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Audit Program Planning Using A Belief Function Framework

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INTRODUCTION

Program planning regarding the nature, extent, and timing of procedures is critical to audit efficiency and effectiveness. The prevailing paradigm in practice to accomplish this task is the Audit Risk Model (SAS no. 47, AICPA 1983). The underlying logic supporting this model is that program plans should be adjusted to the client's risks. To obtain the level of assurance desired, the auditor would thus avoid obtaining insufficient evidence when risks are high ("under-auditing") or of gathering excessive evidence when risks are low ("over-auditing").

Surprisingly archival research of actual audit engagements has not provided strong evidence that, in fact, program plans are highly associated with the level of or changes in client risks (Mock and Wright 1997, 1993; DiPietro, Mock and Wright 1994; Bedard 1989). A potential explanation for these findings may be that aggregating risks and developing a corresponding program planning are very complex tasks that auditors have difficulties performing. Perhaps this is why auditors are found to frequently utilize a *standard audit program*, that is a standard set of audit tests, regardless of the level of client risks (Mock and Wright 1993). The complexity of this task is also evidenced by the recent development by auditing firms of computerized program planning tools (e.g., Arthur Andersen).

The purpose of this research is to examine the feasibility of a Belief-Function[1] approach in assisting auditors on an actual engagement develop a risk-adjusted program plan. This approach has been found to be appropriate in dealing with situations such as program planning where underlying uncertainties associated with the audit evidence cannot be easily expressed in terms of probabilities (Shafer and Srivastava 1990; Srivastava and Shafer 1992). Further, assessments of risk and assurance are obtained as "beliefs", which is an evaluation that appears to be more natural and intuitive to auditors. Additionally, this approach provides a means to systematically aggregate risk assessments (beliefs), a task that prior research has shown to be difficult for decision-makers (Libby and Libby 1985).

Our findings indicate that after initial training the output values of the Belief-Function model accurately reflect the views of the partner regarding the assurance obtained on the engagement in testing the accounts receivable area. Further, sensitivity analyses indicate that output values are insensitive to the use of a categorical scale to elicit beliefs rather than a numerical scale. Since auditors customarily use categorical scales in practice (e.g., high, medium, or low risk), this finding suggests that the Belief-Function approach used in this study would be easier to use than a numerical scale such as probabilities. Finally, sensitively analyses revealed that the model can be used in the program planning or evaluation phases to assess the assurance provided by a given test or set of tests (providing either negative or positive evidence) in attaining a cost-effective engagement.

[1] We assume here that readers are familiar with the belief-function framework. However, we give some basic definitions of various functions in footnote 2. For an introduction to belief functions we advise readers to refer to Srivastava (1993). For a detailed reference see Shafer (1976).

The remainder of this paper is divided into four sections. The next section provides a review of relevant literature and introduces the research questions. The method is then described followed by presentation of the findings. The final section contains a summary of the findings and a discussion of the implications of the results for future research and practice regarding audit program planning.

RELEVANT LITERATURE AND RESEARCH QUESTIONS

Archival Research

Archival research on program planning obtains data from actual engagements to examine the extent to which evidential plans are responsive to the level of and changes in client risks, for instance as prescribed by the Audit Risk Model. Archival studies are important since they reflect actual decisions made in practice. Such decisions are affected not only by client risks but also by economic and organizational factors such as competition, time budgets, accountability, and the use of decision aids (e.g., standard audit programs).

The earliest archival study on program planning was done by Bedard (1989) who asked auditors to identify changes made to evidential plans in the accounts receivable, inventory, and accounts payable areas and to explain the reason(s) for these changes. The nature and extent of tests were generally found to be quite stable with reductions in tests noted when controls improved or errors were not found. Mock and Wright (1993) statistically examined the relationship between risk assessments and program plans over a two-year period. A broad set of engagements and account level risks were examined. Extent was found to be related to the incidence of prior errors. However, contrary to expectations, there was not a strong association between client risks

(inherent and control risks) and program plans. To test the robustness of these findings, Mock and Wright (1997) performed a follow-up study that included a more recent sample, an expanded set of risks (including financial health and risks at the assertion level), and the use of structural modeling to consider potential interdependencies between nature and extent decisions. Although program plans were found to be somewhat more responsive to risks than in the earlier study, once again a weak association was found.

In contrast, O'Keefe et. al. (1994) find evidence that the extent of testing is related to the level of inherent risks. They examine the relationship between labor inputs (quantity and mix) and client characteristics on a cross-sectional sample of engagements conducted by a major auditing firm. They report that both the level of hours and mix (e.g., staff, senior) were significantly associated with client size, complexity, leverage, and inherent risk but not with control reliance, years on the engagement, and non-audit services. These findings suggest audit plans are responsive to inherent but not control risks. However, inherent risk assessments were not taken from the working papers directly but rather the ex post judgment of the engagement partner. Further, inherent risks were measured as a single, binary variable: more risky than average versus less risky than average.

Di Pietro et. al. (1994) report evidence that the nature of tests varies by industry (merchandising versus manufacturing) and that required tests (receivable confirmations) do not appear to inhibit planning flexibility. However, within each industry program plans were not found to be strongly related to the level of or changes in risks.

Two descriptive studies focus on the use of analytical procedures as a form of evidence. Ameen & Strawser (1994) report greater use of analytical procedures when engagements are reoccurring, controls are effective, and inherent risks are low, factors apparently relating to the presumed strength of the underlying accounting data utilized for analytical comparisons. In an interview study, Hirst & Koonce (1996) report that analytical procedures appear to be used as a substantive form of evidence primarily when the control structure is strong and, thus, the likelihood of undetected error is low. Usually simple forms of analytical procedures are employed such as a comparison of current balances or ratios to the prior year. Hirst and Koonce also note that auditors consider several factors in determining the extent of substantive analytical procedures, including inherent risk, knowledge of the client's business, client size, volume of transactions, physical location of records, and complexity of the business. These studies suggest that analytical procedures are used cautiously as a substantive test, reflecting concerns about the strength of such evidence.

In summary, contrary to the Audit Risk Model, prior archival studies have not found that program plans are closely related to client risks. This naturally leads to questions of the reasons for these findings. Mock and Wright (1997) consider this issue and identify potential factors that may account for the unexpected findings. First, they found wide use of standard audit programs, promoting stability in the nature of tests. As a result of accountability, auditors may be reluctant to not perform standard tests.

Second, the lack of a strong relationship between evidential plans and risks may result from the extremely complex cognitive process required to assess and aggregate risks and then design a program tailored to the client situation. Waller (1993) found that

auditors' inherent risk assessments are only marginally associated with the rate of error and that inherent and control risk assessments do not vary across assertions (use of a "most important" heuristic). These findings suggest auditors have difficulties in assessing and aggregating client risks. Further, adapting the audit program to risks is very difficult, perhaps, as suggested by Mock and Wright (1997), leading to the use of a standard audit program.

