Computer Producing a "Fair" Auditor's Report

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The core research activity described in this paper is modelling, implementing, and validating a knowledge-based system, called the "Auditor's Report EXpert" (AREX), that is capable of formulating the opinion on financial statements, as expressed in the auditor's report. The main research question examined in this paper is: can AREX perform the task of formulating the auditor's opinion similarly as may be expected from an experienced auditor? If so, how should AREX be constructed and validated? The knowledge used by AREX is acquired from the literature, and from well-trained auditors through questionnaires and in-depth interviews. After implementation, the knowledge base is presented to experts for review. The AREX performance is validated by test cases and actual auditing cases. From the results of the validation, we may conclude that AREX is successful in performing the task of formulating the auditor's opinion. Three more conclusions are given as well as two recommendations for future research.

1. Introduction

Corporations are required by law to produce annual reports on their financial statements. The financial reports are accompanied by the auditor's report, which contains an independent auditor's opinion on the fairness of the financial statements. To formulate their opinions, auditors use a "personal-judgement" approach. In doing so, they heavily depend on their own experience and expertise. Such an approach may be ineffective and may lead to different auditors coming to different decisions, developing a personal bias, and/or giving misleading judgements. An intriguing question is: can a computer program support an auditor in producing a "fair" auditor's report? A knowledge-based system (KBS) that is able to formulate the auditor's opinion and does so adequately will reduce the inconsistencies of the personal judgements (cf. Brown and Murphy, 1990; Flory, 1991; O'Leary, 2003). Hence, a KBS for the formulation of the auditor's opinion may be considered to be a considerable help to members of the International Federation of Accountants (IFAC). It may expedite and harmonize auditor's opinions, thus making those opinions more reliable. Additionally, a KBS for such a task could also be used as an internal training tool at auditing firms to build up the experience of junior auditors. It will increase the likelihood that the auditors' opinions on financial statements comply with the International Standards on Auditing (ISA). This paper investigates to what extent it is possible to automate the formulation of the auditor's opinion with a KBS.

In our investigation, we developed a KBS called the "Auditor's Report EXpert" (AREX), which is able to formulate the auditor's opinion on financial statements. AREX contains all knowledge associated with the auditor's opinion. AREX is targeted in particular at the auditing practice in Egypt. This country has only a limited number of experienced auditors who are adequate in formulating the auditor's opinion (Wahdan *et al*., 2005a).

To develop AREX, knowledge was acquired from the literature and from an appropriate set of experienced auditors through questionnaires and in-depth interviews, using the Knowledge Acquisition and Design Systems (KADS) methodology (cf. Schreiber, Wielinga, & Breuker, 1993; Post, Wielinga, & Schreiber, 1997). AREX is implemented using the Knowledge Representation Objects Language (KROL) (Shaalan, Rafea, & Rafea, 1998). After implementation, the knowledge base was validated by experienced auditors. The auditors were selected depending on at least one of the following three factors: (i) the number of years of experience (at least 10 years), (ii) the level of education (at least a bachelor degree with a high level of computer skills and of the English language), and (iii) some work performed in international auditing firms. A pilot study was carried out to test the clarity and validity of the questions in all questionnaire lists. The preliminary validation results acquired from experts in Egypt, using test cases and in-depth interviews, indicate that AREX successfully executes the task of formulating the auditor's opinion. The validation of AREX, using actual auditing cases, indicates that AREX is highly accurate.

The outline of the paper is as follows. Section 2 presents background information. Section 3 describes the conceptual model of AREX. Section 4 deals with the actual implementation. Section 5 shows the validation and evaluation. Section 6 provides our main conclusions and points to future work.

2. Background Information

The audit process consists of four phases: (1) planning and designing an audit approach, (2) performing tests of controls, (3) performing analytical procedures and tests of details of transactions and balances, and (4) completing the audit and issuing the auditor's report (Arens, Elder, & Beasley, 2008). In terms of functional areas, Brown and Murphy (1990) distinguish three areas where a KBS can support the audit process: (1) the audit program development, (2) the internal control evaluation and risk analysis, and (3) the technical assistance.

