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A knowledge based model of inherent audit risk assessment

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A KNOWLEDGE BASED MODEL OF
INHERENT AUDIT RISK ASSESSMENT

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Within the academic and professional auditing communities there has been growing concern with accurately assessing the various risks associated with the performance of an audit. One approach to developing sophisticated risk assessment models is to study how experienced auditors use industry and firm specific factors in making risk assessments. This thesis presents a model of inherent risk assessment based on literature reviews and a field study that involved structured and unstructured interviews and observations of experienced auditors during audit planning meetings. Analysis of the data gathered led to the specification of a conceptual model of inherent risk assessment which was implemented as a computer program (a computational model). Auditors were asked to assess the behavior and performance of the computational model. These assessments were used to evaluate the accuracy of both models.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 STATEMENT OF THE PROBLEM

The primary goal of this research project is to provide a better understanding of how inherent risk assessments are currently being performed by auditors in actual field situations. This improved understanding should eventually lead to suggestions on how to better support and improve the inherent risk assessment process. The method used in this research project involved developing a computational model (i.e. computer system) of experienced auditors' inherent risk assessment during audit planning.

In general, inherent risk is the risk that an accounting information system might produce a material error in a general ledger account balance. Economic entities develop accounting information systems that produce account balances. These entities also establish quality control procedures to help insure that those balances are accurate. Auditors also perform error detection procedures on an entity's account balances. The overall risk that a material error will exist in an audited account balance (audit risk) is a function of the error generating propensity of the accounting information system (inherent risk), the effectiveness of the entity's error prevention and detection procedures (control risk), and the effectiveness of the auditor's error detection procedures (detection risk).

The "materiality" concept recognizes that some errors are too small to be of concern. Inherent risk assessments are used by auditors to help determine the nature, timing and extent of their control risk assessment and error detection procedures. Inherent risk evaluation, materiality and their role in auditing planning are discussed in detail in Chapter 2, Section 2.2.

1.2 IMPORTANCE OF THIS RESEARCH

While risk assessment was not specifically mentioned in professional auditing standards until the issuance of Statements on Auditing Standards 1 (SAS 1) by the Auditing Standards Board (ASB) of the American Institute of Certified Public Accountants (AICPA) in 1972 (Boritz, et. al., 1986), audit risk assessment in general and inherent risk assessment in specific have received growing attention within the professional accounting community over the last decade. In 1981 the ASB presented a comprehensive model of audit risk in SAS 39. However, inherent risk was not explicitly included in that model. In a footnote SAS 39 explained that inherent risk had been excluded from the model because inherent risk was too hard and possibly too costly to assess (Cushing & Loebbecke, 1983). However, in 1984 the ASB issued SAS 47 which presented an expanded risk model that explicitly included inherent risk (AICPA, 1985).

There were two practical motivations behind this increased attention to inherent risk assessment. First, it is often impractical to eliminate inherent risk from consideration. Since inherent risk is a necessary part of audit risk, it can only be eliminated from consideration by setting its value to 100%. This implies that the underlying accounting information system being audited always produces material errors. Although this approach is extremely conservative and reduces the auditor's risk of accepting an account balance that has a material error, it is not very realistic in most audit situations. Second, the auditing profession has become increasingly competitive and auditors are becoming more concerned with cost containment and audit efficiency. If inherent risk could be reliably and efficiently assessed and that assessment was something less that 100%, then the auditors could reduce their audit effort and still maintain a desired level of audit risk.

The study of inherent risk assessment is important because little is known about how auditors make inherent risk assessments, what form these assessments take and how they are used in determining the nature, timing and extent of other audit procedures. No process oriented research of inherent risk assessment has yet been done by either academics or practitioners. Because of the lack of both a theory of inherent risk assessment and descriptive empirical research on the inherent risk assessment process, a field study approach was taken in this research project. This approach is consistent with recent statements in the academic literature concerning the importance of studying auditors in their natural decision making environment (Felix & Kinney, 1982; Gibbins & Wolf, 1982; Libby & Lewis, 1977 & 1982). The editors of the Journal of Accounting Research best summarized the need for this type of research when they stated:

> "Auditors work within competitive markets and the fact that they survive must mean they systematically do not make judgment errors. What we need to study today are the actual workingpapers of auditors in order to determine how they make probabilistic judgements in actual audit settings." (Dopuch & Shipper, 1985, emphasis in the original)

1.3 FOCUS AND SCOPE OF THE RESEARCH PROJECT

Inherent risk evaluation was selected as the focus of this research through a top down process of discovery. That is, the initial focus of the research was broadly defined as an attempt to develop an overall model of the audit process. This focus was narrowed during the initial data gathering phase of the project to include only inherent risk assessment during audit planning. The planning phase of an audit was selected as a starting point because planning forms the basis for the entire audit. Within planning, the inherent risk assessment task was selected because it appeared to be the starting point for audit planning.

The scope of the research was limited to developing a prototype computational model of the inherent risk assessment process. Inherent risk assessment is a complex process involving the use of a vast amounts of knowledge relating to economic entities in general and how the interact with their environment as well as to the history and character of the given economic entity being audited. The initial model provided a comprehensive framework which was used to identify issues that need further exploration. The results are preliminary and it is therefore beyond the scope of this thesis to recommend improvements in risk assessment practice.

1.4 SUMMARY OF THE RESEARCH PROJECT

Data for this project was gathered and analyzed in several different ways over several distinct phases. The first phase involved reviewing academic and professional literature and interviewing experienced auditors in an unstructured fashion. The first goal of this phase was to develop a research question that represented a logical first step in modeling the overall audit process and could be addressed in a dissertation sized project, i.e. inherent risk assessment during audit planning. The second goal was to develop a better understanding of the context in which inherent risk assessments are normally made by auditors.

The second phase of this research project built on the first by utilizing the context information to develop structured interviews and role playing exercises to gather more detailed information about the inherent risk assessment process. In addition, the data gathered in the first phase helped identify the use of audit planning meetings by audit team members to discuss inherent risk issues. Two of these meetings were observed in order to provide some concurrent data on inherent risk assessment.

The third phase involved analyzing all the data gathered in the first two phases, developing a conceptual model of inherent risk assessment and expressing that conceptual model in the form of a computer system that produced inherent risk assessments given case data. A computer system based on Artificial Intelligence programming techniques was selected as the medium for expressing the conceptual model of inherent risk assessment because such systems provide a potentially rich and flexible modeling medium while maintaining a high degree of formalism (Stevens & Gentner, 1983).

The fourth phase involved refining the computer system by having two experienced auditors critique and evaluate its performance on cases developed from the working papers and financial statements of one of their audit clients. The system refinement processes was iterative in that the system was gradually modified based on several cycles of auditor input and system modification.

While data for this project as a whole was gathered from eleven different auditors in two "Big Eight"[1] CPA firms, during the model refinement phase data gathering was limited

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[1]The term "Big Eight" refers to the eight largest international CPA firms in the world.

to two auditors from one of these CPA firms to eliminate cross cultural differences between firms. In addition, only three test cases were used to refine the model: two based on the auditors' clients and one developed by the author. Because of the limited number of cases involved, the scope of the model was implicitly limited to the set of issues raised by those cases. However, the resulting model was designed as a general model and contains no explicit limitations on the scope of its activities that would prevent it from dealing with cases based on firms that are different in size or character from the ones represented in the test cases. For example, even though all three test firms were manufacturers, the system could be used to study inherent risk evaluation in a service firm because it adjusts its reasoning to fit the financial data presented in the case.

The final phase of this research project involved a more formal evaluation of the system's performance. The two auditors who participated in the model refinement phase were asked to evaluate the system's analysis of each of the three cases based on a questionnaire and also to answer some general evaluative questions concerning the research project as a whole and the potential usefulness of the system to audit practice.

While this research project did not result in either a definitive model of inherent risk or a working audit tool, it did produce a functioning model of inherent risk that develops a reasonable inherent risk assessment given case data and that can be used to test assertions about the inherent risk assessment process. It also provided evidence about the nature of inherent risk assessment during audit planning. Inherent risk assessment does not just involve developing a point estimate of risk potential for a given account balance but involves developing a causal explanation of how error could occur in a given account. That causal explanation is developed by auditors using both qualitative and quantitative knowledge of how economic entities in general function, how a given entity has functioned recently and recent events that might have affected the entity.

1.5 OUTLINE OF THESIS

The balance of this thesis is broken into seven chapters. Chapter 2 contains an analysis of the inherent risk assessment task based on both the professional and academic audit literatures. Chapter 3 provides a chronological description of the data gathering and analysis phases of this research project and presents both a preliminary and the final conceptual model of inherent risk assessment. Chapters 4, 5, and 6 present the computer system developed as a result of this research. Chapter 4 describes the system in terms of its knowledge bases and inferencing mechanisms. Chapter 5 presents an annotated trace of the system's behavior on a test case. Chapter 6 discusses the architectural details of the system and how knowledge is represented and inferences drawn. Chapter 7 presents an analysis of auditor responses to evaluation questionnaires used in this research project. Finally, Chapter 8 provides a summary of the findings of this research and discusses several directions for future research suggested by those findings.

CHAPTER 2

TASK ANALYSIS OF INHERENT RISK ASSESSMENT

2.1 DESCRIPTION OF TASK ANALYSIS

2.1.1 IMPORTANCE OF TASK ANALYSIS

The goal of this research project is to build an information processing model of the inherent risk assessment process as it takes place during audit planning. Newell and Simon (1972) describe the nature of information processing models of human problem solving and discuss procedures for building such models[2]. They characterize problem solving as search in a problem space for a goal state. The problem space and goal state are constructed by the problem solver based on a set of domain invariant information processing procedures, a store of domain knowledge and constraints

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[2]The term "information processing" has also been used in psychology and accounting research to refer to studies employing the Brunswik Lens Model (see Libby & Lewis, 1977 and Libby & Lewis, 1982 for a review and discussion). The underlying theme of both the Lens Model and the Newell and Simon approaches is the same. That is, that viewing a human being as an information processing system provides a useful context for understanding human judgment behavior. However, the Newell and Simon approach provides a richer framework in that is deals with inputs, processes and outputs used by the decision maker whereas the Lens Model approach only deals with inputs (cues) and outputs (decision) of the process.

placed on the problem space by the task environment. Therefore, the nature of the problem space and goal state are largely determined by the nature and characteristics of the task environment. They describe a **task analysis** as a preliminary step in their model building processes. The purpose of a **task analysis** is to determine the restrictions and requirements a given task places on the problem solver.

Several other researchers have discussed the importance of understanding the task environment in order to properly interpret human behavior. Einhorn and Hogarth (1981) and Libby and Lewis (1977 & 1982) emphasize that human judgments are sensitive to even small changes in the task environments. Decision sensitivity to the task environment has been most thoroughly studied in the context of "framing". "Framing" refers to how a problem description or question is worded. Kahneman and Tversky (1984) demonstrated in a series of experiments that the way a problem is framed has a significant effect on the decisions made by individuals in choice situations.

2.1.2 TASK ANALYSIS PROCEDURES

A task analysis should produce a description of the declarative and procedural knowledge necessary to solve the task (Bhaskar & Dillard, 1979 and Stephens et. al., 1981). There has been no formal process specified for performing a task analysis. To analyze a task, a researcher must either learn to perform the task or have access to people who can perform the task and then make inferences as to what information was required to perform the task. For example, consider the knowledge that would be necessary to solve the following equation: 2 + 2 = X. Some declarative knowledge concerning what the symbols "2, +, = and X" mean and some procedural knowledge of how to combine numbers is required. More specifically, the problem solver needs to know the following:

1. That "2" is a number and reflects a quantity of objects.

2. That "+" refers to an operation on numbers that additively combines their quantity values.

3. How to execute an additive operation on numbers.

4. That "=" defines the goal of the task which is to determine the results of the combination rule specified by "+".

5. That "X" is a place holder for the results requested by the "=".

6. That symbol referents are constant over time and that both "2's" in the problem refer to the same thing.

This simple example highlights two points of task analysis. First, even simple tasks normally require large bodies of knowledge. Second, that well structured tasks usually produce clear-cut task analysis. Potential cultural differences aside, most people would probably solve this example using the same knowledge. However, more complex, ill-structured tasks may not produce unambiguous task descriptions. In more complex environments, similar conclusions can often be reached based on different knowledge bases. This means that when studying more complex tasks, the researcher needs to draw on a variety of sources to describe the task environment and attempt to find basic, underlying pieces of knowledge that are common to many of those sources.

2.1.3 PRELIMINARY ANALYSIS OF INHERENT RISK ASSESSMENT TASK

The first step in building an information processing model of inherent risk assessment was to perform a preliminary analysis of the inherent risk assessment task based on published professional and academic literature. This analysis is preliminary in the sense that analysis of complex tasks tends to be iterative. This iterative process begins by developing an initial task description that is used to interpret the auditors' solving behavior. As a better understanding of that behavior is achieved, the task description can be modified and refined. This modified description then can be used to interpret new behaviors which are observed and can lead to more modifications of the initial task description.

2.2 ROLE OF AUDITING

Professional standards that apply to the performance of external[3] audits by Certified Public Accountants (CPAs) are set by the Auditing Standards Board (ASB) of the American

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[3]External audits are those performed on an entity by an independent, outside party. They are contrasted with internal audits which are performed by employees of the audited entity.

Institute of Certified Public Accountants (AICPA). The ASB states that the objective of an audit of financial statements by the independent auditor is the expression of an opinion that those financial statements "present fairly, in all material respects, an entity's financial position, results of operations, and cash flows in conformity with generally accepted accounting principles" (AICPA, 1988b). An overview of the audit process used to produce this opinion is presented in Figure 1. This figure is a slightly condensed version of the one presented in Arens and Loebbecke (1988).

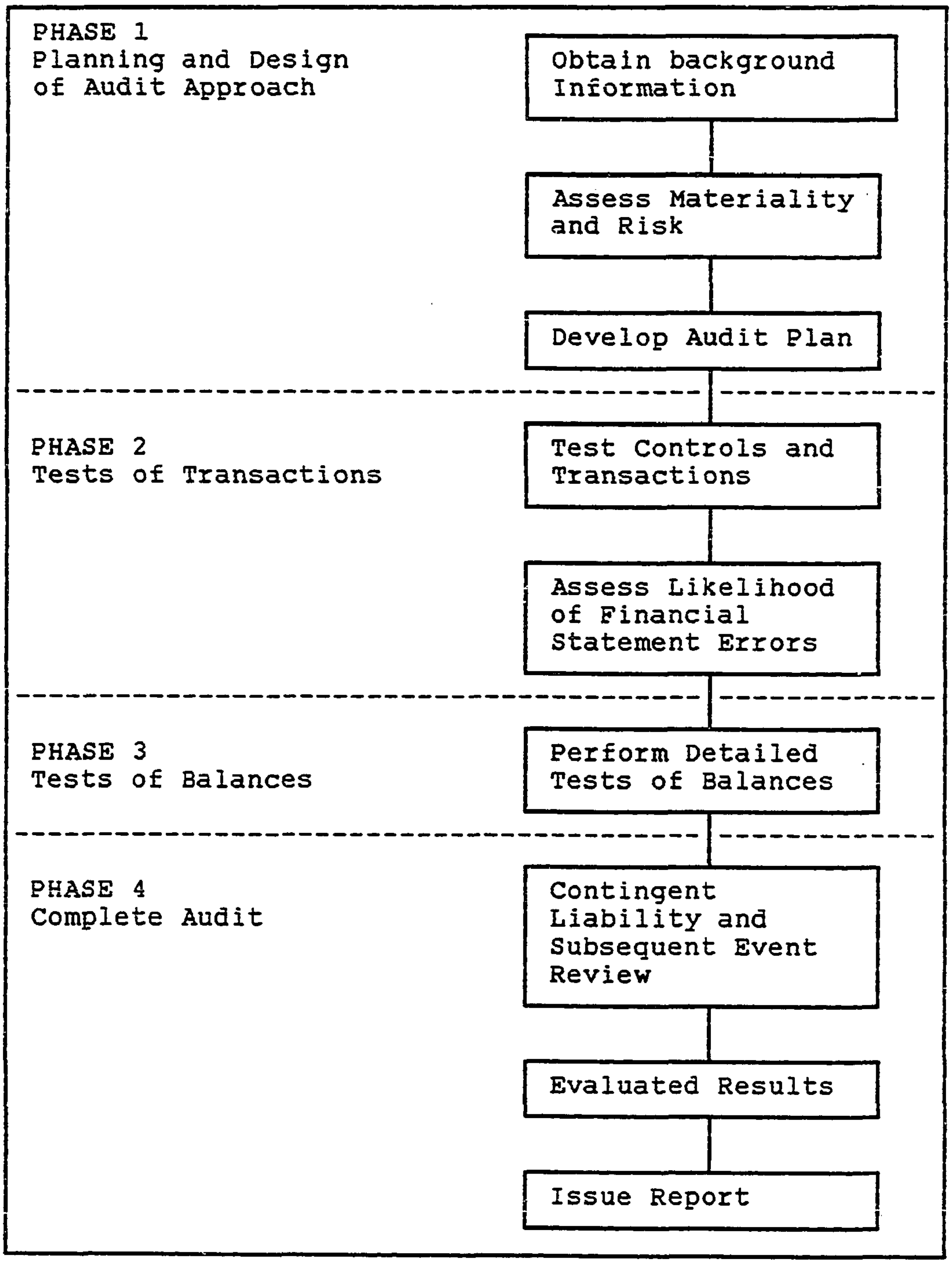

FIGURE 1 Summary of Audit Process

2.2.1 THE ROLE OF INHERENT RISK ASSESSMENT IN AUDITING

Inherent risk assessment is part of the assessment of materiality and risk included in the planning phase of the audit (PHASE 1). The ASB defines **inherent risk** as " the susceptibility of an account balance or class of account balances to error that could be material assuming that there are no related internal accounting controls" (AICPA, 1985). In this definition, the.ASB uses the term "error" to refer to both intentional and unintentional misstatements of the account balance. Typically, intentional errors are referred to as "irregularities" and unintentional errors as "errors". "Internal accounting controls" refer to those policies and procedures that have been established by the audited entity to detect errors and irregularities.

The role of inherent risk assessment in the overall audit risk assessment process is described by the AICPA's risk model:

$$AR = IR * CR * DR$$

Where:

AR = Overall Audit Risk
IR = Inherent Risk
CR = Control Risk
DR = Detection Risk

Audit Risk is the overall risk that a material error will exist in the financial statements. **Control Risk** is the risk that an error that exists in an account will not be detected by the entity's internal control system. **Detection Risk** is the risk that any error that was not detected by the control system will not be detected by audit procedures and therefore affect the financial statements. The AICPA emphasizes that this is a conceptual model, not a formal one, and that the assessments of the various risk components can be made on either a quantitative or qualitative basis (AICPA, 1983). That is, AICPA did not intend the model to imply that auditors should necessarily assign numerical estimates to the components of the risk model and then multiply them together to determine the achieved level of audit risk but should use the model as a conceptual framework for determining the relevant issues and their interaction when assessing risk.

Theoretical and practical problems with the risk model have been debated in the academic literature (see Cushing & Loebbecke, 1983 for a review of these issues). Whatever the form of the risk model, it is included in the professional auditing standards and therefore represents a significant component of the auditor's task environment. The risk model is discussed in this section to assist in describing how the focus of this project, inherent risk assessment, fits into the overall audit process. Therefore, implementation issues surrounding the use of the audit risk model will not be discussed. The discussion of inherent risk assessment would proceed in the same manner independent of the form of the audit risk model.

There are three main steps to the risk assessment process. First, the auditor sets an acceptable level of audit risk. Many factors influence the level of audit risk acceptable to an auditor and this risk level may vary from entity to entity. Second, inherent risk and control risk are assessed. Finally, the level of detection risk needed to achieve the acceptable level of audit risk is established. Three main points should be noted. These are that 1) audit risk is set by the auditor for each audit; 2) inherent and control risks are uncontrollable by the auditor and therefore can only be assessed; and 3) detection risk is a residual value and its level is determined by the other three components of the model (Arens & Loebbecke, 1988).

The auditor achieves the detection risk level determined by the formula through the use of audit tests. The higher the level of tolerable detection risk, the less testing effort that is necessary to achieve the desired level of audit risk. Since audit tests are costly, the ability to increase tolerable detection risk has economic value for the auditor. Holding control risk constant, the lower the level of inherent risk, the higher the level of detection risk and therefore, the less costly the audit.

Audit risk assessment can be applied at two different levels: the financial statement level and the account level. This dichotomy recognizes that there are factors that affect the risk of auditing the entity as a whole (e.g. top management's integrity) and others that affect the risk of individual accounts or small groups of accounts (e.g. the complexity associated with calculating inventory valuation).

Both the ASB's pronouncements and the audit approaches of several large, international CPA firms call for the assessment of inherent risk at both these levels (AICPA, 1988a; Arthur Andersen & Co., 1983; Elliott, 1983; Grobstein & Craig, 1984; Peat Marwick International, 1985).

Risk assessment at the account level can be decomposed into finer levels. Each account balance on a financial statement represent a set of management assertions. These assertions include:

1. Existence or occurrence - the underlying economic object (assets, obligations and equities) represented by the balance does exist or the economic events that lead to the balance did occur.

2. Completeness - the balance reflects all such economic objects.

3. Rights and obligations - in general, that assets are owned and liabilities are owed as of the balance sheet date.

4. Valuation and allocation - calculations used to value the economic objects are based on appropriate procedures and assumptions.

5. Presentation and disclosure - account balances are properly classified and important issues footnoted. (Arens & Loebbecke, 1988)

By assessing inherent risk at this more detailed level, the auditor can develop more thorough estimates of risk levels and more thorough descriptions of sources of risk. Since the purpose of inherent risk assessment is to reduce, where possible, audit testing effort, a more detail inherent risk assessment can lead to more appropriate designs of audit testing procedures and more efficient and effective allocations of audit effort. For example, if the the auditor determines that the primary inherent risk of error in the inventory account is that account's complex valuation calculation, an audit testing plan that places more emphasis on testing the valuation calculation and less on testing the physical count will be more efficient and effective in dealing with that risk than an auditing plan that increases all aspects inventory testing effort by increasing sample sizes for all inventory related tests.