Finally, the Audit Risk Model may not be an appropriate model to reflect the decision process that is involved in practice for program planning. For instance, business factors that are not captured in the model may play an important role. Interviews by Quadackers et. al. (1996) identify audit practice considerations such as budget constraints, staff turnover, and litigation risks which are perceived to be important for program planning. Further, auditors may not plan tests to address risks but rather seek to provide a desired level of "assurance" or "beliefs" that the financial statements do not contain material misstatements. Thus, other frameworks such as the use of a Belief-Function approach may more appropriately capture the decision process.

The next section provides a discussion of an evidential network approach to program planning under Belief Functions. This approach has significant promise in providing a decision aid that addresses a number of the factors identified that may inhibit development of a risk-based program plan, particularly the difficulties of expressing and aggregating risks and of considering the assurance provided by evidence.

Evidential Network and Belief Functions

Srivastava and Shafer (1992, see also Srivastava, Dutta and Johns 1996) have argued that the audit risk model of SAS 47 is deficient in two major ways. One limitation is that it does not incorporate the structure of audit evidence and the other is that it does not use an appropriate framework for representing uncertainties in audit evidence. Regarding the structure of audit evidence, Figure 1 provides an illustrative belief-function network that depicts program planning in one area of the audit (accounts receivable). For simplicity, we have assumed the financial statements consist of only two accounts, accounts receivable and inventory, with inventory being fairly stated with a belief of one. This network is based on risk factors and common tests performed in this area from the audit manual of one of the Big 6 firms (See Mock & Wright 1997). The figure includes both nodes with rounded corners (financial statement items or related objectives and assertions) and rectangles (evidential nodes related to risk assessments or to audit tests). Note that risks are at three levels: "macro" risks for the engagement such as the general control environment; "micro" risks at the account level; and a lower level of micro risks at the assertion level such as for valuation and existence. For accounts receivable these are the most important assertions in terms of likely misstatements (Waller 1993).

Figure 1: General Evidential Network

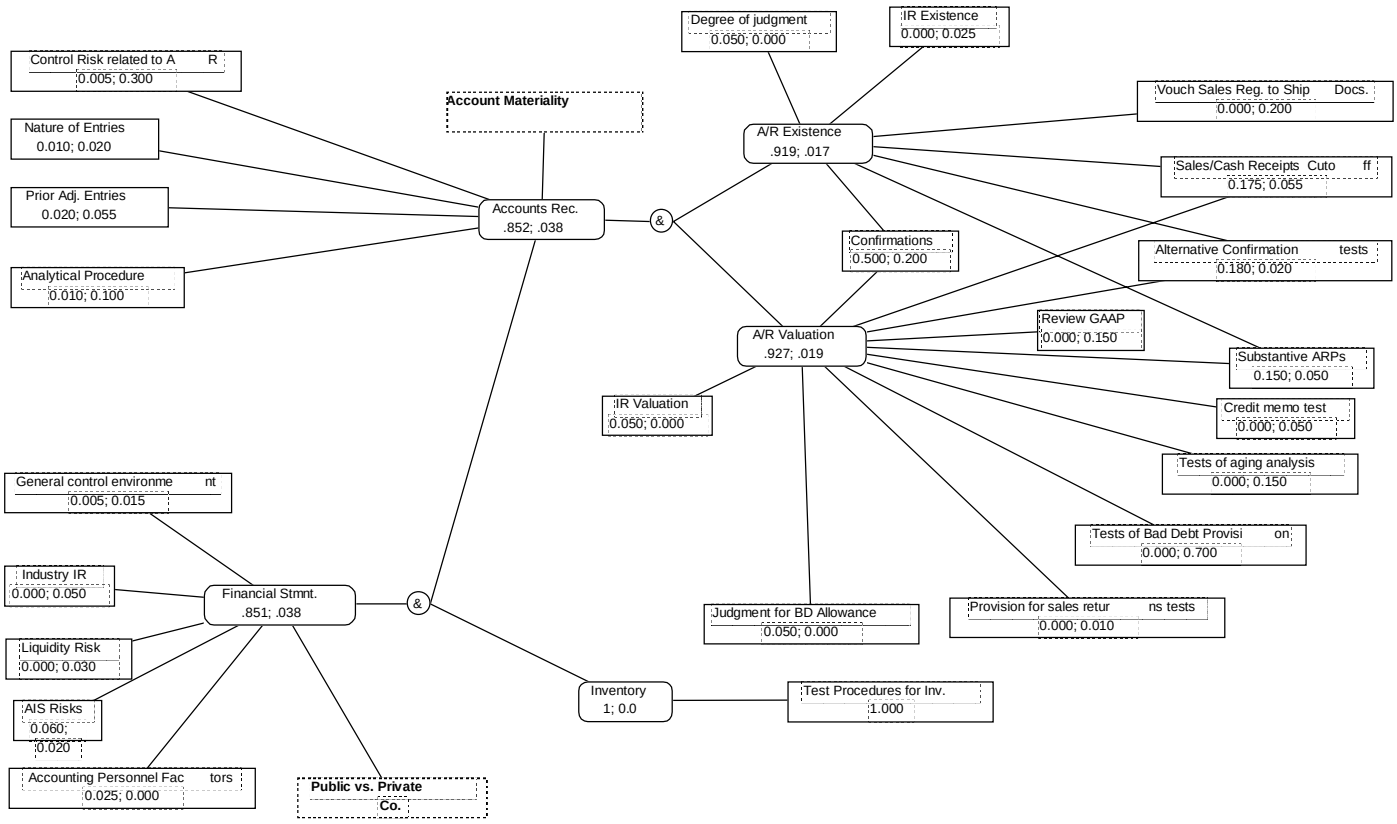


Figure 1 shows that some items of evidence bear upon the financial statement level, some at the account level, and some at the assertion level of the account. Also, there are certain items of evidence that bear on more than one assertion or account. For example, the confirmation of account receivables bears on both the existence and valuation assertions.

In general, an evidential diagram for an audit engagement forms a network of variables, including those relating to the financial statements, balance sheet accounts, transaction streams, and assertions or audit objectives of the accounts and the

transaction streams (see Figure 1). The network structure arises due to the presence of items of evidence that bear on more than one variable. Such situations arise when there are interdependent items of evidence. Srivastava and Shafer (1992) contend that incorporating the interdependencies among the evidence in audit decisions makes the audit process more efficient.

For example, let us assume that the confirmation of account receivables provides 0.8 level of assurance to both existence and valuation assertions. If one treats them as independent then the combined assurance would be 0.64 (the product of 0.8 and 0.8). If they were treated as interdependent, the combined assurance would be 0.8, a much higher level of assurance.

