A Knowledge-Based System for Auditor's Reports

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Most corporations are required by law to produce a yearly report on their financial situation. This financial report is accompanied by an auditor's report, which is an independent auditor's opinion on the fairness of the financial statements. To formulate their report, auditors use a "personal-judgement" approach; i.e., heavily depended on their experience and expertise. This paper focuses on constructing and implementing a knowledge-based system, called "Auditor's Report EXpert" (AREX), that is capable of formulating an opinion on financial statements, as expressed in an auditor's report. The knowledge used by AREX is acquired from literature, and from practicing and academic auditors through questionnaires and in-depth interviews. Preliminary validation of AREX indicates that AREX is successful in performing an auditor's report task.

1. Introduction

Most corporations are required by law to produce a yearly report on their financial situation. This financial report is accompanied by an auditor's report, which is an independent auditor's opinion on the fairness of the financial statements. To formulate their report, auditors use a "personal-judgement" approach; i.e., an approach that is heavily depended on their experience and expertise and may be ineffective.

This paper investigates to what extent it is possible to automate the formulation of an auditor's report with a knowledge-based system. Such a knowledge-based system would be useful in supporting auditors in their task, especially in environments where there is a lack of experience or expertise with creating auditor's reports. Designing the system is a difficult task, because of the high complexity of the auditing environment, and because of the personal-judgement approach used by auditors.

We designed and built a knowledge-based system called the "Auditor's Report EXpert" (AREX), which is able to formulate an auditor's report on financial statements. AREX may help to train new auditors, providing them with structured knowledge for formulating the report on financial statements (Young, 1994; Changchit, 2003). If used consistently, it will decrease the differences in personal judgements between auditors, and will resolve the problems of insufficient disclosure and inconsistencies in auditors' judgements (Brown, 1990; Flory, 1991; McDuffie, Oden, & Smith, 1993). AREX is targeted in particular at the accounting practice in Egypt, which, as a developing country, lacks sufficient auditors experienced in formulating audit opinions.

AREX encodes all the knowledge associated with the auditor's report on financial statements. It supplies auditors with information in three phases of the auditing process, namely (1) basic information gathering, (2) procedure selection, and (3) formulating appropriate opinions. AREX helps to determine the levels of control risk, materiality, and planned detection risk.

To implement AREX, knowledge was acquired from published academic materials, periodicals, and international standards on auditing. Knowledge was also elicited from practicing and academic auditors through questionnaires and in-depth interviews, using the Knowledge Acquisition and Design Systems (KADS) methodology. AREX is implemented using Knowledge Representation Objects Language (KROL). After implementation, auditing experts validated the knowledge base. Preliminary validation results acquired from experts in Egypt indicate that AREX successfully executes the auditor's opinion task.

The outline of this paper is as follows. Section 2 discusses background information and related work. Section 3 describes the conceptual model of AREX. Section 4 deals with the acquisition of knowledge for the implementation of AREX. Section 5 presents the AREX implementation and validation results. Section 6 concludes and points at future work.

2. Background

This section presents background information on the auditor's report (2.1), the auditing environment (2.2), and knowledge-based systems for auditing (2.3).

2.1 The Auditor's Report

A company's director is mainly interested in presenting the results of the company's operations as flattering 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. To achieve this credibility, it is generally accepted that the validation and confirmation of the absence of bias is best provided by an independent auditor's opinion as to the directors' success in achieving disclosure of a fair view (Arens, Elder, & Beasley, 2005; Guy, Carmichael, & Lach, 2003). The auditor is responsible for checking the compliance with auditing standards and attesting that accounts are fairly presented (Hayes, Dassen, Schilder, & Wallage, 2005; PCAOB, 2004; Whittington & Pany, 2003; Guy et al., 2003). Only a sufficiently experienced auditor will lend credibility to financial statements.

During an audit, auditors depend on their personal judgements. This may lead to different auditors reaching different decisions, depending on their expertise and experience. The personal-judgement approach sometimes leads to personal bias and/or misleading audit judgements.

