A Longitudinal Study of Applicable Decision Aids For Detailed Tasks in A Financial Audit

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Abstract

This paper reports on the changes in the extent to which decision aids are perceived to be useful for performing detailed financial audit tasks. The decision aids investigated were automation (AU), decision support systems (DSS), and knowledge based expert systems (KES). Data were collected from highly experienced mangers and partners from various international accounting firms in 1988 and in 1996. The participants were asked to select the decision aid they viewed as applicable for each task in a comprehensive inventory of audit tasks. Overall, 31 percent of the responses indicated usefulness of decision aids for the 433 tasks studied in 1996 as compared with 21 percent of the 332 tasks studied in 1988. The remaining responses indicated that strictly human processing (HP) was appropriate for the particular task. While the data indicate an increase in the choice of tasks for decision aids use between the two years, the fact remains that a majority of the responses (79 percent in 1988 and 69 percent in 1996) indicated HP only. We present a list of detailed tasks for which at least fifty percent of the responses indicated some form of an applicable decision aid in 1996. We also discuss implications for practice and research.

Introduction

In their search for more structured audit approaches, accounting firms invested heavily in decision aids and a top-down approach to the design and execution of audit engagements in the early 1980s (Cushing and Loebbecke, 1986). The objective was to help auditors make better decisions by not falling prey to potential biases and omissions that can occur in unaided decision making situations (Ashton and Willingham, 1988). [1] As a result, all major accounting firms have developed various computerized aids (AU, DSS, and KES) for use in practice since the 1980s. For example, Brown (1991) reported that all the then Big Six accounting firms were either using expert systems and/or they had current projects to develop expert systems for future use.

1. Recent reviews of this literature are provided by W. F. Messier, Jr., 1995, "Research in and Development of Audit Decision Aids," in R. H. Ashton and A. H. Ashton (Eds.), *Judgment and Decision Making Research in Accounting and Auditing*

Despite this interest and investment in decision aids, little is known about the extent of audit tasks subjected to, or applicable for the use of decision aids. This paper has two objectives. First, we present data from managers and partners at the beginning and end of an eight-year period (1988-1996) on perceived usefulness of various decision aids for performing detailed audit tasks. The second objective of the paper is to present a list of detailed audit tasks for which at least fifty percent of the responses indicated usefulness of a decision aid in the 1996 study.

There are a wide variety of decision aids, ranging from simple decision aids to highly complex artificial intelligence based systems. Two examples of a simple decision aid are a list of potential errors cross classified by transaction cycle and audit objective, and a mechanical-aggregation aid. Bonner, Libby, and Nelson (1996) reported that the mechanical-aggregation aid was more useful in improving judgments than the list aid, but both were beneficial to improving auditors' judgments.

Two artificial intelligence tools that have been particularly popular in business are knowledge-based expert systems and neural networks.[2] Knowledge based expert systems are computerized systems which attempt to provide the knowledge base of an expert to assist auditors in the field. While these systems can be updated and revised periodically for the changes in expertise, such changes are not automatic. In contrast, neural networks are mathematical models that are based on the human brain. They are learning systems and attempt to model expertise in a way that goes beyond expert systems by learning as they are used – they automatically update as the knowledge base develops. An example of a

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(New York: Cambridge University Press), pp. 207-228 and by D. Brown and M. M. Eining, 1996, "The Role of Decision Aids in Accounting: A Synthesis of Prior Research," *Advances in Accounting Information Systems* 4, pp. 305-32.

2. For a recent descriptive paper on expert systems and neural networks in accounting and business, see A. A. Qureshi, J. K. Shim; and J. G. Siegel, 1998, "Artificial Intelligence in Accounting and Business," *The National Public Accountant* (September), pp. 13-16.

task where a neural net approach may be applicable is the going concern judgment (Lenard, et al., 1995). However, expert systems have been more popular with practicing auditors because of their deductive reasoning capabilities where a general model is applied to many particular tasks of similar nature. We are aware of only one neural network system that KPMG Peat Marwick had developed for predicting commercial bank failures, which was subsequently abandoned (Bell et al., 1990). As a result we do not present a detailed discussion of neural networks in this paper.

In the remainder of the paper, we first present the definitions we used in the study. A brief discussion of the background literature related to specific decision aids, maintenance of decision aids, and suitability of decision aids for auditing tasks is presented next. The next two sections present the method of research and results. The final section presents a summary and implications from the study.

Definitions

The brief discussion earlier indicates that there are many types of decision aids with various definitions. However, we have adopted the more generally accepted ones as listed in Figure 1.[3]

[Insert Figure 1 Here]

Complete Automation (AU)

Complete automation is used to completely perform a routine task at a high speed without committing any error, unless there is an error due to the program itself or a programming bug in its code. In such a situation, errors occur systematically and repeatedly. In contrast, when routine tasks are performed manually, errors occur randomly as a result of human fatigue, impatience, or boredom. Accounting examples of the tasks that can be automated are footing, recalculation, and cross checking.

