role in disseminating information on new technological developments to active members and in providing guidance, support and training in technology use.

The above discussion suggests that if auditors perceive that the professional accounting body encourages public audit firms to adopt audit technologies, this will increase their acceptance of CAATTs.

H3. The perceived level of professional accounting body support positively affects CAATTs adoption.

3.2. Organization context

The second element of the TOE framework is the organizational context, which is comprised of the organizations characteristics and resources (Tornatzky and Fleischer, 1990). We proposed that firm size represents the organization's resources, and employee IT competency and top management commitment constitute the organization's characteristics.

3.2.1. Firm size directly influences the adoption of CAATTs

Research in developed countries indicates that audit firm size is significant in determining IT audit usage (Lowe et al., 2017). The IS literature has also cited firm size as an antecedent for technology adoption (Bala and Venkatesh, 2007; Thong, 1999; Tornatzky and Fleischer, 1990; Zhu et al., 2003). Compared with smaller-sized firms, larger firms tend to have more economies of scale that enable them to hire more employees and invest in technologies to facilitate technology adoption (Lowe et al., 2017; Zhu et al., 2003).

There is a trend of smaller-sized firms closing the technology gap with larger firms in developed countries. National firms in the US have been found to have almost the same CAATTs usage as the Big 4, and smaller-sized firms have adopted many of the audit technologies previously used by larger firms (Lowe et al., 2017). Although the gap has been closing in the developed world, we expect firm size to still have a significant impact on CAATTs adoption in developing countries such as Malaysia.

H4. Firm size positively affects CAATTs adoption.

3.2.2. Firm size moderates the influence of complexity of clients' AIS on CAATTs adoption

Large firms are more likely to have clients with more complex AIS (Lowe et al., 2017; Janvrin et al., 2008) as these firms are more likely to choose larger audit firms, due to their capability to audit complex AIS (Ismail et al., 2006) and deliver a higher quality of audit work (Davidson, 1993; Francis and Yu, 2009; Gul et al., 2009).

On the other hand, smaller firms might not have sufficient resources to adopt technology to audit clients that have complex IT systems (Curtis and Payne, 2008; Lowe et al., 2017). It might not be cost effective to significantly invest in IT to serve these clients (Axelsen et al., 2017). In addition, smaller firms perceive audit IT as less important (Lowe et al., 2017) and tend to have "low IS audit emphasis" (Axelsen et al., 2017).

Thus, one might expect that for smaller firms with fewer IT-related resources (i.e. the "low IS audit emphasis" firms defined by Axelsen et al., 2017), client AIS complexity would only have a small influence on CAATTs adoption, while for larger firms with greater IT-related resources (i.e. "high IS audit emphasis" firms) client AIS complexity would have a greater influence on CAATTs adoption.

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H5. Firm size moderates the relationship between complexity of clients' AIS and CAATTs adoption.

3.2.3. Top management commitment

An organization's commitment is defined as the level of support given by the audit firm's top management to CAATTs adoption. Top management support is crucial in decision-making decisions for technology adoption in an organization (Bradford and Florin, 2003; Mahzan and Lymer, 2009; Ramamurthy and Premkumar, 1995) as it facilitates the provision of hardware and software facilities and the development of technical expertise (Bradford and Florin, 2003; Sykes, 2015). Top management support also includes management's willingness to provide financial resources for technology adoption (Bradford and Florin, 2003).

Top management has the capability to facilitate structural, procedural and cultural changes in an organization to enable the successful adoption of any new technology (Bradford and Florin, 2003). This will expedite the communication and coordination necessary for pre-adoption planning and technology adoption by its employees. Thus, if the audit firm's management supports the use of new audit technology, the firm's auditors will be more likely to use the technology (Curtis and Payne, 2008; Huang et al., 2008; Mahzan and Lymer, 2009).

H6. Top management commitment will positively affect CAATTs adoption.

3.2.4. Employees' IT competency

Auditors' IT competency is a factor in influencing CAATTs adoption (Axelsen et al., 2017). CAATTs require auditors to have sufficient IT skills to operate the tools and more importantly, interpret the results. For advanced CAATTs such as test data, integrated test facilities, parallel simulations and embedded audit modules, an auditor must understand the computer programming language and be able to verify the client's source code. To interpret the results, the auditors need to have “the ability to understand critical systems” and “capacity to identify general computer controls” (Axelsen et al., 2017). This suggest that

H7. Audit firm employees' IT competency will positively affect CAATTs adoption.

3.3. Technology context (as control variables)

The technological factors in the TOE framework refer to the features that can influence organizations in deciding whether or not to adopt technologies. However, the TOE framework does not explicitly define these features. Thus, we incorporated as control variables the DOI Theory's (Rogers, 1995, 2003) five technology characteristics, namely relative advantage, compatibility, complexity, observability and trialability. Previous research indicates that these characteristics are related to technology adoption (Moore and Benbasat, 1991; Pole and Bondy, 2010; Masrom and Hussein, 2008; Smith et al., 2008; Venkatesh et al., 2003).

The proposed seven hypotheses which explain the influences of CAATTs adoption and the control variables are shown in Fig. 1.

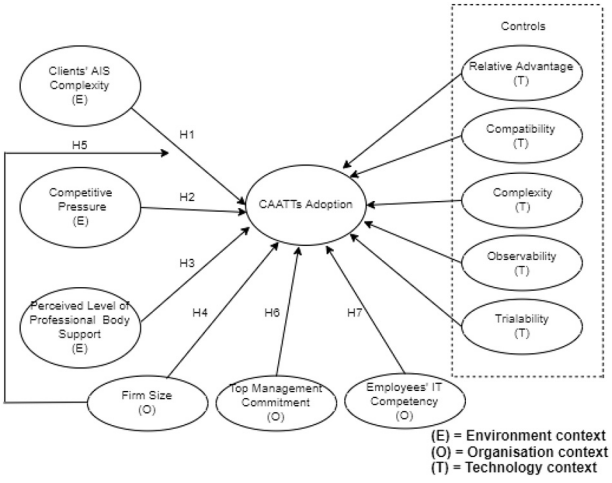

Fig. 1. Proposed research framework for CAATTs adoption.

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Table 2
Respondents.