2.2 The Auditing Environment

Legislators frequently change auditing standards, which make the auditing environment ever more detailed and complex. The auditor are compelled to comply with a set of auditing standards that might be different from one country to another, which further complicates the auditing environment, especially when auditing multinational firms.

The auditor's opinion on financial statements is influenced by three factors: (1) the auditor's professional characteristics (e.g., independence, scope of responsibility, competitiveness, and expertise); (2) the characteristics of the auditing environment (e.g., ability to collect evidence, efficiency of the internal controls, and compliance with auditing standards and other regulations); and (3) the auditee's characteristics (e.g., going-concern ability, disclosure of the accounting principles, compliance with accounting principles, and fairness of the representation of the financial statements). Each of these factors requires an analysis and assessment before auditors are able to formulate their professional opinions on financial statements.

2.3 Knowledge-Based Systems in Auditing

Previous knowledge-based systems in auditing do not deal with the audit process as a whole. Instead, they deal with limited decisions within an audit. The main restriction of these systems is that the knowledge bases reflect only the expertise of a single practitioner. Therefore, the ability to generalize the system's conclusions is restricted (Changchit, Holsapple, & Viator, 2001).

Most knowledge-based systems developed in auditing do not reflect actual decision-making within an organisation. These systems performed well on the test cases but their performance declined in actual audit situations (Smith & McDuffie, 1996; Collier, Leech, & Clark, 1999; Lenard, 2001; Murphy & Yetmar, 1996; Hornik & Ruf, 1997; Linard, 2003). Furthermore, previous studies ignored the role of users in developing a knowledge base and building an explanation facility (Akoka & Comn-Wattiau, 1996; Mak, Schmitt, & Lyytinen, 1997; Bayraktar, 1998). Indeed, most knowledge-based systems developed in auditing did not provide an explanation facility (Comn-Wattiau & Akoka, 1997; Lenard, 1998; Changchit et al., 2001).

Knowledge-based systems for formulating an auditor's opinion on financial statements have received little attention in the literature. Since 1996, much attention was given to the acquisition, from literature, of knowledge required for this task (Smith & 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 an auditor's opinion. Neither has a knowledge-based system been developed which executes this task in practice, as we discovered during a survey among local and international auditing firms in Egypt and the Netherlands.

3. A Conceptual Model of AREX

The conceptual model of AREX focuses on the final stage of the auditing process, which consists of five tasks, namely (1) accumulating final audit evidence, (2) reviewing for subsequent events, (3) evaluating the compliance with auditing standards and accounting principles, (4) checking the fairness of representation and going-concern uncertainties, and (5) formulating the auditor's report (Arens, et al., 2005). Before these tasks can be tackled, the model should (1) test the completeness of the prior auditing stages and (2) collect the results of these stages. To achieve this, the conceptual model of AREX consists of eight submodels, as illustrated in Figure 1. The arrows in the Figure represent output from one of the submodels, which are used as input for another of the submodels.

The eight submodels are the following.

(1) The submodel of *examining controls* provides the level of control risk, which contributes to selecting the audit scope.

(2) The *materiality* submodel provides the preliminary judgement about materiality, which contributes to determining the amount of planned evidence.

(3) The submodel of *assessing planned detection risk* provides the level of planned detection risk and an audit scope of substantive tests. It depends on the level of control risk, inherent risk, and acceptable audit risk.

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

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

(6) The submodel of *fairness of representation* tests whether financial statements are fairly represented in accordance with auditing standards and accounting principles.

(7) The *going-concern* submodel evaluates whether the company has the ability to continue as a going-

concern and whether management plans are effective to resolve the going-concern uncertainties.