To summarize, when expressing an opinion on a set of financial statements, an auditor accepts a certain level of risk that that opinion may be inaccurate. The auditor reduces achieved audit risk to that acceptable level through the execution of certain tests of the accounting information system and account balances. The nature, timing and extent of those tests is influenced by the auditor's assessment of the inherent and control risks associated with each audit. Therefore, auditors assess inherent risk in order to make audit testing procedures more efficient and effective.

2.2.2 NATURE OF AUDIT TESTING

Determination of an audit testing plan involves determining the **nature, extent** and **timing** of audit tests to be employed. The **nature** of audit tests refers to different procedures that can be used to gather different classes of evidence. Arens and Loebbecke (1988) describe seven classes of evidence: physical examination, confirmation, documentation, observation, inquiries of the client, mechanical accuracy verification and analytical procedures. Each class differs in terms of its competence and cost. Determining the nature of the audit tests to include in a testing plan involves two considerations: 1) matching the management assertion that needs to be confirmed with the specific evidence provided by a given test and 2) matching the level of competence associated with evidence provided with the risk level associated with the given account balance.

The nature of the audit test varies with the situation. For example, if the auditor is concerned about the ownership and valuation of the client's accounts receivable, (s)he would probably select an audit test that included direct confirmation from the customer as one of the tests in the audit plan. This is because such a test would provide direct, third party evidence as to the ownership and value of a given account receivable. However, if the auditor were concerned with the completeness of the accounts receivable balance, a review of sales transactions would provide better evidence than direct confirmations since a confirmation sample would have to be drawn from the audited entity's potentially incomplete listing of their accounts receivable. Consequently, omitted receivables, the main focus of the completeness assertion, would not be covered by the sample.

Extent refers to the degree to which a given test will be performed and usually involves the determination of sample size. **Timing** refers to when a given test will be performed. Since an audit covers a specific period of activity ending on a specific date, the timing of audit tests affects the usefulness of a test's results. Tests can be performed during or after the accounting period but tend to provide stronger evidence when performed closer to the end of the period for which they are performed. For example, if the risks associated with a given balance sheet account are high, auditors tend to perform tests associated with that account close to the accounting period ending date. However, if risks associated with a given balance sheet account are low, they would attempt to perform some of their tests of that account prior to the end of the accounting period to allocate audit effort more evenly over time and thus reduce the need for overtime.

The main point of this discussion is that the selection of an audit testing plan is a complex process that involves understanding both the specific nature of potential sources of error in a given account and the specific characteristics of different audit tests. Test selection consists of matching the characteristics of various tests with the characteristics of potential sources of errors in a given account balance for a given entity for a given period of time. The more specific the information included in the inherent risk assessment about the nature of potential error sources the more effective that assessment will be in helping the auditor to make a better match.

2.2.3 ALTERNATIVE CHARACTERIZATIONS OF INHERENT RISK ASSESSMENTS

Inherent risk assessments have been characterized in two ways in the professional and academic literatures: as a quantitative assessment of subjective prior probabilities and as a qualitative identification of potential errors. These two characterizations are not mutually exclusive. However, bringing the two viewpoints together into one risk assessment is difficult because of the difficulty in combining a list of potential sources of error, some of which may be quantifiable and some of which may not, into a point probability estimate. In addition, the two characterizations of inherent risk assessment have different implications for the auditor's information processing capabilities. The quantitative approach implies producing numerical estimates that are used as input into a quantitative probability revision process, usually Bayesian. The qualitative approach implies reasoning with detailed causal models to identify specific potential errors given existence of specific factors. Consequently, the literatures based on these two characterizations have not merged and appear to represent independent approaches to the study of inherent risk assessment.

2.2.3.1 THE QUANTITATIVE VIEW

The quantitative view is closely tied to surface characteristics of the AICPA's audit risk model presented earlier. On the surface, the audit risk model implies that the determination of overall audit risk is a multiplicative relationship between conditional probabilities as would be expected if a Bayesian probability revision process were being employed. However, the AICPA clearly states that the model should be viewed as a conceptual framework and that qualitative risk assessments are also acceptable (AICPA, 1983).

The quantitative view characterizes the audit process as decision making under uncertainty where auditors must make decisions between different courses of action (audit reports) that have different probabilities and costs of error. The primary model used to study decision making under uncertainty has been the Subjective Expected Utility (SEU) model (Boritz et. al., 1986). An audit risk assessment is characterized as subjective prior probability that is updated with inherent and control risk assessments and audit testing results (Felix & Kinney, 1982).

The accuracy of the quantitative view as a descriptive or even normative model of audit risk assessment is unclear. The results of two major studies provide conflicting opinions of the auditor's ability to make the kinds of judgments required by a quantitative view of the risk model. Jiambolvo and Waller (1984) conclude that "... auditor's intuitive combination of the risk components did not correspond closely with the kind of combination dictated by the risk model in SAS 39." However, Libby et. al. (1985) conclude that "[i]t is refreshing that auditor subjects' performance so closely matched predictions from the audit risk model." Boritz, et. al. (1986) provides an extensive discussion of the audit judgment literature which includes the use of the risk model and concludes that there is substantial evidence that auditors do not conform to the SEU model when performing audit judgments. Thus it would appear that the quantitative view does not have strong empirical support as a descriptive model.

One possible problem with the quantitative approach is that SEU theory represents a single person game against nature and implies that the management of the audited entity will not alter their behavior due to the fact that they are being audited (Fellingham & Newman, 1985). Fellingham and Newman present an alternative view that takes into consideration management's reactions to the audit in determining what testing strategies auditors might select. Fellingham and Newman's main conclusion is that the two person game theoretic formulation supports auditors occasionally employing random strategies where as the SEU approach implies that random strategies would be suboptimal. If auditors, indeed, consider management's reactions in determining audit strategies it could lead to risk assessment results that differ from the SEU model.

The quantitative view has been exclusively discussed in the academic as opposed to professional literatures and appears to represent a prescriptive as opposed to a descriptive framework. In contrast, the qualitative view has been presented both prescriptively and descriptively and has been discussed in both academic and professional literatures. Although the qualitative view is not presented explicitly in either the academic or professional literatures, Graham (1985a) expresses concern that attempts at quantification of risk levels could divert attention from important qualitative factors that affect risk.

2.2.3.2 THE QUALITATIVE VIEW

The qualitative view sees the inherent risk assessment process as providing detailed, causal information that can be used to help the auditor select from a large menu of audit tests in order to effectively and efficiently achieve the desired level of detection risk. A qualitative approach is implied by the documentation procedures discussed in both professional and academic literatures (see Graham, 1985b; Grobstein & Craig, 1984; and Peat Marwick International, 1985). These authors present documentation approaches for inherent risk assessment that involve verbal descriptions of situations and events that could potentially affect the error potential of a given account. Although an overall risk level assessment is also called for in the audit approaches being discussed, the level is limited to the qualitative values of "high", "medium" and "low" (Grobstein & Craig, 1984 and Peat Marwick International, 1985).

2.2.3.3 NATURE OF INHERENT RISK ASSESSMENT SUMMARY

Of the two views of inherent risk assessment discussed above, the qualitative view appears to predominate in the professional literature. This literature has a more direct impacts on the auditor's task environment. The qualitative emphasis in the professional literature appears to be due to the richer data set provided by a qualitative assessment of inherent risk. If inherent risk assessment were limited to a point estimate of error probability as implied by the quantitative view, the auditor would be provided with little guidance as to which tests would be best to counter a given instance of inherent risk. All the quantitative approach gives the auditor is a general indication of how effective the audit tests must been in order to counter inherent risk. Granted, this general indicator would represent an formal, quantifiable combination of inherent and control risks, assuming it were based on Bayesian probability revision. But the trade-off for such quantitative precision is a lack of useful information on how to operationally deal with the risk since the goal of the auditor is to control audit risk, not just estimate it.

2.3 INHERENT RISK ASSESSMENT PROCEDURE

The preceding section discussed the nature of the output of the inherent risk assessment process, i.e. the inherent risk assessment itself. This section reviews the academic and professional literature for information on how that output is generated. The discussion is broken into two parts: a review of the inputs or factors that are used to assess inherent risk and the processes used to combine those inputs.

2.3.1 INHERENT RISK FACTORS

Lists of factors that affect inherent risk assessments can be found in both the professional and academic literature. The professional sources are prescriptive in nature and cite factors that auditors should consider (AICPA, 1988a; Graham, 1985; and PMI International, 1985). The academic literature tends to be more descriptive in nature and attempts to identify what factors auditors actually use to assess inherent risk (Boritz, et. al., 1986; Colbert, 1988; and Gibbins & Wolf, 1982). Table 1 presents a categorized listing of all the factors mentioned in a representative sample of the professional and academic literature reviewed for this research project. These categories are consistent with a classification scheme presented in SAS 53 (AICPA, 1988a). Each factor is followed by a number that refers to the publication in which it was mentioned.

TABLE 1 Listing of Inherent Risk Factors

Financial Statement Level

Management operating and financing decisions are dominated by a single person (2)

Management's attitude toward financial reporting is unduly aggressive (2)

Management turnover is high (2,6)

Management places undue emphasis on meeting earnings projections (2)

Management's reputation in the business community is poor (2)

Quality of management, accounting staff and accounting system (5)

Profitability of entity relative to its industry is inadequate or inconsistent (2, 5)

Rate of change in entity's industry is rapid (2)

Direction of change in entity's industry is declining with many business failures (2)

Inventory position is weak (4)

Decentralized organization with weak monitoring (2)

Significant financial pressure (2, 4, 5, 6)

Many difficult accounting issues are present (2)

Significant difficult to audit activity (2)

Problematic related party transactions (2)

Significant misstatements in prior year's audit (2)

Audit opinion to be used in a prospectus (4)

New client with no insufficient audit history (2)

The control environment (3, 4, 5)

Existence and quality of internal audit staff (5)

Plans for large sale or major refinancing (5)

Account Level

Magnitude of account balance (1)

Susceptibility of asset to theft (1, 3)

Complexity required to determine amounts to be entered in the account (1, 3, 6)

Degree of management judgment involved in valuing the account (1, 3)

Degree to which external events affect values in the account (1)

Past history of error (1, 4)

Degree to which client's financial condition motivates management to misstate the account (1)

Sensitivity of operating results to economic factors is high (2)

Experience of the personnel involved in accounting functions involving the account (1, 5)

Volume of transactions associated with the account (3)

Sources:
1 - PMI International, 1985
2 - AICPA, 1988a
3 - Graham, 1985b
4 - Boritz, et. al., 1986
5 - Gibbins & Wolf, 1982
6 - Colbert, 1988

Several conclusions can be drawn from the factors listed in Table 1.

1. The ease with which various factors can be quantified varies considerably. For example, the fact that management's operating and financing decisions are dominated by one person may be much more difficult to quantify than the entity's relative profitability.

2. Different factors can affect more than one different management assertion. For example, the incentives of management to misstate an account balance may affect valuation, completeness, ownership or timing depending on the circumstances.

3. The number of factors that affect a given account balance for a given audit period is potentially large and the nature of the factors potentially diverse. A large subset of the financial statement level factors could exist in any given year. These factors may affect nearly all the accounts being audited to some degree. In addition, a significant subset of account level factors could also affect a given account in a given audit period.

4. Inherent risk factors include consideration of the internal control environment which implies that control risk and inherent risk are not independent.

5. Management's incentives to misstate an account balance are a major inherent risk consideration.

Researchers have attempted to empirically identify factors that affect error rates by analyzing audit working papers to determine levels of association between risk factors and detected errors. Hylas & Ashton (1982) found significant, positive relationships between quality of personnel, cutoff problems and characteristics of the industry and error rates. Johnson (1983) found that the quality of the internal control system, financial pressure and turnover of the chief financial officer was significantly related to error rates.

Ham et. al. (1985) found interactive effects between account type and firm specific and industrial factors and error rates. Accounts receivable and accounts payable errors were more closely linked to firm specific factors and purchasing errors were more closely related to industrial factors. Willingham and Wright (1984) found mixed results when they studied the association between 55 factors and error rates. Some of the factors were significantly and positively related to errors, others were negatively related and others were not related at all. The results of these studies appear to imply that the relationship between various factors that could affect error rates and the incidence of error is not straightforward and may vary over time and by account, firm and industry.

While the results of this research have provided some insight into what factors are associated with errors, the relationship of those results to inherent risk assessment is unclear. The dependent variable is all cases was detected errors, that is, errors that existed in the account balances, which were not detected by the internal control system but were detected by the auditor's tests. However, inherent risk assessment involves determining the possibility of error given no system of internal controls and no audit test. Thus the results of these studies could be biased indicators of inherent risk potential if some errors are more or less likely to be detected by internal control systems and audit tests than others.

2.3.2 PROCEDURES FOR COMBINING RISK FACTORS

The previous discussion of the factors that can create errors implies that risk factor processing procedures may potentially have to combine large sets of diverse inputs that vary greatly in terms of their quantifiability. This same conclusion was reached by Colbert (1988a) after a review of the relevant literature. The discussion on the nature of a inherent risk assessment presented in Section 2.2.3.3 implies that auditors would be better served if the output of the assessment process provided detailed information that allowed the auditor to determine the impact of various risk factors on individual management assertions. Taken together, these implications lead to a picture of a complex, flexible information process that maintains explicit linkages between inputs and outputs.

There has been only one study in the accounting literature that looked at the inherent risk assessment process. In that study, Colbert (1988b) used a Lens model approach. She gave auditors cases containing four factors that had been identified in the literature as effecting inherent risk; two financial statement level and two account level relating to inventory. Each factor was described in such a way as to imply either a high or low rating. The auditors were asked to rate the inherent risk of the inventory account on a nine point scale and then rank the relative importance of the four factors by distributing 100 points among them. The main effects for all four factors were statistically significant in determining risk levels but no interactions were significant.

This study tells us very little about the risk assessment process. First, Colbert did not discuss whether a quantitative assessment of risk (i.e. rating on a nine point scale) was a reasonably realistic reflection of what a risk assessment looks like in practice so it is unclear whether the study had external validity. Second, she used the inventory account as the basis for the test and did not report the absolute risk levels assessed by the subjects. Inventory is a risky account in most audits and it would have been informative to see if there was much variation in risk assessments across cases. Finally, use of the Lens model approach and an ANOVA data analysis technique assumes that the factor combination process is a simple, linear model. The study would have been more useful had it confirmed that assumption by studying the factor combination model directly to determine its nature.

2.3.3 SUMMARY OF THE PRELIMINARY INHERENT RISK ASSESSMENT TASK ANALYSIS

The review of the professional and academic literatures has led to several conclusions about the nature of the inherent risk assessment task and the constraints the task places on the auditor. These conclusions include:

1. The goal of the inherent risk assessment process is to provide useful information for the audit test selection process.

2. To be useful, the input into audit selection process should not only provide some indication of

the likelihood of error but also some details as to reason for the error, i.e. some type of causal explanation.

3. These causal explanations imply knowledge of the nature of economic activity in which the entity is involved, the nature of economic transactions that result in account balances, the types of management assertions implied by account balances, and the types of audit tests normally used by auditors and the nature and competence of the evidence they produce.

4. The factors that can cause errors are many and diverse. Some of these factors can be easily quantified while others can not. The process used to combine these factors has not been studied and is not very well understood. However, evidence indicates that this process needs to be complex and flexible in order to deal with diverse inputs and provide both an indication of overall risk and a causal explanation of the source of risk.

5. People are important factors in inherent risk assessment because they can either intentionally or unintentionally create errors.

CHAPTER 3

DATA ANALYSIS AND CONCEPTUAL MODEL DEVELOPMENT

The empirical data collection and analysis phase of this research project was an extension of the preliminary task analysis presented in the previous chapter. That preliminary analysis led to a list of factors that appeared to affect inherent risk levels; some general observations about the nature of the process used by auditors to link those factors with risks in specific audit situations; and some general conclusions about the form of an inherent risk assessment. The next phase of this research project was to gather empirical data that would provide more direct evidence to which factors auditors attended in assessing inherent risk; provide a more detailed description of the processes used by auditors to evaluate and to combine those factors into risk assessments; and to provide a clearer picture of what form inherent risk assessments take in actual practice.

The goal of the empirical data collection and analysis phase is to produce a conceptual model of auditors' inherent risk assessment processes. This model specifies the classes of information and information processing procedures used by auditors when they assess inherent risk.

The balance of this chapter is broken into four sections which provide a detailed, chronological discussion of the data collection and analysis phases of this research. The first section presents an overview of the research methods employed in this and other similar research projects in accounting and auditing. The second section describes the collection and analysis of empirical data which led to the development of the first prototype system as well as a description of that system. The third section describes how that initial system was refined and revised based on auditor feedback. The final section presents the conceptual model that resulted from these data gathering and analysis efforts.

3.1 OVERVIEW OF RESEARCH METHODOLOGY

Most of the research projects in accounting and auditing that have endeavored to build complex models of judgment processes have concluded with the development of a computational model (computer system) or expert system of that process.[4] The process followed in these projects

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[4]Although this research project is designed to build a psychological model and not an expert system, the distinction between a computational model of a judgment task and an expert system is not clearly defined. The main distinction is based on the ultimate purpose of the research. Psychological model builders are more concerned with faithfully modeling the underlying knowledge representation and psychological processes used by the subjects they study. Expert systems developers are more concerned with developing a useable product that produces
(Footnote Continued)

begins with general, loosely structured approaches and proceeds to more precise approaches that often include a series of iterations between model evaluation and model enhancement.

The earliest example of this process can be found in the work of Clarkson (1962). Clarkson's data gathering employed a multi-method approach that included review of the professional literature; review of notes, documents and working papers of experts; interviews with experts; and case evaluation sessions that included the collection of concurrent verbal protocols. The use of a multi-method approach allows the researcher to alter data gathering and analysis techniques as the modeling issues become more clearly defined and to compensate for inherent weaknesses in one method by gathering additional evidence with other methods.

Literature reviews and unstructured interviews are useful in the early phases on the research when a general understanding of the problem definition and task environment

(Footnote Continued)
practical and reliable results. Even though the goals of these two approaches appear to be quite different, they have much in common. Normally, the better an expert system models actual human behavior, the more acceptable it will be to users. Conversely, more useable output from a psychological model normally indicates a better underlying model of the psychological processes that produced the output. Since the two approaches have much in common, particularly in terms of data gathering and analysis, no further distinction between these two types of research will be made in this thesis.

are being developed. Reviews of existing professional literature provide the researcher with a broad understanding of how the profession characterizes the particular problem under study, how that problem fits into a larger context of professional issues and what guidelines the profession has established for dealing with the problem. The researcher can use this information not only to help structure more precise data gathering but also to improve communication with and understanding of expert subjects.

Document reviews and unstructured interviews provide the researcher more direct evidence on what data and problem solving methods experts use to solve the problem under study. Document reviews give the researcher more detailed and complete data than is available in the professional literature because they normally cover actual cases in their entirety. Unstructured interviews allow the researcher to probe for more detailed explanations of problem solving methods. A key element of literature reviews, document review and unstructured interviews is that they are relatively unobtrusive and do not inject any _a priori_ models into the research.

3.1.1 REVIEW OF ACCOUNTING AND AUDITING EXPERT SYSTEMS DEVELOPMENT METHODS

Nearly all the expert system development projects in accounting and auditing began with unobtrusive and loosely structured approaches (Biggs & Selfridge, 1986; Clarkson, 1962; Dungan & Chandler, 1985; Gal, 1985, Meservy, 1985;

Messier & Hansen, 1986; and Steinbart, 1987). These initial, loosely structured data gathering methods are usually followed by the development of a model of the process under study. These models are frequently implemented as computer programs. The use of a computer program as a modeling medium forces precision on the modeling process and allows for easier interaction between the subjects and the model. Several researchers developed case studies along with the system. They used these case studies to elicit concurrent verbal protocols from subjects. These protocols were compared to a trace of the model's behavior to assist in refining the initial model (Bouwman, 1987; Clarkson, 1962; Kelly, 1985; and Meservy, 1985). A particularly creative application of this general approach was used by Shpilberg and Graham (1986). They had experts sit behind a curtain and simulate a computer's responses as those experts assisted a less experienced auditor performing an income tax accrual task. The entire session was videotaped for later analysis.

The initial models are normally refined by asking experts to interact with the computer systems that reflect the models and to evaluate the system's performance. The level of this interaction can be direct or indirect. Direct interaction involves the expert making changes directly to the program's knowledge base using an editor (c.f. Steinbart, 1987). Indirect interaction involves the researcher making those changes based on input from the expert. The refinement process is usually iterative and involves several cycles between expert feedback and program refinement.

Once the expert and researcher feel that the model is performing satisfactorily, more formal validation procedures are typically applied. If process tracing data (e.g. concurrent verbal protocols) is available, then both the process and output of the program can be compared to the process and output of expert subjects performing the same task (c.f. Bouwman, 1978 and Meservy, 1985). Since these research projects all study complex decision tasks for which there are no normative models, the program's output is usually evaluated by having experts who were not involved in the model's development evaluate the model's conclusions. Sometimes this evaluation is on a blind basis. In this case, the judge or panel of judges perform relative evaluations of the model's conclusions and human subjects' conclusions without knowing the source of the conclusions (e.g. Meservy, 1985). One expert systems development project also tested the system's effect on auditor judgments when it was used as a decision support system (Hansen & Messier, 1986).

3.1.2 EVALUATION OF RESEARCH METHODS USED IN PRIOR STUDIES

The preceding discussion illustrates the variety of data gathering and analysis techniques that have been used to develop expert systems in accounting and auditing and the importance of a multi-method approach. Multi-method approaches allow the researcher to trade-off the inherent strengths and weaknesses of each individual method.

Document and literature reviews deal with archival data and therefore are totally unobtrusive and do not suffer from **demand effects. Demand effects** refers to the propensity of human subject to give rational explanations for their behavior when asked by researchers even though those reasons may not reflect the reasons they considered at the time of their behavior. However, the evidence contained in documents and professional literature may also be biased or incomplete. For example, there still may be large differences between what people admit to in writing and what the actually do. In addition, professional standards are usually written for a dual audience: consumers and regulators of professional services and the professionals themselves. These standards are often general and vague so as to present the image of standard setting and guidance without unduly constraining professional behavior.