3. These definitions were adopted from M. J. Abdolmohammadi, 1987, "Decision Support and Expert Systems in Auditing: A Review and Research Directions," *Accounting and Business Research* (Spring), pp. 173-185.

Most bookkeeping activities are now typically performed by general ledger software packages and thus are automated.

Decision Support Systems (DSS)

Decision Support Systems or DSSs are appropriate when only parts of a task can be programmed, as compared with automation of the whole task. Thus, a DSS is an interactive computer-based software that assists decision makers partially by addressing certain parts of a problem. These DSSs typically use certain statistical or mathematical models that process and analyze data for the decision maker. Examples of auditing tasks that are typically performed using DSSs are statistical sampling and analytical review procedures.

Knowledge-based Expert Systems (KES)

A KES is developed by the creation of a software incorporating the decision rules of one or more experts. These decision rules are elicited and expressed with a number of IF-THEN rules in the software and are provided to decision makers for consultation. To employ a KES, the decision maker provides answers to questions posed by the system. The KES then presents a recommendation to the decision maker. The decision maker has the option of accepting or rejecting the recommendation developed by the KES. An example of a KES is ExperTAX, a tax planning expert system developed in the 1980s by Coopers & Lybrand. Qureshi et al. (1998) describe several expert systems in use in various business settings.

The difference between DSS and KES is that DSS is provided to assist the person who is very knowledgeable about a domain in making a decision. A KES is intended to replace an expert in

providing assistance to a less knowledgeable decision maker in making a decision.[4] An expert system includes "user interface, a knowledge base that includes facts and rules, and an inference engine that includes reasoning methods" while a DSS consists of "user interface, database, and model base"(Benbasat and Nault 1988, p. 261). The KES is meant to distribute expertise while using a DSS, the user and the system work together to solve the problem. Thus, the user has more control over procedures and alternative strategies in a DSS than in a KES.

Strictly Human Processing

Some tasks may be considered to require strict human processing. These are the tasks for which AU, DSS, or KES is not viewed as useful as a primary decision aid.

Background

Efficiency and effectiveness gains are among the reasons why accounting firms use decision aids. These gains are attributed to several advantages. For example, a major benefit of decision aids is that they provide a structure for the task allowing auditors to view all important aspects of the audit task in a systematic way. This in turn will help auditors facilitate their thoughts (Pieptea and Anderson 1987) and to focus on relevant issues. Another consequence of providing structure to a task is that it will result in high levels of consistency between decision makers and between decision situations. Consistency has been found to be a valuable benefit of using a KES (Brown and Murphy 1990).

The process of developing a decision aid forces the documentation of various aspects of the decision process. This aspect can lead to improved decision making and communication by presenting common frameworks in which to discuss problems or decisions (Brown and Murphy 1990, p. 70).

4. For more detailed information about the relationship between DSS and ES, one might refer to E. Turban's *Decision Support and Expert Systems*, published by MacMillan Publishing Co., New York, New York, 1990.

A KES has several other benefits from a practical perspective, such as staff training (Elliott and Kielich 1985) and expertise development for novices (Eining and Dorr, 1991). It can also allow for knowledge sharing resulting in expertise being more widely available throughout the organization (Graham 1990, p. 15) that could provide a decision maker with an additional opinion to compare to his or her own while at the same time being able to deal effectively with large amounts of data (Brown and Murphy 1990).

Finally, a KES helps to make decisions in a shorter decision time. In a study by Eining and Dorr (1991), students who used a KES to make internal control assessments spent less time to reach a conclusion than did students who did not have a decision aid. Auditing firms that have implemented KES in the past generally cite increased auditor efficiency as a benefit of using such systems (Brown and Murphy 1990).

Against these advantages, several shortcomings can also be identified with decision aids. For example, evidence suggests that having access to a decision aid may actually prolong the decision process in some situations where an aided decision maker has the opportunity to explore and consider more alternatives than an unaided decision maker (Mackay, Barr, and Kletke 1992). Most relevant to KES, is the cost of developing and maintaining the system. The cost and effort of soliciting information from experts to build the system, as well as the cost of updating and maintaining the system as conditions change, are substantial. Of course in comparison with KES, DSS is less expensive to develop due to its use of databases and computing resources which are common to the organization (Pieptea and Anderson, 1987).