(8) The *auditor's report* submodel generates the proper auditor's report on financial statements that should be formulated based on the output of all models.
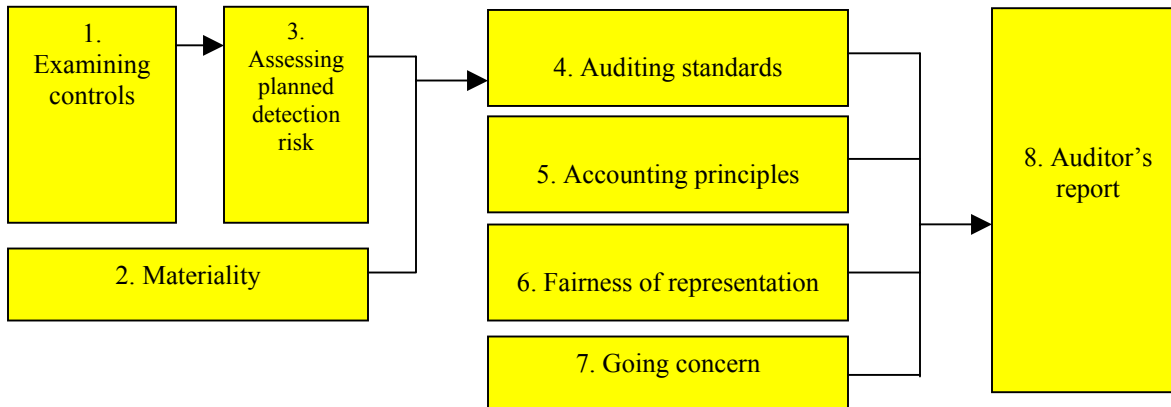

Figure 1 The conceptual model of AREX

4. Knowledge Acquisition

The knowledge required to build AREX was acquired from literature on International Standards on Auditing (ISA), from academic materials, from periodicals, and from academic and practicing auditors. The knowledge acquisition process was structured according to the KADS methodology (Hickman, Killin, Land, & Mulhall, 1989; Wielinga, Schreiber, & Breuker, 1992; Schreiber, Weilinga, & Breuker, 1993; Post, Wielinga, & Schreiber, 1997), using the submodels specified in the previous section.

In the development stage of AREX, knowledge was elicited from 32 experienced auditors (from both academia and practice) during unstructured and structured interviews. In structured interviews, questionnaires were sent to the auditors before the interviews. The questionnaires were divided into eight parts, each covering one submodel. In the last part, covering the auditor's report submodel, the questionnaires presented fifteen auditing situations that needed to be solved by the auditors as test cases.

The acquired knowledge was validated by letting practicing and academic auditors review the results of the knowledge acquisition process. Disagreements between auditors were first given to a small sample of the auditors for resolution. If they could not reach consensus, the lead expert made the final decision.

KROL was used to represent the AREX knowledge base. (Shaalan, Rafea, & Rafea, 1998). KROL encompasses multi-paradigm knowledge representations, such as first-order predicate logic, objects, and rules. The combination of object and rule processing provides a firm basis for handling complex problems. To represent the AREX

knowledge, we used objects, concepts, properties, prompts, values, and value sources.

5. AREX Implementation

The KADS expertise model distinguishes three types of knowledge, namely (1) domain knowledge, (2) inference knowledge, and (3) task knowledge. The AREX implementation of these three types of knowledge is discussed in subsections 5.1, 5.2, and 5.3, respectively. Subsection 5.4 discusses the AREX user interface, and subsection 5.5 presents the preliminary validation results.

5.1 Domain knowledge

Domain knowledge consists of knowledge of a specific system. In this case, it is the knowledge required for creating an auditor's report. Domain knowledge is represented in the forms of rules, facts, objects, hierarchies, properties, and relations. The AREX domain knowledge is stored in a concept hierarchy consisting of objects with their relations. Figure 2 depicts the AREX concept hierarchy. Table 1 lists the number of concepts, properties, questions, and rules within each submodel and within a whole system.