There are three main limitations associated with previously developed KBSs made for an auditing area. They are: (1) the knowledge bases reflect only the expertise of a single practitioner, thus the ability to generalize the system's conclusions is restricted (Changchit, Holsapple, & Viator, 2001), (2) the KBSs do not reflect any actual decision-making in auditing firms – they perform well on test cases but their performance declines on actual audit cases (Smith and McDuffie, 1996; Collier, Leech, & Clark, 1999; Lenard, Alam, Booth, & Madey, 2001; Lenard, 2003), and (3) they do not deal with the audit process as a whole, but focus instead on limited aspects of the auditor's concern within a specific cycle (they do not consider at least the following six aspects: tests of controls, tests of details of transactions and balances, the audit risk, the materiality of auditor's findings, a fair representation, and the auditor's opinion formulation). Furthermore, previous studies ignored the role of users in developing a knowledge base and building an explanation facility (Akoka and Comyn-Wattiau, 1996; Mak, Schmitt, & Lyytinen, 1997; Bayraktar, 1998). Many of the previous systems did not have an explanation facility at all (Changchit *et al.*, 2001).

So far, a complete KBS for formulating the auditor's opinion received little attention in the literature. Since 1996, much attention was given to the acquisition of knowledge from the literature (Smith and McDuffie, 1996). To the best of our knowledge, previous research has failed to deal adequately with the irregularities, inconsistencies, and complexities of the task of formulating the auditor's opinion. Up to now, no single KBS has been developed which executes this task in practice, as we established during a survey among local and international auditing firms in Egypt and the Netherlands (Wahdan, *et al*., 2005a).

3. Conceptual Model OF AREX

This section presents the auditor's opinion (3.1), the audit environment (3.2), and the conceptual model of AREX (3.3).

3.1 The Auditor's Opinion

A company's director is mainly interested in presenting the results of the company's operations as satisfactory as possible. This interest may conflict with the objective of preparing accounts to present a fair view. The auditor's report lends credibility to financial statements by validating the techniques and procedures used to report the company's results (Guy, Carmichael, & Lach, 2003; Arens *et al*., 2008). The auditor is responsible for checking the compliance with accounting principles and for attesting that financial statements are fairly presented (Whittington and Pany, 2003; PCAOB, 2004; Hayes, Dassen, Schilder, & Wallage, 2005).

Since auditors depend on their personal judgements during the audit, this may lead to different auditors reaching different decisions, depending on, among others, their experience and expertise (Curtis and Hayes, 2002; O'Leary, 2003). Thus, the main research question is: can AREX perform the task of formulating the auditor's opinion as may be expected from an experienced auditor?

3.2 Audit Environment

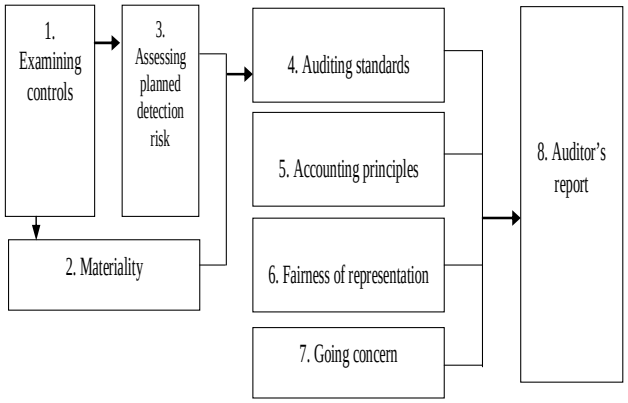
The audit environment can be described in several different ways. However, two issues dominate such a description: (1) legislators frequently change auditing standards, which make the audit environment ever more detailed and complex, and (2) the auditors are compelled to comply with a set of auditing standards that might be different from one country to another, which further complicates the audit environment, in particular when auditing multinational firms (cf. Ernst & Young, 2005; PriceWaterhouseCoopers, 2004, 2005, 2006).Therefore, the audit judgements require a thorough analysis before auditors are able to formulate their professional opinions on financial statements.

3.3 Conceptual Model Structure

Our conceptual model structures the final stage of the auditing process, which consists of five tasks, namely: (1) accumulating final audit evidence, (2) reviewing the subsequent events, (3) evaluating the compliance with existing accounting principles, (4) checking the fairness of the representation and going-concern uncertainties, and (5) formulating the auditor's opinion (Arens *et al*., 2008). Before these tasks can be performed, the conceptual model should: (1) test the completeness of the prior auditing stages, and (2) collect the findings of these stages.

To complete the testing and collecting phase, the conceptual model of AREX distinguishes eight models (see Figure 1). The arrows in Figure 1 indicate that the output from one of the models is used as input for the other. For example, the output of the model of examining controls forms the input of the materiality model and the model of assessing planned detection risk.