Another shortcoming may be that use of an expert system by novices can inhibit the development of the novice's knowledge base. For example, Murphy (1990) reported that use of an

expert system, versus a manual practice aid, inhibited the novices' ability to develop semantic memory (domain knowledge) and episodic memory (using episodes from experience to apply the domain knowledge). Similarly, the use of a KES may reduce the quality of one's professional judgment. For instance, by frequently deferring to the conclusions offered by expert systems, auditors may miss opportunities to develop their professional judgment in specific audit areas (Yuthas and Dillard, 1996). Finally, decision aids can be transferred to competitors, or used against the auditor in a court of law for having relied too much on the decision aid. A counter argument here is that the auditor may be held liable for an incorrect decision because he or she did not take advantage of the available technology (Foltin 1994; Sutton, Young, and McKenzie 1994).

Development and Maintenance of Decision Aids

Development and maintenance of decision aids is a challenging task due to rapid changes in information technology. For example, Gill (1995) reports that approximately one-half of the 97 expert systems developed by 1987 for several domains, including auditing, were abandoned by 1995. About one-third of those that could still potentially be used were not being maintained, while the other two-thirds were still in use. The most common reasons for not using the systems were attributed to the shortage of people in the organizations who dedicated themselves to maintaining the system, and that users did not buy into the system because they had not been involved in developing it.

It has also been reported that the manner in which tasks have been selected for decision aid development in general, and expert system development in particular has remained ad-hoc in nature. However, the management science and information systems literatures suggest that there is a contingency between task structure and decision aid type: automation for structured tasks, DSS for semi-structured tasks, and KES for unstructured tasks. Abdolmohammadi (1991a) provided data

indicating that task structure is a major factor in auditors' choices of applicable decision aids. Nevertheless, the data in a related study showed that only 13 percent of a long list of audit tasks indicated a contingency relationship between task structure and decision aid type (Abdolmohammadi 1991b). Also of interest is that the structure of the audit methodology of the accounting firm may have an impact on the choices of tasks for decision aids development. For example, in a study of forty-five auditing tasks that auditors had indicated were suitable for expert systems development, (Abdolmohammadi and Bazaz 1991) found that the audit firm that would be classified as semi-structured in its audit approach was more likely to indicate suitability for expert systems for these tasks than auditors from the highly structured or highly unstructured firms.[5]

Other authors have provided lists of evaluation criteria for subjecting tasks to expert system development. Han and Choi (1995) applied a list of 14 evaluation criteria (e.g., task is knowledge intensive) to the forty-five tasks that had been selected for expert system development by auditors in Abdolmohammadi and Bazaz (1991). The perceptions of the participating auditors were confirmed by the fact that the tasks received average and above average ratings on the fourteen criteria for expert systems development. Other researchers have proposed checklists for development of decision aids. Beckman (1991), for example, used practical (e.g., potential benefits) and technical considerations (e.g., availability and characteristics of a domain expert) to compile a series of checklists for deciding whether to pursue implementation of expert systems.

5. Accounting firms were classified according to their audit methodology approach by Cushing and Loebbecke, 1986, "Comparison of Audit Methodologies of Large Accounting Firms," and W. Kinney, 1986, "Audit Technology and Preference for Auditing Standards," *Journal of Accounting and Economics*, pp. 73-89. While significant changes have occurred since these initial classifications to accounting firms, a recent study indicates that audit methodology classification is still a viable source of variation for some decisions such as staff assignment. See D. Prawitt, 1995, "Staffing Assignments for Judgment-Oriented Audit Tasks: The Effects of Structured Audit Technology," *The Accounting Review* (July), pp. 443-65.

Finally, Karan, Murthy, and Vinze (1995) asked auditors to respond to twenty-nine statements about task characteristics for each of nine auditing tasks with the purpose of determining whether the responses would indicate suitability for expert systems development. Task complexity, expertise requirements, task manageability, and task objectives were found to have significant effects. Two of the tasks deemed most suitable for KES development were indeed those for which the most KES systems already exist: determination of compliance with GAAP and audit work program development. [6] In the current study, we identify a long list of tasks for which auditors selected decision aids as useful for performing each task.

Research Method

The data reported on in this paper resulted from two large scale studies, one performed in 1988 (Abdolmohammadi 1999) and the other performed in 1996 (Abdolmohammadi and Usoff 2001). For both studies, experienced auditors were asked to evaluate the suitability of each task for decision aid development. Table 1 presents a summary of the tasks used and the subjects' experience. There were 332 tasks in the 1988 study and 433 tasks in the 1996 study. While 247 of these tasks were exactly the same, other tasks were either worded differently, or were completely new to the 1996 study. Distributions of these tasks across the audit are presented in Panel A of Table 1, classified by six typical phases of the audit process: Orientation, Control Structure, Tests of Controls, Substantive Tests, Forming Opinion, and Financial Reporting.

[Insert Table 1 Here]

6. Publicly available knowledge about existing KES systems may not be complete. V. Karan, U. S. Murthy, and A. S. Vinze, 1995, "Assessing the Suitability of Judgmental Auditing Tasks for Expert Systems Development: An Empirical Approach," pp. 441-55, note that one Big Six firm, for example, does not disclose information about its use of KES while two others disclose information about existing and *planned* systems.