5.2 Inference Knowledge

Inference knowledge is knowledge that is used in the reasoning process. In AREX, inference knowledge is stored in the form of rules. AREX generates the proper auditor's opinion by applying user-supplied facts to the encoded rules.
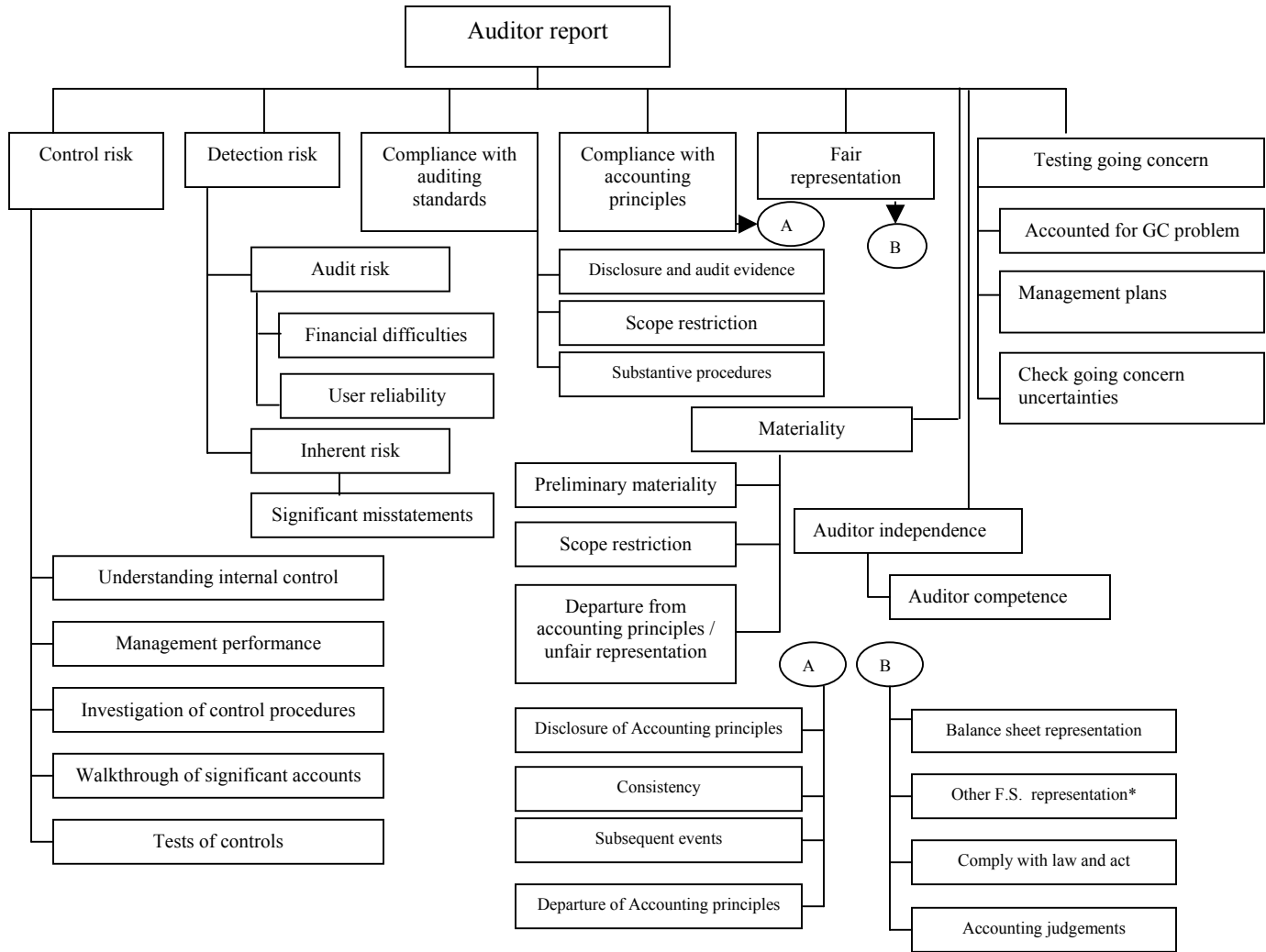
Figure 2. AREX concept hierarchy
* F.S.: financial statements

Submodels of AREX	Concepts	Properties	Questions	Rules
1. Examining controls	8	73	64	183
2. Materiality	3	21	17	21
3. Detection Risk	6	27	14	35
4. Auditing Standards	4	20	17	66
5. Accounting Standards	5	13	12	106
6. Fairness of Representation	5	23	18	79
7. Going concern uncertainties	4	26	20	41
8. Auditor report	3	29	22	31
Total (AREX)	**38**	**232**	**184**	**562**

Table 1. AREX submodels' concepts, properties, questions, and rules

5.3 Task Knowledge

Task knowledge is knowledge related to the goal of the task and the activities that contribute to achieving the goal. In AREX, eight tasks are distinguished, which correspond to the eight different submodels displayed in Figure 1. The eight tasks are defined by their input, output, goals, control, and features. When AREX is used, the eight tasks are used to structure the information that the user must supply.