The impact is much more prominent if the evidence bears on more than two assertions. For example, if the evidence supports three assertions at 0.8 level of assurance to each, then the combined assurance under the independence assumption would be 0.51 (0.8^3). However, under the interdependence assumption, the combined assurance is still 0.8. Consideration of such interdependencies is not possible in the audit risk model of SAS 47. In describing their assertion-based approach to auditing, Leslie and et. al (1986) consider the structure of evidence when they combine assurances obtained at various account levels. However, they do not consider the interdependencies among the evidence. The evidential network approach used in the present study explicitly captures the interdependencies among the evidence through the construction of an evidential network.

The second limitation with the audit risk model of SAS 47 deals with the representation of uncertainties in the evidence. It is generally accepted that the audit

risks in the model are measured in terms of probabilities. However, the probability interpretation is problematic as is pointed out by Srivastava and Shafer (1992, see also Srivastava 1993):

> ... according to SAS 47, if an auditor decides not to consider inherent factors, then the inherent risk is set equal to 1. Since a probability of 1 means certainty, this seems to be saying that it is certain that the account is materially in error. But this is not what the auditor has in mind when deciding not to depend on inherent factors. The auditor's intention is represented better by belief-function plausibility of 1 for material error, which says only that the auditor lacks evidence based on inherent factors.
>
> In a less extreme situation, the auditor may believe, on the basis of inherent factors, that the account is fairly stated and yet be unwilling to rely on theses factors past a certain point. In this case, the auditor may, as SAS No. 47 suggests, assign a value less than the maximum, say 70 percent, to inherent risk. If interpreted in probability terms, this number says that the inherent factors give a 30 percent chance that the account is not materially misstated and a 70 percent chance that it is materially misstated. This suggests that the evidence is negative, contrary to the auditor's intuition. The probability interpretation is even more confusing if the auditor sets the inherent risk at 50 percent. What does this mean? Does it mean that the auditor is completely ignorant about the state of the account, or does it mean there is more evidence that the account is not being materially misstated than when only 30 percent assurance was assumed?

Belief functions[2] provide a flexible and adaptable framework for representing uncertainties and combining evidence (Akresh et al. 1988). Since belief functions permit uncommitted beliefs, they provide a framework for interpreting the auditor's choice in a straightforward manner. For example, when the auditor sets the inherent risk at 70 percent based say on moderate positive audit planning evidence, this judgment implies that the evidence indicates a 30 percent degree of support that there are no material

[2] There are three types of functions useful in our discussion: (1) an m-function or basic probability assignment function, (2) a Belief function, and (3) a Plausibility function. Suppose we have n mutually exclusive and collectively exhaustive set of states: a_1, a_2, a_3, ... a_n. Under the belief-function framework, uncertainty can be assigned to each single element of the set, each subset of two, each subset of three, and so on, to the entire set. These uncertainties assigned to various elements and subsets are called m-values or the basic probability assignments. The sum of all the m-values equals one. When uncertainty is assigned to only single elements, the belief-function framework becomes a probability framework. The belief function for a subset of elements is defined as the sum of all the m-values for the individual elements in the subset and the m-values for any subsets contained in the subset of interest. For example, belief in the subset $\{a_1, a_2\}$ is: $Bel(\{a_1, a_2\}) = m(a_1)+m(a_2)+m(\{a_1, a_2\})$. The plausibility function for a subset of elements A is defined as: $Pl(A) = 1-Bel(\sim A)$.

errors. This then leaves 70 percent of the auditor's belief uncommitted. Based on just the positive evidence that led to the 70% inherent risk factor, the auditor has no evidence that the account is materially misstated. However, there still is 70 percent plausibility that the account could be materially misstated.

Moreover, the belief-function interpretation of risk appears to be more intuitively appealing than the probability interpretation. For example, suppose the auditor has performed analytical procedures related to an account and finds the recorded balance to be reasonable but does not want to put much weight on this evidence. Based on just this evidence, an auditor may assign a low level of support, say 0.2, that the account is not materially misstated ('a'). Under a probability framework, this assessment is interpreted as if the auditor is implying that the account is materially misstated ('~a') with 0.8 level of support. However, the auditor may believe that the positive analytical procedures evidence provides no indication that the account is materially misstated. Under belief functions, the remaining 0.8 degree of support represents an uncommitted belief that is assigned to the entire frame. In terms of belief functions these judgments can be expressed as Bel(a) = 0.2 and Bel(~a) = 0, or in terms of m-values as m(a) = 0.2, m(~a) = 0, and m({a,~a}) = 0.8.

In the evidential network approach under belief functions, items of evidence are combined using Dempster's rule of combination. Dempster's rule is similar to Bayes' Theorem in probability. We have used the computer program "Auditor's Assistant" developed by Shafer, Shenoy, and Srivastava (1988). This program allows users to draw the evidential network and uses Dempster's rule to combine various items of evidence in the network.

The values noted in various nodes in Figure 1 indicate the level of belief in support of (left value) and against (right value) various assertions. For instance, the

values surrounding the node labeled "Accounts Rec." indicate that after the evidence is obtained there is an 85% level of belief that the account is fairly stated and a corresponding 4% belief the account is not fairly stated. In contrast to probabilities, these values do not need to sum to 100%. Using beliefs rather than probabilities implies that the unallocated 11% in this node represents the auditor's uncertainty or lack of knowledge (not having collected enough evidence to resolve uncertainly to an acceptable level) as to whether the account is fairly stated or not.

The evidential network approach for audit decisions is a comprehensive way to capture all the evidence and their interrelationships, and also to consider the relationships among assertions or audit objectives, and the relationship among accounts and financial statements. Using belief functions for representing uncertainties in the evidential reasoning approach makes the process more effective for the following reasons. First, under the belief-function framework, we can easily distinguish between positive and negative evidence. For example, suppose an item of evidence supports an account that it is fairly stated ('a') with, say, 0.2 level of assurance, and provides no support for its negation. This evidence can be expressed in terms of belief functions as Bel(a) = 0.2, and Bel(~a) = 0 or in terms of m-values as m(a) = 0.2, m(~a) = 0, and m({a,~a}) = 0.8. Similarly, a weak negative item of evidence with, say, 0.3 level of support that the account is materially misstated, ~a, and no support for 'a' can be expressed as Bel(a) =0, and Bel(~a) = 0.3, or m(a) = 0, m(~a) = 0.3, and m({a,~a}) = 0.7.