Because knowledge of, and experience with, all audit tasks was necessary for the assessment of decision aids, participation in the studies was limited to managers and partners in accounting firms. For both studies, the procedures for collecting the data were generally similar. We contacted partners in offices of the then Big-Six accounting firms in several cities. Each contact partner was sent a packet, which included a cover letter and the task instrument. The contact partner was also provided with a sample inter-office memorandum to facilitate distribution to participants. The contact partner was requested to collect the completed questionnaires and send them to the authors by a deadline. As presented in Panel B of Table 1, a total of 49 responses were received in 1988 as compared with 41 responses in 1996. The response rate was over 50 percent in both years. On average, the auditors who participated in the 1996 study possessed 9.48 years of experience with a standard deviation of 4.96 years. The mean years of experience of participants in the 1988 study were 10.01 with a standard deviation of 5.56 years. The experience levels were not significantly different between the two years (t-statistic = 0.48, which is statistically insignificant). Eight of the 1996 study participants were partners as compared with 14 of the 1988 participants. The remaining participants in both studies were managers with the exception of a few supervising seniors.

Each participant received a booklet containing a list of detailed audit tasks. In the 1988 study, each participant evaluated all 332 tasks, while in the 1996 study, each participant evaluated approximately one-third of the 433 tasks. In addition to the decision aids questions, the participants were asked to provide demographic information as well as an assessment of the task structure and knowledge base demands for task performance. An overview of the project as a whole was also provided in the questionnaire packet. In this paper, we focus on the decision aid responses only. For

each audit task, participants were instructed to indicate whether the task was most suited for AU, DSS, KES, or HP.

Results

Perceptions of Decision Aid Applicability by Audit Phase for All Tasks

A comparison of applicable decision aids for all tasks investigated between 1988 (332 tasks) and 1996 (433) is reported in Panel A of Table 2. This table is organized by the phases of a typical financial audit, and in the aggregate. As the aggregate line shows, across the entire inventory of audit tasks, a large percentage of the responses indicated strict human processing both in 1996 (69 percent) and in 1988 (79 percent). While more responses in 1996 indicated the suitability of decision aids than in 1988, the difference is not statistically significant (Chi-square = 2.77). Overall, only nine percent of all responses in 1996, and seven percent in 1988, indicated automation, followed by 12 percent and seven percent indicating DSS, 10 percent and seven percent indicating KES.

[Insert Table 2 Here]

The phase by phase results indicate similar conclusions for the phases of Control Structure, Tests of Controls, and Substantive Tests where the decision aids responses are not statistically different between 1996 and 1988 (Chi-squares = 6.08, 5.99, and 2.46, respectively). However, significantly more responses indicated the use of decision aids for the Orientation (Chi-squares = 6.97, $p = 0.07$), Forming Opinions (Chi-squares = 8.37, $p = 0.04$), and Financial Reporting (Chi-squares = 9.56, $p = 0.02$) phases of the audit in 1996 than in 1988.

Panel B in Table 2 presents the data for the 247 matched tasks between the 1996 and 1988 studies. The results are similar to Panel A with one exception: the Tests of Controls phase. Unlike the data in Panel A, the matched data in Panel B indicate that significantly more responses indicated the

applicability of decision aids in 1996 than in 1988 (Chi-square = 8.22, significant at the 0.04 level). The remaining results are similar in the sense that there was no statistical difference between the two years for the aggregate data, Substantive Tests, and Control Structure. However, there were significantly more responses indicating the appropriateness of decision aids in 1996 for the Orientation (Chi-square = 8.07, significant at the 0.05 level), Forming Opinions (Chi-square = 7.83, significant at the 0.05 level) and Financial Reporting (Chi-square = 8.59, significant at the 0.05 level) phases of the audit than in 1988.

Perceptions of Decision Aid Applicability by Audit Phase for Programmable Tasks

The data in Table 2 are for all tasks studied. A major issue of concern is whether the tasks that are generally viewed as non-programmable should be included in this analysis. To investigate the issue further, we classified the tasks into programmable and non-programmable. We define a task as programmable if at least 50 percent of the subjects indicate applicability of a decision aid for the task. Table 3 presents the results. We present the data in two categories: all tasks and matched tasks. For each category, we present the number and the percentage of the tasks within each audit phase that was viewed as programmable. The aggregate line is the total number of tasks that were selected as programmable in that category for that study.