Figure 1: The conceptual model of AREX



We list the eight models below, together with a brief description (Wahdan, *et al*., 2005b).

(1) The model of *examining controls* provides an assessment of the control risk. It contributes to determining the effectiveness of the internal control system and to selecting the audit scope. To achieve this, the model consists of eight subtasks: (1) auditor competence (e.g., education status, sufficiency of training status, and continuous education), (2) auditor independence (e.g., assignment, fees, switch, separation, interests, and others), (3) understanding internal controls, (4) management integrity (questionable/unquestionable), (5) investigating internal controls, (6) walkthrough of significant accounts, (7) tests of controls, and (8) the control risk (see Figure 2).

(2) The *materiality* model provides the preliminary judgement about materiality (i.e., the expected impact of misstatements on decisions of the users of the financial statements). It contributes to determining the amount of planned evidence. For example, in Figure 2 (middle), the materiality of the scope restriction depends on whether unavailable information contains illegal acts, subjectivity, suspense accounts, and party transactions, and whether it affects market actions, etc.

(3) The model of *assessing planned detection risk* provides an assessment of the chance that misstatements are not detected and of the audit scope of the substantive tests. It depends on the control risk, inherent risk, and acceptable audit risk. For example, in Figure 2 (middle left), inherent risk is related to the results of previous year, industrial circumstances, etc.

(4) The *auditing standards* model checks whether the auditor collects appropriate audit evidence and whether the audit complies with the auditing standards.

(5) The *accounting principles* model tests whether the financial statements are prepared in accordance with applied accounting principles.

(6) The model of *fairness of representation* tests whether the financial statements are fairly represented in accordance with the accounting principles

(7) The *going-concern* model evaluates whether the company has the ability to continue as a going concern, and whether the management plans are effective to resolve the going-concern uncertainties.

(8) The *auditor's opinion* model generates the proper auditor's opinion on financial statements after collecting the outputs from all the above models.

4. AREX Implementation

The knowledge of a KBS is divided into three categories: facts, heuristics, and beliefs (Van den Herik, 1988). Some distinguish facts, assumptions, and heuristic rules (Baldwin-Morgan and Stone, 1995; Smith and Smith, 1995) ignoring the principal component of belief (this may happen since they choose implicitly for a certain belief; for instance, in a KBS on e-commerce: protection vs. free trade). In addition, Knowledge elicitation is the extraction of knowledge from experts. It is a primary bottleneck to the development of reliable and practically usable KBSs (Van den Herik, 1986; Jamieson and Szeto, 1989; Jones and Miles, 1998). Thus, the knowledge required to build AREX was acquired from the literature on ISA (IFAC, 2008), academic materials, periodicals, and experienced auditors. The knowledge acquisition process was structured according to the KADS methodology, using the models specified in the previous section. In the development stage, knowledge was elicited from 32 experienced auditors during interviews. Questionnaire No. 1 (available from the first author) was divided into eight parts, each covering one model. The acquired knowledge was validated and disagreements among the auditors were resolved.

It is remarked that knowledge engineers are using shells and dedicated AI languages (Van den Herik, 1988) that contributes to performing the task. So, we use KROL to represent the AREX knowledge. KROL combines object and rule processing. This combination allows the task of formulating the auditor's opinion to be divided into suitable frameworks for more efficient programming and system operation. To represent the AREX knowledge, we used concepts, properties, prompts, values, and value sources.