Second, we can easily express a mixed item of evidence using belief functions. For example, if an item of evidence provides, say, 0.2 level of assurance that the

account is fairly stated, and 0.3 level of assurance that the account is not fairly stated then one can write this as Bel(a) = 0.2, Bel(~a) = 0.3 or in terms of m-values as m(a) = 0.2, m(~(~a) = 0.3, and m({a,~a}) = 0.5. Third, in the evidential network approach, each item of evidence is directly connected to the variable it pertains to and thus the impact of the evidence is direct. Suppose that the inherent factors such as economic factors, industry related factors, management related factors, all together provide combined negative evidence, say, 0.10 level of assurance that an account is not fairly stated and no support to 'a' that the account is fairly stated, i.e., Bel(~a) = 0.10 and Bel(a) = 0. Although there is no support to 'a', the plausibility[3] that the account is fairly stated is still 0.9. Plausibility represents the maximum level of assurance that could be obtained, given the current information, assuming that all the subsequent items of evidence are in its favor. However, if 0.95 is the threshold level of assurance to accept the account balance as fairly stated, then the auditor would not accept the account in the above example. Instead, the auditor could either collect more evidence or decide that an adjustment is needed. Based on additional evidence, the auditor could either conclude that the 0.95 threshold has been achieved or again determine that an adjustment needs to be made.

It should be noted that continuous values may be elicited to quantify these beliefs or alternatively discrete values may be obtained (e.g., high, medium, and low risk). In practice, auditors usually do not express uncertainties in terms of numerical values, but rather use discrete scales such as "high" or "low" risk. Thus, discrete elicitation scales may lead to greater acceptability and ease of use among auditors than continuous

[3] As mentioned in footnote 2, Pl(a) = 1 - Bel(~a) = 1 - 0.1 = 0.9.

probability scales. This aspect is further explored later in the sensitivity analysis section.

Research Questions

As described in the prior section, a Belief-Function decision tool appears to have significant promise in assisting auditors in the planning phase to aggregate risks and develop a program plan tailored to risks. As such, the primary objective of this study is to assess the feasibility of this decision aid. In addressing this broad objective, the following research questions are examined:

Q1: What is the structure of the evidential model for an illustrative client?

Q2: What is the overall level of belief in the various assertions generated by the evidential model after assessments have been elicited from an audit partner?

Q3: How sensitive is the evidential model output to a range of possible input values?

The final question considers whether a categorical scale can be substituted for numerical values to facilitate elicitation of beliefs and the extent to which the approach can be used to evaluate the relative impact of evidence on audit conclusions. The next section describes the method employed to address these questions.

METHODOLOGY

The present study examines the use of a Belief-Function approach in program planning by examining an actual audit engagement in the accounts receivable area. The method involves 1) developing an evidential model of an actual audit, 2) eliciting beliefs from the auditors who conducted the audit and 3) performing various types of sensitivity analyses to evaluate the model.

Developing an Evidential Model

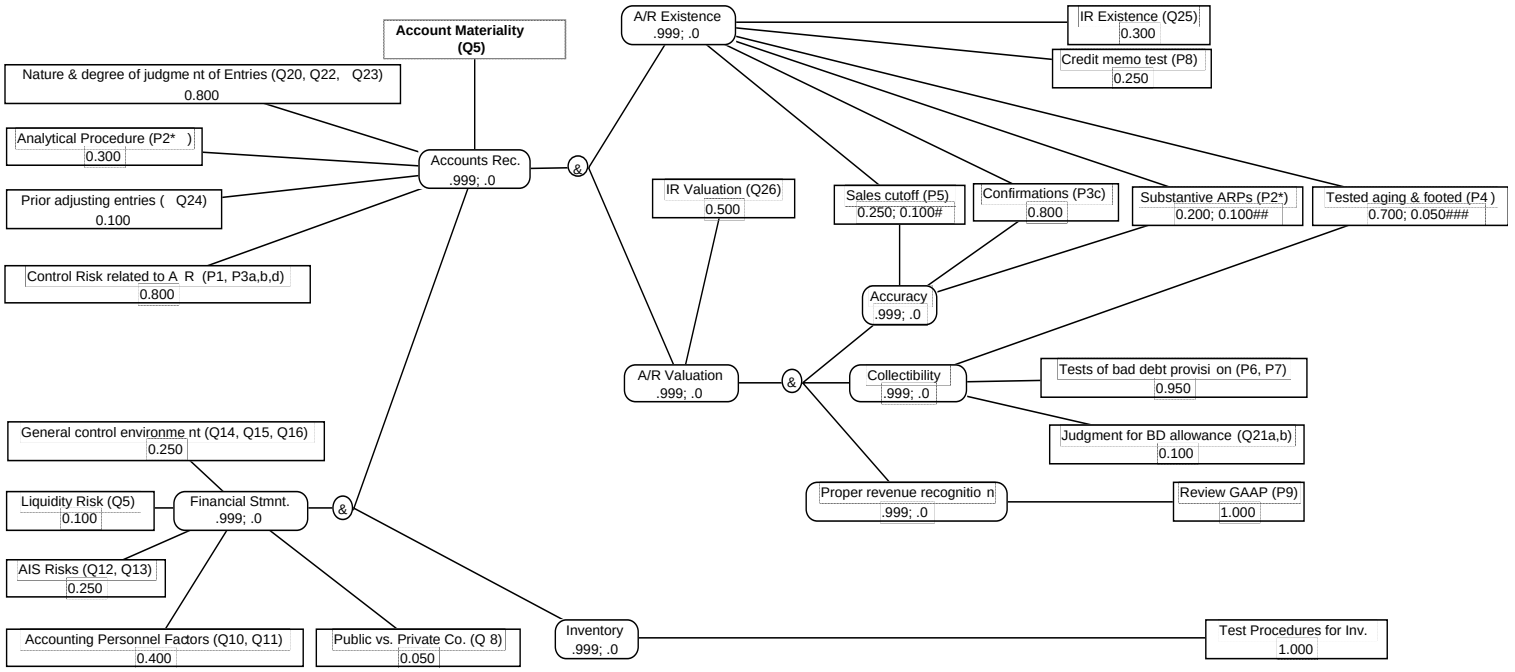
The initial steps entailed developing an evidential model based on an actual audit of a Big 6 firm. To extend the earlier archival work by Mock and Wright (1993, 1997), a manufacturing client setting was sought. From the clients audited by the particular office studied, one labeled “Client A” was selected for study. Next we reviewed the standard audit program used in this office to audit the revenue cycle and specifically accounts receivable.

The audit firm that we visited tailors the standard audit program (see Appendix B) to the particular client being audited. Once the tailored audit program was obtained, the evidential network (model) was developed using an approach similar to that used by Mock & Wright (1993). First, risk assessments and audit demographics were obtained by asking a manager familiar with the audit to complete a detailed questionnaire while reviewing the workpapers actually generated during the audit. The results of this process are contained in Appendix A which documents client financial information, the fee basis used, planned audit hours and other key data.

Second, a copy of the actual audit program was made available for our review (see Appendix B). Based on both of these sources and the generic model depicted in Figure 1, an initial version of the model was developed (see Figure 2) which focuses on accounts receivable and the existence and valuation assertions. .