[Insert Table 3 Here]

Overall, Table 3 shows that a significantly larger proportion of the tasks were identified as programmable in 1996 than in 1988 for all tasks (Chi-square = 26.67, significant at the 0.001 level) and for the matched tasks (Chi-square = 26.75, significant at the 0.001 level). This trend can be seen in each of the audit phases of Orientation, Control Structure, Tests of Controls, and Financial Reporting. However, the two other audit phases had results that were inconsistent with the results at the aggregate

level. First, for neither of the categories (all tasks or matched tasks), did we find any task indicated as programmable for the Forming Opinion phase in 1996 or 1988. Second, and perhaps more surprising, is that the proportion of tasks selected as programmable for the Substantive Tests phase was less in 1996 than in 1988. We discuss this issue further in the summary and conclusions section.

Finally, to provide specific guidance for future investigation, we present a detailed list of all programmable tasks that were identified in the 1996 study in Table 4. The reason why we selected the 1996 detailed list to present was that these data are more recent, and therefore present more current guidance than the 1988 data. The results are presented in Table 4.

[Insert Table 4 Here]

Summary and Conclusions

A detailed list of 433 audit tasks were subjected to a study in 1996 in which managers and partners assessed the applicability of decision aids to each audit task. In a similar study in 1988, we collected comparable data for a list of 332 audit tasks. Two hundred and forty-seven of the tasks were exactly the same in both years. In this paper, we present comparative decision aid data, comparing the studies in total and comparing matched tasks across the two studies.

A general observation from the detailed data is that for a majority of audit tasks, the highly experienced participants assessed complete human processing as the method for performing the task. This observation was generally consistent for both the 1996 and 1988 data. However, while only a limited number of tasks were deemed to benefit from decision aids (i.e., automation, decision support, or expert systems) in both studies, relatively more of the comparable tasks were selected for decision aids in 1996 than in 1988. For example, while only 11 percent of the comparable tasks in the

Orientation phase were deemed applicable for decision aids use in 1996, this proportion was larger than the 9 percent of the same tasks in the 1988 study.

Similarly, while 26 percent of the comparable tasks in the Control Structure, 41 percent in the Tests of Controls, and 6 percent in the Financial Reporting phases were selected for decision aids in 1996, the rates for the same sets of tasks from the 1988 study were, respectively, 0 percent, 18 percent, and 0 percent. This result may be a reflection of the impact that the computer technology has had on practice in recent years. However, the results indicate a smaller number of the comparable tasks in the Substantive Tests phase chosen for decision aids development in 1996 (15 percent) as compared with 1988 (20 percent). For example, fewer of the matched tasks in the Inventory sub-phase received decision aid selection in 1996 than in 1988. These results may be affected by the strategic audit approaches of late that do not emphasize tests of details. Finally, the Forming Opinion phase did not indicate any difference between the two years: 100 percent of the tasks were selected for strictly human processing in both years.

The results of the study have several important practice and research implications. The decision aids data are helpful for research and development of decision aids in auditing. A previous study reported that despite the heavy emphasis on decision aid development in auditing in recent years, there is no systematic model to identify audit tasks for decision aid development (Abdolmohammadi 1991a and Abdolmohammadi 1991b). Such developments are still done largely on a one-task-at-a-time basis. In this study we collected decision aid choices of highly experienced auditors for a comprehensive inventory of audit tasks. Researchers and decision aid developers can consult this list for future work.

The magnitude of this research required participation of only managers and partners to assess the detailed tasks. This was necessary because managers and partners are the only group of auditors

with sufficient amount of knowledge and experience with all audit tasks to be able to evaluate the tasks under investigation on the necessary dimensions. These professionals are extremely busy and their participation in a study such as ours is on the basis of availability and interest. Consequently, we had no way of randomly selecting the participants, who were chosen through a contact partner in each of the participating offices. To the extent that lack of random selection can affect our results, caution must be exercised in interpreting the data.

Also, given the large number of audit tasks (433 in all), we divided the tasks into three approximately equal groups or versions in the 1996 study. This was based on the experience from the 1988 study in which all 332 tasks were presented to the participating auditors, requiring approximately three hours of response time. To reduce the time requirement and possible fatigue, each participant in the 1996 study received only one version, and thus only a third of the total tasks. Nevertheless, the time required to respond to all parts of each of the versions of the task instrument was approximately 90 minutes. This required a major commitment from highly busy professional auditors. A consequence of this time demand was that despite the great assistance we received from our contacts, we had only 14 or 15 participants for each of the three versions of the task instrument. The sample size, while sufficient for statistical analysis, was nevertheless a limitation. Future studies may be needed to tackle a much smaller number of tasks, with a larger group of auditors to investigate the issues further.

A related issue is that due to small sample sizes, we could not investigate the effects of a number of potentially confounding variables. For example, while it was desirable to investigate the effects of professional rank (i.e., manager versus partner) on the results, there were very few partners per each version to allow a meaningful comparison with managers. Similarly, we collected data to independently classify audit firms by their audit methodology and the use of high technology in their audits.

Unfortunately, the number of participants was too small to allow partition for analysis of the data for these variables. The same is true for participant's audit specialty. We simply did not have enough data to afford partition by these demographic variables.