In auditing research, the document reviews typically involve working papers. Auditors receive considerable training in good working paper techniques and great emphasis is placed on their accuracy and completeness. Extensive review procedures have been implemented by CPA firms to insure audit quality and working papers are the main information source for these reviews. In general, audit working papers represent a detailed, accurate and complete record of audit procedures performed, evidence gathered and conclusions drawn by auditors during the execution of an audit. However, these working papers are not covered by privileged communication laws and can be subpoenaed in case of a lawsuit. Therefore, auditors normally take great care in how they present their working papers and what comments they include in them[5]. In addition, information contained in the literature and in documents may be incomplete and may need further explanation.

In spite of these potential problems, the professional literature and audit documents and working papers provide a rich source of information for researchers. The literature provides a prescriptive picture of how the profession feels an audit task should be performed and represents a standard by which auditor performance is judged. Document reviews provide objective evidence of what actions were actually taken as the audit task was being performed. Both these sources can provide the researcher with relatively cheap information because they do not involve using experts' time.

Interviews and retrospective protocols suffer from the problems of **demand effects** and **reconstructive memory** (Nisbett & Wilson, 1977 and Norman, 1983). **Demand effects**

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[5]For example, when I asked an auditor why there was no explicit link between the inherent risk level shown on one working paper to the factors that led to the determination of that risk level, he responded that the linkage was highly judgmental and that the partner in charge of the audit did not want the reasoning documented so he could avoid having to explain it in court, should that ever be necessary.

are partially caused by the subject's desire to make a favorable impression on the researcher based on the subject's understanding of the researcher's goals. For example, the author arrived early for an interview which was scheduled for early one Monday morning and noticed the subject coming into the office carrying a copy of the CPA firm's audit manual. It is highly unusual for audit managers to take audit manuals home over the weekend. The most likely reason that the subject took the manual home was to prepare himself for the interview.

Another problem with interviews and retrospective protocols stems from the **reconstructive** nature of **memory**. Humans tend to reconstruct memories based on prototype memory structures as opposed to recalling detailed accounts of the behavior that actually occurred (Anderson, 1980). Consequently, subjects may indicate how they think they would have acted in a given situation as opposed to how they actually acted. However, interviews and retrospective protocols give subjects considerable latitude in expressing their understanding of the problem and their approach to solving it. These methods also allow the researcher to interact with the subject and clarify points.

The strengths and weaknesses of concurrent verbal protocols have been discussed at length in psychology and accounting (c.f. Anderson, 1984; Boritz, et. al., 1986; Ericsson & Simon, 1984; and Norman, 1983). The main problems with protocols is that they may be incomplete; the verbalization process may alter the underlying cognitive processes of interest; they produce data that consists of a listing of what the subject did and in what order, but may not indicate the reasons for the subject's actions or the cognitive processes that were at work[6]; and they generate large volumes of data that is physically difficult to analyze and manage. In addition, protocols are normally based on case studies. Since human behavior tends to be highly task sensitive (see discussion in Section 2.1.1), great care must be taken in developing the cases used to insure that those cases are realistic and capture the problem under study. The main strengths of protocols is that the are a direct record of reasoning processes that give descriptions of activities rather than explanations and are therefore less susceptible to demand effects than interviews or retrospective protocols.

3.1.3 SUMMARY OF RESEARCH METHODS USED IN THIS STUDY

This study employed an inductive, multi-method approach similar to those discussed above. An inductive approach was adopted because the lack of existing theories on inherent risk assessment. A lack of developed theory implies the need for an inductive or grounded theory approach to theory

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[6]This characteristic may account for the difficulty Biggs et. al. (1985) had in using concurrent verbal protocols to identify the rules used by subjects to evaluate EDP systems.

development (Glaser & Stauss, 1967). A multi-method approach was adopted for the reasons cited above.

The first step was to review the extant professional and academic literature in order to develop an initial task analysis. The results of this review are described in Chapter 2. Second, a review of relevant documents and manuals from two "Big Eight" CPA firms was performed to obtain background information on their respective audit approaches, the role that inherent risk assessment played in their audit approaches and any firm policies on how inherent risk was supposed to be assessed and documented. Third, unstructured interviews were conducted to obtain expert auditors' opinions on inherent risk assessment and to assist in developing a plan to study the process. Fourth, the background data gathered in the first three steps were used to develop scenarios for more structured interviews with experienced auditors. The scenarios for these interviews included retrospective reviews of actual working papers, role playing exercises involving actual client data and the unobtrusive observation of actual audit planning meetings.

The fifth step in the project consisted of analyzing the data collected in the first four steps and developing the initial conceptual model. This conceptual model was used to develop a system which was reviewed and evaluated by auditors. Up to this point, data collection had involved two CPA firms and nine subjects. Two subjects in one CPA firm were selected to help refine the computational model.

Data collection was limited to one CPA firm to avoid cross cultural differences between firms. Since these cross cultural differences primarily involved differences in documentation methods, this limitation should not have a major impact on the generality of this research's findings.

The author worked with each subject to develop a separate case based on one of his clients. The case development process was iterative and involved several meetings between the author and auditor to present modified versions of the system and obtain the auditor's feedback. Once the subjects felt the system was appropriately analyzing the key issues in the case, they were asked to evaluate the system's performance using questionnaires that provided some structure to the evaluation (see Appendix E for a copy of those questionnaires). The subjects evaluated three cases, one they had helped prepare, one the other subject had helped prepare and one prepared by the author. Their responses are included in Appendix G and discussed in Chapter 7. The balance of this chapter presents a detailed discussion of each of these steps as well as a description of the conceptual models that resulted from these steps.

3.2 THE INITIAL PROTOTYPE SYSTEM

3.2.1 DOCUMENT REVIEWS

The document review phase began with the audit manuals of the two participating CPA firms. These manuals provided theoretical discussion on the role in the overall audit process of inherent risk assessment, lists of factors that affected inherent risk, discussions of the responsibilities of various members of the audit team and descriptions of documentation standards for inherent risk assessment. In auditing, documentation usually involves preparing working papers that indicate the steps taken, information reviewed and conclusions drawn from a particular audit procedure. In many cases, blank working papers are provided by firms. These blank working papers help structure the audit procedures being performed. Therefore, blank working papers used to document inherent risk assessments were also reviewed.

The document review phase resulted in a comprehensive picture of how each CPA firm treated inherent risk assessment within their respective audit approaches. The main conclusions drawn from this phase were:

1. Inherent risk assessment was performed every year and was used during audit planning to identify areas within the client firm that would need different, typically increased, audit attention in the current year compared to the prior year. Inherent risk assessments changed from year to year based on changing circumstances.

2. Inherent risk assessment was documented in different ways by the two firms. One firm required a verbal description of the risk and how potential risk was to impact on audit procedures. The second firm required a rating of the risk level, either high, medium or low, on one working paper with an identification of critical and significant factors that affected the audit on another. The factors were never explicitly linked to the ratings.

3. There were no policies or procedures that specified how inherent risk was to be assessed;

however, examples of factors that affected risk were provided.

4. The primary responsibility for risk assessment rested with the audit manager and in-charge accountant.[7]

3.2.2 UNSTRUCTURED INTERVIEW

The unstructured interviews were designed to fulfill two functions: to introduce the researchers to key members of the audit firms involved and to confirm and expand the conclusions drawn from the document review. The first interviews occurred prior to the document review, were more introductory in nature and resulted in access to audit manuals and blank working papers. However, the participants in these introductory interviews were also asked to discuss the CPA firm's overall approach to auditing and audit planning. Issues of client confidentiality were discussed when it became clear that access to firm policy and procedure manuals and confidential client working papers would be required during the research project. In the case of one of the firms, the author was asked to sign a nondisclosure agreement.

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[7] Professional staff in CPA firms are organized in a hierarchical structure from junior accountant to partner. The levels include junior accountant, senior accountant, in-charge or supervising senior accountant, manager and partner. The manager is primarily responsible for general engagement staffing and planning and supervision and review of the field work. The in-charge accountant is responsible for developing detailed time budgets and audit programs and supervising the day to day activities of the junior and senior accountants in the field.

A second group of interviews was conducted after the documents had been reviewed. In these interviews, the subjects were asked to discuss their firm's approach to audit planning and inherent risk assessment. Frequently during these discussions the subjects would draw on personal experiences to illustrate how certain factors affected the audit procedures used in specific cases.

All the interviews were tape recorded and a transcript of each interview was produced. These transcripts were reviewed and the following conclusions drawn:

1. The conclusions from the document review phase were confirmed.

2. Inherent risk assessment involves considerable judgment on the auditor's part and auditors tend to draw on an extensive set of personal experiences to make those assessments.

3. The inherent risk assessment process usually occurs over an extended period of time. The auditor uses observations made during meetings with clients, reviews of client documents and financial data as well as discussions with other audit team members as input data for the risk assessment process.

4. The list of specific factors that affects inherent risk assessments was expanded based on the specific examples used by subjects to illustrate their points.

3.2.3 STRUCTURED INTERVIEWS

The next problem addressed by the research project was how to observe the inherent risk assessment process directly. Although the process of documenting risk assessments by filling out working papers was an observable activity, the assessment process itself was relatively ill-defined, occurred over an extended period of time, and was not typically documented as it was being performed but was documented after major conclusions had been drawn. Therefore, it was impractical to attempt to observe auditors assessing inherent risk during actual audit engagements. Instead, three different scenarios in which fairly concentrated discussion of inherent risk assessment would occur were selected based on the general understanding of each CPA firm's audit process obtained during earlier phases of the research, consultation with subjects and the author's own audit experience. These scenarios included: 1) retrospective review of audit planning working papers, 2) transfer of a client from one audit manager to another and 3) audit planning meetings between audit team members. In all cases these scenarios involved actual clients and, except for one of the two planning meetings observed, were tape recorded and transcribed[8].

3.2.3.1 RETROSPECTIVE PROTOCOLS

The retrospective protocol scenario consisted of an audit manager going through an extensive review of a set of audit planning working papers. One audit manager reviewed the working papers from two recent audits. The researcher

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[8]After the transcript of the first planning meeting had been produced and a copy send to the engagement partner involved, the partner decided that the issues being discussed were too sensitive and requested that no further tape recordings be made. The author took field notes during the second planning meeting and summarized those notes immediately following the meeting.

who was present at the meetings asked questions that were designed to identify what factors affected inherent risk in that specific audit, how the auditor became aware of those factors, how those factors affected risk and why they were important. The data gathered from these sessions is subject to the problems of retrospective protocols discussed in Section 3.1.2. However, the problems of demand effects and reconstructive memory were somewhat mitigated by the presence of documents that were prepared at the time decisions were being made (i.e working papers). As discussed in Section 3.1.2, these working papers normally represent detailed, complete and accurate records of audit activities and conclusions. By having the working papers present during the session, the subject was more likely to produce an accurate recall of the inherent risk assessment judgments (s)he made while planning the audit.

3.2.3.2 CLIENT TRANSFER EXERCISE

The client transfer scenario involving audit managers was selected because it represented an activity that normally occurred within CPA firms and that involved extensive discussions of inherent risk factors. Members of an audit team are periodically rotated by CPA firms in order to preserve auditor independence. Much of the credibility of CPA firms as external auditors lies with their independence from the audited entity. CPA firms feel that members of the audit team should not serve too long on the same audit because of the risk of developing too many close, personal relationships. Because of the audit manager's key role in planning and supervising the audit, whenever managers are rotated, the outgoing manager usually briefs the incoming manager on key audit issues. These audit issues usually include inherent risk factors.

The advantages of this scenario over the retrospective protocol scenario were that two experts representing potentially different views of inherent risk were involved and the data were collected concurrently with the problem solving activity. The audit manager who played the role of the outgoing manager was told to select a client as the subject of the session, select an audit manager to play the role of the incoming manager and to bring any documents that he would normally use in a similar circumstance to the meeting. The outgoing manager was asked to select an incoming manager who would have the necessary qualifications to actually take over the client, e.g. experience in the client's industry.

One client transfer session was used. The session involved two auditors from the same CPA firm that provided subjects for the retrospective protocol sessions. The outgoing auditor had been involved in an unstructured interview, the incoming auditor had not been involved in the research project prior to this exercise. The session consisted of the outgoing audit manager going through the working papers that he had selected and discussing key issues with the incoming manager while the incoming manager asked questions. In this scenario, the researcher present deferred from asking questions until the two subjects had concluded their discussions. The researcher's questions involved clarifying the reasons certain items were or were not considered risky. Both participants felt that the scenario was very realistic and the incoming manager indicated at the end of the session that he was ready to proceed with initial planning for the job.

3.2.3.3 AUDIT PLANNING MEETINGS

One CPA firm, which had not provided subjects for the two structured interview scenarios discussed above, had a practice of conducting regular audit planning meetings, called general risk assessment meetings, that involved the engagement partner, manager and in-charge accountant. Two of these meetings were unobtrusively observed by the author. The author refrained from asking question during the meeting and conducted in depth interviews with each of the participants following the meeting. The main advantage of this scenario over the two discussed above was that the meetings were not staged for the purposes of this research, but were actual working meetings.

Although the meetings were fairly informal, the audit manager had prepared a written agenda for the meetings in advance and led most of the discussions during the meetings. The purposes of the meetings were to insure that all key members of the audit team were aware of the current status of the audit and were in agreement concerning key risks associated with the audit and how those risks were to be addressed. Although a broad range of issues were discussed, the primary focus of the meeting was 1) to identify issues that had come up during the prior year's audit, 2) to identify audit related events that had occurred during the year and 3) to determine how those issues and events should alter the audit approach in the current year.

3.2.3.4 STRUCTURED INTERVIEW CONCLUSIONS

The data collected from the structured interviews were analyzed in two steps. First, the transcripts and field note were read to provide some general conclusions on what was learned from this phase of the research. Second, formal data coding rules were developed and a more structured, comprehensive review of both the unstructured interview and structured interview data was performed. The results of the formal analysis and the conceptual model that was developed from that analysis are discussed in the next section. The initial conclusions that were drawn from the more general analysis of the structured interview data are summarized below:

1. Auditors appear to make linkages between risk factors and risk assessments based on a broad based knowledge of how businesses in general operate and characteristics of the specific audited firm.

2. People run businesses and therefore people have a strong impact on inherent risk. Auditors assume that if management is motivated to produce certain

accounting numbers, there is a risk that management will do so using unacceptable means.[9]

3. Expectations play an important role in directing the auditors attention toward potential problems. Auditors seem to form pictures of what the financial statements should look like based on knowledge of the audited firm's historic performance and changes in the firm's environment. They are concerned about deviations from that picture that they find in reviewing preliminary data.

3.2.4 DEVELOPMENT OF THE INITIAL PROTOTYPE SYSTEM

Once the series of structured interviews was completed and the transcripts were reviewed at a general level, a plan was developed to systematically analyze the data, develop a conceptual model based on that analysis and then program a system that would accurately reflect that conceptual model.

3.2.4.1 FORMAL ANALYSIS OF INTERVIEW DATA

The formal analysis of the data proceeded in two phases. First, the transcripts and field notes were reviewed to identify a comprehensive list of inherent risk factors that had been mentioned. This was accomplished by looking for explicit statements of the general form "I altered the scope on that account because ..." or "I felt that that account would be more risky because...". This review resulted in the development of an extensive list of items which was classified into three categories: financial statement level factors, account level factors and audit firm factors. This

[9] This finding is consistent with the game theoretic formulation used by Fellingham and Newman (1985).

classification scheme was developed by the author after reviewing the list of factors generated from the transcripts but is identical to the classification scheme subsequently published in SAS 53 (AICPA, 1988a). The results of this analysis is included in Appendix A. The list of factors and the classification scheme provided evidence concerning both the knowledge components involved in inherent risk assessment and the level of fineness or specificity with which auditors dealt with these components.

The second phase of data analysis consisted of reanalyzing the transcripts and field notes to determine why the factors in the list were important and how auditors made linkages between these factors and levels of inherent risk. The specific procedure involved locating places in the transcripts where inherent risk factors were mentioned and reviewing the surrounding text for any explicit comments about why the factor was important and how it affected risk. Such explicit comments were rare. Consequently, the bulk of the analysis in this phase involved inferring relationships between factors and risk assessments based on general business knowledge, and confirming these inferences with auditors.

For example, one subject stated that he had become a little more skeptical about management's judgments, particularly related to valuation accounts, when he discovered a potential management buyout plan. He went on to state that the audit scope for the valuation accounts (e.g. allowance for doubtful accounts) was increased in this case. The following inferences were made from these comments:

1. The auditor felt management motives were important in assessing risk because of the importance of management judgement in determining, and therefore potentially manipulating, certain account balances.

2. The auditor was using knowledge about the effects changes in valuation accounts would have on reported earnings, the relationship between reported earnings and stock prices, and the effect stock prices would have on the potential cost of a management buyout as a basis for developing his concern for the increased risk association with valuation accounts.

Comments of this type were important in helping to develop both the conceptual model and the assertions supporting it which are presented in the next section. In addition, an analysis of the inferred relationships led to the inclusion of a general model of fundamental economic relationships that exist within any firm as part of computational model which is described in chapters 4 through 6.

3.2.4.2 PRESENTATION OF THE INITIAL CONCEPTUAL MODEL

The results of all data analysis efforts discussed so far were brought together in a comprehensive conceptual model of inherent risk assessment. This model development process was subjective in nature and based on an effort to account for as many of the factors, linkages between factors and other conclusions drawn from the empirical data as possible. This section presents a description of that conceptual model. This model represents the first attempt in this study at developing a comprehensive model of inherent risk assessment and was revised during subsequent data gathering and analysis sessions. It is presented here in order to provide a more complete picture of how the final conceptual model, which is presented in Section 3.4, evolved. Since this initial model was significantly revised during the research project, the discussion here will be limited to describing this model in general terms. A more detailed discussion of this initial model and the empirical and theoretical support for it is presented in Dhar et. al. (1988) and Peters, et. al. (forthcoming). More detailed discussions of the theoretical and empirical support for the final conceptual model will be presented in Section 3.4.2.

Figure 2 presents a graphic representation of the model and is intended to provide a global view of the inherent risk evaluation process.

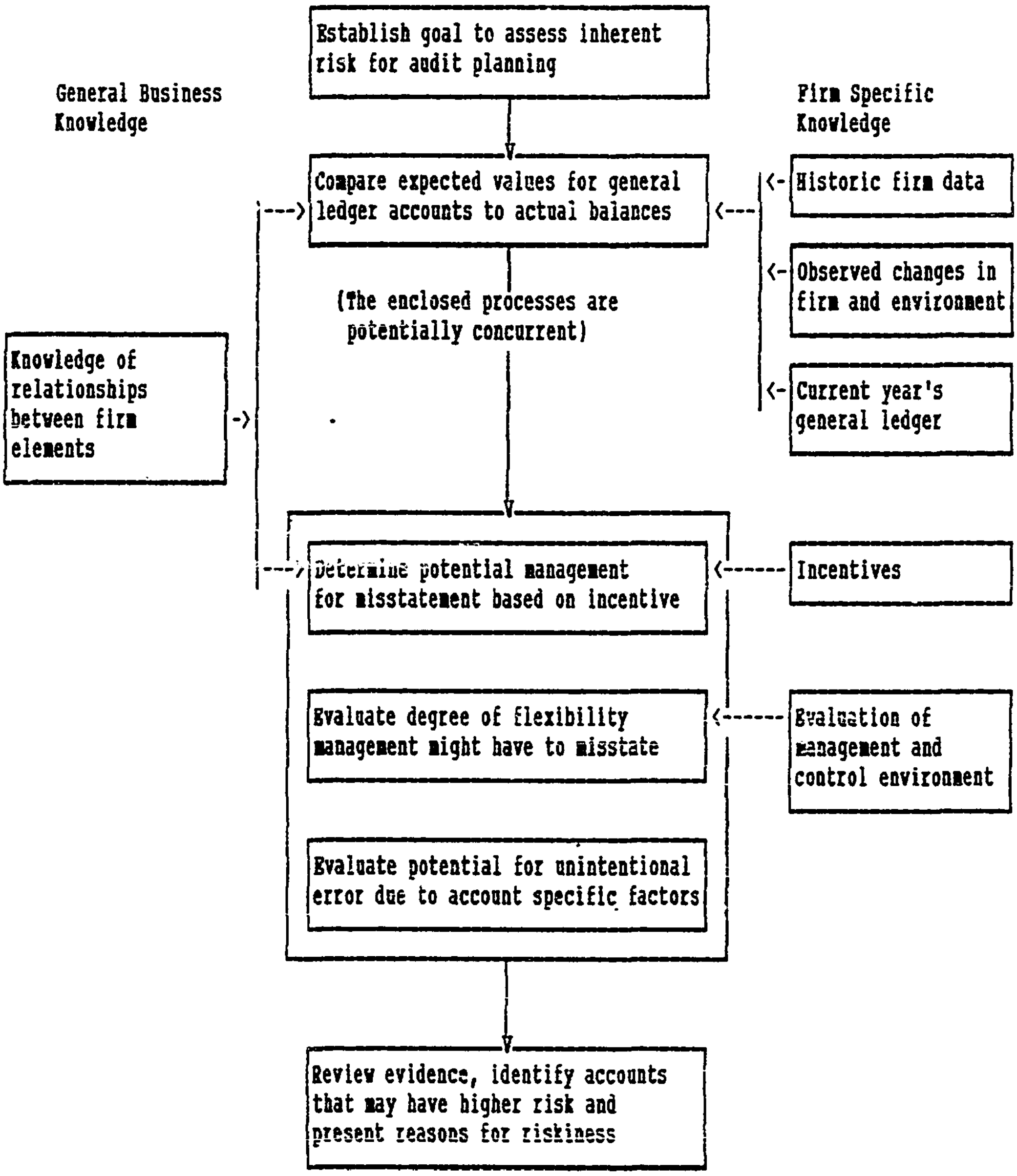

FIGURE 2 Initial Conceptual Model

The model asserts that the auditor begins the inherent risk evaluation process by generating expectations for account balances. The auditor identifies changes that have occurred in the firm and/or its environment and determines how those changes should interact with historic trends to produce an expected balance in the account. In order to do this, the auditor uses an understanding of the relationships between firm/environmental factors and general ledger accounts. These relationships constitute an internal model of the firm. The auditor uses this firm model to determine how changes should affect the balances in a given account.

This expectation generation and testing process was included in the model and identified as the starting point for inherent risk assessment based on three main classes of evidence. First, statements in the interview transcripts that referred to "gaining an understanding of the client's business" and "developing expectations" as a basis for inherent risk assessment were interpreted to imply both the existence of an expectation generation and testing process and the use of that processes by auditors as a starting point for inherent risk analysis.