Position of individual respondent	Per cent	Services offered	Per cent
Firm partner	13.8	Financial auditing	100.0
Managing partner	12.8	IT auditing	19.0
Audit manager/audit director	38.3	Internal auditing	25.8
Senior auditor	35.1	Taxation	89.9
		Financial advisory	58.9
		Business advisory	45.6
Organization Size		**Mean**	**SD**
Firm size		47.28	142.41

4. Methodology

Over a three-month period, we distributed surveys to all 1367 audit firms listed in the Malaysian Institute of Accountants (MIA) Member Firms Directory. This listing was used because MIA is the statutory body that regulates the accounting profession in Malaysia. We followed up with two reminders through emails and random phone calls.[1]

The respondents were audit managers/audit directors (38.3%) followed by senior auditors (35.1%), firm partners (13.8%) and managing partners (12.8%). They had an average of >9.5 years of experience in their current audit firms and an average of 12 years of audit experience each (refer to Table 2). Besides financial audit services, the firms also provided the following services: taxation (89.8%), financial advisory (58.9%), business advisory (45.6%), internal auditing (25.8%) and IT auditing (19.0%).

Out of 201 responses, five incomplete responses that exceeded 15% of the questions were deleted from the data (Hair et al., 2014). For those below 15%, we calculated the missing data by construct and found them to be below 3%. As the missing data by construct is below the 5% threshold, this study used the expectation-maximization (EM) algorithm implemented in the SPSS software to infer the missing values (Hair et al., 2012b). We also eliminated four straight-line responses while another four outlier responses were excluded based on extreme values highlighted in the SPSS boxplot (Tukey, 1977). After the data-cleaning process, a total of 188 responses were found to be usable for further analysis. To analyze the results from the firm level, we averaged multiple responses from the same firm to produce a single response. In total, we analyzed responses from 158 firms.

We used the intra-class correlation (ICC) to determine whether multiple responses from the senior management in the same firm were similar. We found that of the 30 firms, responses in 26 (87%) firms were significantly similar at $p < 0.05$, and 4 (13%) firms did not have significant evidence of similarity. We also tested the required sample size using a power-analysis (G*Power) software and found the responses to be adequate to use the partial least squares structural equation modeling (PLS-SEM) (Cohen, 1988; Goodhue et al., 2007; Hair et al., 2014; Sawyer and Ball, 1981). In addition, we compared the responses of early respondents with late respondents to test for non-response bias and found no significant differences (Sax et al., 2003).

4.1. Measurement of variables

The questionnaire items were mainly derived and adapted from previous survey instruments that were already tested and validated (refer to Table 3). A pilot test with audit firm professionals was conducted preceding the final field survey to confirm reliability and further improve clarity of both the questionnaire instructions and questions. The responses in the pilot test were not included in the data analysis.

We followed the recommendations of Podsakoff et al. (2003) on the design of research procedures and statistical controls to manage Common Method Variance (CMV).

Firstly, two different measurements of independent and dependent variables were used in the questionnaire. The scale endpoints and formats for the independent variables ranged from a bipolar measurement scale of 'Strongly disagree' to 'Strongly agree' whereas the dependent variables' scale endpoints were a unipolar measurement of 'Never used at all' to 'Extensively used'. This technique diminishes method biases caused by scale endpoint commonalities.

Secondly, the instructions in the questionnaire assured respondents that there are no preferred, right or wrong answers for their perceptions about audit-technology adoption. Nevertheless, it would be appreciated if they answered the questions as honestly as possible. These procedures are designed to reduce the respondent's hesitation and bias in answering the questionnaire (Podsakoff et al., 2003).

Thirdly, questionnaires were distributed to partners, managing partners, audit managers and senior auditors in order to obtain responses from a range of respondents that represents the firms. This was done to minimize the common-rater effect.

Herman's Single Factor Test was conducted to determine if common method bias occurred in the study (Craighead et al., 2011). All items of the independent and dependent constructs were tested to analyze whether the majority of the variances

[1] This research has obtained approval from the Monash University Human Research Ethics Committee (MUHREC).

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Table 3
Construct measures.

Adoption of CAATTs:	
Calculated by totaling the product scores of CAATTs applications.	
Product score of a specific CAATTs application: Percentage of audit task conducted using (a) audit automation, (b) generalized audit software, (c) database SQL search & retrieval, (d) test data, (e) parallel simulation software, or (f) embedded audit modules, scaled as 1:0% (never use at all), 2: 1–15%, 3: 16–30%, 4: 31–45%, 5: 46–60%, 6: 61–75% and 7: 76–100% (extensively used)	
Clients' AIS Complexity	
CC1. Majority of our clients have complex accounting systems	Ahmi and Kent (2013)
CC2. Most of our clients have highly-computerized financial reporting systems	Janvrin et al. (2008)
CC3. Majority of our clients have complex business environments	Ahmi and Kent (2013)
CC4. It is difficult to access audit evidence from clients' data manually	Ahmi and Kent (2013)
Competitive Pressure	
CP1. Our firm experienced competitive pressure to implement CAATTs	Bradford and Florin (2003)
CP2. Our firm would have experienced a competitive disadvantage if CAATTs had not been adopted	Bradford and Florin (2003)
CP3. Our firm's competitors have adopted CAATTs to a high extent	Venkatesh and Bala (2012)
Perceived Level of Professional Body Support	
PA1. Professional accounting bodies support CAATTs usage	Zhu and Kraemer (2005)
PA2. Auditing standards that are set up by professional bodies support CAATTs usage	Zhu and Kraemer (2005)
PA3. Professional accounting bodies highly recommend CAATTs usage	Zhu and Kraemer (2005)
PA4. Professional accounting bodies provide incentives to implement CAATTs	Zhu and Kraemer (2005)
Top Management Commitment	
T1. Top management closely ties CAATTs with firm's competitive strategies	Bradford and Florin (2003)
T2. Top management provides adequate financial resources for CAATTs implementation	Bradford and Florin (2003)
T3. Top management gives strong support for CAATTs usage in firm's operation	Bradford and Florin (2003)
Employees' IT Competency	
EC1. Our employees are IT literate	Thong (1999)
EC2. Our employees' understanding of CAATTs is very good	Thong (1999)
EC3. Our firm has at least one employee who is a CAATTs expert	Thong (1999)
EC4. Our employees know how to operate CAATTs	Thong (1999)
EC5. Our employees have experience with CAATTs	Thong (1999)
Firm size	
Number of employees (including firm's partners)	Kee et al. (2013); Zhu and Kraemer (2005)
Relative Advantage	
RA1. CAATTs will improve audit efficiency through reduced paperwork	Venkatesh and Bala (2012)
RA2. CAATTs will increase audit firm's productivity	Venkatesh and Bala (2012)
RA3. CAATTs will reduce error rates in audit process	Venkatesh and Bala (2012)
RA4. CAATTs will help reduce cost in auditing operations	Venkatesh and Bala (2012)
Compatibility	
TF1. CAATTs are compatible with our firm's work procedures	Venkatesh and Bala (2012)
TF2. CAATTs will fit in well with auditors' tasks in performing audits	Venkatesh and Bala (2012)
TF3. CAATTs are compatible with our firm's current ways of doing audit	Venkatesh and Bala (2012)
Complexity	
C1. CAATTs are difficult to understand	Moore and Benbasat (1991)
C2. CAATTs are technically-complex audit tools	Moore and Benbasat (1991)
C3. It is difficult for employees to use CAATTs in auditing	Moore and Benbasat (1991)
C4. Using CAATTs requires a lot of mental effort	Moore and Benbasat (1991)
C5. Learning to operate CAATTs is hard for employees	Moore and Benbasat (1991)
Observability	
O1. Our firm has seen what others do using their CAATTs	Moore and Benbasat (1991)
O2. It is easy for our firm to observe other firms using CAATTs	Moore and Benbasat (1991)
O3.Our firm had plenty of opportunities to see CAATTs being used	Moore and Benbasat (1991)
Trialability	
TR1. Our firm has a great deal of opportunity to try various CAATTs	Moore and Benbasat (1991)
TR2. CAATTs were available to our firm to adequately test run the software	Moore and Benbasat (1991)
TR3. Before deciding whether to use CAATTs, our firm was able to properly try them out	Moore and Benbasat (1991)
TR4. Our firm was permitted to use CAATTs on a trial basis long enough to see what they could do	Moore and Benbasat (1991)