An earlier study reported that the choice of decision aid type for a task may be dependent on a number of factors such as the auditors' electronic data processing specialty, rank, and audit firm methodology (Abdolmohammadi 1991a, Abdolmohammadi 1991b). We could not test these propositions in the current study due to the small sample sizes. We should note, however, that in a study with 134 auditors and only 30 audit tasks (all in the risk assessment area), researchers also found a majority of the tasks to be deemed subject to strict human processing, not any kind of decision aids (Abdolmohammadi and Read 1996). In that study the researchers reported that for the few tasks for which the median decision aid was other than strictly human processing, a statistically significant contingency was found between task structure and decision aids. This is the result that was also found in our studies. Future research is particularly needed to better understand the nature of the audit tasks that auditors consider subject to human processing as compared with those for which some kind of decision aid can be utilized.

While the sample size limitation prevented us from delving into the effects of these demographic variables, we believe that the sample sizes were large enough for data analysis at the aggregate and audit phase levels that we performed. It is our hope that these results will assist researchers and professionals alike to better understand the assessment of decision aid applicability at a detailed task level. The longitudinal nature of the two studies together show how the perceptions of highly experienced auditors have changed for some audit areas but have remained consistent over the eight year time period for

other areas. The results should assist in the research and development efforts for decision aids that can enhance auditor efficiency and effectiveness in today's competitive environment.

Figure 1

Decision Aid Definitions Used in the Study

Decision Aid Type	Meaning
1. Complete Automation	Some tasks such as footing, recalculation, and cross checking may be done completely by a computer based on some predetermined formula. This is referred to as complete automation.
2. Decision Support Systems (DSS)	A DSS is an interactive computer-based software that assists decision-makers in making decisions. DSSs use certain statistical or mathematical models and data to make inferences for the use of the decision-maker.
3. Knowledge-based Expert Systems (KES)	A KES is an interactive computer-based software that assists decision-makers in using expert(s) decision rules to make their decisions. To create a KES, the decision rules of the expert(s) must be elicited and expressed in terms of a number of IF-THEN rules. To employ a KES, the decision-maker provides answers to questions posed by the system. The KES then presents a recommendation to the decision-maker. The decision-maker has the option of accepting or rejecting the recommendation developed by the KES.
4. Strictly Human Processing	Some tasks may not be suitable for automation, DSS, or KES. These tasks require strictly human processing. It should be noted that all decision aids have a human processing component to them.

Table 1

Subjects and Tasks Studied

Panel A: Number of Tasks by Audit Phase

Audit Phase	Tasks in 1996 Study	Tasks in 1988 Study	Matched Tasks
Orientation	58	45	35
Control Structure	48	41	35
Tests of Controls	38	34	17
Substantive Tests	244	171	128
Forming Opinion	27	23	15
Financial Reporting	18	18	17
Aggregate	433	332	247

Panel B: Participating Auditors

	Sample Size	**Years of Audit Experience**	
		Mean	**Standard Deviation**
1996 Study	**41**	**9.48**	**4.96**
1988 Study	**49**	**10.01**	**5.56**
***t*-statistic**			**0.48***

* Not significant

Table 2

Applicability of Decision Aids for Tasks Studied

Panel A: Percentage of Decision Aid Responses for all Tasks

Audit Phase	1996 (433 Tasks) Percent of Auditors Indicating				1988 (332 Tasks) Percent of Auditors Indicating				Chi-Squared	P-Value
	AU	DSS	KES	HP	AU	DSS	KES	HP		
Orientation	9	17	8	66	3	9	12	76	6.97	0.07
Control Structure	4	17	16	63	1	8	16	75	6.08	0.11
Tests of Controls	11	11	16	62	3	10	13	74	5.99	0.11
Substantive Tests	12	10	7	71	12	7	3	78	2.46	0.48
Forming Opinions	1	5	16	78	1	1	6	92	8.37	0.04
Financial Reporting	2	13	13	72	0	4	8	88	9.56	0.02
Aggregate	9	12	10	69	7	7	7	79	2.77	0.43

Panel B: Percentage of Decision Aid Responses for Matched Tasks

Audit Phase	1996 (247 Tasks) Percent of Auditors Indicating				1988 (247 Tasks) Percent of Auditors Indicating				Chi-Squared	P-Value
	AU	DSS	KES	HP	AU	DSS	KES	HP		
Orientation	8	16	5	71	3	8	12	77	8.07	0.05
Control Structure	4	17	16	63	1	8	16	75	6.08	0.11
Tests of Controls	15	14	15	56	5	11	11	73	8.22	0.04
Substantive Tests	13	11	6	70	13	8	3	76	1.72	0.63
Forming Opinions	1	4	18	77	1	2	6	91	7.83	0.05
Financial Reporting	2	12	13	73	0	4	8	88	8.59	0.04
Aggregate	10	13	9	68	8	8	7	77	2.22	0.53