Second, analysis of references in the interview transcripts to linkages between inherent risk factors and levels of inherent risk were used to infer that auditors were using a comprehensive firm model. For example, in the instance discussed in Section 3.2.4.1, the auditor's ability to predict how changes in valuation accounts affected reported earnings and subsequently stock prices implied that the auditor was using in his reasoning processes some form of comprehensive, internal firm model which contained explicit linkages between valuation accounts, expenses, net revenue and stock prices. Third, previous researchers have found evidence for the existence and use of internal firm models in similar tasks (Bouwman, 1983 and Selfridge et. al., 1986).

The model asserts that the inherent risk assessment process continues with an attempt to gather more data on expectation failures. For accounts that contain actual balances that are outside a reasonable range of the expected balance, the auditor reviews factors that might create or affect management's incentives to misstate the account balances (e.g. the existence of a compensation plan keyed to reported earnings). At the same time, the auditor considers factors that might affect the likelihood that management could or would deliberately misstate that particular account balance (e.g., the degree of judgment allowed in the determination of account balances). The auditor also would consider such mechanical factors as the complexity of the transactions, volume of transactions or complexity of reporting standards for a particular account since such factors might also be responsible for deviations from expected balances.

This expectation failure explanation process was included in the model based on two classes of evidence.

First, statements in the transcripts of unstructured interviews as well as discussions in the professional and academic literatures supported the inclusion of an analysis of management incentives in the model because these incentive issues were frequently mentioned in both places. However, these sources dealt with the incentive issue at a very general level. In case specific settings (i.e. structured interviews) incentive issues were not raised unless there was some specific evidence that those incentive issues were having an effect on account balances. Therefore, the model asserts that incentive issues are only raised if there are expectation failures to explain.

Second, a review of the complete list of factors included in Appendix A lead to the conclusion that most of those factors contributed to unintentional error potential. However, there was little evidence in the transcripts to indicate where in the inherent risk assessment process the issue of mechanical error was considered or how it related to other issues.

Based on the analysis of expectation failures, the auditor decides if additional evidence will be needed to determine whether the difference between the expected balance and the actual balance was due to an error in the expectation generating process, a legitimate response by management to a change in the environment, an unintentional error, or a questionable response by management.

The model is asserting here that an inherent risk assessment consists of not just a point estimate of risk level, but a causal explanation of how existing factors and circumstances might create errors in account balances. This assertion about the nature of risk assessments was supported by the conclusions drawn from the literature review (see Section 2.3.3) and by reviewing the form risk assessments took in the interviews.

In summary, the inherent risk evaluation process described above is expectation driven, i.e. auditors expectations play a central role. These expectations about general ledger account balances are based on the auditor's knowledge of historical trends and specific changes in the audited firm's environment that affected the audited firm. Further, the output of this evaluation process is an analysis of factors that might explain differences between expected and actual account balances. These factors include management's incentives and abilities to affect the account balance as well as the complexity associated with calculating the account's balance.

This model reflects the following conclusions drawn from the empirical data gathering phase of this research:

1. The ultimate goal of inherent risk assessment is to produce information that can be used to alter audit tests. These test are normally executed on an account level basis. Therefore, the model deals with risk assessments at the account level.

2. Risk assessments that consist solely of point estimates of error propensity are not very useful to the auditor in using that risk assessment to plan an audit. Therefore the model's output consists of explanations of what existing conditions that could be creating the risk.

3. There are a variety of factors that affect inherent risk. These factors can be classified as financial statement level or account level, but this classification scheme does not go far enough. Factors can be further characterized as 1) events that cause changes in the firm or its environment, 2) evaluations of personnel and activities within the firm (i.e. mechanical factors) and 3) incentives that affect management motives. The model reflects the separate roles of managerial incentives, evaluations and observed changes (i.e. the results of events).

4. Auditors develop expectations that help direct their evaluation of inherent risk potential. Therefore, the model is expectations driven and concentrates on analyzing those accounts where expectations are not met.

5. General business knowledge is important in making linkages between factors and risk levels as well as developing expectations. Therefore, the model includes a reference to an internal model of the firm which is used to develop expectations for general ledger accounts and link incentives and evaluations to those accounts.

3.2.4.3 DESCRIPTION OF THE INITIAL PROTOTYPE SYSTEM

The conceptual model described above was used as a framework to guide the development of a computer system that would assess inherent risk. The details of this system are reported in Dhar, et. al. (1988) and Peters et. al. (forthcoming). Therefore, the description here will be limited to a general overview of the key features of that system. The main reason for developing the system was to create a framework in which the various assertions of the conceptual model could be tested as part of a comprehensive model of inherent risk assessment. Since the evidence supporting the conceptual model was incomplete and not very detailed, several simplifying assumptions had to be made in developing the system. The author's main intent at this point in the research was to build a system that encompassed all major facets of the conceptual model in order to establish a framework for further data gathering even though that system would necessarily be overly simplistic due to incomplete evidence.

3.2.4.3.1 EXPECTATION GENERATION

The system began its analysis of a case by applying auditor input expected changes in firm model elements to historical financial data to generate expected changes in general ledger account balances. Firm model elements included general ledger balances, general ledger totals or subtotals, or other quantifiable factors that had a direct effect on a general ledger balance (e.g. market demand, product price or direct labor hours). These auditor input expected changes contained three pieces of information: the firm model element, the percentage change and a comment. The comment was used by the system for display purposes and was not directly involved in its analysis. The only historical data available to the system was the previous year's general ledger balances. If the expected change involved a general ledger account, the system used that expected change. If the expected change involved an "other quantifiable factor", the system used its internal firm model to generate expected changes in general ledger balances. The system could not deal with observed changes in general ledger totals or subtotals.

The system could generate either quantitative or qualitative expected changes. That is, if sufficient quantitative data were available, the system would generated an expected percentage change in a general ledger account balance. If sufficient quantitative data were not available, the system would generate a estimated change magnitude (high, medium or low) and a direction (increase or decrease). For example, if the auditor indicated that direct labor rates were going up by 2% because of a new labor contract and the system did not have historical rate information, the system would generate a small expected increase in manufacturing costs. The system's knowledge base included a table for converting percentage changes to qualitative change magnitudes and a calculus for combining qualitative change values.

3.2.4.3.2 EXPECTATION CHECKING

Once the system had processed all auditor input data and generated expected changes for all affected general ledger accounts, it compared each one to the actual difference between prior year's and current year's balances. It assumed that if there were nc auditor input expected changes that affected an account, then the change from last year's balance should be zero. Therefore, it had expected changes for all general ledger accounts, either zero or nonzero. As it compared the expected and actual changes for each account, it created a record of accounts with expectations failures (i.e. accounts whose expected and actual changes differed). When the system checked quantitative changes, it allowed a range of plus or minus three per cent of last year's balance before it recorded an expectation failure. When it checked qualitative changes, it converted the difference between the current balance and prior balance to a qualitative value using a table and recorded an expectation failure if there was a difference in either direction or magnitude.

3.2.4.3.3 EXPECTATION FAILURE EXPLANATION

Next the system took each recorded expectation failure and searched its list of incentives to see if any applied to the account involved in the expectation failure. It checked incentives by using its internal firm model to determine if the incentive motivated management to manipulate the account balance. If it did, it checked the account to determine if it was subject to management manipulation. Each account in the firm model was coded to indicate whether it was subject to management manipulation or not. The results of this analysis consisted of a record of whether or not the incentive affected the account, the direction management would be motivated to manipulate the account based on the incentive, and an indication of whether the account was subject to manipulation or not. This information was stored with the expectation failure information. The system did not include a mechanism for dealing with mechanical error potential because the data analysis performed to this point did not provide enough guidance on how to structure that mechanism.

3.2.4.3.4 ANALYSIS CREATION

The system concluded its analysis by producing a natural language summary of the evidence it had accumulated concerning each expectation failure and incentive. This summary indicated the expected change in a given account and how it was calculated, the actual change, a statement about the account's susceptibility to management manipulation and a list of incentives that affected the account. This evidence summary did not actually constitute an "analysis" in that the system could not merge various pieces of evidence and draw conclusions. For example, if two incentives affected the account and those incentives motivated management to manipulate the account in opposite directions, the system had no way of determining which incentive might have a greater affect and merely listed both. The analysis portion of the program was left in this incomplete state to allow auditors to indicate how they would combine the various pieces of evidence.

3.3 REFINEMENT OF THE CONCEPTUAL MODEL

Two auditors who were involved in the initial data gathering phases of the research were asked to critique the system's performance on a test case. Their responses are summarized in the next section.

3.3.1 INITIAL AUDITOR CRITICISMS OF COMPUTATIONAL MODEL

In general, the auditors' reactions were positive. They specifically liked the system's explicit treatment of management incentives and its ability to develop and test expectations based on historical data. However, they pointed out several problems with the system, which are discussed below.

3.3.1.1 OVEREMPHASIS ON EXPECTATIONS

The model's control of attention was totally driven by expectations it creates based on user input. However, both auditors pointed out that their analyses are to a large extent driven by the structure of the general ledger, beginning with current assets and ending with extraordinary items. More importantly, as this systematic process proceeds, expectations about values of accounts yet to be reviewed become increasingly constrained. If the actual value does not fit with expectations, a reinterpretation of previously reviewed accounts becomes necessary. This type of reinterpretation did not take place in the model.

3.3.1.2 OVEREMPHASIS ON INCENTIVES

A second criticism was that the model emphasized management motives too strongly. While incentives are an important determinant of inherent risk, they are usually not considered by auditors unless the values affected by the incentive are close to some critical boundary. In addition, the auditors did not view all incentives as having equal potential impact on management's actions. For example, violating a bond covenant would be considered more important than not achieving a budgeted goal.

3.3.1.3 EXTRAPOLATION OF DATA

The initial computational model used the prior year's balance as a basis for developing an expected balance for the current year. Auditor's tend to use more complicated processes that take into consideration recent trends in account balances as well as the type of economic activity that generates the account balances. In fact, some accounts do not lend themselves to extrapolation at all, e.g. extraordinary items. In addition, the initial computational model assumed that full year, unaudited balances would be available for analysis. However, audit planning typically occurs prior to the client's year end. Because of this, auditors can not be expected to have actual, unaudited year end balances with which to test their expectations.

3.3.1.4 MECHANICAL ERRORS

The initial computational model did not include the module for assessing unintentional, mechanical errors included in the conceptual model because of lack of evidence on how auditors assessed these mechanical factors and how they combined those assessments with other evidence. These errors are mainly due to complexities associated with valuing individual accounts. Examples of these types of errors include mathematical error in calculating inventory values or accidentally failing to include all outstanding invoices in the accounts payable balance. In addition, the initial conceptual and computational models did not deal with financial statement level risk factors. (e.g. management's concern for the internal control environment or high employee turnover in the accounting department). The auditors felt that these two classes of factors were extremely important in determining the appropriate inherent risk for a given account.

3.3.2 MODEL REFINEMENT METHODOLOGY

The first step in dealing with the problems cited by the auditors was to determine the appropriate scenario in which to gather more detailed data. Two major decisions were made concerning that scenario. First, the data gathering was limited to one CPA firm to avoid cross-cultural differences. These differences mainly involved documentation procedures. Second, two subjects were selected and detailed cases built and analyzed based on their input. Two subjects were used in order to avoid too much idiosyncratic behavior and to have some capability for cross validation while limiting the magnitude of the refinement task.

The CPA firm that was selected for further study was the same one involved in the planning meeting observations. Selection of the firm was based on the relative availability of subjects and willingness on the part of the firm to participate. Selection of the setting for further data gathering sessions was based on the observation that the audit manager was primarily responsible for the content of the risk assessment meetings and had prepared an agenda prior to the meetings. The setting selected as the basis for further study was characterized as an audit manager reviewing client data while preparing the agenda for a risk assessment meeting.

Two audit managers were asked to select one of their clients for use in developing test cases for the system to analyze. No formal constraints were place on the client selection process. However, in order to make the data gathering sessions as contemporaneous with the actual audit planning as possible, they were asked to select clients where the audit planning process was currently underway. General characteristics of the two firms are summarized in Table 2[10]

[10] Due to confidentiality agreements between the author, the CPA firm and the client involved, more detailed information about the firms can not be presented here.

TABLE 2 Summary of Test Client Characteristics

Characteristic	Firm A	Firm B
Ownership	Publicly traded	Wholly owned subsidiary of Japanese Firm
Type of industry	Manufacturing	Manufacturing
Product	Carbide based metal working and mining parts and supplies	High technology silicon wafers
Annual sales	$355,000,000	$85,000,000
Top management	Considered strong	Considered strong
General operating health	Steady and strong profits	Improving profits but history of losses
Financial position	Strong	Strong due to support of parent
Internal control environment	Strong	Strong but potential incentive problem due to earnings pressure

The data collection sessions consisted of the auditor going through the data set that he used in preparing for the risk assessment meeting and explaining his reasoning to the author. Therefore, the data from these sessions represented retrospective protocols. However, as in earlier retrospective protocols used in this research, the protocol data were supported by detailed working papers and notes generated at the time the initial analysis was made. Because of the sensitive nature of the issues discussed, these sessions could not be tape recorded and the author documented the auditors comments by taking detailed notes on key points.

The data collection sessions were iterative. Before the initial interviews, the initial prototype system was modified to deal with as many of the general problems discussed in Section 3.3.1 as possible. Then initial interviews were held where basic data concerning the test firm were gathered. These data were used to build a case for the system to analyze. The analysis was then reviewed by the auditor and more modifications were made to the system. The process was terminated when the auditor felt that the system was producing a reasonably good analysis. "Reasonably good" was defined as an analysis that might be expected from a new junior accountant. At that point, the evaluation questionnaires included in Appendix E and discussed in Chapter 7 were filled out.

3.3.3 SUMMARY OF IMPROVEMENTS MADE TO THE SYSTEM

Several significant improvements were made to the system during the refinement process. Most of these reflect attempts to deal with issues raised when auditors first reviewed the system. In essence, the auditors' initial reactions determined what needed to be changed and the refinement process tested various approaches to those changes by altering portions of the system and having the auditors evaluate the new results. The following is a summary of the major changes that were made to the system. A comprehensive discussion of the final conceptual model is presented in the next section, detailed discussions of the system and its behavior on a test case are presented in Chapters 4, 5 and 6.

1. The overall flow of analysis was changed from one totally driven by expectation failures to one that systematically proceeded through every item in the financial statement data. In addition, the system was given the ability to defer or redo its analysis of an account based on that account's relationship to other accounts (see item 4).

2. The expectation generation process was enhanced to take into consideration more historical data on account specific characteristics and fine tuned to better reflect the subject's problem identification behavior.

3. The role of incentives was deemphasized. In the initial system, incentives were always checked and inferences drawn regardless of the status of the accounts affected by the incentive. In the final system, incentives were only checked when close to some boundary. In addition, incentives were explicitly linked to events that management could potentially trigger to respond to those incentives. Information associated with these events allows the system to differentially weight the impact of incentives.

4. The model of the firm was expanded to include knowledge of events and higher order relationships between accounts. These changes enabled the system to notice relationships between accounts that the auditor felt were important. For example, accounts payable and inventory are related because of their common cutoff calculation. In addition, these relationships were used to further constrain expected values for accounts and to indicate to the system when an account needed to be reinterpreted based on the results of the analysis of another account.

5. A module was added to the system that dealt with the potential for mechanical errors and with financial statement level risk factors. The financial statement factors are considered only to the extent they impact on the risk associated with a specific account.

6. An analysis and summary feature was added to the system. The initial system merely brought related data together but did not classify or weight that information. The current system performs some analysis on the data and classifies its findings as to whether they indicate a problem with the actual account balance or expected balance. Also, the system presents a summary at the end of case processing that ranks the problems identified during that processing.

3.4 PRESENTATION OF THE FINAL CONCEPTUAL MODEL

The conceptual model described in Section 3.2.4.2 and Figure 2 was revised concurrently with the revisions to the system as feedback was received from auditors. The revision process demonstrates the main role the system played in the study of inherent risk assessment; that is, to provide a framework for representing and testing a complex model of inherent risk assessment in its entirety as opposed to testing specific pieces of the model in isolation. A diagram of the final conceptual model is presented in Figure 3. This diagram shows the declarative knowledge accessed by the auditor, the processes used to evaluated this knowledge, and the order in which these processes are applied.

This section is broken into two parts, the first describes the conceptual model in more detail. The second part discusses specific assertions about the inherent risk assessment process made by the model and presents theoretical and empirical evidence that supports those assertions.

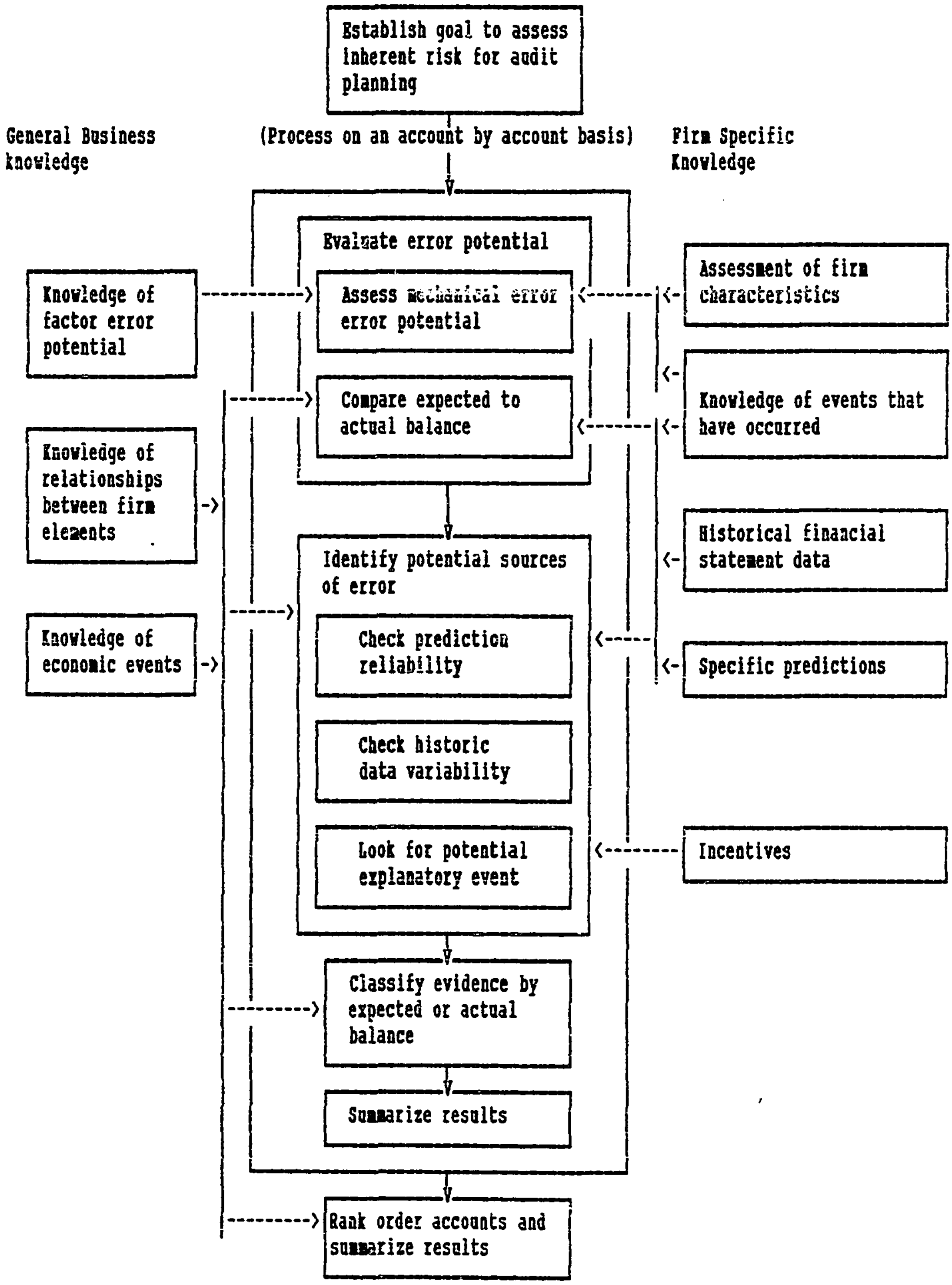

FIGURE 3 Conceptual Model

3.4.1 DESCRIPTION OF THE CONCEPTUAL MODEL

The inherent risk assessment process is triggered when the auditor establishes a goal to assess the potential riskiness of a set of accounts for a given entity. The auditor proceeds though each account in a normal general ledger order, i.e. beginning with current assets and ending with other income and expenses. The auditor assesses the risk of each account in turn, but does so by taking into account evidence that was noted or conclusions that were drawn while reviewing previous accounts. Linkages between accounts are based on normal economic activity associated with business entities.

The auditor begins assessing inherent risk for an account by determining if there is any evidence to indicate that an error may have been created. (S)he gathers this evidence by evaluating qualitative, mechanical risk factors[11] that could create an error and by comparing expected and actual account balances. These two processes are independent in that the auditor is concerned about the

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[11]For example, the system deals with the following "qualitative, mechanical risk factors": changes in calculation method, level of calculation complexity, changes in the data processing system, degree of judgment involved in valuation, history of error, general control environment, level of personnel turnover (general or account specific), reporting standard complexity, changes in reporting standards, level of staff training, level of supervision (general or account specific), theft potential, number of different types of transactions involved in an account, and volume of transaction activity involved in an account.

results of each regardless of the results of the other. That is, the auditor is concerned about the potential for error in the account based on qualitative, mechanical factors even though the account balance may not deviate from an expected balance. Also, the auditor is concerned about deviations from expectations even though there may not be any qualitative factors present that could account for that deviation.

The auditor uses knowledge of the relative error potentials of various qualitative factors; his/her assessments of the level of those factors in a given case; and knowledge of events that have occurred in a given case to produce hypotheses about mechanical error potential. The auditor uses an internal model of the firm; historical financial data and knowledge of events that have occurred to generate expected account balances. These expected balances are compared to the most recent actual account balances available to the auditor and any significant differences are noted.

Mechanical error potential is explained by the factors involved, their error potential and assessed level. However, an expectation failure merely represents evidence of a potential problem without providing any explanation as to the potential source of that problem. If an expectation fails, the auditor knows only that the two numbers are different. Therefore, if an expectation fails, the auditor seeks additional information that might explain that failure. Since the problem is a lack of agreement between two figures, it is important to remember that the source of the problem could be related to either one or both. Therefore, the auditor looks for evidence concerning the reliability of the expected balance and the actual balance independently. The same knowledge used to create and test expected balances is used in this analysis.