was explained by one general factor. The extraction of the test result indicates that the largest variance explained by an individual factor was 40.07%. The cumulative percentage of the first component is <50%, which confirmed that common method bias was not a significant problem in this study.

4.1.1. Measurement of dependent variable

The dependent variable was defined as the extent of CAATTs usage by audit firms in the audit process. Since this study is on CAATTs adoption in general, we included the most popular CAATTs applications, i.e., Audit Automation Software, Test Data, Generalized Audit Software, Database SQL Search and Retrieval, Embedded Audit Modules and Parallel Simulation Software (Braun and Davis, 2003; Cerullo and Cerullo, 2003; Debreceny et al., 2005a; Hall, 2011; Malaysian Institute of Accountants, 2003). The operationalization of the CAATTs applications is shown in Table 4.

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Table 4
Operationalization of CAATTs Applications.

CAATTs application	Definition	Source
Audit Automation/Electronic Audit Working Papers Software	Software which produces a trial balance and other schedules useful to record evidence in an audit or assurance engagement.	Braun and Davis, 2003; International Federation of Accountants, 2009; Malaysian Institute of Accountants, 2003
Generalized Audit Software	Audit software which helps the auditor access client's systems database, extract relevant data and perform analysis of audit function.	Braun and Davis, 2003; Hall, 2011; Mahzan and Lymer, 2014; Malaysian Institute of Accountants, 2003
Embedded Audit Modules	Programmed audit module incorporated into client's application program to identify transactions that meet auditor's measures. The identified transaction is reviewed in real time or in batches.	Braun and Davis, 2003; Greenstein-Prosch et al., 2008; Malaysian Institute of Accountants, 2003
Database SQL Search & Retrieval	Software that uses relational structures between data files and query language that facilitates data retrieval and use.	Cerullo and Cerullo, 2003; Greenstein-Prosch et al., 2008; Malaysian Institute of Accountants, 2003
Parallel Simulation Software	Abstraction of client's real application system that is developed to imitate the results produced by client's application. Auditor may use model to compare the results and evaluate the reliability of information generated by client's system.	Braun and Davis, 2003; Hall, 2011; Malaysian Institute of Accountants, 2003
Test Data	A set of transaction input data prepared by auditor to test the application program or procedural operations.	Braun and Davis, 2003; Hall, 2011; Malaysian Institute of Accountants, 2003

The measurement of this variable was adopted from prior literature (Rai et al., 2009; Venkatesh and Bala, 2012), i.e., the total product score of the number of CAATTs applications adopted and extent of audit tasks conducted by utilizing these CAATTs. According to Venkatesh and Bala (2012), this aggregate score is a "robust measure to assess the extent of implementation and

Table 5
Cross loadings and item loadings of reflective items.

	CAATTs	CAIS	CP	PAB	TM	EC	Size	RA	TF	C	O	TR
CAATT	**1.000**	0.494	0.410	0.432	0.414	0.463	0.408	0.341	0.384	0.156	0.362	0.397
cc1	0.394	**0.919**	0.569	0.524	0.607	0.501	0.255	0.535	0.553	0.297	0.564	0.662
cc2	0.379	**0.849**	0.483	0.419	0.542	0.537	0.198	0.525	0.536	0.277	0.419	0.526
cc3	0.489	**0.923**	0.564	0.539	0.579	0.488	0.287	0.543	0.532	0.299	0.597	0.703
cc4	0.462	**0.813**	0.591	0.556	0.570	0.449	0.226	0.528	0.551	0.344	0.493	0.634
cp1	0.398	0.508	**0.888**	0.559	0.550	0.500	0.114	0.498	0.551	0.317	0.513	0.469
cp2	0.338	0.631	**0.906**	0.586	0.602	0.531	0.193	0.623	0.605	0.297	0.450	0.539
cp3	0.337	0.530	**0.836**	0.585	0.410	0.468	0.118	0.427	0.427	0.311	0.499	0.495
pa1	0.341	0.513	0.564	**0.905**	0.469	0.465	0.186	0.532	0.494	0.209	0.414	0.512
pa2	0.413	0.558	0.583	**0.918**	0.547	0.510	0.204	0.637	0.575	0.161	0.461	0.546
pa3	0.399	0.493	0.611	**0.862**	0.491	0.416	0.168	0.554	0.511	0.291	0.632	0.521
t1	0.320	0.586	0.512	0.492	**0.879**	0.509	0.003	0.627	0.627	0.241	0.443	0.443
t2	0.390	0.630	0.544	0.487	**0.949**	0.739	0.157	0.671	0.814	0.100	0.406	0.534
t3	0.430	0.612	0.596	0.584	**0.955**	0.720	0.146	0.702	0.829	0.118	0.419	0.533
ec2	0.358	0.587	0.528	0.482	0.659	**0.858**	0.215	0.610	0.712	0.142	0.452	0.496
ec3	0.434	0.486	0.498	0.411	0.621	**0.897**	0.208	0.525	0.639	0.064	0.315	0.423
ec4	0.465	0.506	0.527	0.529	0.686	**0.962**	0.215	0.610	0.734	0.007	0.375	0.466
ec5	0.430	0.473	0.524	0.464	0.647	**0.928**	0.236	0.549	0.688	−0.006	0.319	0.455
Size	0.408	0.278	0.162	0.208	0.118	0.237	**1.000**	0.186	0.208	0.010	0.120	0.150
ra1	0.354	0.520	0.561	0.609	0.696	0.620	0.194	**0.944**	0.732	0.078	0.318	0.404
ra2	0.257	0.524	0.485	0.544	0.582	0.528	0.188	**0.885**	0.656	0.165	0.275	0.449
ra3	0.316	0.609	0.552	0.604	0.680	0.569	0.138	**0.901**	0.667	0.061	0.343	0.448
tf1	0.376	0.599	0.584	0.566	0.802	0.781	0.199	0.710	**0.976**	0.040	0.410	0.548
tf2	0.362	0.611	0.613	0.588	0.815	0.690	0.203	0.798	**0.953**	0.027	0.393	0.574
tf3	0.378	0.590	0.555	0.563	0.776	0.735	0.197	0.683	**0.973**	0.082	0.435	0.541
c2	0.140	0.331	0.271	0.144	0.035	−0.031	−0.085	0.069	−0.062	**0.850**	0.292	0.225
c3	−0.018	0.314	0.227	0.138	0.042	−0.028	−0.062	−0.029	−0.060	**0.821**	0.313	0.296
c4	0.029	0.213	0.261	0.184	0.151	0.019	−0.116	0.092	0.049	**0.816**	0.253	0.167
c5	0.135	0.312	0.339	0.268	0.200	0.104	0.092	0.097	0.110	**0.918**	0.382	0.287
o1	0.236	0.551	0.512	0.535	0.404	0.384	0.199	0.362	0.414	0.294	**0.813**	0.577
o2	0.188	0.411	0.372	0.381	0.216	0.203	0.014	0.149	0.196	0.337	**0.786**	0.496
o3	0.410	0.532	0.508	0.505	0.459	0.386	0.087	0.325	0.416	0.337	**0.918**	0.621
tr1	0.188	0.513	0.506	0.391	0.293	0.375	0.118	0.324	0.363	0.245	0.537	**0.711**
tr2	0.445	0.698	0.545	0.579	0.526	0.519	0.241	0.447	0.545	0.239	0.601	**0.943**
tr3	0.379	0.633	0.507	0.586	0.600	0.489	0.041	0.493	0.607	0.238	0.619	**0.912**
tr4	0.269	0.638	0.423	0.421	0.373	0.313	0.096	0.344	0.395	0.264	0.602	**0.865**