AU = Automation; DSS = Decision Support Systems; KES = Knowledge-based Expert Systems; HP = Strictly Human Processing

Table 3

Number and Percentage of Tasks Considered Programmable*

	All Tasks		Matched Tasks	
Audit Phase	1996	1988	1996	1988
Orientation	11 (19%)	3 (07%)	4 (11%)	3 (09%)
Control Structure	12 (25%)	0 (00%)	9 (26%)	0 (00%)
Tests of Controls	11 (29%)	3 (09%)	7 (41%)	3 (18%)
Substantive Tests	35 (14%)	29 (17%)	19 (15%)	26 (20%)
Forming Opinions	0 (00%)	0 (00%)	0 (00%)	0 (00%)
Financial Reporting	2 (11%)	0 (00%)	1 (06%)	0 (00%)
Aggregate	71 (16%)	35 (11%)	40 (16%)	32 (13%)
Chi-Square	26.67		26.75	
Significance	0.000		0.000	

*A task was considered programmable if at least fifty percent of the responses indicated that some type of decision aid would be applicable for the that task.

TABLE 4
Detailed Audit Tasks with at Least Half of the Participants Choosing a Decision Aid

		Percent of Auditors Indicating			
		AU	DSS	KES	HP
ORIENTATION PHASE					
1	The evaluation of key financial management characteristics (general planning, budgets, financial statements, managerial and internal reports and documents, liquidity, ability to generate working capital).	7	33	27	33
2	The assessment of the profitability of the entity relative to its industry.	20	27	13	40
3	The assessment of the sensitivity of operating results to inflation and changes in interest rates.	13	27	13	47
4	The assessment of the rate of change in entity's industry.	20	20	13	47
5	The determination of the outside debt (degree to which client is leveraged).	33	20	0	47
6	The performance of analytical review of interim financial statements to identify potential accounting or auditing problems affecting current year.	7	50	14	29
7	The evaluation of projected income error discovered in prior year's audit.	7	33	20	40
8	The aggregation of all factors identified above to assess engagement risk.	7	20	33	40
9	The assessment of the volume and complexity of transactions flow and control over these flows.	27	20	13	40
10	The evaluation of extent of system computerization and application risks associated with processing transactions. (Risks and controls vary from one application system to another.)	20	13	20	47
11	The aggregation of all factors identified above to assess inherent risk for each account.	7	27	20	46
	AGGREGATE ORIENTATION PHASE	**15**	**26**	**17**	**42**
CONTROL STRUCTURE PHASE					
1	The completion of a generalized questionnaire, checklist, or narrative memorandum that organizes and summarizes the information obtained by applying the procedures for preliminary evaluation.	27	20	20	33
2	The evaluation of policies and procedures to safeguard records and assets (e.g., recovery procedures, and detection of unauthorized access to assets and records).	7	20	27	46
3	The evaluation of policies and procedures for authorization and approval (general and specific) of transactions and activities.				
4	The evaluation of policies and procedures to prevent or detect errors and irregularities.	7	20	27	47
5	The evaluation of the policies and procedures to secure the accuracy and completeness of the accounting records.	7	20	33	40

TABLE 4 (CONTINUED)

Detailed Audit Tasks with at Least
Half of the Participants Choosing a Decision Aid

		Percent of Auditors Indicating			
		AU	DSS	KES	HP
6	The evaluation of the policies and procedures for the timely preparation of reliable financial information.	7	20	33	40
7	The determination of the controls that could be relied upon should compliance tests indicate low error rates.	0	27	40	33
8	The determination of the existence and adequacy of processing controls (e.g., review account distribution by responsible official, variance analyses).	0	29	21	50
9	The determination of the existence and adequacy of safeguarding controls.	0	29	21	50
10	The evaluation of development controls concerning the design and testing of new systems.	0	40	13	47
11	The evaluation of controls pertaining to changes to existing systems	7	33	20	40
12	The evaluation of the existence and adequacy of EDP application controls: input, file, processing, and output controls	7	27	20	46
	AGGREGATE CONTROL STRUCTURE PHASE	**6**	**26**	**25**	**43**
TEST OF CONTROLS PHASE					
1	The determination of the level of adherence to authorization and approval (general and specific) policies and procedures for transactions and activities.	14	14	29	43
2	The determination of recording accuracy of transactions (accurate classification, correct amount, proper period, and adequate detail).	29	21	14	36
3	The determination of the degree to which the client segregates incompatible functions within the data processing department.	14	21	36	29
4	The determination of the degree of segregation between data processing and user department personnel performing review procedures.	14	7	43	36
5	The determination of the level of adherence to control procedures for access to data and computer programs.	35	7	29	29
6	If computer assisted audit techniques are feasible, the preparation of test data to be processed using client's programs, and the comparison of obtained results with anticipated results.	43	36	14	7
7	The definition of the population from which the sample is to be drawn, and ensuring that it is appropriate for the specific audit objective.	14	22	14	50
8	The determination of the maximum rate of deviations from a prescribed control procedure that will be acceptable, without altering planned reliance.	21	21	21	36
9	The definition of error or deviations in relation to the tests' objectives.	21	15	21	43
10	The definition of the sampling item and of sample size in relation to the control procedure to be tested.	29	29	14	29
11	The projection of sample results to the population.	62	23	0	15
	AGGREGATE TEST OF CONTROLS PHASE	**27**	**20**	**21**	**32**