In Figure 3, the section labeled "Identify potential sources of error" refers to the follow-up investigation performed by auditors on expectation failures. Within this section, the processes that deal with prediction reliability and historical data variability generate evidence concerning the reliability of the expected balance. The process that looks for missing events generates evidence concerning the reliability of both expected and actual balances depending on the nature of the potential missing event. The system's knowledge base classifies events as either acceptable or unacceptable. Acceptable events are legitimate business practices while unacceptable events are either improper management judgments or management fraud. Evidence that indicates an acceptable event may have occurred supports a hypothesis that the expected account balance is in error, i.e. the expected balance is based on incomplete data and should have reflected the event. Evidence that indicates an unacceptable event may have occurred supports a hypothesis that the actual balances is in error since the event should not have taken place.

Once all the evidence concerning a given account has been gathered, the auditor weighs the evidence that relates to the expected balance versus the actual balance and comes to some conclusions about the error potential in the actual account balance. That is, evidence supporting an error in the expected balance is offset against evidence supporting an error in the actual balance in determining likelihood of error in the actual balance. Once all accounts have been processed, the auditor will usually summarize his/her analysis by identifying which accounts contain the greatest error potential.

3.4.2 CONCEPTUAL MODEL ASSERTIONS

This section presents five major assertions underlying the conceptual model and discusses theoretical and empirical evidence that support those assertions. The empirical support takes the form of selected excerpts from transcripts. Although the discussion includes only a few representative samples[12], all of the transcripts contain statements that support all of the assertions in the model. The fact that the transcripts were taken from data collection sessions that involved different firms, different auditors at different levels of responsibility and in

[12] Because of client confidentiality agreements, only small excerpts of transcripts that have been authorized by the CPA firms involved can be presented here.

different task settings provides strong support for the model.

Assertion 1: Inherent risk assessments are generated on an account by account basis.

The review of the professional and academic literature emphasized that risk assessments are ultimately used to develop specific testing plans for individual accounts. In addition, the audit procedures of the two audit firms participating in our study emphasized account level risk assessment. One of the CPA firms used an optional form that records auditors' assessments of inherent risk on an account by account basis. The other firm was beginning to use a form that tied account level risk assessment to the use of specific audit procedures which address those risks. In addition, there was strong evidence across all transcripts that auditors ultimately boil risk assessment down to the account level in order to be more precise in adjusting their audit effort. For example, the following two quotes deal with auditors' reactions to the working paper that required an account by account assessment or risk.

> "I think it probably lays out on paper how one's mind works. I probably think that way but I don't need that working paper to help me think that way because I already do."

> "... which will take the financial statement captions and try to isolate whether we think it's high flow, low flow, medium flow, you know, what type of risk we think is associated with it in better attempt to design appropriate audit approaches and I think I'd want to do that here."

Assertion 2: Auditors generate expectations concerning account balances and investigate balances that differ from these expectations.

The role of expectations in auditing is referred to in SAS 53 (AICPA, 1988a) which emphasizes the importance of following up on conditions or circumstances that differ from the auditor's expectations. The role and importance of expectations and expectation failures has also been widely discussed and studied in cognitive psychology. The general conclusions that can be draw from this literature is that expectations are generated by humans using mental models of a particular domain (Norman, 1983 and Pennington & Hastie, forthcoming). These expectations are used to help build a causal background which affects the significance of subsequent observations (Einhorn & Hogarth, 1985). In essence, these expectations direct the human attention and help them distinguish important from unimportant observations in the environment. Therefore, the importance of an expectation lies in its failure. Schank (1982 and 1986) points out that most of human learning comes from attempting to explain expectation failures. The importance of expectation failures derives from their relationship to the underlying mental model that produced them. Expectation failures are indications of an inaccurate or incomplete model. Much of human learning involves updating and improving these mental models based on the analysis of expectation failures.

Mental models are very important to human reasoning as they form the basis a person's understanding of a given domain (Stevens & Gentner, 1983). Although the concept of "understanding" is not clearly defined, Schank (1986) characterizes "understanding" as the ability to explain outcomes in a given domain. Consequently, humans devote much of their reasoning resources to maintaining the accuracy of these mental models.

To summarize, much of human reasoning can be characterized as attempting to sort out significant from insignificant observations from the environment. Significance is largely determined by expectations in that observations that indicate an expectation failure also indicate a problem with the human's model of a given domain. The accuracy of the model is important because of its use to predict and diagnose activity within that domain (Einhorn & Hogarth, 1981b).

The importance and role of expectations has been demonstrated in the KEKADA system (Kulkarni & Simon, 1988) that models the scientific discovery process. This example was selected because of the considerable similarity between the scientific discovery task and the auditing task. Both tasks involve generating hypotheses about unknown relationships or states of nature based on preexisting knowledge and then testing those hypotheses by gathering evidence. In the KEKADA system, expectation setters draw on knowledge of previous experimental results to develop expectations about the outcomes of new experiments. Those expectations are compare with the actual results and the results of the comparisons are used to alter hypothesis weights and suggest problems that need further experimentation.

In the model presented here, expectation failures fulfill a similar role. They help determine the likelihood of error in a given account and focus the system's reasoning mechanisms on attempting to find explanations for the expectation failure.

The following quotes taken from one general planning interview and one planning meeting provide empirical support for the importance of expectations in inherent risk assessment. Subjects in these interviews made several references to having some notion of what they expected to find in an audit. They appeared to have developed ranges within which they expected given account balances to fall. These ranges may be imprecise and based on the expected direction of change for the account as opposed a quantified values.

General planning interview:

"So you almost have a preconceived notion of what you are going to see and as long as you see that you got the explanation ready for it so you don't have to do much digging."

Specific client planning meeting:

S1 - "We, it just seems unusual with a high volume company like this you think you would develop percentages, you know, this seems like with the type of business they would be in you could develop reserve percentages but ..."

S2 - "Actually, you would think so but their history of write offs has not been, has not been significant."

Assertion 3: Auditors generate expectations based on changes in events or circumstances relative to prior years.

Unstructured general planning interviews as well as firm documents provide evidence that identifying changes from the previous year is a critical part of initial audit planning. Specific examples from structured interviews that involved specific clients confirmed this observation. In all cases, the main thrust of the auditor's initial data gathering during audit planning was determining what had changed from last year. The only exception is with large, sophisticated clients where the auditor has a continuous relationship with the client and becomes aware of these changes as they occur.

General planning meeting:

"So what I end up doing is concentrating on what's different or unique about this year versus last year. That's where you get into what's changed."

Specific client planning meeting:

Normally [XYZ, Co.] is so simple when you think about it, debt, totally financing inventory and receivables with very little investment and fixed assets that I would have just honed in on inventory and accounts receivable, compared it to last year's audit report which we have, which I brought into the meeting and I would have said, 'well, is it level, went up or did it go down.' Receivables up or down.' That type of thing."

Assertion 4: Management's incentives and abilities to manipulate account balances are of special importance in assessing inherent risk.

Evidence on the issue of the importance of management incentives in choosing accounting methods appears in theoretical and empirical research in accounting. In a summary of this research, Watts and Zimmerman (1986) conclude that accounting method choices can be driven by the existence of bonus plans, bond covenants and public pressures that affect management's incentives to report certain financial and operating results. The transcripts of both structured and unstructured settings provide ample evidence that management incentives were a key consideration in evaluating inherent risk. In addition, accounts that are subject to management judgment (e.g., the allowances for doubtful accounts and obsolete inventories) were almost always considered more risky.

> "Why, when someone says to me, 'What is the inherent risk on the engagement?', I first think of people. That's what I do. And the strength of management and the ability of management to override what ever the systems create or to influence whatever the systems create, dramatically so."

> "... a sophisticated, multinational organization that's well controlled and has very formal budgetary and planning controls in it's normal reporting, I think the thing that you've got to, the key factor is what is the likelihood of management overriding those controls. ... The way company management is compensated comes into play because, to the extent that even financial management is rewarded based on the achieved level of reported results, it creates an incentive to make those reported results reach the target levels."

Assertion 5: To be useful, inherent risk assessments should provide an analysis of why a given account is risky rather than merely a quantitative estimate of risk.

Support for this assertion in the professional and academic literatures was summarized in Section 2.2.3.3. That summary indicated that to be useful in altering audit testing plans, an inherent risk assessment needs to contain more information than just a point estimate of the level of risk involved in a given account. Several quotes in the transcripts demonstrated the complexity of inherent risk assessment and the importance of interrelationships between accounts. While quantitative estimates may reflect an auditor's overall feeling about an account, they do not indicate why the account is risky or what aspects of the account contribute to its riskiness. The transcripts contain several examples of auditors making this basic point. In order to be actionable, an inherent risk assessment needs to indicate why a particular account is risky in a specific audit context.

> "We look for interrelationships. We look to see if sales are down, you would expect receivables to be down. If sales are up and you see that receivables are down, you might ask yourself, 'Has he done a better job in collecting the accounts? Did he offer a special discount program?' And if sales are up and receivables are down, has he invested the money in inventory or is he holding it in cash. You know, are all those things consistent?"

> "So what's so critical about it and why. In not very general terms but very specific terms. Out of this one hundred million dollar balance what piece am I really concerned about. Okay, there's probably five million out of that one hundred million that I'm really concerned about but how to I get there?"

Apart from supporting the specific assertions of the model, the transcripts also provide support for the overall model. The following quote provides a description of the overall process.

> "I think the process you go through to obtain that knowledge really is to gain an understanding of the client's business, an understanding of the client, an understanding of how the fluctuations in the economy might affect a client's business. You compare the client's business to other businesses in the same industry to see if they are having consistent operating results and if not if there are logical reasons for it and if they are having consistent operating results if that is what you expected. I mean you develop expectations in your mind of what you expect to see and to the extent results don't conform to that yet. You begin asking questions and then you obtain the knowledge."

The evidence found in the transcripts to support the conceptual model is further strengthened by the existence of supporting evidence from other researchers. Bouwman (1978 & 1983) found evidence that financial analysts used an internal model of the firm to drive their expectations and analysis. In addition, the model presented here is closely related to a similar model of auditing inferred by Johnson et. al. (forthcoming) in their analysis of auditors' fraud and error detection. The fact that they have had similar results using significantly different methods and subjects adds considerably to the validity of the conceptual model.

CHAPTER 4

SYSTEM OVERVIEW

4.1 PURPOSE OF SYSTEM DEVELOPMENT

The computer system developed in this research project is a computational model of inherent risk evaluation during audit planning. Computational modeling served several purposes in this study. First, computers are a natural modeling medium for complex judgment tasks. Since both humans and computers are information processing systems, using a computer to model a human decision making processes and behavior provided a natural match of modeling technology to phenomenon being modeled (Newell & Simon, 1972, Newell & Simon, 1976).

Second, the system was used as a concrete referent to solicit more detailed knowledge of inherent risk evaluation from auditors. The solicitation process involved building a prototype system that made initial, naive assumptions concerning the nature of knowledge representation and processing mechanisms and then refining those assumptions as subjects critiqued the system's behavior. This process lead to revisions of both the prototype system and the underlying conceptual model of the judgment behavior. For example, auditors' reactions to the initial system led to a change in the basic flow of both the system and the conceptual model.

The first conceptual model developed was strongly expectation driven in that only those accounts that had unexpected values were assumed to be analyzed by auditors. When auditors critiqued the first prototype system, they commented that there were other qualitative factors that could create errors in accounts and therefore affect inherent risk assessment even if the balance was not out of line with expectations. Further discussions with auditors lead to conceptual and computational models that were checklist driven in a manner that insured every account was reviewed. Several auditing researchers have used auditor/computer-model interactions to build a detailed understanding of a given judgment task (c.f. Gal, 1985; Meservy, 1985; Meservy, et. al., 1986; Shpilberg & Graham, 1986 and Steinbart, 1987).

Finally, the use of computer programs forced the model development process to be more rigorous. Computer programs need to be precisely specified in order to produce reasonable behavior. For example, the conceptual model provides only vague, general guidance on how auditors select, evaluate and combine various factors or cues in making inherent risk assessment. The conceptual model identifies cue classes (e.g. observed changes, historical financial data, incentives) but does not specify how individual cues within these classes are identified as relevant to a specific case, evaluated in terms of their impact on inherent risk and combined with other cues to form a risk assessment. In order to produce reasonable inherent risk assessments, the system must deal with each of these issues in a precise way.

4.2 DESCRIPTION OF THE SYSTEM

A computer system can be described at several different levels of abstraction. Newell (1982) presents four main levels that can be used to describe such models: device, circuit, program and knowledge. At the knowledge level, the model is viewed as an agent which is composed of a set of goals, a set of actions and a body. The agent is viewed as processing knowledge to select actions to achieve goals. Actions are synonymous with the concept of operators discussed in Newell and Simon (1972) and are responsible for affecting the agent's external environment or changing the agent's state of knowledge. The following discussion presents the system as an information processing model (Newell & Simon, 1972) at the knowledge level. (More details of the system's architecture are discussed in Chapter 6.) Such a presentation requires specification of the goals and actions used by the agent to solve the problem under study (Card, et. al., 1980, Newell, 1982).

Figure 4 presents an overview in a flowchart format of the goals involved in inherent risk assessment and the actions used to achieve those goals. The levels of subgoals are indicated with a number preceding each goal statement. The lower the number, the higher the level of the goal. The actions and decisions involved in goal attainment are expressed as processes and conditional statements using standard flowchart symbols. These goals, actions and decisions constitute the system's **procedural knowledge** or knowledge of how to access, manipulate and draw inferences from **declarative knowledge** in order to achieve goals. The system's declarative knowledge is made up of facts about components of businesses, interrelationships between those components and effects economic events have on those components.

The distinction between procedural and declarative knowledge is common in cognitive psychology (c.f. Anderson, 1980 and Anderson, 1983). Psychologists have also found it useful to further decompose declarative knowledge into **semantic** and **episodic** components (Loftus & Loftus, 1976 and Norman, 1976). Semantic memory contains facts and attributes involving stimuli and episodic memory contains records of experiences and events. The system's declarative knowledge base contain components that parallel these classes of memory structures.

A general description of each of the system's procedural and declarative knowledge bases will be presented next. A detailed discussion of a trace of the system's behavior is included in the next chapter.

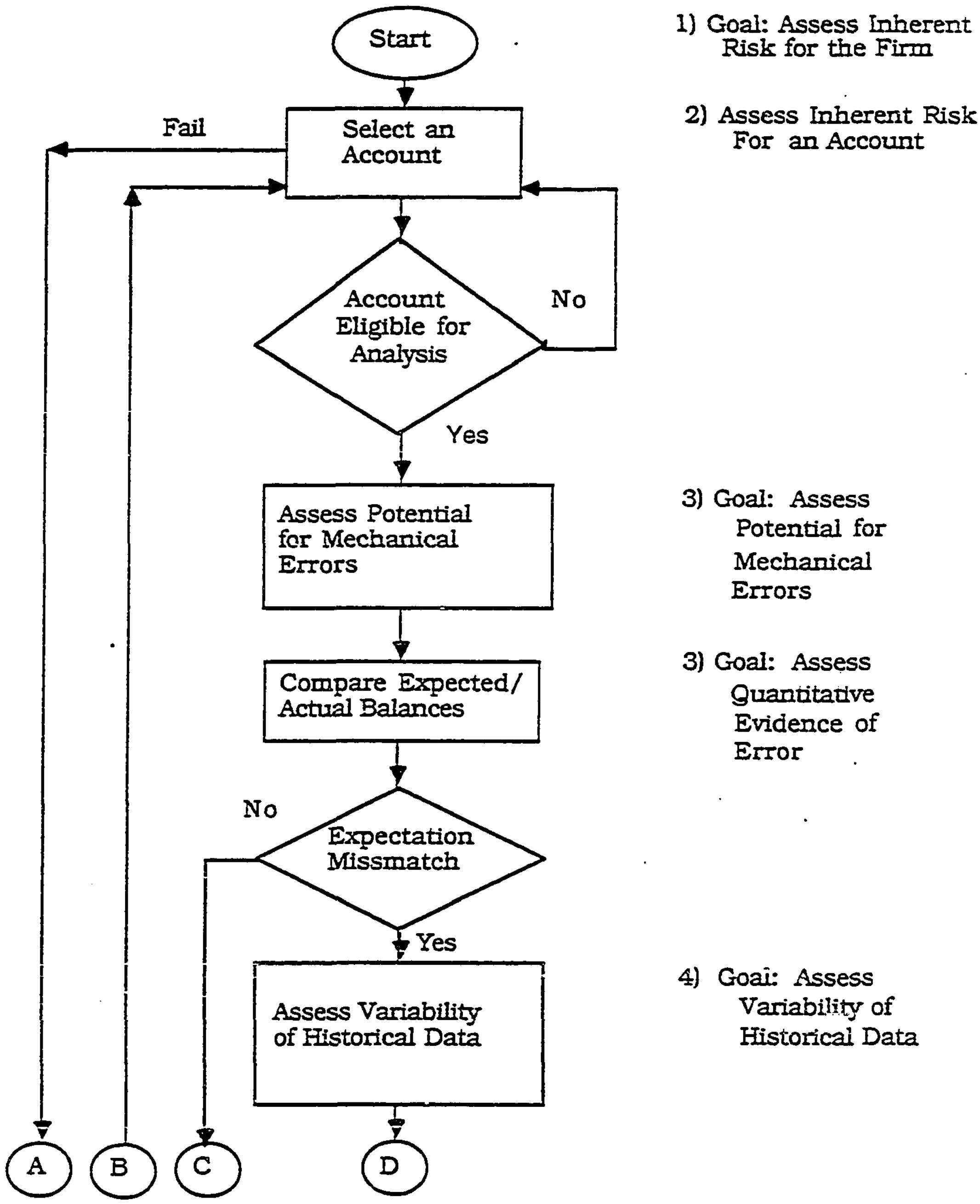

Figure 4 Top Level Flow of Control

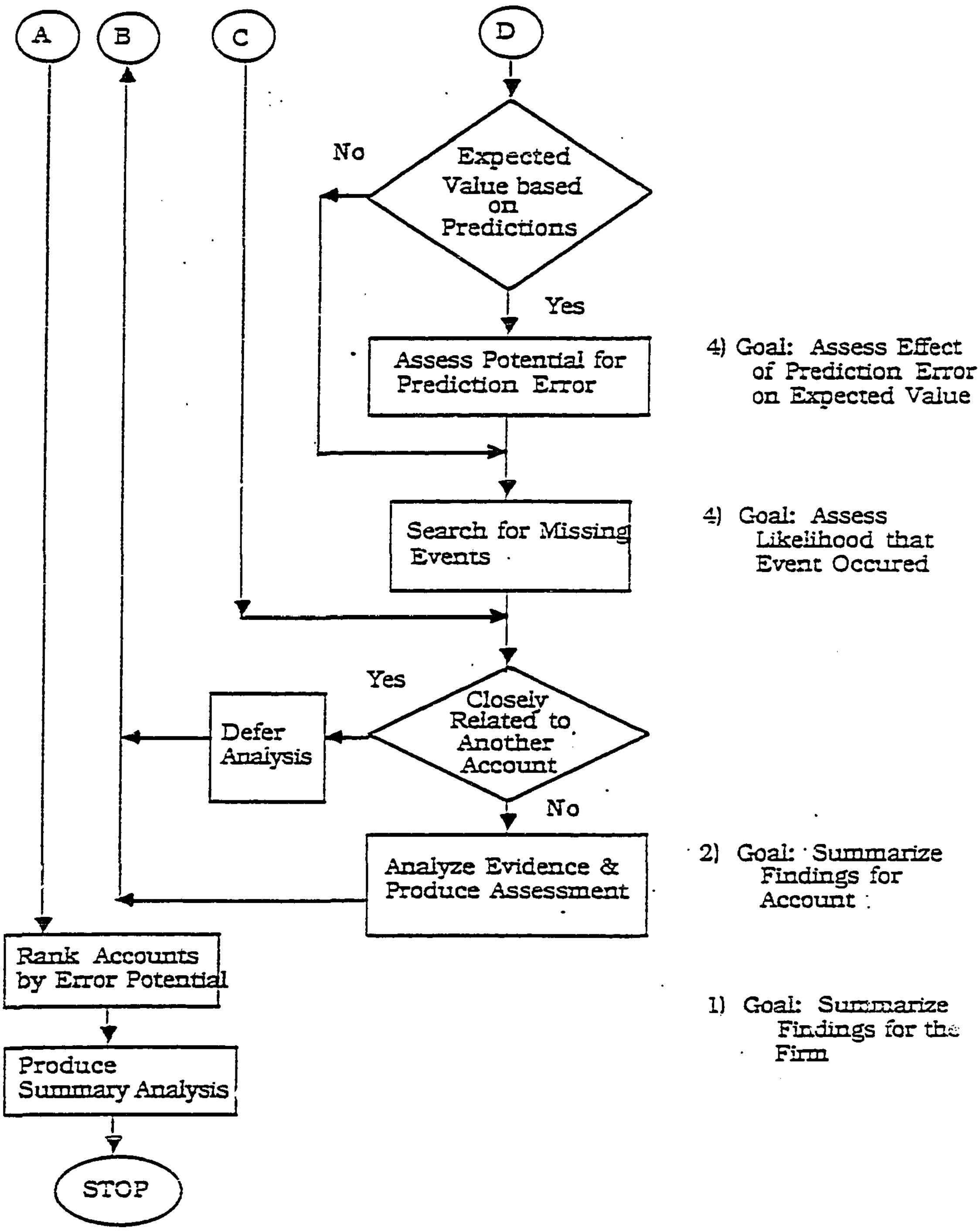

Figure 4 (Cont'd.)

4.2.1 PROCEDURAL KNOWLEDGE

The top level goal of the system is to assess the relative risks for various accounts in the firm's financial statements. The system accomplishes this goal by first assessing the risk of individual accounts and then ranking the relative risks of each account. In order to insure that every account is included in the analysis, the system looks at each account for which it has current financial data in standard general ledger order (i.e. begins with current assets and works through assets, liabilities, equity, revenues and expenses).