Figure 2

Evidential Diagram for Accounts Receivable for Client A



#(0.250, 0.100) indicates 0.25 level of support for Existence and 0.1 for Accuracy.
##(0.200; 0.100) indicates 0.2 level of support for Existence and 0.1 for Accuracy.
###(0.700; 0.050) indicates 0.7 level of support for Collectibility and 0.05 for Existence.

Model Validation and Belief Elicitation

Phase 2 of our model building methodology involves validation of the initial model by the audit partner and then eliciting appropriate beliefs and possible ranges of beliefs for client A. Beliefs were elicited using the approach developed by Srivastava, Dutta and Johns (1996) where auditors are asked the following question for each item of evidence obtained:

> Considering each item of evidence in isolation, that is ignoring all other audit evidence, what is the amount of support provided either supporting and/or not supporting the related assertion?

Partner beliefs were elicited in three stages or rounds (see Table 1). For the first round, the researchers visited the partner in his office and provided background concerning the research project and general instructions concerning beliefs and how they relate to probability. The particular client studied was briefly discussed and the partner assured us that he was very familiar with the details of the client and felt comfortable in providing the requisite beliefs. The model shown in Figure 2 was then reviewed by the partner and he was asked first to assess its validity and then to specify his beliefs for each type of evidence collected. For example, with respect to the assertion related to the collectibility of receivables, he was asked to consider the evidence that was collected in tests of the bad debt provision and estimate the amount of evidence either supporting and/or not supporting the collectibility assertion. These types of assessments provided the first round input beliefs listed in Table 1.

Table 1: Elicitation of Beliefs for Various Items of Evidence (Appendices A and B provide the details of questions, Qs, and audit procedures, Ps).

Items of Evidence	First Round		Second Round		Third Round	
	Input Beliefs	Output Beliefs	Input Beliefs	Output Beliefs	Input Beliefs	Output Beliefs
Evidence at the Financial Statement level:		0.814		0.999		0.993
General control environment (Q14, Q15, Q16)	0.25		0.25		0.25	
Liquidity Factors (Q5)	0.05		0.10		0.10	
AIS Factors (Q12, Q13)	0.25		0.25		0.25	
Accounting Personnel Factors (Q10, Q11)	0.25		0.40		0.40	
Public vs. Private Co. (Q8)	0.05		0.05		0.05	
Evidence at the account level:		0.814		0.999		.993
Nature of judgment of entries (Q20, Q22, Q23)	0.10		0.80		0.50	
Analytical Procedure (P2*)	0.10		0.30		0.30	
Prior adjusting entries	0.05		0.10		0.10	
Control factors related to AR (P1, P3a,b,d)	0.10		0.80		0.50	
Evidence at the A/R Existence level:		0.976		0.999		.997
IR Existence (Q25)	0.30		0.30		0.30	
Credit memo test (P8)	0.25		0.25		0.25	
Sales cutoff (P5)	0.20		0.25		0.25	
Confirmations (P3c)	0.70		0.80		0.80	
Substantive ARP (P2*)	0.10		0.20		0.20	
Tested aging & footed (P4)	0.05		0.05		0.05	
Evidence at the A/R Valuation level:		0.817		0.999		.993
IR Valuation (Q26)	0.15		0.50		0.15	
Evidence at the Accuracy level:		0.818		0.999		.994
Sales cutoff (P5)	0.05		0.10		0.10	
Confirmations (P3c)	0.05		0.80		0.80	
Substantive ARP (P2*)	0.10		0.10		0.10	
Evidence at the Collectibility level:		0.997		0.999		.999
Tested aging & footed (P4)	0.70		0.70		0.70	
Test of bad debt provision (P6, P7)	0.95		0.95		0.95	
Judgment for BD allowance (Q21a,b)	0.10		0.10		0.10	
Evidence at the Proper revenue recognition level:		1.00		1.00		1.00
Review of GAAP (P9)	1.00		1.00		1.00	

As is indicated in Table 1 (see the "Output Beliefs" column), the elicited beliefs resulted in a .814 belief that the account is fairly stated at the account level, a .976 level of belief concerning the existence assertion, a .817 level of belief concerning the valuation assertion, etc[4]. These assessments are all conditional on the evidence obtained in the planning process (see Appendix A) and from the audit program (see Appendix B)[5].

Once the initial assessments were made, the model was reviewed by the authors for its general validity. Several aspects seemed inconsistent with the partner's and manager's characterization of the client as being a long-term client with little inherent risk and a relatively strong general control environment. They also indicated that the account was an area within the audit where they likely had over audited ("beat it too death") and where none of the collected evidence indicated a likelihood of error or misstatement. More specifically, although the assessed overall level of belief of .81 is moderately high, what the partner was expressing verbally concerning the client did not seem to match very well with these results. This possible inconsistency could have been the result of several factors including the partner's lack of familiarity with the notion of beliefs, with our elicitation methodology, with the structure of the model itself or with other aspects.

[4] Note that in the present case the belief at the financial statement level is the same as the belief at the accounts receivable level. The reason for this result is that the financial statement is assumed to consist of only two accounts, accounts receivable and inventory. Since the inventory account is assumed to be fairly stated with certainty (a belief of one), only the level of uncertainly in accounts receivable will directly impact the uncertainty at the financial statement level. However, if the inventory account had some level of uncertainty then the two beliefs, the belief at the financial statement level and at the account level, would be different.

[5] Note that this case study was in a real sense a pilot test of our elicitation methods and also a training process for the partner. Once we have fine tuned both the training process and the details of elicitation, it should not be necessary to conduct several rounds of elicitation.

Given these concerns, two other elicitation rounds were conducted via telephone conversation where the overall model including its output values was discussed and each of the input factors was reassessed. For example, during round one the partner had assessed “control factors related to internal control” at a level of .10 whereas he had stated that the controls related to the processing of receivable were very strong. Once this apparent inconsistency had been pointed out, the partner changed his assessment to .80. The second round assessments resulted in output values for all levels and assertions that were .999 or 1. These assessments may have been extreme in the other direction and a third round of assessments were elicited. This round resulted in both input assessments and output values that seem reasonably consistent with the partner’s verbally expressed feelings concerning his belief that the account and it’s related assertions were strongly supported by the available evidence. The round three model (see Table 1) resulted in an overall belief of .993 that the account was fairly stated. Further, beliefs related to specific assertions being met ranged from .993 to .999.

Sensitivity Analyses

To further assess the reasonableness of the output of the model, sensitivity analysis was performed. This analysis helps address a number of research issues such as whether the risk assessments could be expressed on a categorical scale rather than numerical beliefs. Table 2 presents the results of our sensitivity analysis.

Table 2: Sensitivity analysis for various scenarios*.