TABLE 4 (Continued)

Detailed Audit Tasks with at Least
Half of the Participants Choosing a Decision Aid

		Percent of Auditors Indicating			
		AU	DSS	KES	HP
SUBSTANTIVE TESTS PHASE					
1	The use of ARP during the conduct of examination in conjunction with other procedures applied by the auditor to individual elements of financial information.	33	13	7	47
2	The use of ARP at or near the conclusion of the examination as an overall review of the financial information.	33	13	7	47
3	The selection of a sample of remittance advices and tracing to accounting records (accounts receivable detail, bank statements, recorded cash receipts).	29	14	7	50
4	The footing of cash receipts journal and cash disbursement journal and tracing to general ledger postings and bank statements.	40	7	7	46
5	The preparation of various ratio analyses for sales, cost of sales and interest income.	21	29	0	50
6	The comparison of payables, purchases and payments to budgets and prior periods.	46	20	7	27
7	The footing of the purchase journal for selected period.	64	0	0	36
8	The agreeing of purchase journal to general ledger.	53	7	0	40
9	The computation of various ratios for purchases, payables, etc.	66	20	7	7
10	The request for confirmation of suppliers' statements and preparation of a summary of confirmation results.	33	20	7	40
11	The ensuring that related costs of freight, brokerage, customs duties, and sales taxes for domestic and foreign purchasing transactions are recorded immediately.	20	20	13	47
12	The verification of computation of period accruals.	27	20	13	40
13	The tracing of purchases from receiving reports to purchase journal (voucher register) including quantities, prices and other relevant data.	40	7	7	46
14	The verification that allowable discounts on selected purchase invoices were taken.	27	7	20	46
15	The agreeing of prices charged on selected purchase invoices to purchase orders or other authority for the acquisition of goods and services.	40	7	7	46
16	The verification of arithmetic on selected purchase invoices.	53	7	13	27
17	The comparative analysis of depreciation expense including tax basis depreciation.	40	27	6	27
18	The comparative analysis of repairs and maintenance expense.	27	27	6	40
19	The recomputation of depreciation (amortization) - book and tax basis.	73	7	13	7
20	The recomputation of capitalized interest.	67	13	0	20
21	The determination of the appropriateness of treatment of leases as capital leases.	13	13	27	47

TABLE 4 (Continued)

Detailed Audit Tasks with at Least
Half of the Participants Choosing a Decision Aid

		Percent of Auditors Indicating			
		AU	DSS	KES	HP
22	The comparison of cost of sales and gross profit percentages by product line to prior period and to budget and obtaining explanation for large variations.	15	23	23	39
23	The comparative analysis of inventories by location as compared to prior periods.	23	31	8	38
24	The computation of various inventory ratios.	61	8	8	23
25	The checking of clerical accuracy (additions and extensions of inventory listing).	67	0	0	33
26	The testing of market price computation to published information.	42	25	0	33
27	The obtaining of market or current values, as of year-end date, of investments and comparing to book value.	33	17	8	42
28	The recomputation of amortization of premium or discount.	17	33	0	50
29	The comparative analysis of indebtedness to industry and prior years.	8	25	17	50
30	The comparative analysis of effective interest rates including relationship to relevant external factors.	8	33	25	33
31	The ensuring that all lease obligations are properly classified either as capital or operating.	0	33	25	42
32	The documentation of analytical review procedures performed.	8	17	25	50
33	The determination that imputed premium or discount is properly accounted for.	17	17	17	50
34	The verification of computation of interest expense and accruals and amortization of premium or discount.	33	25	8	33
	AGGREGATE SUBSTANTIVE TESTS PHASE	**35**	**17**	**10**	**38**
FINANCIAL REPORTING PHASE					
1	The consideration of the existence of certain regulatory agencies' rules as to disclosures and financial statement presentation of specific items.	0	25	25	50
2	For subsidiaries whose principal business activity is leasing property or facilities to other members of an affiliated group, ensuring that the proper consolidation method is used.	0	25	25	50
	AGGREGATE FINANCIAL REPORTING PHASE	**0**	**25**	**25**	**50**

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