Account level risk assessment proceeds through three main steps or subgoals. First the system evaluates the potential for mechanical error in the account balance based on qualitative evidence. Second, the system looks for evidence that an error exists in the account balance by generating an expected balance for the account and comparing the actual balance to the expected balance. If there is a significant difference between expected and actual balances, the system looks for reasons for the difference. The reasons fall into two classes: reasons why the expected balance may be unreliable and reasons why the actual balance may be in error. Expected balances can be unreliable because they were generated using historical financial data that contains too much variation to form reliable predictions; they were based on user supplied predictions that are unreliable; and/or there is data relevant to generating a reliable expected balance that is missing. Actual balances may be wrong due to mechanical errors or unacceptable, intentional acts by the firm's management to alter the balance.

Finally, the system combines the evidence to produce an analysis of the potential for error in both the actual balance and the expected balance. A weight that represents the likelihood of error in the actual balance is calculated and assigned to the analysis. The weight is the difference between the strength of evidence supporting the possibility of an error in the actual balance less the strength of the evidence supporting an the possibility of an error in the expected balance.

The order in which the first two steps (mechanical error assessment and expected/actual balance comparison) are performed is arbitrary because these steps are independent of each other. Assessment of mechanical error potential is based on qualitative factors and is performed regardless of whether there is a mismatch between expected and actual account balances. Although this evidence is relevant to determining the likelihood that the actual balance is in error given a difference between expected and actual balances, this relationship is not made until the system pulls all the evidence together and produces its analysis. The following discussion presents a description of each of the three main steps the system uses to assess account level inherent risk.

4.2.1.1 MECHANICAL ERROR POTENTIAL

For each account, the system determines if there is any qualitative evidence that a mechanical error might have occurred in the account balance. This evidence is supplied by the user in the form of assessments of various factors that affect the potential for mistakes (See 4.2.2.2 for a description of assessments). Examples of these assessments might include significant errors in last year's account balance or a strong internal control environment. If the net weight of the evidence contained in the assessments is positive, the system will create an hypothesis that there is an error in the account balance (See 4.2.2.3 for a description of hypotheses).

The system contains decision rules that evaluate whether a given assessment implies an increased or decreased risk of error and the relative magnitude of the assessment's effect on error potential. Magnitudes are selected from a limited set of values (-1, -.5, 0 .5, 1, 2). These values indicate the support a given assessment gives to the hypothesis that there is an error in the current balance of an account. Negative values indicate a decreased risk of error in the actual balance. In general, assessments that affect a specific account are weighted four times as heavily as assessments concerning the firm as a whole when considering error potential for that account. Also, assessments that reflect an increase in error potential are weighted twice as strongly as those that reflect a decrease.

These weighting rules reflect several assertions about how auditors weight and combine cues. First, auditors believe factors directly related to an account are more important in determining risk for that account than factors that are general to the firm. Second, auditors are naturally conservative and are more concerned about evidence of potential error than evidence that errors do not exist. Traditionally, this conservatism has been based on cost considerations. If auditors increase audit effort due to suspicions of potential errors in an account balance and the errors do not exist, the expected cost of the increased audit effort is less than not increasing audit effort when material errors do exist and ending up being sued for negligence (Arens & Loebbecke, 1988). The decision to use a weighting scheme that weights specific evidence four times higher that general evidence and evidence supporting an error in the actual balance twice as high as evidence not supporting an error was arbitrary.

Finally, auditors use a simple addition rule to combine cues. The decision to base cue combination on a simple linear model was supported by human judgment research that indicates such simple linear models have high predictive ability (Abdel-khalik & El-Sheshai, 1980 and Dawes & Corrigan, 1974) and that people tend to predict the likelihood of events based on the number of supporting reasons they can think of (Hoch, 1984 and Tversky & Kahneman, 1973).

4.2.1.2 QUANTITATIVE EVIDENCE OF POTENTIAL ACCOUNT ERROR

The system looks for evidence that there is an error in the current balance of an account by comparing the current balance to an expected balance. If the system finds a significant difference in these two values, it makes a note of an expectation failure and looks for reasons that would help explain the difference (See 4.2.2.3 for a description of expectation failures).

4.2.1.2.1 EXPECTED VERSUS ACTUAL BALANCE COMPARISON

There are several main issues involved in the generation of expected balances and the comparison of those values to the current balance: 1) generating the expected balance, 2) normalizing the current or expected balances and 3) determining the magnitude of the acceptable difference between the expected and actual balance (i.e. defining "significant").

4.2.1.2.1.1 GENERATION OF EXPECTED BALANCES

Expected balances are generated based on historical financial data and specific case data entered by the user. Two methods are used to generate an initial expected balance based on historical financial data. The selection of the method is based on the nature of the economic activity that determines the account balance and the nature of changes to the account balance. For accounts whose balances are based on infrequent, large transactions and change in an irregular fashion, the initial expected balance is the prior year's ending balance. For accounts whose balances are based on a large set of frequently recurring transactions and change in regular patterns, the initial expected balance is based on a forecasting algorithm that uses whatever historical data are available (normally at least 3 years).

The distinction between accounts based on recurring and nonrecurring activity was included in the system because of one subject's reaction to the behavior of an earlier prototype system. The earlier system used a forecasting algorithm to generate expected balances for all accounts. The subject felt that he would be concerned about large changes from prior year's balances in certain accounts (e.g. treasury stock) regardless of historical trends because some accounts don't change much unless there is significant new activity in them and any such activity deserves auditor attention.

The forecasting algorithm currently employed by the system is a double exponential smoothing algorithm with an alpha of .95. This algorithm was selected because it places a heavier weight on more recent data and adjusts its forecast for prior errors in predictions. The ability to reflect prediction error in the forecast is useful because most audits are of continuing clients where the auditor has a sense of historical performance. The double exponential smoothing algorithm also compared quite well to published empirical evidence on auditors' forecasts (Biggs & Wild, 1985). The Biggs and Wild data were run through the forecasting algorithm with different alpha values and the alpha value that produced patterns of forecasts that most closely matched Biggs and Wild's subjects' performance was selected.

The final step in generating the expected balance is to merge any case specific predictions that affect the account with the initial expected balance generated from historical financial data. These specific predictions can be either a direct prediction entered by the user that an account balance should change or an implied prediction based on the fact that a specific event occurred. For example, the user could indicate that the property account balance should increase because the client just bought a new building or the user could indicate that an equipment purchase event had occurred and the system would infer an increase in the property account. In the first case, the user is making a direct prediction concerning an account balance and in the second the user is making a statement that a particular event occurred and the system is inferring from the occurrence of that event that a change should occur in one or more account balances.

The direct prediction mechanism is left over from earlier prototypes of the system that did not have the capacity to deal with events (Dhar, et. al., 1988). The direct predictions mechanism is currently used in cases where the system does not yet have the capacity to properly deal with an event that is relevant to a specific case. The main class of events currently excluded from the system's knowledge base are those that involve precise, quantitative effects on accounts (e.g. changes in interest expense due to fluctuations in the prime rate).

4.2.1.2.1.2 NORMALIZATION OF BALANCES

The need to normalize current and expected balances occurs because the current balance is frequently based on less that a full year's activity. Normalization is based on quarterly increments because quarterly data are usually available to the auditor. The system annualizes part year revenue and expense account balances using prior year's quarterly data if it is available or by assigning equal weights to each quarter represented in the account balance if prior quarterly data is unavailable. Expected balances for balance sheet accounts (i.e. asset, liability and equity) need to be adjusted if they are based on the forecasting algorithm because that algorithm assumes it is predicting a value that is a fixed period in the future (i.e. one year). Therefore, when predicting part year balances for balance sheet accounts the system adjusts the predicted amount to reflect the number of quarters represented by the current year's balance.

4.2.1.2.1.3 COMPARISON OF BALANCES

Finally, the system compares the normalized expected and actual balances to see if they differ by more than a significant amount. Significance is determined in two ways depending on whether the expected balance is based on the prior year's balance or a forecast of historic data. For accounts whose expected value is based on the prior year's balance, the system uses a user set materiality criterion to determine significance. This approach reflects subjects' comments discussed earlier that for accounts that change infrequently, any material change from the prior year is worthy of auditor scrutiny.

For accounts whose expected value is based on the forecasting algorithm, the system considers the level of forecasting error experienced in building the expected value and a default percentage to determine significance. The system uses the default percentage as a minimum level of acceptable difference. It then calculates a second percentage based on the average prediction error experienced by the forecasting algorithm in generating the expected balance. If the calculated percentage is greater than the default percentage but less that five times the default percentage, the system uses the calculated percentage. Otherwise is uses either the default percentage or five times the default percentage depending on the size of the second percentage. See Figure 5 for a summary of this decision rule.

Selection of the default percentage and the multiplier five involved in these decision rules was arbitrary. However, an attempt was made to reflect the following observations: 1) subjects had some minimum difference that they considered insignificant, 2) above that minimum difference, they took into consideration the variability of historical data, 3) there was a point where a difference became significant regardless of the variability of the historic data.

Condition	Value Used
FP < DP	DP
FP > DP and FP < 5 * DP	FP
FP > 5 * DP	5 * DP

Where: FP = percentage based on forecasting algorithm

DP = default percentage

FIGURE 5 Expectation Failure Decision Rule

In addition to these considerations, auditors also occasionally condition their concern for a difference between expected and actual balances based on the level of substantive audit testing they expect to perform on the account. This observation is based on one subject's comments as to why he was concerned about some differences and not others. The subject pointed out that some accounts are substantively tested regardless of any other evidence they may turn up and those tests will locate any problems in the account balance. For example, there are usually a relatively small set of notes payable to banks which are normally all confirmed with the banks as part of substantive testing procedures. The subjects would not be too concerned about encountering fairly large fluctuations in this account balance during audit planning since they know each item in the balance will be thoroughly tested as a normal part of the audit. The system incorporates a decision rule that reflects this conditioning process. Once the system has decided on a significance level using the decision rules described in Figure 5, it applies another set of decision rules to adjust the significance level for the amount of substantive testing normally done on the account balance. If the amount of substantive testing is high, the level is increased.

The system's use of a percentage of actual value to calculate significant differences is based on findings in audit research that significance judgments of this type reflect Weber's Law. Weber's Law suggests that a just noticeable difference is a constant ratio of the standard on which it is established (Dickaut & Eggleton, 1975 and Rose et. al., 1970). Enhancements to this simple approach were added to better reflect the subject's comments referred to above.

4.2.1.2.2 EXPLANATION OF EXPECTED/ACTUAL DIFFERENCES

If there is a significant difference between the system's expected balance and the actual account balance, the system tries to identify potential sources for this difference. These sources could be due to either errors in developing the expected balance or errors in the actual balances. The system looks for potential errors in the expected balance in three ways: 1) for accounts whose expected balances are based on the forecasting algorithm, by calculating a statistic that reflects the magnitude of the forecasting error experienced in developing the expected balance, 2) for accounts whose expected balances are also based on predictions, by assessing the reliability of those predictions and 3) by looking for acceptable events that may have occurred which would explain the expected/actual difference. The system assesses the potential for errors in actual balances by looking for unacceptable events that may have occurred.

The system assesses the possibility of an error in the predictions used in calculating an expected balance by first determining if a change in a prediction would eliminate the expected/actual difference it is currently analyzing. If it would, the system applies some decision rules to the confidence level that is associated with the prediction to arrive at the likelihood that the prediction is in error.

The system searches an event network looking for events that would explain the expected/actual difference by locating events which match a pattern of financial data (See 4.2.2 for a description of the event network). A "pattern of data" reflects the fact that events affect more than one account. Subjects indicated that they do not spend much time concerning themselves with this type of reasoning during planning since they will be gathering more data during field testing. However, they would recognize the possibility that the occurrence of some major, infrequently occurring event might explain a pattern of data and specifically ask the client about it.

The system uses a relatively simple set of decision rules that first screen out all events that occur frequently (e.g. cash sales) and then checks the pattern of account balance changes suggested by the event against the financial data to see if they match. If the data match, a distinction is made between events that are classified as acceptable and those that are not. All events in the systems event network are classified as whether they would be acceptable to the auditor (e.g. cash sale event) or unacceptable (e.g. predating of invoices). If a difference between an expected and actual account balance is due to the occurrence of an acceptable event, this represents an error in the expectation generation process for failing to consider the event. If the difference is due to the occurrence of an unacceptable event, this reflects a problem in the account balance since the event should not have occurred. Therefore, the possible occurrence of an acceptable event is used to add support the possibility of error in expected balances and the possible occurrence of an unacceptable event adds to the support for actual balance errors. The system takes into consideration incentives management might have to affect event occurrences and the latitude they might have to influence events in determining the magnitude of support to add to a given hypothesis.

4.2.1.3 SUMMARIZE FINDINGS FOR AN ACCOUNT

The system concludes its analysis of an account by combining evidence of errors in the actual and expected balances for an account. It generates two hypotheses, one that asserts the actual balance is in error and one that asserts the expected balance is in error. It prints out a paragraph that summarizes the evidence for both hypotheses.

4.2.1.4 DEALING WITH ACCOUNT RELATIONSHIPS

The above description implies that each account is processed in turn with no digressions. The system recognizes that some accounts have strong relationships to other accounts and that their balances should reflect those relationships; for example, inventory balances are usually closely related to sales levels. These relationships are referred to as **compiled causal** relationships in the firm model (see 4.2.2.1.2). The system will not conclude its analysis of an account until all other closely related accounts have been analyzed to the point of identifying potential sources of error in those related accounts. The system contains internal goal setting mechanisms that allow it to defer activities until certain conditions have been met. Once the related account has been analyzed, the system will analyze the relationship between the accounts to see if it is following an expected pattern of behavior and if it is not, generate a new expected balance for the accounts involved based on their relationship. For example, if accounts receivable as a per cent of sales changes more than expected, the system will determine what the receivable account balance should be in order to bring receivables as a per cent of sales back into line.

Furthermore, the system recognizes that there are more subtle relationships between accounts; for example, accounts payable balances are related to inventory balances because they share a common cutoff procedure. These relationships are referred to as **causal** in the firm model (see 4.2.2.1.2). Since there are many of these more subtle relationships, the system does not check them in determining whether to defer concluding its analysis of a given account. However, once the analysis of an account is concluded and if there is evidence of an error in the actual balance in the account, the system will check these more subtle relationships to see if any other account is affected by that error and, if that second account has already been analyzed, it will reanalyze the account based on this new evidence.

The distinction between what constitutes a strong relationship and what constitutes a more subtle relationship is somewhat arbitrary. The current distinctions used by the system were based on comments by the subjects in this research project.

These alterations in the systematic or checklist based flow of control of the system reflect two strategies used in artificial intelligence to deal with uncertainty, decision deferral (Stefik, 1981) and data dependent backtracking (Stallman & Sussman, 1977). The choice of strategies is based on how often conclusions may have to be modified. Frequent alteration of an analysis of one account based on the analysis of another account would be expected for strong relationships and therefore the system employs decision deferral for strong relationships. Less frequent alterations are expected for more subtle relationships; therefore the system does not defer processing in these cases.

4.2.2 DECLARATIVE KNOWLEDGE

The declarative knowledge base contains three main classes of information: general, case specific and temporary. The general knowledge consists of data structures that make up a model of a typical firm. The case specific data consists of historical financial data and user entered observations specific to a given firm. The temporary knowledge consists of inferences that are developed as the system proceeds with its analysis.

4.2.2.1 GENERAL KNOWLEDGE

The general knowledge base contains two main classes of data: financial relationships involving economic objects and events that affect economic objects. These two classes represent the system's semantic and episodic memories respectively (Loftus & Loftus, 1976 and Norman, 1976) and combine to form a model of a typical firm. This firm model is the kind of intuitive causal model that as Libby and Lewis (1982) observe, appears to drive many decision making strategies studied in behavioral accounting research. The use of such a firm model was first employed by Bouwman (1978, 1983) in building a computer program that simulated a financial analyst screening potential investment opportunities. Selfridge et. al. (1986) also employed a firm model in their GC-X system that simulates auditors' going concern evaluation judgments. The use of a firm model is an example of a more general class of model based reasoning techniques referred to in the artificial intelligence literature as qualitative reasoning methods (Hart et. al., 1986). The following discussion expands on the reasons behind the use of such domain models and compares the system's model to the Bouwman's (1978) and GC-X's (Selfridge et. al., 1986) models.

4.2.2.1.1 SUPPORT FOR THE USE OF A FIRM MODEL

A firm model is an instance of a more general class of domain models that have been discussed extensively in the psychology and artificial intelligence literatures. Domain models reflect the associational structure of human memory. In general, human memory contains a complex network of relationships between concepts and objects (Anderson, 1980 and Anderson, 1983). Much of this knowledge is based on the day to day events that humans experience (Newell, 1979 and Schank, 1982). Different researchers have attached different names to the groups of related associations that form domain models. Terms that have been used include "scripts" (Abelson, 1976 & Schank & Abelson, 1977), "frames" (Minsky, 1977), and "schemata" (Bobrow & Norman, 1975).

Birnberg and Shields (1984), Gibbins (1984) and Waller and Felix (1984) discuss these memory structures and how they relate to accounting and auditing decisions. The central theme of their discussions is that associational knowledge which is derived from a human's day to day experiences is stored in related clusters of associations. These clusters can form domain models which can be used to facilitate prediction, explanation and causal reasoning.

Additional empirical support for the assertion that human beings use domain models for a large class of reasoning process has come from a variety of sources. Bouwman (1978) reviews the use of these models for a variety of diagnostic tasks. A specific example from medical diagnosis is the INTERNIST/CADUCEUS project (Pople, 1982) and from business planning is the PLANET system (Dhar, 1984). In addition, there is a growing group within the artificial intelligence community that are looking at model based reasoning methods in the hopes of better capturing the human's common sense reasoning capabilities (see the special issue of Artificial Intelligence, December, 1984 and Dhar & Pople, 1987 for an overview of the field).

Empirical support for the use of firm models in accounting and auditing judgment tasks has come from three main research projects: Bouwman (1987, 1983), Selfridge et. al. (1986) and this research. Bouwman inferred the use of a firm model based on the concept of minimally required knowledge to explain the reasoning behavior of financial analysts performing screening activities. A similar line of reasoning was used by Selfridge et. al. to explain the causal reasoning exhibited by their subjects. In this research, subjects frequently refer to how various changes in a firm and its environment effect account balances and the risk of error associated with account balances (see Appendix A for a list of factors noted by auditors during data gathering sessions for this research). The concept of minimally required knowledge implies that the auditors must have knowledge of linkages between environmental factors and account balances. The number and richness of these linkages implies that the subjects were using some comprehensive model of a firm.

4.2.2.1.2 COMPOSITION OF A FIRM MODEL.

Domain models are used by humans to predict and explain the behavior of a given physical system (de Kleer & Brown, 1984). In order to achieve these goals, the model specification should meet three criteria: **compositionality, locality** and **functionality** (Bobrow, 1984). **Compositionality** requires that the behavior of a model (i.e. changes in components) must be derivable from the nature of the components and their interrelationships. **Locality** requires that effects must propagate locally, through shared connections which represent causal relationships. **Functionality** requires that the model reflect the modeled system's function and that components which are functionally equivalent be interchangeable in the model. Specification of domain models involves making clear two ontological assumptions used in the model design: the nature of the components in the model and the nature of the relationships between those components (Bobrow, 1984).

The following description of the system's internal model of the firm presents details of the model's components and the interrelationship between those components, compares those components and interrelationships to Bouwman's (1978) and GC-X's (Selfridge, et. al., 1986) and indicates how the design of the model meets the three criteria specified by Bobrow.

The system's internal firm model is made up of several classes of **components:** accounts, account totals and subtotals, financial indicators (e.g. ratios) and other quantifiable business concepts (e.g. market demand, market share, labor hours). These components are very similar to the component's in Bouwman's (1987)[13] model and the GC-X's (Selfridge, et. al., 1986) Financial Reasoning Network. A set of descriptive information is associated with each component in the system's model. This information includes such things as the nature of the component (account, total,

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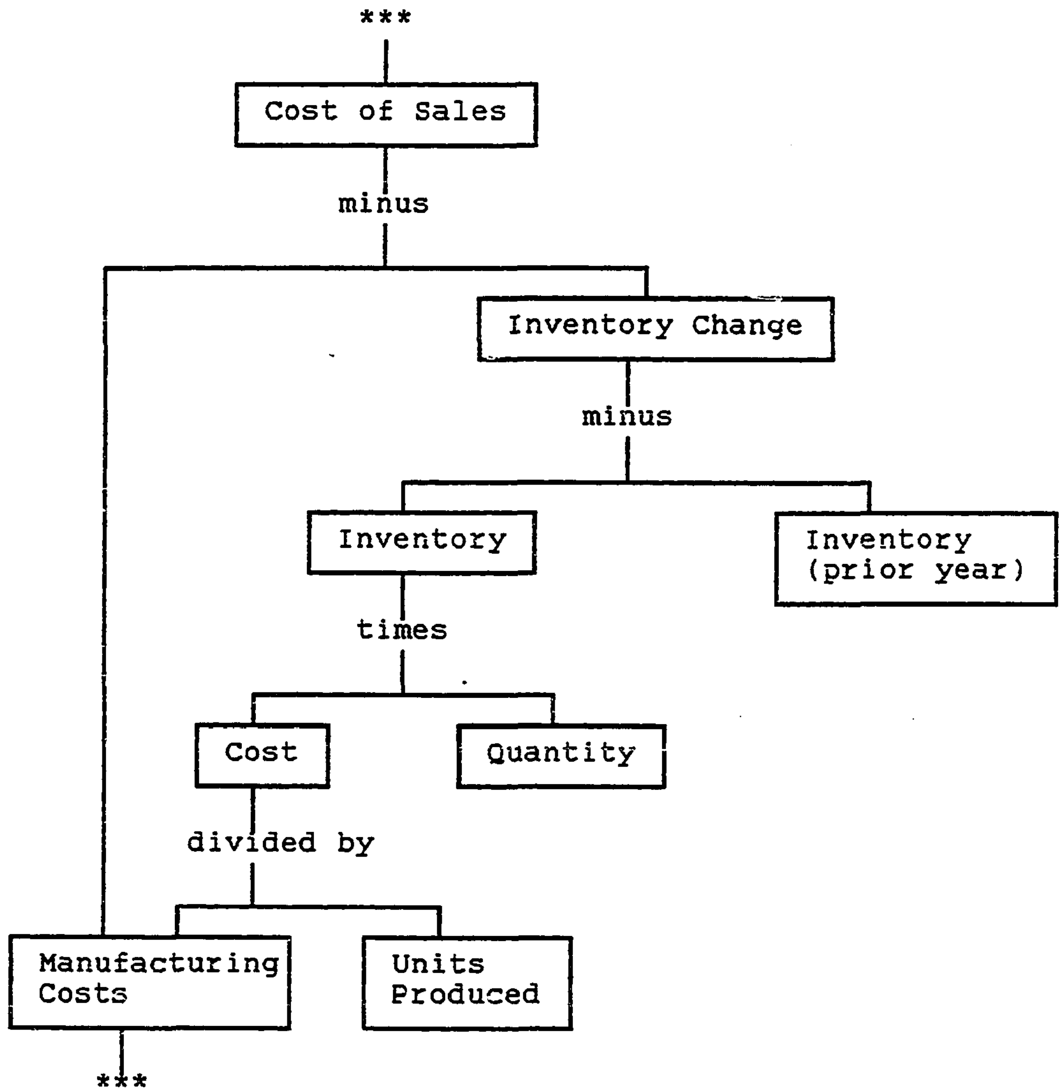
[13]Bouwman distinguishes between an internal model of a firm and a dictionary. The nature of the components and the interrelationships in both are similar to the components and their interrelationships in the system reported here. His distinction appears to be irrelevant to the fundamental nature of a qualitative model and so will not be referred to in this discussion.

etc.), whether the account, subtotal, or total is an asset, liability, equity, revenue or expense, and the extent of the substantive audit effort normally associated with the account. This descriptive information is represented in a hierarchy and is similar to the object knowledge base included in the GC-X system.