Item loadings on the assigned constructs are presented in bold.
CAATTs = CAATTs Adoption; CAIS = Clients' AIS Complexity; CP = Competitive Pressure; PAB = Perceived Level of Professional Accounting Body Support; TM = Top Management Commitment; EC = Employees' IT Competency; Size = Firm size; RA = Relative Advantage; TF = Compatibility; C = Complexity; O = Observability; TR = Trialability.

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utilization of technology adoption" because this operationalization provides two essential characteristics of IT/IS adoption. The scores of each CAATT were aggregated to form a single-item total score for the dependent variable of CAATTs adoption.

Consistent with IS adoption literature (Rai et al., 2009; Thong, 1999; Venkatesh and Bala, 2012), the percentage of audit tasks conducted through CAAT\Ts was assessed in seven groups i.e. 0% (never use), 1–15%, 16–30%, 31–45%, 46–60%, 61–75% and 76–100% (extensively used), and labeled 1 to 7 respectively. Then the responses for each CAATTs application were aggregated to form the single-item total score for the dependent variable of CAATTs adoption.

4.1.2. Measurement of control and independent variables

The items for all constructs, except firm size, were measured using a seven-point bipolar scale ranging from 'Strongly disagree' (1) to 'Strongly agree' (7). For firm size, the construct was measured by the number of employees (Thong, 1999; Tornatzky and Fleischer, 1990).

4.2. Data analysis technique

We conducted statistical analysis using the PLS-SEM technique, which is useful for research that has a relatively small sample size (Klarner et al., 2013; Saraf et al., 2013). PLS-SEM is a non-parametric statistical method that does not require data to be normally distributed (Hair et al., 2011; Hair et al., 2012b; Henseler and Sarstedt, 2013).

According to Hair et al. (2012a), the technique is particularly appropriate in situations where "theory is less developed" and the "study is exploratory" in nature. It is also suitable when the objective of the study emphasizes predicting and explaining the variance of the main dependent variable by using different independent variables. In addition, PLS-SEM can be used for analyzing a continuous moderator where CB-SEM is not possible (Hair et al., 2017a; Hair et al., 2017b). These conditions are

Table 6
Loadings, AVEs, Composite Reliability and Cronbach's alpha for measurement items.

Construct	Item	Loading	AVE	Composite Reliability	Cronbach's alpha
CAATTs Adoption	CAATTs	1.000	1.000	1.000	1.000
Clients' AIS Complexity	cc1	0.919	0.769	0.930	0.899
	cc2	0.849			
	cc3	0.923			
	cc4	0.813			
Competitive Pressure	cp1	0.888	0.770	0.909	0.851
	cp2	0.906			
	cp3	0.836			
Perceived Level of Professional Body Support	pa1	0.905	0.802	0.924	0.876
	pa2	0.918			
	pa3	0.862			
Top Management Commitment	t1	0.879	0.861	0.949	0.919
	t2	0.949			
	t3	0.955			
Employees' IT Competency	ec2	0.858	0.832	0.952	0.932
	ec3	0.897			
	ec4	0.962			
	ec5	0.928			
Firm size	Size	1.000	1.000	1.000	1.000
Relative Advantage	ra1	0.944	0.793	0.939	0.913
	ra2	0.885			
	ra3	0.901			
	ra4	0.880			
Compatibility	tf1	0.976	0.936	0.978	0.966
	tf2	0.953			
	tf3	0.973			
Complexity	c2	0.850	0.738	0.914	0.897
	c3	0.821			
	c4	0.816			
	c5	0.918			
Observability	o1	0.813	0.707	0.878	0.805
	o2	0.786			
	o4	0.918			
Trialability	tr1	0.711	0.744	0.920	0.887
	tr2	0.943			
	tr3	0.912			
	tr4	0.865			

Item ec1, pa4 and c1 were deleted due to low loadings (<0.70) (Hair et al., 2010).
AVE = Average Variance Extracted; CR = Composite Reliability.

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applicable to the present study as the main objectives are to develop a model that explains CAATTs adoption. We also analyze the moderating effect of continuous firm size on the influence of clients' AIS complexity in CAATTs adoption.

5. Results

Firstly, at the item level, cross loadings of items were examined (see Table 5). Four indicators i.e. Complexity 1 (C1), Relative Advantage 4 (RA4), Employee's IT Competency 1 (EC1) and Perceived Level of Professional Body Support 4 (PA4) scored below the acceptable standard loading of 0.7 and were excluded from the analysis (Hair et al., 2011).

The results met the discriminant validity test as all items loaded higher on their own constructs than on other constructs of the model (Hair et al., 2011). We then performed the measurement model and structural model testing as established by Hair et al. (2014).