	Case 1			Case 2	Case 3	Case 4	Case 5	Case 6	Case 7
	Lowest Scale Values	**Mean Scale Values**	**Highest Scale Values**						
Evidence at the Financial Statement level:	**0.908**	**0.989**	**0.99**	**0.945**	**0.775**	**0.775**	**0.836**	**0.909**	**0.911, 0.020**
General control environment (Q14, Q15, Q16)	0.10	0.20	0.30	0.20	0.20	0.20	0.20	0.20	0.10, 0.00
Liquidity Risk (Q5)	0.00	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.00, 0.05
AIS Risks (Q12, Q13)	0.10	0.20	0.30	0.20	0.20	0.20	0.20	0.20	0.00, 0.05
Accounting Personnel Factors (Q10, Q11)	0.30	0.50	0.70	0.50	0.20	0.20	0.20	0.20	0.00, 0.05
Public vs. Private Co. (Q8)	0.00	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.05, 0.00
Evidence at the account level:	**0.908**	**0.989**	**0.999**	**0.945**	**0.775**	**0.775**	**0.836**	**0.909**	**0.911, 0.020**
Nature of judgment of entries (Q20, Q22, Q23)	0.30	0.50	0.70	0.50	0.20	0.20	0.20	0.20	0.00, 0.00
Analytical Procedure (P2*)	0.10	0.20	0.30	0.20	0.20	0.20	0.20	0.20	0.00, 0.05
Prior adjusting entries	0.00	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.00, 0.05
Control factors related to AR (P1, P3a,b,d)	0.30	0.50	0.70	0.50	0.20	0.20	0.20	0.20	0.00, 0.00
Evidence at the A/R Existence level:	**0.951**	**0.996**	**0.999**	**0.945**	**0.775**	**0.775**	**0.913**	**0.965**	**0.958, 0.002**
IR Existence (Q25)	0.10	0.20	0.30	0.00	0.00	0.00	0.20	0.20	0.20, 0.00
Credit memo test (P8)	0.10	0.20	0.30	0.00	0.00	0.00	0.20	0.20	0.20, 0.00
Sales cutoff (P5)	0.10	0.20	0.30	0.00	0.00	0.00	0.20	0.20	0.20, 0.00
Confirmations (P3c)	0.70	0.80	0.90	0.00	0.00	0.00	0.00	0.60	0.90, 0.00
Substantive ARP (P2*)	0.10	0.20	0.30	0.00	0.00	0.00	0.20	0.20	0.20, 0.00
Tested aging & footed (P4)	0.00	0.05	0.10	0.00	0.00	0.00	0.05	0.05	0.05, 0.00
Evidence at the A/R Valuation level:	**0.912**	**0.990**	**0.999**	**0.945**	**0.775**	**0.775**	**0.853**	**0.916**	**0.919, 0.011**
IR Valuation (Q26)	0.10	0.20	0.30	0.00	0.00	0.00	0.20	0.20	0.20, 0.00
Evidence at the Accuracy level:	**0.932**	**0.992**	**0.999**	**0.945**	**0.775**	**0.775**	**0.863**	**0.945**	**0.934, 0.007**
Sales cutoff (P5)	0.00	0.05	0.10	0.00	0.00	0.00	0.05	0.05	0.05, 0.00
Confirmations (P3c)	0.70	0.80	0.90	0.00	0.00	0.00	0.00	0.60	0.90, 0.00
Substantive ARP (P2*)	0.00	0.05	0.10	0.00	0.00	0.00	0.05	0.05	0.05, 0.00
Evidence at the Collectibility level:	**0.993**	**0.999**	**1.00**	**0.945**	**0.775**	**0.775**	**0.966**	**0.966**	**0.984, 0.003**
Tested aging & footed (P4)	0.70	0.80	0.90	0.00	0.00	0.00	0.80	0.80	0.80, 0.00
Test of bad debt provision (P6, P7)	0.90	0.95	1.00	0.00	0.00	0.00	0.00	0.00	0.90, 0.00
Judgment for BD allowance (Q21a,b)	0.00	0.05	0.10	0.00	0.00	0.00	0.05	0.05	0.05, 0.00
Evidence at the Proper revenue recognition level:	**0.977**	**0.998**	**1.0**	**0.945**	**0.775**	**0.989**	**0.991**	**0.991**	**0.999, 0.000**
Review of GAAP (P9)	0.90	0.95	1.0	0.00	0.00	0.95	0.95	0.95	1.00, 0.00

*Various strength categories are defined as follows: Very Low (VL) = [0, 0.05, 0.1], Low (L) = [0.1, 0.2, 0.3], Median = [0.3, 0.5, 0.7], High (H) = [0.7, 0.8, 0.9], and Very High (VH) = [0.9, 0.95, 1.0]. The first and the last number in the parentheses represent the lower and upper ends of the interval with the middle being the mean.

First, based on the numerical inputs of the strength of evidence provided by the audit partner, we divided the assurance levels into five categories, very low ranging from 0.0 to 0.1, low from 0.1 to 0.3, medium from 0.3 to 0.7, high from 0.7 to 0.9, and very high from 0.9 to 1.0. Next, we associated the partner's input values with the above categories and recalculated the output values for the three different input values under each categories, one for the lower end of the values, one for the middle value, and the third for the highest value for each category (see Case 1 in Table 2).

Note that all the output values (in bold numbers) lie in the "very high" category for the given input values. This result is consistent with the partner's stated feeling that a high level of confidence had been achieved for all of the assertions within this area of the audit engagement. Our results show that, given that the partner’s input values of the strength of evidence lie in any of the five categories (very low, low, medium, high or very high), the output values are quite insensitive to the particular numerical values chosen within the respective ranges.

This result has an important practical implication. The auditor could have assessed and input the strength of evidence in terms of the five categories, rather than input a particular numerical assessment. For calculation purposes, one can convert these categorical inputs into numerical values and combine the evidence and convert the numerical outputs back into various categories. This alternative assessment process would eliminate the difficult task of assessing the strengths of evidence in numerical terms by the auditor.

Case 2 in Table 2 deals with an extreme case or scenario where no evidence at the assertion level is obtained. The only evidence that is gathered is at the financial

statement level and the account level. The input values used in this case are the middle values of the assessed strengths by the partner in terms of various categories. Note that the output values are still quite high even though no evidence is assumed to have been collected at the assertion level[6]. Surprisingly, these output levels still are close to the partner's overall belief that the likelihood of error is very low (.993 belief that the account is fairly stated at the end of round three).

Case 3 deals with a scenario similar to Case 2 except the level of support is either low or very low for the evidence at the financial statement level and at the account level. However, no evidence is gathered and evaluated at the assertion level. In this case, all the output values are 0.775. This is, at best, a medium level of support since auditing standards prescribe that audit risk be set at a low level. In such a case, further evidence is needed to achieve the desired level of assurance.