The model includes three types of **relationships** between model components: **calculational, causal** and **compiled causal.** The **calculational** relationships are represented as formulas and indicate how the value of one component can be calculated from the values of a group of other components. The values that can be calculated include qualitative (i.e. increase, decrease, no change), absolute quantitative (e.g. a balance in a given account) and relative quantitative (e.g. the percentage change an account balance). Relative quantitative values are the quantitative counterpart to the qualitative values and are calculated whenever the system has precise data. If some of the data is qualitative, it converts all values to qualitative and calculates a qualitative result. Both Bouwman's model and the GC-X model only propagate qualitative values[14]. An example of

[14]The dictionary relationships in Bouwman's model were capable of propagating absolute quantitative values but these were converted to qualitative values when they were passed into the firm model. In addition, Bouwman's model could propagate value judgments (e.g. too high, too low).

calculational relationships is shown by the model segment presented in Figure 6.



*** Linkages to other calculational relationships

Figure 6 Example of Calculational Relationships

Causal relationships reflect the fact that model components are affected by economic events. These events are linked together in causal chains. Causal relationships can be of three types: enabling, causal and blocking. These relationships are represented as causal chains between an event network and the components of the firm model. Typically, a value change in a component is related to an event. These relationships are two way. That is, if a value change in an account enables an event to take place, the event is said to be enabled by the value change. Enabling relationships represent necessary conditions in that they must occur before the resulting event or state change can occur. Causal relationships represent sufficient conditions in that if they occur the resulting value change or event will occur. Blocking relationships represent "unless" conditions in that they can prevent causal or enabling relationships from being effective. Such causal relationships are explicitly included in the GC-X model in the form of an event network and implicitly included in the direction of the relationships of Bouwman's model.

The selection of these three classes of causal relationships was based on Schank's work (Schank, 1975 and Schank, 1980). The system's event network does not include "initiates" and "reasons" causal links discussed by Schank because these deal with mental acts and the system's knowledge base does not include information on mental acts. The system's event network includes blocking causal links not mention by Schank because subjects periodically referred to the ability of value changes and events to block other events and value changes. These causal links are comparable to those used by the GC-X system. The GC-X system employs a much larger set but the additional links relate to reasoning about goals and needs which appear to be necessary in evaluating management plans as GC-X does but do not appear to be necessary in modeling auditor's inherent risk evaluations. An example of causal relationships is presented in the firm model segment show in Figure 7.

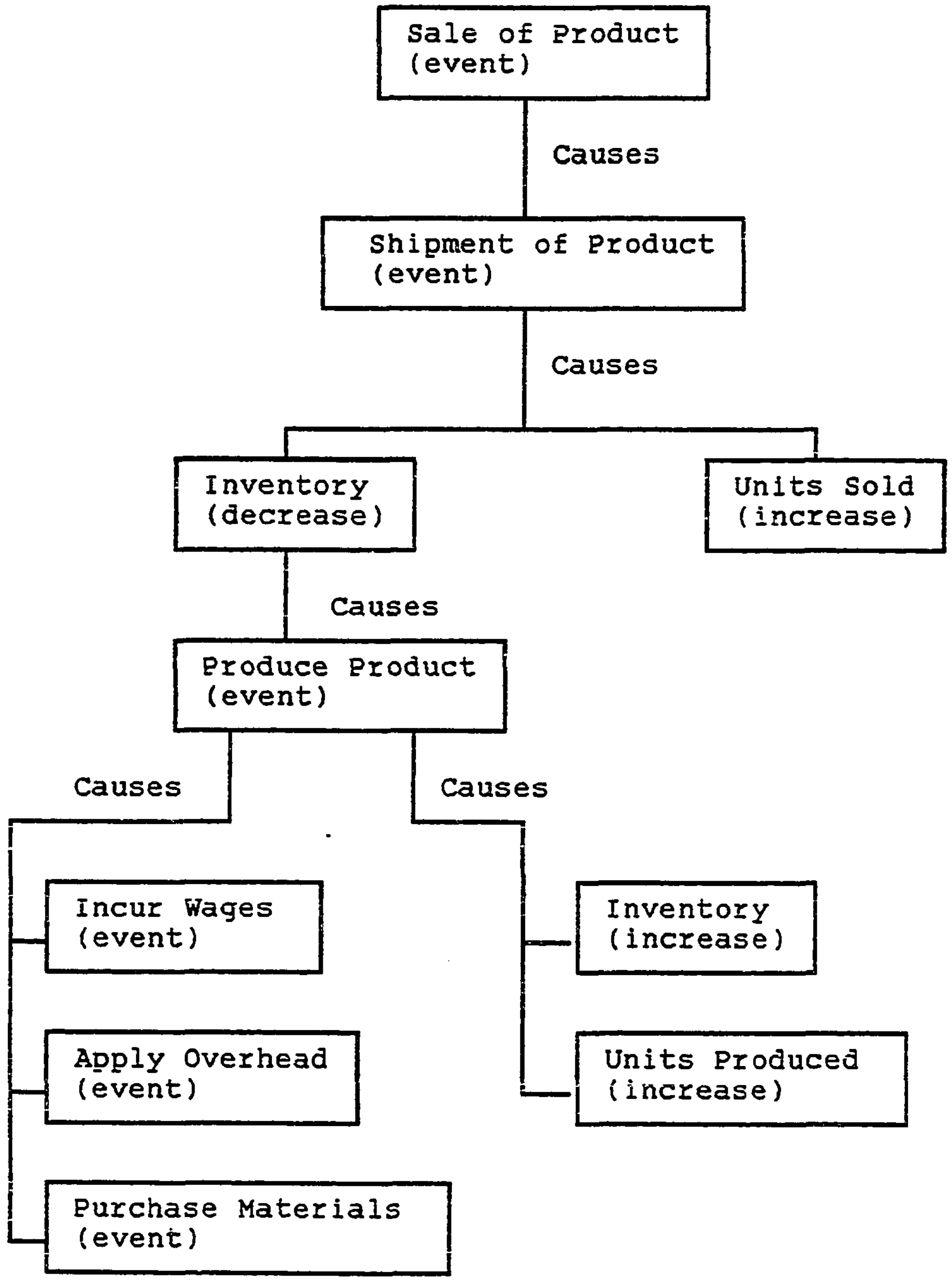


Figure 7 Example of Causal Relationships

The third class of relationships included in the system are **compiled causal** relationships. These types of relationships are not found in Bouwman's or GC-X's internal firm model. They are very similar to the planning links used in the CADUCEUS medical diagnostic system (Pople, 1982). The main purpose of these links is to facilitate more rapid inference development by the system. They reflect the effect of a causal chain between two model components. For example, one such relationship included in the system is the fact that accounts receivable and sales balances tend to move together. This relationship is based on a causal chain that reflects the effect of a sale event on an accounts receivable accrual event. The system will use the compiled causal relationship to look for potential problems and then refer to the underlying causal chain if it requires more detailed information.

The system's firm model meets the criteria discussed by Bobrow (1984). It is **compositional** because the behavior of any one component of the model is strictly determinable by the behavior of other components, **local** because the effects are based on specified causal relationships[15] and **functional**

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[15]The desirability of explicitly stating causal relationships in a manner similar to that used by the system has been debated extensively in the artificial intelligence literature (See Iwasaki & Simon, 1986a &d 1986b and de Kleer & Brown, 1986). Although the Iwasaki and Simon approach is based on a more developed formalism from economics, the (Footnote Continued)

because the behavior of the model maps on well to the behavior of a normal business enterprise.

4.2.2.2 CASE SPECIFIC KNOWLEDGE

The case specific knowledge is the information entered into the system by the user prior to processing a case. It contains the information the user feels is relevant to the description of a given case. Six classes of information are accepted by the system: **event occurrences, assessments, financial data, general background data, incentives** and **predictions**.

Event occurrences are observations by the user that one or more of the events in the system's event network have occurred during the audit period. Entering event data into the system involves indicating which event has occurred and supplying relevant parameters for that event. For example, if the user was aware that the FASB had issued a pronouncement that affected how the audited firm would have to report certain pension liabilities and expenses, the user would indicate to the system that a reporting standard change event had occurred and the system would prompt the user to indicate which accounts, classes of accounts or transactions were affected and the expected direction of the

(Footnote Continued)
causal relationships in that formalism are implicit in that they are embodied in sets of simultaneous equations and therefore use of the Iwasaki and Simon approach would make explanation more difficult.

effect (i.e. whether the change would generally increase, decrease or not affect the balance in the accounts, all other things being equal).

Assessments are evaluations the user has made of key factors affecting the audited firm. Assessments are entered by indicating which account or class of accounts is affected (if any), what factor is being assessed and the level of assessment. The factor name allows the system to link the assessment information to decision rules associated with that factor (See 4.2.1.1 for a discussion of how the system applies this information). For example, the user might indicate that the audited firm's general control environment was strong and/or that there had been a significant history of error in the calculation of units in inventory in the past. The system can evaluate the impact of a large subset of the factors mentioned by subjects during the system development stage of this research (See Appendix A for a list of those factors).

The **financial data** used by the system consists of whatever historical financial information is provided by the user. The information is not entered directly but provided to the system in a standard ASCII file. The system's internal firm model is flexible enough to recognize a variety of different, commonly used account names and classes of information (i.e. quarterly, annual, budget) and adjusts its reasoning to fit the data provided. The system uses this information primarily to help generate expected balances and compare those expected balances to actual balances.

The **general background data** used by the system is currently fairly limited. This information consists of the number of quarters covered by current period financial data and by the audit period and the nature of the audited firm's ownership (e.g. publicly traded, closely held).

The **incentive** data consists of boundaries around model component values that would affect management motives to alter account balances. They represent either a restriction placed on model components as part of a contract (e.g. bond covenant); arrangements that tie management's compensation to account balances (e.g. bonus plans tied to reported earnings); or expectations by outsiders concerning account balances (e.g. public expectations of steadily growing earnings). In general, incentives represent agreements or expectations that influence management's motives to see that certain accounts achieve certain balances.

Predictions allow the user to fill in gaps in the system's knowledge base by making direct statements about how a given account balance should change. Normally the system makes inferences about account balance changes from the nature of events that occurred. However, if an event is missing from its knowledge base, the user can make a direct prediction.

Together the above six classes of information allow the user a considerable amount of freedom is describing a given case. They also cover both quantitative and qualitative factors commonly mentioned by subjects as important to inherent risk assessment.

4.2.2.3 TEMPORARY KNOWLEDGE

The temporary knowledge base consists of inferences that the system generates during its analysis of a case. These inferences fall into four classes: **expected change values, expectation failures, event scores, hypotheses** and **analyses.**

Expected change values are generated when the system determines how an account balance should change from a given base state. That base state represents the expected current period balance of an account assuming no changes in the normal operation of the audited firm. This base state can be either the prior year's balance or a projected current period's balance generated by the forecasting algorithm. The system merges information from events that have occurred and predictions that have been entered to generate these change values and maintains a history of how the value was calculated (i.e. what events and predictions were used in calculating the value).

This expected change value calculation is based on what de Kleer and Brown (1984) call the causality rule, that a system component will not change unless acted upon. The use of a base state which is the result of a forecasting algorithm as a basis for calculating that change in certain circumstances recognizes that certain system components are constantly being affected by a variety of forces that change in a regular, predictable fashion and that the auditor is interested in changes that occur above and beyond those that reflect this normal or base pattern of change.

Expectation failures are noted by the system when an expected account balance is significantly different from an actual account balance. This inference is the result of the expected versus actual balance comparison procedure discussed in 4.2.1.2.1. Expectation failures retain a record of the source of both expected and actual balances and a list of any subsequent hypotheses generated to explain the difference between these balances.

Event scores are calculated whenever the occurrence of an event would explain a pattern of expectation failures. Event scores are combined incentive and ability scores for a given event. They contain a numeric value that is greater than or equal to one and a record of how the score was calculated. The incentive portion of the score is based on how many incentives which are close to their boundaries would be affected by the event in the right direction. That is, the occurrence of the event could have pushed the incentive closer to its boundary. The ability portion of the score is based on an assessment of how much control management might have over the occurrence of the event. The final score is the product of the incentive and ability portions.

Hypotheses contain assertions that the system makes concerning potential errors in expected or actual account balances. They are generated as a result of both the evaluation of mechanical error potential (4.2.1.1) and the search for evidence of error in the account balance (4.2.1.2). Hypotheses contain a description of the nature of the assertion, a weight value that reflects the system's strength of belief in the assertion and indications of where the assertion came from and how the weight was calculated. An assertion is described by indicating what account is affected, whether the actual or expected balance is affected and (optionally) the direction and magnitude of the effect. For example, a typical assertion might be that the actual balance of an account is in error due to a series of assessments that combine to indicate a significant likelihood of error. However, these assessments do not indicate the direction of the potential error. Weights are calculated using a simple linear combination rule. The use a linear rule and evidence was discussed in Section 4.2.1.1.

An **Analysis** contains the results of the system's efforts to combine all available evidence concerning a given account. This evidence has been summarized based on whether it supports an hypothesis of an error in the actual account balance or whether it supports the hypothesis of an error in the expected account balance. Information concerning expectation failures is also included but an expectation failure could be caused by either an inaccurate expectation or an inaccurate current balance and therefore is not directly used to support either general hypothesis.

Together, the procedural and general, case specific and temporary declarative knowledge make up the system's knowledge base. The discussion of the procedural knowledge dealt with how the general and case specific knowledge is combined to draw inferences which became the temporary knowledge base. The next chapter goes through a case is some detail in order to make the system's functions more concrete.

CHAPTER 5

TRACE OF THE SYSTEM'S BEHAVIOR

5.1 INTRODUCTION

This chapter contains an annotated trace of the system's analysis of a test case. This case was not one of the two used to develop the system, but was developed by the author based on publicly available information. It was one of the three cases used in the validation study described in Chapter 7. This case was created mainly to meet a strict client confidentiality agreement entered into with the national CPA firm who provided subjects for the later phases of this research. It was designed to be as similar as possible to the cases that were used to develop the system. A complete copy of the case materials is included in Appendix B.

In the following discussion, the system's comments are in **bold type** and are single spaced. The author's explanations are in standard type and double spaced. The system's comments are presented exactly as they appear on the screen with a trace feature turned on. That is, the system's comments are complete and unedited. The trace function was designed to provide printouts of key turning points in the system's reasoning process. These turning points include:

1) the beginning of an analysis of a new account or relationship between accounts

2) alteration of the range used to judge expectation mismatches

3) discovery of an expectation mismatch

4) review of a particular assessment

5) creation of an hypothesis

6) deferral or discontinuance of the analysis of a given account or relationship between accounts

7) production of a summary analysis for a given account or for the case as a whole.

5.2 INPUT AND INITIALIZATION OF CASE INFORMATION

A case is defined by a set of user entered qualitative and quantitative data. Qualitative data includes instances of the case specific data types described in the previous chapter (i.e. assessments, incentives, observed events, predictions and general case data). Examples of input screens for each of these data types is presented in Appendix C. The quantitative data include line item or account balances from balance sheets and income statements; the system's firm model is used to calculate totals and subtotals.

The system displays qualitative information using a natural language translation to make it more intelligible to the user. The natural language production technique used is based on template filling which makes the flow of the presentation somewhat rigid. However, this approach was selected because it was a quick and easy way to develop some form of natural language production capability. More sophisticated language generation can be developed but is beyond the scope of this research.

The information input for the sample case is as follows:

Assessments -

1. a high level of supervision for accounts payable

2. a high level of supervision for receivables

3. a high level of internal controls

4. a high level of complex calculations for inventory

Incentives -

1. liquidity restriction which is based on the restriction that current ratio is greater than 2.0

2. gross profit bonus which is based on the restriction that gross profit is greater than 1.2 times the prior years' gross profit

3. earnings per share growth which is based on the restriction that earnings per share is greater than 2 times the prior years' earnings per share

Observed events -

1. the occurrence of a reporting standard change involving pension accruals which should cause an increase in the accounts normally affected by a pension accrual

2. the occurrence of an employee stock purchase

3. the occurrence of a calculation method change involving other assets which should cause no change in other assets

4. the occurrence of a debt retirement involving long term debt

5. the occurrence of a new debt issuance involving notes payable - banks

6. the occurrence of a sale of affiliate

7. the occurrence of a prior year adjustment involving inventory

Predictions -
1. a prediction of 60.0 per cent decrease in the current period's cumulative translation adjustment with a high confidence based on change in the value of the dollar

General data are not displayed in a natural language format and the display for the general data input for this case can be found in Appendix C. The general data for this case includes the period being audited (i.e. full year or one of four quarters)[15], the period covered by the current balance in the financial statement data (e.g. four quarters), the general materiality level criteria and any specific materiality criteria[16], and the type of ownership (e.g. publicly traded).

These data were extracted from the case description and represent a fairly complete translation of the main points mentioned in the case. The assessments capture the general information about the strength of both the firm wide control systems and the control systems specific to accounts payable and accounts receivable. They also reflect the complexity of inventory valuation methods. The incentives are based on

[15] The current implementation of the system can only handle full year audits.

[16] A materiality criterion is defined as a per cent of an account balance. The system allows the user to specify a default materiality criterion and a list of override materiality criteria. These criteria are used to determine whether an account balance is large enough to analyze and whether a change from the previous year's balance is significant or not.

the specific background items numbers 3, 4 and 6 mentioned Appendix B. The observed events are based on the events listed in the case description with the exception of the last event which is covered by the prediction. This highlights a system limitation mentioned in the last chapter. The system can not handle general economic changes like changes in the value of the dollar or changes in prime interest rate. This information must be explicitly entered as a prediction. Finally, the inventory error problem mentioned in item 2 of the specific background items is reflected in the last observed event.

Once the qualitative and quantitative information has been entered, the system is ready to analyze the case.

Clearing previous values from the firm model.

Linking assessments and predictions into firm model elements

The process of linking the qualitative data into the firm model involves identifying firm model elements affected by the predictions and assessments and storing the name of the prediction or assessment with that element. Linking observed events is more complex. Each event contains information about how it affects the firm model. It also contains additional parameters that need to be filled in to complete the event description. Each observed event data structure contains the name of the event and the values for any parameters required by the event. When the observed event data are being entered by the user, the system checks the event affected to see if any additional parameters are required. If so, the system prompts the user for values for each of the parameters and adds these parameter values to the observed event data structure.

For example, one of the simple observed events is the affiliate sale. It contains no additional parameters. The most complex is the reporting standard change. The reporting standard change event requested information about what the standard change affected (either a firm model element or in this case another event, i.e. pension accrual) and the direction of the effect (in this case whether the effect would be the same as increasing normal pension accruals or decreasing them). The system stores the event name and parameter information in a separate data structure (i.e. observed event) to allow for multiple occurrences of the same event.

Each event uses the information in the observed event data structure to expand ramify, i.e. to create other assessments and predictions that reflect the event's impact on the firm model. The following are a list of the additional assessments and predictions created during the model initialization phase. The number in parenthesis after each item is the number of the above observed event that led to the creation of the new assessment or prediction.

Assessments -

5. a high level of different reporting standards for administrative expenses (1)

6. a high level of different reporting standards for other taxes and expenses payable (1)

7. a high level of different reporting standards for accrued liabilities (1)

8. a high level of different calculation methods for other other assets (3)

9. a medium level of different types of transactions for interest expenses (5)

10. a medium level of different types of transactions for notes payable - banks (5)

11. a low level of supervision for inventory (7)

Predictions -

2. a prediction of an increase in the current period's administrative expenses with a medium confidence based on reporting standard change (1)

3. a prediction of an increase in the current period's other taxes and expenses payable with a medium confidence based on reporting standard change (1)

4. a prediction of an increase in the current period's accrued liabilities with a medium confidence based on reporting standard change (1)

5. a prediction of an increase in the current period's paid in capital with a medium confidence based on employee stock purchase (2)

6. a prediction of an increase in the current period's common stock with a medium confidence based on employee stock purchase (2)

7. a prediction of no change in the current period's other assets with a high confidence based on calculation method change (3)

8. a prediction of a decrease in the current period's long term debt with a high confidence based on debt retirement (4)

9. a prediction of a decrease in the current period's interest expenses with a high confidence based on debt retirement (4)

10. a prediction of a decrease in the current period's current portion of long term debt with a high confidence based on debt retirement (4)

11. a prediction of an increase in the current period's notes payable - banks with a high confidence based on new debt issuance (5)

12. a prediction of an increase in the current period's interest expenses with a high confidence based on new debt issuance (5)

13. a prediction of a decrease in the current period's investment in affiliates with a high confidence based on sale of affiliate (6)

The ramification of the reporting standard change event provides an excellent example of the ramification process. The reporting standard change affected pension accruals in such a way that the accounts affected by a pension accrual would increase, all other things being equal. This information was input as an observed event data structure which contains the name of the event (reporting standard change), either the firm model element or transaction involving firm model elements affected by the reporting standard change (in this case, a pension accrual) and the direction that reporting standard change would alter the normal balances of the firm model elements affected. The system's event ramification process created the following set of assessments and predictions based on information stored in the reporting standard change event data structure:

Predictions -
a prediction of an increase in the current period's administrative expenses with a medium confidence based on reporting standard change

a prediction of an increase in the current period's other taxes and expenses payable with a medium confidence based on reporting standard change

a prediction of an increase in the current period's accrued liabilities with a medium confidence based on reporting standard change

Assessments -
a high level of different reporting standards for administrative expenses

a high level of different reporting standards for other taxes and expenses payable

a high level of different reporting standards for accrued liabilities

The predictions communicate to the firm model the expected changes in account balances caused by the event's occurrence and the assessments reflect the system's belief that whenever you have a reporting standard change, the risk of error in the accounts affected by the reporting standard change will increase. The medium confidence associated with the predictions is based on a heuristic rule that predictions of account balance changes for accounts whose balances are normally the result of a large volume of regularly recurring transactions are less certain than for accounts whose balances are the result of large, infrequently occurring transactions.