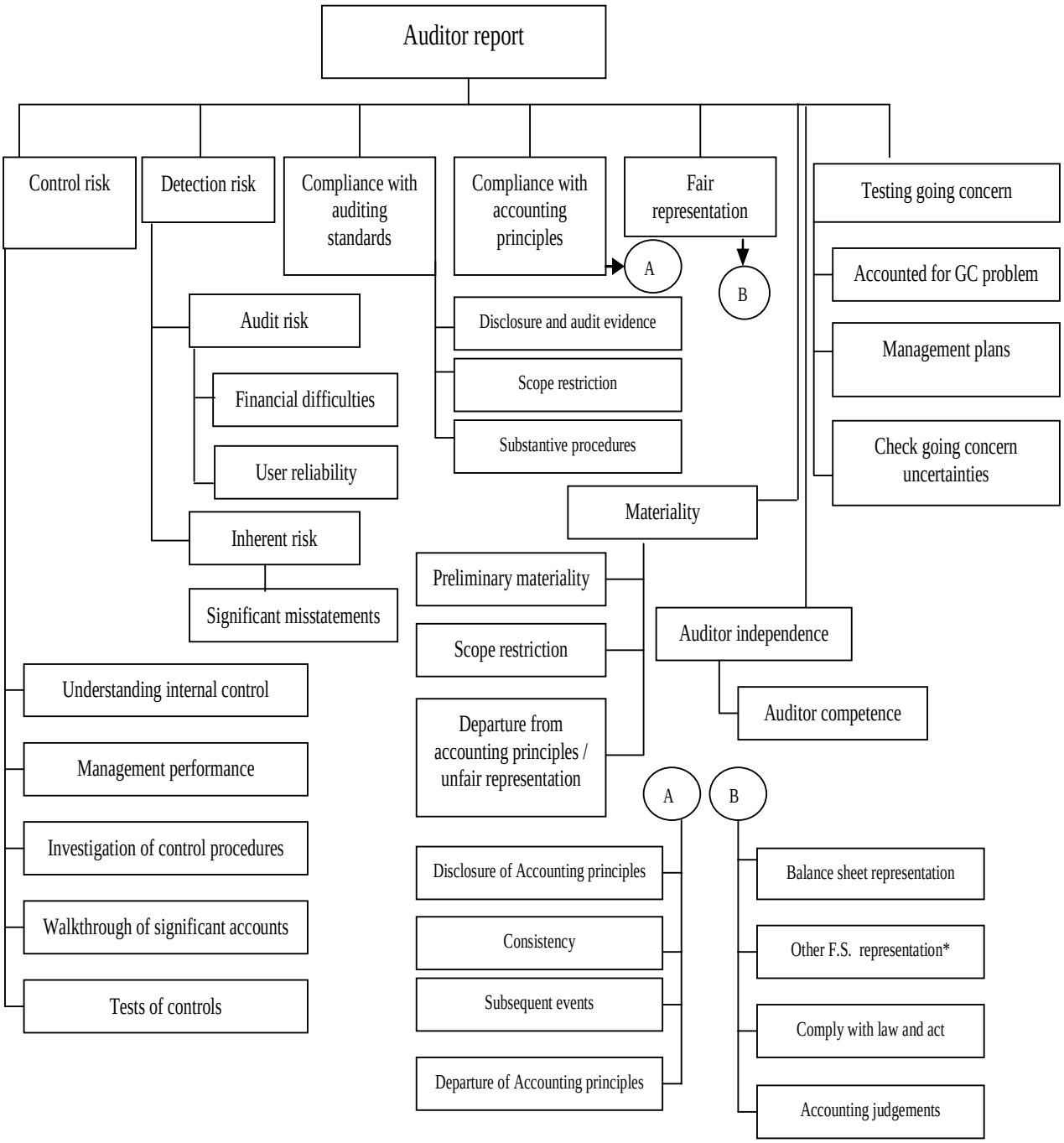
The AREX expertise framework distinguishes three types of knowledge:

First, the domain knowledge consists of the knowledge required for creating the auditor's report. The AREX domain knowledge is stored in a concept hierarchy consisting of objects with their relations. Figure 2 depicts the AREX concept hierarchy.

Second, the inference knowledge contains knowledge that is used in the reasoning process (Van den Herik, 1986; Brown and O'Leary, 1995). We used encoded rules. AREX generates the proper auditor's opinion by applying user-supplied facts to the encoded rules.

Third, the task knowledge is knowledge on the formulation of the auditor's opinion and the relevant activities. In AREX, the eight models are used to structure the information that the user must supply. Figure 2 illustrates the main concepts and sub-concepts. Each concept has properties, prompts (questions), values, and value sources. In total, AREX contains 8 models, 38 concepts, 232 properties, 185 questions, and about 1000 rules.

Figure 2: AREX concept hierarchy.



* F.S.: Financial Statements

Interaction with AREX happens through a user interface and an explanation facility. Via the user interface, users can supply AREX with information in two different ways. The first way is through sequential questions posed by AREX, i.e., AREX queries the user on needed information. The second way is through sheet screens. The user can choose the values and/or the order of values, which he/she would like to assign to properties, and can thus obtain information on how the system works, why properties are needed, and how intermediate conclusions are derived. It provides the possibility of deleting any improper items, of printing conclusions and their reasoning, of stopping the program, and of moving to the previous and next models.