In Case 4, suppose the auditor gathers information about GAAP and, a priori, decides that a 0.95 (very high) level of support is required that revenue is properly recognized. Given the case 4 assumptions, the “achieved” level of assurance that revenue is properly recognized is 0.989. However, the assurance levels for the rest of the variables are still 0.775, a medium level. This result may still not be acceptable to the auditor if the overall desired threshold is 0.90 or above. This result suggests that testing of just one assertion is inadequate, since there are other very significant assertions that must be examined and a satisfactory level of assurance should be obtained for all important assertions.

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[6] This high level of overall assurance is obtained even without any audit procedures being performed at the assertion level and is due to the fact that input beliefs from the factors at the financial statement level and the account level together yield an overall high level of support. This result reflects the audit partner's judgment about the assessment of overall assurance before conducting detail tests at the assertion level.

Case 5 deals with the scenario in Case 4, with one difference that the auditor now has collected and evaluated all the evidence except confirmations and test of bad debt provisions (the corresponding input values are zeros, see column related to Case 5). However, the overall assurance for all of the variables is not still equal to or above a desired threshold level, say 0.9. As seen in column seven in Table 2, a total of 0.836 level of assurance is obtained for the receivable account and for the financial statements as a whole. However, as is evident from Case 6, if the auditor obtains a medium, say 0.6, level of support from confirmations, the respective output for all the variables becomes higher than 0.9 which may be an acceptable level of assurance. Such an analysis shows the impact of various items of evidence at various levels of the account.

Thus, this type of analysis should aid an auditor in planning and conducting an audit more efficiently by providing an indication of the relative importance of a given piece of evidence on overall audit conclusions. If a test is found to have little impact, the auditor may consider whether it is sufficiently cost-effective or is needed to achieve a desired level of confidence. Through continued sensitivity analyses the auditor can plan a cost-effective set of tests.

Case 7 deals with a scenario where the auditor initially has some negative evidence about the financial statements and the account although the general control environment is assumed to be positive and provides a low level of support. The column corresponding to Case 7 contains two sets of numbers. The first number represents the level of support for the corresponding variable that it is true and the second number represents the support for its negation. We assume that the client's liquidity measures

are not good and that the accounting information system has some problems. In addition we assume that the company has recently hired graduates from college to fill positions vacated by senior employees who have recently left the company for better jobs. Also, analytical procedures provide some red flags for errors and irregularities. Moreover, last year's audit shows that errors and irregularities in the current year financial statements are possible. The impact of all these items of evidence on the corresponding variables is expressed in terms of weak negative evidence. In order to obtain an acceptable level of overall assurance, say 0.9, the auditor clearly needs to obtain a much higher level of assurance as compared to Case 6. This assurance could be obtained from confirmations and/or other tests.

CONCLUSIONS

This paper has presented an exploratory case study of audit planning using a belief function framework. Based on two prior archival studies of Mock and Wright (1993, 1997), a general audit planning model was developed (see Figure 1). This model presents a general evidential structure that the participating firm uses to link assertions to audit evidence in testing accounts receivable.

A case study was conducted where the general model was adapted to develop a specific model for an actual audit of a manufacturing client (see Figure 2). Assessments of the strength of evidence were provided by the partner in charge of the audit and the structure of the model was validated by this partner. Sensitivity analysis was then used to evaluate the main features of the model.

Major Findings

As a preliminary indication of the feasibility of the model, initial development efforts produced a model yielding output values consistent with the beliefs of the partner regarding evidence evaluation and conclusions in testing accounts receivable on the engagement. Additionally, sensitive analyses revealed that output values do not vary considerably when numerical assessments of beliefs are combined into a categorical scale. These results suggest that the elicitation of beliefs may not be a difficult problem, since auditors are accustomed to using such scales (e.g., “high”, “medium”, or “low” risk) rather than numerical values.

Additional sensitivity analyses demonstrated that the model can be used to assist auditors in integrating evidence to evaluate the adequacy of the evidence to provide the overall desired level of assurance. Further, the model provides information of the relative impact of a given test (or set of tests) on overall assurance and can accommodate both positive (confirming) or negative evidence. These features of the approach enable an auditor in the planning stage to consider the expected value of an audit test in formulating a cost-effective audit program and ex post to evaluate the impact of test results on overall assurance. If further assurance is necessary, additional tests may need to be conducted or adjustments to the financial statements proposed.

Implications for Future Research and Practice

This research was an exploratory study to examine the feasibility of a belief-function approach to audit planning and evidence evaluation. As such, while the initial findings reported here suggest this approach is promising as a valuable audit tool, there are several fruitful avenues for future research. To simplify the data accumulation and

analyses, the model examined evidential evaluation for only a single account and for two important assertions. Further, it is assumed that only two accounts are present. To enhance realism further work is needed to expand this analysis to consider multiple accounts. Further, often evidence impacting one account provides indirect evidence affecting another. This is the reason auditors normally test cycles such as the revenue cycle rather than individual accounts. Also, as noted, data regarding cost, ease of use, and perceptions of feasibility are needed to further assess the usefulness of the approach.

In the development and refinement of the model it was found that beliefs varied considerably over the initial trials. This result was likely because of the need for training regarding the notion of beliefs and to provide familiarity with the elicitation method and the model. Prior research on the effectiveness of decision tools such as the one examined here has shown that training is important to ensure effectiveness of the tool (e.g., Libby and Libby 1989). A direct practice implication is that the use of this approach will require initial training and testing. Also, research is needed to consider the effectiveness of alternative elicitation and training methods.

The belief function approach has significant promise for audit practice in assisting auditors deal with the complex tasks of aggregating risks, evaluating the potential value of alternative tests in designing a program that is efficient and achieves audit objectives, and in assessing the inferential value of evidence (both positive and negative) on audit conclusions. Further, technological advances make the computational operations of such a tool quite feasible. Advances in this area have significant potential for improving practice, since evidence planning and evaluation are at the very core of the auditing

function. As well articulated in auditing standards, the auditor has a primary duty to ensure that sufficient, competent evidence is obtained to be able to express an opinion.

Appendix A

Completed Risk Assessment Questionnaire

I. General Client Information

1. Engagement Code: A

2. Client Industry Manufacturing

3. Years this client been audited by your firm: 10+

4. Fee Basis: Fixed Fee

5. Client Financial data in thousands of dollars ($000's)

Total assets	$ 533,000	
Total revenues	$ 110,000	
Audit gauge	$ 1,200	
Net income (loss)	$ 50,000	
A/R balance	$ 49,000	(less 4,000 allowance)
A/P balance	$ 133,000	
Current liabilities	$ 42,000	
Long-term liab.	$ 00	

Number of A/R accounts: 739

6. Total planned auditing time on engagement, including staff, manager, and partner hours: 1,000 hours

7. Indicate CHANGES in the following personnel on the engagement

In-charge	No Change
Manager	Change
Partner	No Change

8. The client's shares are: Private company

9. Indicate whether the company had a material (i.e., greater than gauge) bonus incentive plan for management based on reported profits. NO

II. Client Situational Factors

Below are a series of questions on the general environment/conditions surrounding the audit engagements this year and in prior years. Questions are presented on a continuous scale; YOU MAY PLACE A CHECK MARK AT ANY PLACE ALONG THE SCALE.