5.4 User Interface

Users can supply AREX with information in two different ways. The first way is to let AREX query the user on needed information. AREX asks the user questions one-by-one, which the user must answer before he can continue. Each question assigns a value to one property.

The second way is to let AREX present the user with the required information in the form of a sheet, which covers one relation in a submodel. The user can choose in which order to assign values to properties, and can get information on how the system works, why properties are needed, and how intermediate conclusions are derived. The sheet screen is illustrated in Figure 3.

5.5 Preliminary validation of AREX

Preliminary validation of AREX was carried out in Egypt. A questionnaire was submitted to 32 practicing and academic auditors. The questionnaire consisted mainly of fifteen auditing situations that needed to be solved by the auditors as test cases. These cases were solved by AREX too, and the results were compared with the auditors' findings. The results of the comparison indicate that AREX derived the same answer as the auditors in thirteen auditing situations. AREX derived different answers in two situations regarding the work of another auditor. While Egyptian auditors do not apply this standard (the work of another auditor), two auditors can review the company's accounts and issue one report, which is assigned by both of them. This standard is considered during the final version of AREX. In addition, it was noticed that some of auditors made a wrong decision in some situations, but they changed their decision, as AREX generates, within the interviews. Therefore, we can conclude that the results of the comparison indicate that AREX derived the same answer as the auditors. Three auditors who used a prototype of AREX in hypothetical cases indicated that AREX performs an auditor's opinion task well, and considered it a useful tool to formulate the auditor's report on financial statements in practice. They expressed that AREX provides a foundation for the auditing process, by its definition of concepts, properties, and relations. AREX may help to train new auditors, providing them with structured knowledge for formulating the auditor's report. AREX performance was considered acceptable and AREX knowledge was viewed as relevant to the task. Further research, using real cases, is needed to validate the AREX effectiveness, efficiency, and acceptance.

6. Summary and conclusion

This paper describes the construction and implementation of AREX, the Auditor's Report EXpert system. AREX comprises a conceptual model of an auditor's report, which is divided into eight submodels. The eight submodels are used to structure the information that the user must supply AREX with. The AREX domain knowledge was acquired from practicing and academic auditors, and from the literature. Preliminary validation of AREX by auditors in Egypt showed that it is successful in generating the auditor's report on financial statements.

We conclude that preliminary results indicate that the task of creating an auditor's report can be performed by a knowledge-based system. Additional research is needed to validate the effectiveness, efficiency, and acceptance of AREX, using real cases. This validation will be carried out in the second half of 2005.

References

Akoka, J. & Comyn-Wattiau (1996). A Knowledge-Based System for Auditing Computer and Management Information Systems. Expert System with Applications, 11, 361-375.

Akoka, J. & Comyn-Wattiau (1997). An Expert System for Financial and Accounting Information System Auditing. Computer Audit Update, 8-19.

Arens, A.A., Elder, R.J. & Beasley, M.S. (2005). Auditing and Assurance Services: An Integrated Approach. PEARSON: Prentice Hall, New Jersey.

Bayraktar, D. (1998). A Knowledge-Based Expert System Approach for the Auditing Process of Some Elements in the Quality Assurance System. International Journal of products economics, 56-57, 37-46.

Brown, C.E & Murphy, D.S. (1990). The Use of Auditing Expert Systems in Public Accounting. Journal of Information Systems, 4, 63-73.