5.1. Measurement model

Table 6 exhibits the convergent validity of the measurement model. The loadings, composite reliability and Cronbach's alpha of all variables' items were higher than 0.7, while the average variance extracted (AVE) values for all constructs were more than the threshold of 0.5, thus providing evidence of convergent validity in this study (Hair et al., 2014).

We also tested the discriminant validity of the measurement model to identify whether each variable is really discrete from another variable in the model. This was assessed both at item and construct levels through cross loadings using the Fornell-Larcker criterion and heterotrait-monotrait ratio of correlations (HTMT) values.

The results of the Fornell-Larcker criterion correlations between constructs are shown in Table 7. The square roots of AVE for all pairs of constructs were greater than the correlations between the constructs, thus satisfying the discriminant validity test (Fornell and Larcker, 1981; Hair et al., 2014). In addition, the HTMT values for all pairs of constructs were below the 0.90 threshold (results not shown), which demonstrates that the constructs are discrete from one another and thus meet the discriminant validity assessment (Henseler et al., 2015).

Before assessing the structural model, we also checked the inner variance inflation factor (VIF) values of each independent variable. The VIF values range from a minimum of 1.25 to a maximum of 4.7 (results not shown), which is below the 5.0 maximum (Hair et al., 2010; Hair et al., 2014; Venkatesh and Bala, 2012). This indicates that there is no collinearity problem.

5.2. Structural model

The structural model analysis was conducted to test our hypotheses regarding CAATTs adoption (refer to Fig. 2).

The results revealed that among the environment variables, complexity of clients' AIS (H1) ($\beta = 0.191$, $p < 0.1$) and perceived level of professional accounting body support (H3) ($\beta = 0.17$, $p < 0.05$) have significant impacts on CAATTs adoption. However, competitive pressure (H2) did not.

All three organizational variables, namely top management commitment (H6) ($\beta = 0.178$, $p < 0.1$), firm size (H4) ($\beta = 1.368$, $p < 0.05$) and employee IT competency (H7) ($\beta = 0.181$, $p < 0.05$), were statistically significant. Four of the technological control variables, namely observability ($\beta = 0.045$, $p < 0.05$), compatibility ($\beta = -0.177$, $p < 0.05$), trialability ($\beta = -0.03$, $p < 0.10$) and relative advantage ($\beta = -0.088$, $p < 0.10$), significantly influence CAATTs adoption. Complexity does not have any significant influence.

Table 7
Fornell-Larcker Criterion correlations between constructs.

	CAATTs	CAIS	CP	PAB	TM	EC	Size	RA	TF	C	O	TR
CAATTs	**1.000**											
CAIS	0.511	**0.877**										
CP	0.410	0.633	**0.877**									
PAB	0.437	0.586	0.656	**0.896**								
TM	0.420	0.656	0.595	0.564	**0.928**							
EC	0.472	0.556	0.567	0.516	0.714	**0.912**						
Size	0.581	0.294	0.294	0.242	0.268	0.387	**1.000**					
RA	0.362	0.615	0.587	0.635	0.750	0.632	0.266	**0.891**				
TF	0.391	0.620	0.603	0.591	0.824	0.757	0.311	0.753	**0.968**			
C	0.156	0.354	0.341	0.231	0.135	0.035	0.009	0.091	0.028	**0.859**		
O	0.372	0.596	0.557	0.566	0.452	0.395	0.097	0.374	0.426	0.373	**0.841**	
TR	0.412	0.726	0.569	0.589	0.545	0.501	0.274	0.489	0.572	0.280	0.676	**0.863**

Diagonals (bolded) represent the square root of the AVE and off-diagonals represent the correlations. CAATTs and Size are single-item constructs.
CAATTs = CAATTs Adoption; CAIS = Clients' AIS Complexity; CP = Competitive Pressure; PAB = Perceived Level of Professional Accounting Body Support; TM = Top Management Commitment; EC = Employees' IT Competency; Size = Firm size; RA = Relative Advantage; TF = Compatibility; C = Complexity; O = Observability; TR = Trialability.

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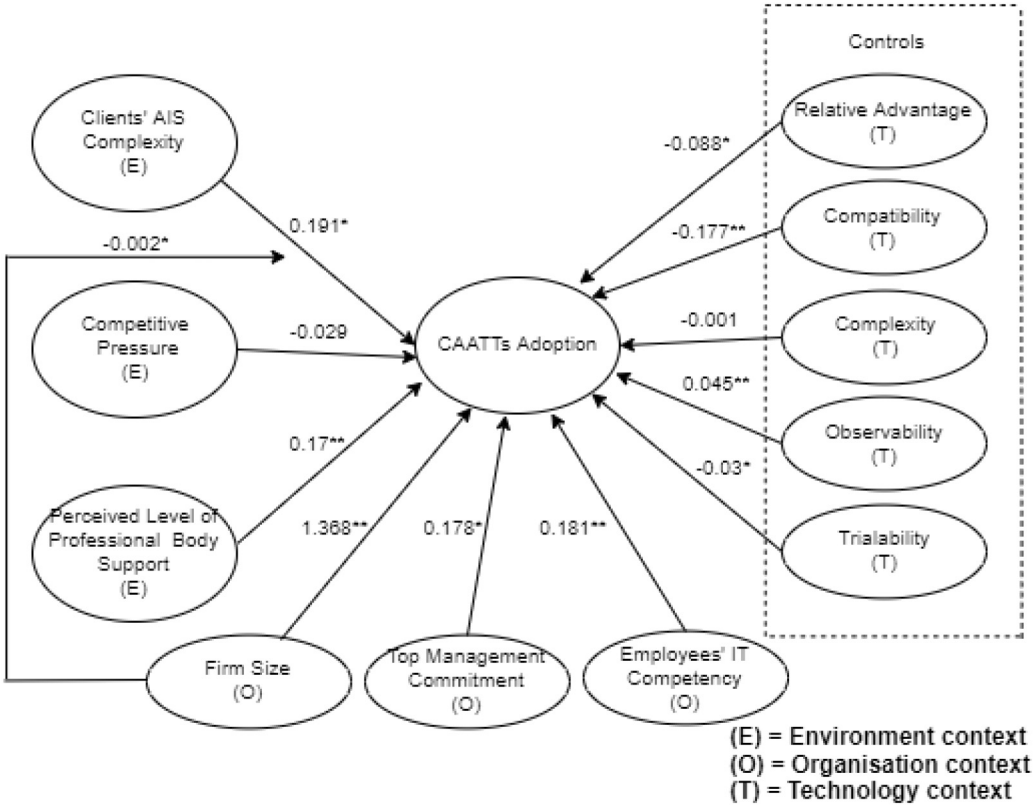

Fig. 2. Structural model.