5. Validation and Evaluation

Below we present the validation and evaluation of AREX. It starts with a preliminary validation (5.1), followed by a field-test validation (5.2), and by an auditors' evaluation (5.3).

5.1 Preliminary Validation

A preliminary validation of AREX was carried out in Egypt. First, questionnaire No. 2 (available from the first author) was submitted to 32 auditors. It consisted of fifteen auditing cases that needed to be handled by the auditors as test cases. These test cases were handled by AREX too. The results generated by AREX were compared to the auditors' results.

The outcomes of the comparison indicated that AREX in two cases arrived at different answers with regards to the work of another (additional) auditor (viz. in relation to ISA 600). We note that Egyptian auditors generally do not apply this standard; instead, in Egypt it is common practice that two auditors review the company's accounts and issue one report, which is signed by both of them. In the other thirteen cases, it was noticed that there was roughly some 23% of disagreements in decisions between AREX and the auditors. We discussed the reasons of the different decisions with the auditors. After discussion, we arrived at the conclusion that AREX performed better than the auditors; the auditors revised their decisions in accordance with AREX's results. Second, three auditors were tempted to use the AREX prototype in three of their own hypothetical cases. The results indicated that AREX performed the task of formulating the auditor's opinion in a manner identical to their own formulation.

5.2 Field-Test Validation

Following the preliminary validation, we submitted AREX to 26 experts in order to elicit their comments on how AREX performs the task of formulating the auditor's opinion in the terms of accuracy (cf. Back, 1993-1994). Each auditor selected one or more auditing cases from his files and compared his results with AREX results. A total of 42 different cases were considered in this way. In 41 of these 42 cases, recommendations of AREX complied with the auditors' recommendations, as shown in Table 1. In the remaining case, the auditor's opinion was a *qualified* opinion except for some existing multiple uncertainties instead of a *disclaimer* of opinion as was AREX's decision and as is required by the ISA 570. We discussed the case with the auditor, but he remained at the different opinion, that depended on the materiality of multiple uncertainties.

Originally, there was one other (preliminary) disagreement between AREX's decision and an auditor's decision. In this case, AREX recommended that the auditor's opinion on the client's financial statements should be an *adverse* opinion, while the auditor's opinion was a *qualified* opinion. However, after a detailed discussion of the auditing case, the auditor admitted that AREX was correct, and that the client should have had an *adverse* opinion. However, the auditor conceded that he has formulated a *qualified* opinion in order to retain the client.

So, the accuracy of AREX's decision is 98% (41 out of 42 cases). Therefore, we may conclude that AREX performs the task of formulating the auditor's opinion in a similar way as may be expected from an experienced auditor.

Table 1: The comparison between AREX decisions and the auditors' decisions on actual auditing cases.

Number of auditors	Number of cases audited by each auditor	Total of cases audited	Number of agreements	Number of disagreements
3	3	9	8	1
10	2	20	20	0
13	1	13	13	0
26		42	41	1
		100 %	98%	2%

5.3 Auditors' Evaluation

After the auditors had used AREX in processing the actual auditing cases, their attitudes were examined through questionnaire No. 3 (available from the first author) using five-point Likert scales (ranging from strongly agree = 5 to strongly disagree = 1; and from very good = 5 to very poor = 1). The examined data include the auditors' evaluation of AREX's effectiveness (5.3.1), its efficiency (5.3.2), its acceptance (5.3.3), and of AREX and its models (5.3.4). A summary of the results is given in Table 2.

Table 2: Auditors' evaluation of the effectiveness, efficiency, and acceptance of AREX and its models.

Part.1: Effectiveness of AREX **Questions (Strongly agree = 5… Strongly disagree = 1)**	Mean n = 26	Minimum	Std. dev.
1. AREX is useful in practice	4.42	3.00	0.58
2. AREX is useful as a training device for new auditors	4.88	4.00	0.33
3. AREX's logic is sound	4.54	3.00	0.58
4. AREX's logic reflects professional competence	4.54	3.00	0.58
5. AREX approached the auditor's opinion task in the same manner I would	4.35	3.00	0.69
6. AREX helps auditors formulate their opinions on financial statements according to ISA	4.50	4.00	0.51
7. AREX provides guidelines for auditors as to the required procedures to formulate their opinions on financial statements	4.54	4.00	0.51
8. AREX helps auditors to understand in a better way how they formulate their opinion on financial statements	4.35	3.00	0.75
9. AREX provides the auditors with the appropriate auditor's report type	4.38	3.00	0.63
Questions (Very good = 5… Very poor = 1)			
10. The explanation facility	4.50	3.00	0.58
11. AREX's competence to perform the auditor's opinion task	4.54	3.00	0.65
12. AREX's accuracy	4.27	3.00	0.53
13. AREX's completeness	4.19	3.00	0.63
14. AREX's relevancy	4.42	3.00	0.70
15. AREX's knowledge and expertise	4.50	3.00	0.58