Changchit, C., Holsapple, C. W. & Viator, R.E. (2001). Transferring Auditors' Internal Control Evaluation Knowledge to Management. Expert System With Applications, 20, 275-291.
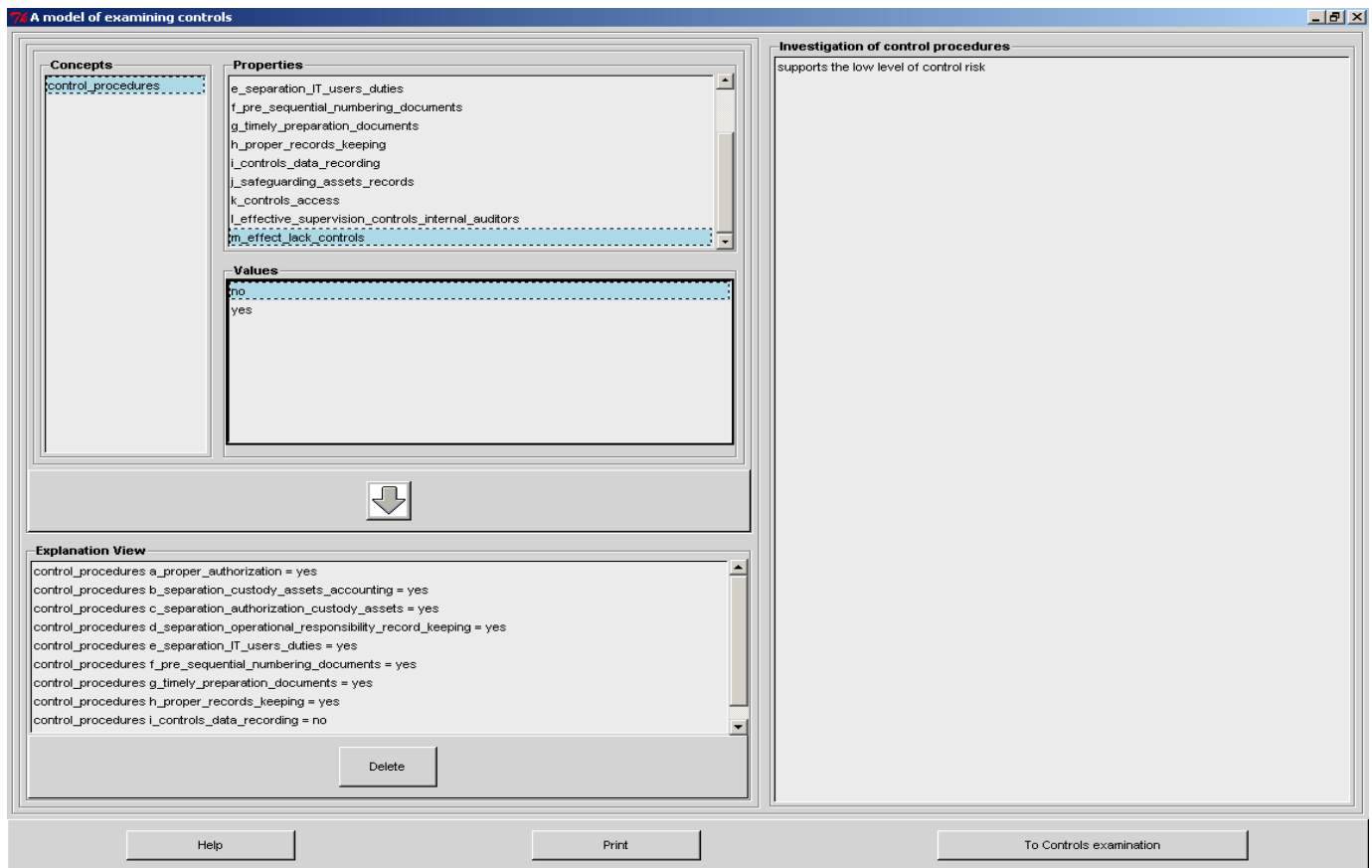
Figure 3. The sheet screen

Changchit, C. (2003). The Construction of an Internet-Based Intelligent System for Internal Control Evaluation. Expert System With Applications, 25, 449-460.