In testing the moderating effects, we assessed the statistical significance of path coefficients using the bootstrap procedure with 5000 re-samples (Hair et al., 2012b). We found that the moderating effect of Client AIS Complexity * Size (H5) was marginally significant ($\beta = -0.002$, $p < 0.1$). As shown in Fig. 3, the line labeled Larger Firm Size has a steeper gradient compared with Smaller Firm Size. This indicates that the positive relationship between client AIS complexity and CAATTs adoption was indeed stronger for larger audit firms compared with smaller audit firms.

We compared the predictive accuracy and relevance of models with and without the moderating effect to the control model (Table 8). The control model with only the technological factors had an R^2 of 22.6%. Model 2 had an R^2 of 44.5%. The amount of variance explained by the variables in Model 2 was moderate in predicting CAATTs adoption. According to Hair et al. (2011), a R^2 value of 0.25, 0.5 and 0.75 can be described as weak, moderate and substantial, respectively. The R^2 was reasonably high compared with other IT adoption studies using the PLS-SEM (Zhu and Kraemer, 2005) and audit-technology usage study (Bierstaker et al., 2014). Model 3, which included the moderating effect of firm size on client AIS complexity, had an R^2 of 49.9%.

The predictive relevance (Q^2) evaluates how well the model can predict the relevance of the observed values (Geisser, 1974; Stone, 1974). A Q^2 value greater than zero demonstrates that the model has predictive relevance. Contrariwise, a Q^2 value of zero or less shows that the model lacks predictive relevance (Hair et al., 2012a, 2012b). The Q^2 of Model 3 and Model 2 had the same

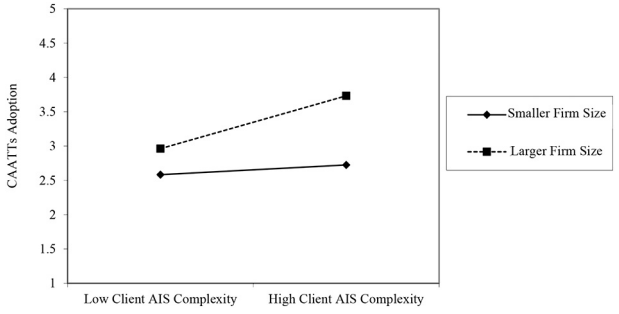

Fig. 3. Interaction Plot of Client AIS Complexity*Firm Size on CAATTs Adoption.

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Table 8
Comparisons between the Control Model and Proposed Model.

Relationship	Model 1	Model 2	Model 3
R^2	0.226	0.445	0.499
Adjusted R^2	0.200	0.403	0.457
Q^2	0.206	0.419	0.419

Model 1: Control factors only (technological factors).
Model 2: Model without the moderating factor (technological, organizational and environmental factors).
Model 3: Proposed model (technological, organizational and environmental factors and moderating effects).
R^2 refers to model's predictive accuracy.
Q^2 refers to model's predictive relevance.

value of 0.419, which was higher than Model 1's 0.206. The addition of the moderating variable (firm size) does not improve the Q^2.

6. Discussion and conclusion

Most research on CAATTs adoption is focused on developed countries. Despite its importance, CAATTs adoption in developing countries is low. This paper aims to fill this gap by examining the organizational and environmental factors that might explain this technology adoption in this context.

This study found support for the influence of both these types of factors on CAATTS adoption in the Malaysian setting. Two of the three environmental factors, namely clients' AIS complexity and PABs support, were found to be significant determinants of CAATTs adoption. We did not find any evidence to support the factor of competitive pressure from other audit firms.

All three organization context variables – firm size, top management commitment and employees' IT competency – were found to have a significant effect on CAATTs adoption. Additionally, firm size had a moderating effect in explaining the influence of clients' AIS complexity on CAATTs adoption.

Our results with respect to clients' AIS complexity, firm size, top management commitment, employees' IT competency, observability and complexity are consistent with prior studies in developed countries (Ahmi and Kent, 2013; Axelsen et al., 2017; Curtis and Payne, 2008; Huang et al., 2008; Janvrin et al., 2008; Lowe et al., 2017; Mahzan and Lymer, 2009; Moore and Benbasat, 1991). Prior research suggests that complexity negatively influences users in adopting technology (Moore and Benbasat, 1991; Rogers, 2003; Thong, 1999). However, consistent with Huang et al., (2008) we find that CAATTs complexity does not significantly affect CAATTs adoption.

Other results are not consistent with prior studies. We did not find competitive pressure to have a significant influence on CAATTs adoption. This unexpected result for competitive pressure could be because the majority of the audit firms are smaller-sized firms that focus on the local area (see Table 2). These firms have less complex clients and using CAATTs may not result in significant improvement in audit efficiency or quality. In addition, contrary to our expectations, three of the five control variables (relative advantage, compatibility, and triability) have significant negative influences on CAATTs adoption. We tested a model with the five control technological factors only and the results show that all the variables have positive relationships (results are not shown). With the inclusion of organizational and environmental factors together with the moderating factors, the beta weights change to negative except for observability. This finding suggests that the technological factors (relative advantage, compatibility and trialability) are negatively related to adoption when taking environmental and organizational factors into consideration.

This paper proposed two variables not examined in previous studies i.e. PABs support and firm size moderation of the clients' AIS complexity. Perceived PABs support had a positive influence on audit firms' CAATTs adoption. PABs provide professional certification to members such as the certified information systems auditor (CISA), which helps auditors develop the IT skills needed to adopt CAATTs. PABs also provide professional education and training programs that help develop their IT competency and knowledge, which facilitates CAATTs adoption.

It was also found that firm size had a moderating effect in explaining the association of clients' AIS complexity with CAATTs adoption. For smaller firms with fewer IT-related resources, clients AIS complexity has a smaller influence on CAATTs adoption, while for larger firms with greater IT-related resources, client AIS complexity has a greater influence on CAATTs adoption.

This research contributes to AIS and auditing literature by providing evidence that organizational and environmental factors (i.e. client AIS complexity and PABs support) do significantly affect CAATTs adoption in a developing-country context. This paper also makes a unique contribution by modifying the TOE framework (Tornatzky and Fleischer, 1990) to study CAATTs adoption. This study also found that competitive pressure does not significantly affect CAATTs adoption unlike findings of other studies. Furthermore, this research used the organization-level lens to view CAATTs adoption whereas previous research used the individual-auditor responses.

The limitations of this study are our assumption that participants would be able to report correctly and accurately the usage levels of the various CAATTs at the organization level, since obtaining the actual CAATTs usage data was not feasible. We specifically focused on the perception of CAATTs adoption in the context of audit firms in public practice due to their unique environment. Thus, the generalization of the findings in this study might not be suitable in other contexts, e.g. the perception of CAATTs adoption in internal auditing.