Part.2: Efficiency (Q.1) and acceptance (Q. 2-7) of AREX **Questions (Strongly agree = 5…Strongly disagree = 1)**	Mean N = 26	Minimum	Std. dev.
1. AREX decreases the time needed for the auditor's opinion task on financial statements	4.19	3.00	0.69
2. It is easy to follow the logic of AREX	4.46	3.00	0.65
3. AREX's advice could be trusted	4.27	3.00	0.67
4. AREX 's advice is professionally accepted	4.35	3.00	0.80
Questions (Very good = 5… Very poor = 1)			
5. Phrasing of questions in AREX	4.31	3.00	0.68
6. The ease of understanding AREX's logic	4.42	3.00	0.64
7. AREX is an overall support tool for the auditing tasks	4.50	3.00	0.58

Part.3: AREX models **Questions (Very good = 5… Very poor = 1)**	Mean N = 26	Minimum	Std. dev.
1. The model of examining controls	4.50	3.00	0.65
2. The model of assessing planned detection risk	4.31	3.00	0.73
3. The materiality model	4.50	3.00	0.58
4. The auditing standards model	4.31	3.00	0.74
5. The accounting principles model	4.46	3.00	0.65
6. The fairness of representation model	4.50	3.00	0.58
7. The going-concern model	4.46	3.00	0.65
8. The auditor's opinion model	4.58	4.00	0.50

5.3.1 Effectiveness

Effectiveness deals with the impact of AREX on the decision quality, and increased accuracy (Baldwin-Morgan and Stone, 1995; Changchit *et al.,* 2001). The effectiveness of AREX includes both user-friendliness, which is the system's ability to explain questions and conclusions, and potential usefulness, which is the system's ability to satisfy an auditor's requirements (Baldwin-Morgan and Stone, 1995). From Table 2, part 1, we may conclude that AREX is effective in performing the task of formulating the auditor's opinion.

5.3.2 Efficiency

Efficiency may be measured by the time required to perform a task or by the number and organizational levels of persons involved in the task (Back, 1993-1994; Changchit *et al.,* 2001). From Table 2, part 2, question 1, we may conclude that the use of AREX improves the personal productivity.

5.3.3 Acceptance

The auditors' acceptance of AREX is influenced by the auditors' confidence in the AREX's recommendations and the ease of using AREX (cf. Boritz and Wensley, 1992). From Table 2, part 2, questions 2 to 7, we may conclude that the users have confidence in AREX logic and conclusions.

5.3.4 AREX and its Models

From Table 2, part 3, we may conclude that the performance of the AREX models is good. The auditors' overall evaluation of AREX is good (mean average across all 30 attributes = 4.44).

Finally, the reliability of the auditors' answers measured by internal consistency (Coefficient Alpha) is 96%. This means that there is a high consistency among the auditors' answers on the questions in questionnaire No. 3. During and after the validation, it was clear that the auditors were impressed by the outcome of AREX and by its features. As a sequel, they suggested several points of how to improve the application of AREX.

6. Conclusions and Future Research

This paper describes the modelling, implementation, and validation of AREX. It addresses the question: can AREX perform the task of formulating the auditor's opinion similarly to as may be expected from an experienced auditor? If so, how should AREX be constructed and validated? From our implementation, tests, and validations we may derive two main conclusions: (1) AREX is successful in generating the auditor's report, and (2) the eight models embodied in AREX are correct. So, computers may produce a "fair" auditor's report.

More specifically, the auditors' evaluation of the effectiveness, efficiency, and acceptance of AREX are quite positive, i.e., they scored well on our scales. From the reviews of 26 highly experienced auditors in local and international auditing firms in Egypt, we may conclude that the following statements are true: (1) the task of creating the auditor's report can be performed by a KBS, and (2) AREX is suitable and acceptable to formulate the auditor's opinion.

Being able to produce a "fair" auditor's report there are two issues for future research. First, the auditor's requirements should be investigated and substantiated. Second, auditors should list a number of recommendations to incorporate in AREX in order to improve the performance any further.

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