Collier, P.A., Leech, S.A. & Clark, N. (1999). A Validation Expert System for Decision Making in Corporate Recovery. International journal on intelligent Systems in Accounting, Finance & Management, 8, 75-88.

Comyn-Wattiau & Akoka, J. (1997). Expert Systems for Computer and Management Information Systems Auditing. Computer Audit Update, 17-27.

Flory, S.M. (1991). Here's an Expert System-Based Support Tool for Making Accounting Decisions. The CPA Journal Online.

Guy, D.M., Carmichael, D.R. & Lach, L.A. (2003). Practitioner's Guide to GAAS. JOHN WILEY and SONS, INC., Canada.

Hayes, R., Dassen, R., Schilder, A. & Wallage, P. (2004). Principles of Auditing: an introduction to international Standards on Auditing. FT Prentice Hall, Amsterdam.

Hickman, F.R., Killin, J.L., Land, L., Mulhall, T., Porter, D. & Taylor, R.M. (1989). Analysis for Knowledge-Based Systems: A Practical Guide to KADS Methodology. ELLIS Horwood Limited, john Wiley and Sons, New Your.

Hornik, S. & Ruf, B.M. (1997). Expert Systems Usage and Knowledge Acquisition: An Empirical Assessment of Analogical Reasoning in the Evaluation of Internal Controls. Journal of Information Systems, 1, 57-74.

Lenard, M.J., Alam, P., Booth, D. & Madey, G. (2001). Decision-Making Capabilities of a Hybrid System Applied to the Auditor's Going-Concern Assessment. International journal on intelligent Systems in Accounting, Finance & Management, 10, 1-24.

Lenard, M.J. (2003). Knowledge Acquisition and Memory Effects involving an Expert System Designed as a Learning Tool for Internal Control Assessment. Decision Sciences Journal of Innovative education, 1, 23-38.

Lenard, M.J., Madey, G.R. & Alam, P. (1998). The Design and Validation of a Hybrid Information System for the Auditor's Going Concern Decision. Journal of Management Information Systems, 219-237.

Mak, B., Schmitt, H. & Lyytinen, K. (1997). User Participation in Knowledge Update of Expert Systems. Information& Management, 32, 55-63.

McDuffie, R.S., Oden, D.H. & Smith, L.M. (1993). The Potential for Use of Expert systems in Oil and Gas Tax Accounting. Oil & Gas Tax Quarterly, 41, 389-397.

Murphy, D. S. & Yetmar, S.A. (1996). Auditor Evidence Evaluation: Expert Systems as credible Sources. Behaviour & Information Technology, 15, 14-23.

PCAOB (2004). An Audit of Internal Control over Financial Reporting Performed in Conjunction with an Audit of Financial Statements. Washington, DC, PCAOB Release 2004-001, PCAOB Rulemaking, Docket Matter No.008.

Post, W., Wielinga, B. & Schreiber, G. (1997). Organizational Modeling in Common KADS: The Emergency Medical Service. IEEE EXPERT, 46-52.

Schreiber, G., Weilinga, J. & Breuker, J. (1993). KADS, A Principled Approach to Knowledge-Based System Development. Academic Press "AP", Harcourt Brace Javanovich, Publishers, London.

Shaalan, K., Rafea, M. & Rafea, A. (1998). KROL: a Knowledge Representation Object Language on top of Prolog. Expert System with Applications, 15, 33-46.

Smith, L.M. & McDuffie, R. S. (1996). The Use of an Audit Reporting Expert System in the Classroom. Presented at the Southwest American Accounting Association Annual Meeting, San Antonio.

Whittington, O.R. & Pany, K. (2003). Principles of Auditing and Other Assurance Services, Mc Graw Hill, Boston.

Wielinga, B.J., Schreiber, TH. & Breuker, J.A. (1992). KADS: a modeling approach to Knowledge engineering. Knowledge Acquisition, 4, 5-53.

Young, R. (1994). Discussion of the Effects of Explanation Type and User Involvement on Learning from and Satisfaction with Expert Systems. Journal of Information Systems, 8, 18-21.