10. Rate the level of knowledge of the entity's accounting personnel (i.e., controller and staff) in terms of their awareness and understanding of accounting principles and practices and how to apply them. Consider college degrees held, training courses attended, and your observations of the personnel.

	Extremely high knowledge level						Extremely low knowledge level
Current year	|----	|--2[7]--	|----	|--X--	|----	|----	|---- |

11. Rate the accounting personnel's general attitude in accomplishing their responsibilities (controller and staff.)

	Extremely conscientious						Unconscientious
Current year	|----	|--X--	|----	|----	|----	|----	|---- |

[7] The less experienced manager rated this item here.

12. To what degree did the entity's financial information system(s) change in the fiscal year in terms of input, output, or degree of computerization?

	Significant change						No Change
Current year	|----	----	----	----	----	----	--X--|

13. To what degree is (are) the entity's financial information system (s) computerized?

	Completely computerized						Completely manual
Current year	|--X--	----	----	----	----	----	----|

14. Rate the overall level of general controls, including potential for management override. Consider factors such as organizational structure, documentation policies, existence of budgets and comparison of budgets to actual results, and existence of an internal audit department.

	Extremely strong general controls						Extremely weak general controls
Current year	|----	----	X----	----	----	----	----|

15. Rate management's (i.e., CEO, CFO, and other operating officers) aggressiveness in committing the entity to high risk ventures or projects.

	Extremely aggressive						Extremely conservative
Current year	|----	----	----	----	----	--X--	----|

16. Evaluate the extent of high level management turnover (i.e., CEO and other key operating officers).

	Extremely high turnover						No turnover
Current year	|----	----	----	----	----	----	--X--|

Questions specifically related to Accounts Receivable And Related Allowance For Collectibles

20. Rate the degree to which judgment (including estimates) was required in arriving at the entries to the accounts receivable account.

	Extreme judgment was required						Little or no judgment was required
Current year	|----	----	----	----	----	----	--X--|

21. Rate the degree to which judgment (including estimates) was required in arriving at the entries to the allowance for uncollectible accounts.

	Extreme judgment was required						Little or no judgment was required
Current year	|----	--X--	----	----	----	----	----|

22. Rate the degree of complexity underlying the entries made to the accounts receivable and related allowance for collectibles. For example, summarizing cash receipts usually is not complex, whereas calculating the liability and expense related to federal income taxes is often highly complex.

	An extremely high level of complexity underlying the entries						Little or no complexity underlying the entries
Current year	|----	----	----	----	----	----	--X--|

23. Rate the relative number of unusual transactions (includingrelated party transactions) included in the accounts receivable and related allowance for uncollectibles as
compared to similar clients in the industry.

	A significant number of unusual transactions						Very few or no unusual transactions
Current year	|----	----	----	----	----	----	--X--|

24. Indicate the total number of audit differences found affecting the Accounts Receivable and related Allowance for Uncollectibles accounts:

	Number of Differences	Number of Differences Equaling or Exceeding Planning Materiality
Current year	0	0

25. Indicate the level of assessed Inherent risk of the likelihood for a material error due to **Existence** problems: ***Low Risk***

26. Indicate the level of assessed Inherent risk of the likelihood for a material error due to **Valuation** problems: ***Low risk***

III. Planned Substantive Audit Programs

The focus of Section 2 of the questionnaire is to obtain information on the planned substantive procedures chosen in the Revenue & Receipts Cycle). Also, the extent of testing (planned hours) among procedures is investigated.

CONTROL RISK

28. The level of control risk for the Revenue and Receipts cycle after tests of controls:

	Low Risk	Moderate Risk	Maximum Risk	Controls not Relied on
Current year	|----|----|--X--|----|----|----|----|			_____

29. The level of control risk for the Revenue & Receipts cycle before tests of controls, if any were performed":

	Low Risk	Moderate Risk	Maximum Risk	Controls not Relied on
Current year	|----|----|--X--|----|----|----|----|			_____

Substantive Audit Program (See Table __ for summary of audit program used)

Appendix B

Audit program used on Client A for trade and nontrade accounts receivable, and revenue related accounts.

[Note that *Done By* and *Workpaper Reference* columns were completed in actual workpapers]

OBJECTIVES: The purpose of this workpaper is to (1) document the audit procedures performed to determine whether trade and nontrade accounts receivable, and revenue related accounts are fairly stated at 12/31/95, and (2) to document the related (audit firm) risk assessments.

Audit Procedures	Done By	Workpaper Reference
(1) Obtained an understanding of internal controls over the revenue and receipts cycle, utilize internal audit review performed during 1995 to aid in testing the cycle. (2) Performed substantive analysis procedures on: (a) trade receivables (b) revenue and other miscellaneous income Identified certain controls which were the basis for a systems-based approach to testing the existence of trade receivables. During interim and final, we performed tests of controls to determine whether those controls appeared to be in place and operating effectively. Those tests included: (a) discussions with credit department personnel (b) inspection of relevant reconciliations and documentation of reviews (c) confirmation of invoice balances with customers using analysis (d) other procedures considered necessary (4) Tested and footed the trade accounts receivable aging as of interim using Audit Firm analysis and rolled forward the account to year-end; performed substantive analysis procedures on the aging at final. (5) Tested cut-off at year-end by tracing a sample of sales at the end of December and the beginning of January to supporting shipment information and verifying that sales were recorded in the proper period.		

Audit Procedures	Done By	Workpaper Reference
(6) Reviewed, and determined the adequacy of, the reserve for uncollectible accounts; analytically reviewed bad debt expense. (7) Performed a collectibility review on all accounts which were past due and greater than $50,000. (8) Reviewed subsequent period credit memos for material credits issued after the balance sheet date. (9) Reviewed accounting principles for appropriateness and consistency. (10) Reviewed classification, description, and other disclosure matters as considered necessary ***Conclusion*** Based on the procedures performed, and documented above, with the exception of any audit differences noted in the workpapers, trade and nontrade accounts receivable, revenue, and related accounts appear fairly stated at 12/31/95 and relevant accounting principles appear proper and consistently applied. Note that the results of the tests of controls over the existence of trade receivables gave reasonable assurance that those controls were in place and operating effectively as of the balance sheet date.		

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