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Future research could examine CAATTs adoption at a more granular level. For example, which specific CAATTs are adopted by the different audit firm sizes such as, the Big 4, national and local firms? How do CAATTs tools differ with various client AIS industries such as, banking, hospitals, retail and manufacturing? Another opportunity for research is to look at determinants of the perception of professional accounting body support. Future research on these topics might be undertaken using the in-depth qualitative approach and "explanation theory" espoused by Axelsen et al., (2017).

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Appendix 1. Literature review related to factors affecting CAATTS adoption

Author (year), Country	Method	Respondents/Sample Size	Objectives of Study	Theory Applied/Factors Included	Key Findings	Gap/Limitation
Ahmi and Kent (2013) UK	Web-based survey	205 out of 3587 external auditors in SMPs	Investigate the utilization of generalized audit software (GAS) & factors that influence the use of GAS by external auditors.	IT audit quality model (Havelka and Merhout, 2007)	GAS widely used in financial statement audit rather than in other types of audit. Exploratory factor analysis: client, job relevance, auditing, cost and resources (GAS implementation), cost and resources of audit engagement, personal knowledge, technological IT availability and management support.	Individual perspective of external auditors
Axelsen et al. (2017) Australia, NZ, Canada and UK	Interview	55 auditors and IS auditors	Examine the role of IS auditors in financial audit. Identify the factors that influence that role.	'5 W + 1H' framework - Who carries out the IS audit? - What is done in the IS audit? - Why are the IS audit tasks done? - When are these tasks done? - How are the IS tasks done?	- Four key factors that affect use of IS audit tools: i) auditors' ability to understand critical systems. ii) auditors' ability to identify general computer controls. iii) auditor preference for substantive or control testing. iv) auditor perspective on audit efficiency.	IS auditor's function in the organization
Banker et al. (2002) US	Interview and quantitative panel data	Auditors in an international public accounting firm	Explore the impact of IT on audit firm's service production.	Task-Technology Fit	- The firm held mandatory IT training classes for professional staff. - Adoption of IT (audit software & knowledge-sharing applications) in auditing improves individual auditor's efficiency, reduces time in preparing working papers, facilitates decision-making process, improves decision quality and business process productivity and increases firm's revenues.	Individual perspective of external auditors
Bierstaker et al. (2014) US	Surveys in a seminar and in Big 4 firms	181 auditors (72 auditors from the Big 4, 109 auditors from national, regional and local firms)	Identify and examine factors influencing auditors' use or non-use of CAATTs.	UTAUT - Performance Expectancy - Facilitating Conditions - Social Influence - Effort Expectancy	- Performance Expectancy and Facilitating Conditions influenced auditors in using CAATTs. - Social Influence and Effort Expectancy were insignificant.	Individual perspective of external auditors

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Author (year), Country	Method	Respondents/Sample Size	Objectives of Study	Theory Applied/Factors Included	Key Findings	Gap/Limitation
Braun and Davis (2003) US	Survey using email with Internet link	90 legislative auditors from various states in the US	Examine auditors' experience in using Audit Command Language (ACL) and Interactive Data Extraction and Analysis (IDEA).	None	- Auditors have a low perception of their skills in using ACL and IDEA although they perceived using these tools as beneficial to their work.	Individual perspective of legislative government auditors
Curtis and Payne (2008) US	Experiment of case study questionnaire survey during firm's training session	139 responses from 181 auditors in a single Big 4 firm	Examination of contextual factors and individual characteristics affecting decisions on audit-technology implementation.	UTAUT and budgeting theory - Contextual factors (budget period and management support). - Individual characteristics (risk preferences).	- Firms can influence new technology usage by using longer-term budgets and evaluation periods. - Auditors are more likely to implement new technology when the managing partner encourages the technology implementation. - Risk-seeking individual auditors are more likely to use technology in auditing regardless of budget pressures. - Risk-averse auditors are influenced by budget pressures in deciding on audit technology usage.	Individual perspective of external auditors
Curtis and Payne (2014) US	Questionnaire survey	75 financial auditors in one Big 4 accounting firm	Examine whether: - UTAUT can be effectively adapted for research in an external audit setting. - Relationships of UTAUT differ due to budget pressure.	UTAUT	- When budget pressure is high, intention to utilize CAATTs is driven by Effort Expectancy through Performance Expectancy. - When budget pressure is low, intention is driven by Social Influence through Performance Expectancy. - Gender significantly interacts with Social Influence.	Individual perspective of external auditors
Debreceny et al. (2005b) Singapore	Depth interview	3 internal and 3 external auditors in the financial industry	Determine how GAS is used in the banking sector.	None	- Bank auditors used GAS to a limited extent only. - Difficulty of using GAS, the cost-effectiveness and wrong perceptions of GAS were reasons for the limited use.	Individual perspective of auditors in the banking industry
Greenstein-Prosch et al. (2008) US and Germany	Questionnaire survey	587 out of 2500 audit professionals	Compare IT usage and knowledge between US and German auditors.	TAM - Self-efficacy	- >25% of audit practitioners in both countries have low levels of perceived knowledge on audit technologies. - US auditors have a significantly higher level of perceived audit automation knowledge than German auditors, except for knowledge in GAS, where both nationalities have the same knowledge level.	Individual perspective
Huang et al. (2008) Taiwan	Questionnaire survey	117 out of 500 internal auditors in Taiwan	Examine factors of CAATTs' acceptance by internal auditors.	TAM - Perceived ease of use. - Perceived usefulness. - External factors (organizational support and systems quality).	- Perceived ease of use has no significant effect on the auditors' behavioral intention to use CAATTs. - Perceived ease of use significantly affects their	Individual perspective of internal auditors

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Author (year), Country	Method	Respondents/Sample Size	Objectives of Study	Theory Applied/Factors Included	Key Findings	Gap/Limitation
					perceived usefulness of CAATTs. - Organizational support and systems quality influence perceived ease of use and perceived usefulness of CAATTs.	
Ismail and Zainol Abidin (2009) Malaysia	Questionnaire survey	95 out of 1110 audit firms in Malaysia	Investigate the level of IT knowledge and IT importance.	None - Descriptive study	- IS audit is still at an early stage in Malaysia yet GAS is perceived as important. - 21% of audit firms use GAS, 16% provide IS audit service. - Mean rating of IT knowledge level in audit automation is lower than mean rating of the importance of the technologies.	Audit firms' perspective No investigation on the factors influencing CAATTs adoption.
Janvrin et al. (2008) US	Questionnaire survey in a seminar and survey in Big 4 firms	181 auditors (72 auditors from Big 4, 109 auditors from national, regional and local firms)	Examine: - What audit IT is used most frequently by auditors? - Which audit IT is rated as more important by the auditors?	None - Audit firm size	- There is a difference between which audit IT auditors currently use, and which they perceive as important. - Firm size has an effect on audit IT use and importance; Big 4 firms are more likely to use and rate highly the audit IT than smaller firms.	Individual perspective of external auditors
Janvrin, Bierstaker & Lowe (2009) US	Same respondents as per Janvrin et al. (2008)	Same data as per Janvrin et al. (2008)	Examine how control risk assessment and audit firm size impact the use of computer-related audit procedures for clients with complex IT.	None - Audit firm size - Control risk assessment	- CAATTs use varies by audit phase and audit firm size. - CAATTs generally used to gain understanding of client's systems and business processes, and for testing computer controls. Low utilization of CAATTs during substantive testing. - In Big 4 firms, control risk tends to be assessed at less than maximum. - CAATTs and IT specialists are more likely to be used by Big 4 firms than smaller audit firms.	Individual perspective of external auditors Only tested the firm size variable in CAATTs adoption.
Janvrin et al. (2009b) US	Same respondents as per Janvrin et al. (2008)	Same data as per Janvrin et al. (2008)	Identify the factors that influence individual auditor's adoption of CAATTs.	UTAUT - Performance Expectancy - Effort Expectancy - Social Influence - Facilitating Conditions	- Performance Expectancy and Facilitating Conditions are significant factors in influencing CAATTs adoption by individual auditors.	Individual perspective of external auditors
Kim et al. (2009) US	Questionnaire survey	185 out of 1600 internal auditors	Evaluate perceived usefulness and perceived ease of use at a different complexity level of audit software.	TAM - Perceived ease of use. - Perceived usefulness.	- Negative relationship between complexity feature and audit software acceptance. - Internal auditors lack organizational and social encouragement in using technology in auditing. - Perceived usefulness had more impact on acceptance when the audit software was less complex, whereas	Individual perspective of internal auditors

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Author (year), Country	Method	Respondents/Sample Size	Objectives of Study	Theory Applied/Factors Included	Key Findings	Gap/Limitation
					perceived ease of use had more influence on acceptance when the audit software was more complex.	
Lowe et al. (2017) US	Questionnaire survey	65 auditors from online survey and 26 auditor responses from survey conducted in an audit conference	Evaluate individual auditors' perception of importance of IT audit and whether these perceptions have changed over the last decade. Determine whether firm size affects IT adoption.	None	- Auditors perceived IT as important and would use IT more in their audits. - Big 4 auditors were not significantly more likely to use IT tools than non-Big 4 in most audit applications. - Non-Big 4 firms' IT capabilities have caught up with the Big 4 over the last decade.	Individual auditor perception. Audit-firm level data on the research question on size and capability.
Mahzan and Lymer (2009) UK and Malaysia	Questionnaire survey and interview	46 members of the Chartered Institute of Internal Auditors in UK responded to the survey. A further 10 interviews were done with the internal auditors (8 UK and 2 Malaysian companies)	Explore factors for GAS adoption by internal auditors. Also studied the best practices in implementation, and the challenges, and benefits post-implementation.	UTAUT - Performance Expectancy - Facilitating Conditions - Social Influence - Effort Expectancy	- Performance Expectancy (CAATTs benefits) & Facilitating Conditions (auditor expertise, management support, external auditor and regulatory body) influence GAS adoption. - Social Influence & Effort Expectancy not significant. - Technical complexity and attitude of internal auditors were found to be barriers to the usage of CAATTs.	Individual perspective of internal auditors
Mahzan and Lymer (2014) UK and Malaysia	Interview	Same interview data as per Mahzan and Lymer (2009)	Two moderating variables, experience and voluntariness, were added to the Mahzan and Lymer (2009) study.	UTAUT - Performance Expectancy - Facilitating Conditions - Social Influence - Effort Expectancy - Experience - Voluntariness	- Results of qualitative study as per Mahzan and Lymer (2009): - Voluntariness and Experience have no moderating effects on Social Influence. - Experience has no effect on the Facilitating Conditions to adopt CAATTs. - Experience has a moderating effect on Effort Expectancy. Experienced auditors were less likely to have lower Effort Expectancy when it came to adopting CAATTs.	Individual perspective of internal auditors
Mahzan et al. (2009) Malaysia	Questionnaire survey	154 respondents from a survey carried out at an auditing conference	Examine the extent of CAATTs usage in Malaysia.	None	- 20% to 30% of respondents used CAATTs. - Features, ease of use and cost are the three criteria that influenced the internal auditors in using CAATTs.	Individual perspective. Descriptive statistics on the usage of CAATTs by internal auditors.
Mahzan and Veerankutty (2011) Malaysia (There are other research objectives and results but only those relevant to this paper are presented)	Questionnaire survey	73 responses from public-sector auditors	What are CAATTs mostly used for during the audit process?	None CAATTs used as a) problem-solving aids; for b) data integrity testing; c) systems analysis and documentation; d) systems or program testing; e) as an administrative tool.	- CAATTs are mostly used as a problem-solving aid in the public sector. - However, the results indicated that the various usage of CAATTs are not significant among the different usage classifications.	Individual perspective of public-sector auditors

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Omonuk (2015) Nigeria	Questionnaire survey	160 auditors and 160 audit report users	Examine whether auditors effectively audit computerized accounts. Identify the relationship between CAATTs' use and audit quality.	None	- CAATTs are effectively used. - There is a positive relationship between the use of CAATTS and audit quality.	Individual perspective of external auditors
Ramen et al. (2015) Mauritius	Questionnaire survey	133 firms consisting of 581 auditors registered with the Mauritius Institute of Professional Accountants (MIPA)	Develop a conceptual model that includes organization/cultural factors in the individual and organizational view of adoption.	UTAUT, TRI, TOE and Denison's culture models	- Individual auditor's intention to adopt is subject to organizational factors. - Found positive correlations of UTAUT, TRI and TOE factors with adoption.	Mixes individual perspective with audit firm-level view of adoption Need more rigorous testing of the validity of the proposed model.
Widuri et al. (2016) Indonesia	Interview	Interviews with 27 audit firms, 6 regulators and 1 professional accounting body	Determine key factors in audit firms' adoption of GAS.	TOE	- In the Indonesian context, language compatibility and regulator/-professional body support are important factors driving adoption. - "Environmental factors are essential precursors to GAS adoption".	Audit-firm level perspective
Zainol et al. (2017) Malaysia	Questionnaire survey	120 SMPs	Determine the factors affecting behavioral intention.	UTAUT	- There is a significant influence of Performance Expectancy, Social Influence and Facilitating Conditions on behavioral intention to adopt CAATTs. - There is no statistical significance of Effort Expectancy on behavioral intention to adopt CAATTs.	Using an individual perspective adoption framework on organizational -level data

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