This event ramification also illustrates the system's simplistic way of dealing with alternative account structures for the same transaction. That is, the fact that different firms may use different accounts to record the same transaction. In this case, the credit side of the pension accrual is represented as two accounts, accrued liabilities and other taxes and expenses payable. Since either one or the other of these accounts normally appears in a balance sheet, the system merely ignores the assessment and prediction that involves the account without a balance. The system could not differentiate which of these two liability accounts was used in a pension transaction if both were present in the balance sheet.

5.3 ANALYZING A CASE

Event ramification is the last step in the system initialization process. Once it is completed the system is ready to analyze the data. As indicated in the previous chapter, the flow of this analysis is in standard general ledger account order, i.e. beginning with current assets on the balance sheet and proceeding through the balance sheet and income statement and ending with extraordinary items. This flow can be altered in three ways, two of which are illustrated below. First, the system can defer its analysis of a given account until another account has been processed. Second, the system can defer its analysis of a given account, perform limited processing of another account and then return to its analysis of the first account, i.e. produce specific information for a second account while processing another account. Finally, the system can reanalyze an account if new information is developed later in the process.

The following is the system's complete analysis of the test case included in Appendix B. The input data for this analysis was presented in section 5.2 above.

Reviewing cash

Increasing the acceptable difference between expected and actual values because cash usually requires a high level of normal substantive audit testing.

Discontinuing analysis of cash because actual values are close to expected.

The system began its analysis with cash, increased its tolerance range for expected/actual differences, calculated expected and actual account balances, compared the two and determined that the difference between the two was within tolerable limits.

Reviewing short term investments

Making a note of a difference between no expected change in the current period's short term investments based on a change from last year's balance and an actual 21.31 per cent increase compared to last year's balance.

Producing a summary analysis of short term investments.

Short term investments may be more risky because the account balance is higher than would be expected based on a change from last year's balance.

The system compared the current balance in the short term investments account to last year's balance because it has classified this account as one whose balance is determined by few, large transactions. It noted a difference between this year's balance and last year's and then summarized its findings because short term investments are not closely related to any other account in the firm model. Since it has no other data concerning short term investments, its analysis simply states that it noted a difference.

Reviewing receivables

Assessing the general control environment.

Assessing the supervision level associated with receivables

Results of assessing the potential for mechanical error in receivables do not indicate a potential problem.

Making a note of a difference between no expected change in the current period's receivables based on a change from last year's balance and an actual 10.49 per cent increase compared to last year's balance.

The system processed the assessments associated with receivables and reached the conclusion that there was no evidence of error based on those assessments. Note that the general control environment assessment will be reviewed whenever specific assessments exist for a given account but will be ignored otherwise. The system found an expected/actual balance difference but deferred its analysis at this point because it knows receivables are closely linked to sales and it wants to process sales before it concludes on receivables.

Reviewing inventory

Assessing the general control environment.

Assessing the calculation complexity of inventory

Assessing the supervision level associated with inventory

Creating an hypothesis with a weight of 3.5 that there is an error in the current value of inventory because of a mechanical error

Making a note of a difference between no expected change in the current period's inventory based on a projection of prior years' values and an actual 59.01 per cent increase compared to that projected value.

The system's analysis of inventory did result in the creation of an error hypothesis based on the existing assessments. As with receivables, processing was deferred because the system is aware of inventory's strong relationship with sales.

Reviewing prepaid expenses

Making a note of a difference between no expected change in the current period's prepaid expenses based on a projection of prior years' values and an actual 102.26 per cent increase compared to that projected value.

Producing a summary analysis of prepaid expenses.

Prepaid expenses may be more risky because the account balance is higher than would be expected based on a projection of prior years' values.

Reviewing net property, plant and equipment

Discontinuing analysis of net property, plant and equipment because actual values are close to expected.

Reviewing investment in affiliates

Discontinuing analysis of investment in affiliates because actual values are close to expected.

Reviewing miscellaneous other assets

Assessing the general control environment.

Assessing the level of change in calculation method for other assets

Creating an hypothesis with a weight of 0.5 that there is an error in the current value other assets because of a mechanical error

Making a note of a difference between no expected change in the current period's other assets based on a change from last year's balance and a prediction of no change in the current period's other assets with a high confidence based on calculation method change and an actual 30.97 per cent decrease compared to last year's balance.

Creating an hypothesis with a weight of 0.5 that there is an error in a prediction of no change in the current period's other assets with a high confidence based on calculation method change which should be -0.31 because of a inaccurate prediction

Producing a summary analysis of other assets.

Creating an hypothesis with a weight of 0.5 that there is an error in the actual value other assets because of a mechanical error

Creating an hypothesis with a weight of 0.5 that there is an error in the expected value of other assets because of a inaccurate prediction

Miscellaneous other assets may be more risky because the account balance is lower than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to significantly different calculation methods for other assets. This error may have occurred in spite of a high level of internal controls for the firm. However, there is some evidence that there may be an error in developing expected values due to a potential error in a prediction of no change in the current period's other assets with a high confidence based on calculation method change.

The system's analysis of miscellaneous other assets demonstrates some features not previously used. First, the expected value generated was based both on a change from the previous year's balance and a prediction. Second, the system recognized the fact that predictions are inherently uncertain and created an hypothesis of prediction error based on the inverse of the prediction's confidence. Finally, in producing its summary analysis, the system separated evidence supporting an error in the actual balance from evidence supporting an error in the expected balance.

This separation is evidenced by the two new, but seemingly redundant, hypotheses that show up right after the message about producing a summary analysis. In separating evidence, the system creates two new summary hypotheses, one based on evidence supporting an error in the actual account balance and one based on evidence supporting an error in the expected balance. A record of the supporting data that led to these hypotheses is also combined and included in each new hypothesis. It used this separation to structure its summary analysis. Even though the weights of the two competing hypotheses net to zero, the system will still produce the summary to flag the fact that something unusual is going on in the account. However, when the system produces its overall summary at the end of its analysis, it will not rate the problem with this account very high.

Reviewing notes payable - banks

Assessing the general control environment.

Assessing the variation in transaction types for notes payable - banks.

Creating an hypothesis with a weight of 0.5 that there is an error in the current value notes payable - banks because of a mechanical error

Discontinuing analysis of notes payable - banks because actual values are close to expected.

Producing a summary analysis of notes payable - banks.

Creating an hypothesis with a weight of 0.5 that there is an error in the actual value notes payable - banks because of a mechanical error

Notes payable - banks may be more risky because there is some evidence that there may be an error in this account due to moderately different types of transactions for notes payable - banks. This error may have occurred in spite of a high level of internal controls for the firm.

Reviewing current portion of long term debt

Discontinuing analysis of current portion of long term debt because actual values are close to expected.

Reviewing accounts payable

Assessing the general control environment.

Assessing the supervision level associated with accounts payable

Results of assessing the potential for mechanical error in accounts payable do not indicate a potential problem.

Reviewing accounts payable as a percent of inventory

Making a note of a difference between no expected change in the current period's accounts payable as a percent of inventory based on a projection of prior years' values and an actual 24.17 per cent decrease compared to that projected value.

Making a note of a difference between an expected 39.91 per cent increase in the current period's accounts payable based on its relationship to inventory and an actual 6.09 per cent increase.

Producing a summary analysis of accounts payable.

Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory.

The system's analysis of accounts payable demonstrates another feature, the use of a relationship between accounts to produce an expected balance in an account. The system will only create an expected balance for an account based on its relationship to other accounts if that relationship itself is different than expected. In this case, accounts payable as a percent of inventory changed more that the system expected and so it calculated how much the current accounts payable balance would have to change in order to eliminate the expected/actual difference in the ratio of accounts payable to inventory.

Reviewing accrued liabilities

Assessing the general control environment.

Assessing the reporting standard volatility of accrued liabilities.

Creating an hypothesis with a weight of 1.5 that there is an error in the current value accrued liabilities because of a mechanical error

Discontinuing analysis of accrued liabilities because actual values are close to expected.

Producing a summary analysis of accrued liabilities.

Creating an hypothesis with a weight of 1.5 that there is an error in the actual value accrued liabilities because of a mechanical error

Accrued liabilities may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for accrued liabilities. This error may have occurred in spite of a high level of internal controls for the firm.

Reviewing deferred revenue

Discontinuing analysis of deferred revenue because actual values are close to expected.

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Page 148

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Discontinuing analysis of paid in capital because actual values are close to expected.

Reviewing cumulative translation adjustment

Discontinuing analysis of cumulative translation adjustment because actual values are close to expected.

Reviewing retained earnings

Discontinuing analysis of retained earnings because this account is usually not directly audited.

Reviewing treasury stock

Discontinuing analysis of treasury stock because the balance in immaterial.

The analysis of retained earnings and treasury stock demonstrate two criteria used by the system to skip an account altogether, the account is not normally audited directly and the account is immaterial.

Reviewing sales

Making a note of a difference between no expected change in the current period's sales based on a projection of prior years' values and an actual 7.31 per cent increase compared to that projected value.

Reviewing inventory as a percent of sales

Making a note of a difference between no expected change in the current period's inventory as a percent of sales based on a projection of prior years' values and an actual 55.4 per cent increase compared to that projected value.

Making a note of a difference between an expected 2.32 per cent increase in the current period's inventory based on its relationship to sales and an actual 59.01 per cent increase.

Producing a summary analysis of inventory.

Creating an hypothesis with a weight of 3.5 that there is an error in the actual value inventory because of a mechanical error

Inventory may be more risky because the account balance is higher than would be expected based on a projection of prior years' values and its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

The system's analysis of inventory demonstrates the use of its decision deferral mechanism. It waited until it had developed expected/actual differences for sales before it concluded its analysis of inventory. The reason is that inventory and sales normally have a strong relationship and the system defers its reasoning in such cases[17].

Creating an hypothesis with a weight of 1.75 that there is an error in the current value accounts payable because of a mechanical error

Reevaluating the risk assessment of accounts payable based on new evidence.

Producing a summary analysis of accounts payable.

Creating an hypothesis with a weight of 1.75 that there is an error in the actual value accounts payable because of a mechanical error

Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory. There is some evidence that there may be an error in this account due to a potential error in inventory.

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[17] The selection of this deferral strategy was based on a few comments by one of the subjects used in developing the system. A better picture of general reasoning strategy issues like this will be provided when concurrent verbal protocol data is analyzed.

The system's analysis of accounts payable illustrates another way in which its reasoning differs from a straight checklist. Once it had concluded its analysis of inventory and determined that there was some evidence of a potential error in the current balance of inventory, it searched its event network and found that inventory and accounts payable share a common cutoff and therefore hypothesized that there might also be an error in accounts payable that would be related to the problem in inventory. The weight value assigned to the accounts payable hypothesis is somewhat arbitrary and currently is one half the weight of the inventory hypothesis. The system then went back and created a new analysis of accounts payable based on this new evidence.

Reviewing receivables as a percent of sales

Discontinuing analysis of receivables as a percent of sales because actual values are close to expected.

Creating an hypothesis with a weight of 3 that there is an error in the current value receivables which should be lower than it is because of a predating of invoices

Producing a summary analysis of receivables.

Creating an hypothesis with a weight of 3 that there is an error in the actual value receivables because of a predating of invoices

Receivables may be more risky because the account balance is higher than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to predating of invoices.

The analysis of receivables demonstrates the system's ability to search for events in its event network that might explain a pattern of data. In this case, both receivables and sales were higher than it expected. It located an event called "predating of invoices" that would explain this pattern of behavior. It then checked the incentive structures to see if management would have any incentive to manipulate sales and receivables in the same direction as these accounts differed from expected balances. It found that the gross profit incentive was close to the cutoff value and that the "predating of invoice" event is one that management can control and one that could create the pattern of data it is currently analyzing.

To summarize, the hypothesis concerning a problem with receivables because of "predating of invoices" event is based on the following findings: 1) both receivables and sales are higher than was expected, 2) a "predating of invoices" event could explain this pattern, 3) management has considerable ability to engage in a "predating of invoices" event, and 4) the bonus plan criterion is close to its boundary thus giving management an incentive to manipulate sales.

The emphasis during this event search process is on the evidence that supports the possibility that the event occurred. Once that is established, hypotheses concerning the accounts affected by the event are generated and the evidence passed along as part of the supporting data for the hypotheses. A similar hypothesis will show up shortly when the system gets to sales.

Reviewing cost of goods sold

Assessing the gen. ral control environment.

Assessing the calculation complexity of inventory

Assessing the supervision level associated with inventory

Creating an hypothesis with a weight of 3.5 that there is an error in the current value cost of goods sold because of a mechanical error

Reviewing cost of goods sold as a percent of sales

Making a note of a difference between no expected change in the current period's cost of sales as a percent of sales based on a projection of prior years' values and an actual 7.42 per cent decrease compared to that projected value.

Making a note of a difference between an expected 7.51 per cent increase in the current period's cost of goods sold based on its relationship to sales and an actual 0.46 per cent decrease.

Creating an hypothesis with a weight of 3 that there is an error in the current value sales which should be lower than it is because of a predating of invoices

Producing a summary analysis of sales.

Creating an hypothesis with a weight of 3 that there is an error in the actual value sales because of a predating of invoices

Sales may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to predating of invoices.

In this block of reasoning the system processed some of the deferred goals from earlier in its analysis. It begins its processing of cost of goods sold and reaches the point were it has evaluated expected/actual differences. It then completes its analysis of sales which was deferred due to the close relationship between sales and cost of goods sold. The system created an hypothesis involving the predating of invoices issue noted above and then produced its summary analysis of sales.

> **Creating an hypothesis with a weight of 1.5 that there is an error in the current value deferred revenue because of a mechanical error**
>
> **Reevaluating the risk assessment of deferred revenue based on new evidence.**
>
> **Producing a summary analysis of deferred revenue.**
>
> **Creating an hypothesis with a weight of 1.5 that there is an error in the actual value deferred revenue because of a mechanical error**
>
> **Deferred revenue may be more risky because there is some evidence that there may be an error in this account due to a potential error in sales.**

The system knows that deferred revenues are usually part of a common economic transaction that involves sales and therefore concludes that if there is an error in sales, there may be one in deferred revenue.

> **Producing a summary analysis of cost of goods sold.**
>
> **Creating an hypothesis with a weight of 3.5 that there is an error in the actual value cost of goods sold because of a mechanical error**
>
> **Cost of goods sold may be more risky because the account balance is lower than would be expected based on its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.**

In evaluating the risk potential for cost of goods sold, the system is using the firm model to hypothesize that assessments that affect inventory will directly affect cost of goods sold because cost of goods sold is in part based on inventory changes.

Reviewing product development

Discontinuing analysis of product development because actual values are close to expected.

Reviewing selling expenses

Discontinuing analysis of selling expenses because actual values are close to expected.

Reviewing administrative expenses

Assessing the general control environment.

Assessing the reporting standard volatility of administrative expenses.

Creating an hypothesis with a weight of 1.5 that there is an error in the current value administrative expenses because of a mechanical error

Discontinuing analysis of administrative expenses because actual values are close to expected.

Producing a summary analysis of administrative expenses.

Creating an hypothesis with a weight of 1.5 that there is an error in the actual value administrative expenses because of a mechanical error

Administrative expenses may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for administrative expenses. This error may have occurred in spite of a high level of internal controls for the firm.

Reviewing interest expenses

Assessing the general control environment.

Assessing the variation in transaction types for interest expenses.

Creating an hypothesis with a weight of 0.5 that there is an error in the current value interest expenses because of a mechanical error

Making a note of a difference between no expected change in the current period's interest expenses based on a change from last year's balance, a prediction of a decrease in the current period's interest expenses with a high confidence based on debt retirement, and a prediction of an increase in the current period's interest expenses with a high confidence based on new debt issuance and an actual 69.1 per cent decrease compared to last year's balance.

Creating an hypothesis with a weight of 0.5 that there is an error in a prediction of an increase in the current period's interest expenses with a high confidence based on new debt issuance which should be -0.69 because of a inaccurate prediction

Creating an hypothesis with a weight of 0.5 that there is an error in a prediction of a decrease in the current period's interest expenses with a high confidence based on debt retirement which should be -0.69 because of a inaccurate prediction

Producing a summary analysis of interest expenses.

Creating an hypothesis with a weight of 0.5 that there is an error in the actual value interest expenses because of a mechanical error

Creating an hypothesis with a weight of 1.0 that there is an error in the expected value of interest expenses because of a inaccurate prediction

Interest expenses may be more risky because the account balance is lower than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to moderately different types of transactions for interest expenses. This error may have occurred in spite of a high level of internal controls for the firm. However, there is some evidence that there may be an error in developing expected values due to a potential error in a prediction of an increase in the current period's interest expenses with a high confidence based on new debt issuance and a potential error in a prediction of a decrease in the current period's interest expenses with a high confidence based on debt retirement.

Reviewing income tax expense

Increasing the acceptable difference between expected and actual values because income tax expense usually requires a high level of normal substantive audit testing.

Making a note of a difference between no expected change in the current period's income tax expense based on a projection of prior years' values and an actual 347.14 per cent increase compared to that projected value.

Creating an hypothesis with a weight of 2 that there is an error in the expected value of income tax expense because of a variability in historic data

Producing a summary analysis of income tax expense.

Creating an hypothesis with a weight of 2 that there is an error in the expected value of income tax expense because of a variability in historic data

Income tax expense may be more risky because the account balance is considerably higher than would be expected based on a projection of prior years' values. However, there is some evidence that there may be an error in developing expected values due to the variability of historical data.

Reviewing unusual charges

Discontinuing analysis of unusual charges because the balance in immaterial.

Reviewing average shares outstanding

Discontinuing analysis of average shares outstanding because this account is usually not directly audited.

The system has now concluded its analysis of the individual accounts and will present its summary for the case. This summary contains a presentation of the individual account conclusions ranked by net weight of the hypotheses (i.e. weight of actual error hypothesis less expected error hypothesis). The ranking represents a partial ordering in that the first account mentioned is considered to be potentially most risky and subsequent accounts are either equally risky or less risky than accounts that preceded them.

In addition, the system notes dependencies in accounts so inventory would receive a somewhat higher rating than cost of goods sold because part of the problem in cost of goods sold depends on problems in inventory. It selects all accounts with a net weight greater than 1.0 for presentation. It indicates which accounts may have problems but were below the summary analysis cutoff point. It also indicates which accounts contain expect/actual differences but there was no other information to generate hypotheses and which accounts were dropped from consideration and why.

Presenting a summary of my analysis:

The most serious problem is that Inventory may be more risky because the account balance is higher than would be expected based on a projection of prior years' values and its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Sales may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to predating of invoices.

A less serious problem is that Cost of goods sold may be more risky because the account balance is lower than would be expected based on its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Receivables may be more risky because the account balance is higher than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to predating of invoices.

A less serious problem is that Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory. There is some evidence that there may be an error in this account due to a potential error in inventory.

A less serious problem is that Accrued liabilities may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for accrued liabilities. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Deferred revenue may be more risky because there is some evidence that there may be an error in this account due to a potential error in sales.

A less serious problem is that Administrative expenses may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for administrative expenses. This error may have occurred in spite of a high level of internal controls for the firm.

There may also be problems with the account balances of interest expenses, notes payable - banks, and other assets.

In addition, the account balances of other liabilities, prepaid expenses, and short term investments are not what I expected them to be. However, I don't have enough evidence to determine whether my expectations are at fault or not.

> There are differences between my expectations and the account balances of income tax expense but my expectations appear to be in error.
>
> I did not find any problems with cash, common stock, cumulative translation adjustment, current portion of long term debt, deferred income taxes - long term, federal income taxes payable, investment in affiliates, long term debt, net property, plant and equipment, paid in capital, product development, and selling expenses.
>
> I ignored treasury stock and unusual charges because their balances were immaterial.
>
> I did not analyze average shares outstanding and retained earnings because these items are usually not a concern in this case.

This concludes the system's analysis of the test case. At this point, the user is returned to the main case menu and is free to alter any of the input data and rerun the analysis.

CHAPTER 6

DESCRIPTION OF SYSTEM ARCHITECTURE

6.1 GENERAL CONCEPTS EMPLOYED BY THE ARCHITECTURE

The purpose of this chapter is to describe major features of the system at the program level (Newell, 1982). The chapter discusses the data structures and computational approaches used to represent and process the knowledge structures discussed in Chapters 4 and 5. A complete set of printouts for each class of data structures used in the system as well as individual examples of each class is contained in Appendix D. Appendix D contains an index to aid the reader in locating a specific data structure. The reader is encouraged to refer to Appendix D to obtain examples for the data structures discussed below.

The primary concerns in choosing an architecture for the system were psychological validity and flexibility. Although it is difficult if not impossible to determine the psychological validity of various representation schemes at program level (Anderson, 1978), there is considerable theoretical and empirical support for separating declarative knowledge from procedural and representing declarative knowledge as a network and procedural knowledge in the form of production systems (Anderson, 1983). Therefore the system was not built using the available expert systems shells based strictly on rule formalism[18] that some other accounting researchers have used (c.f. Dungan & Chandler, 1985; Gal, 1985; Hansen & Messier, 1986; Steinbart, 1987) but was written directly in the LISP programming language (see Selfridge et. al., 1986 and Shpilberg & Graham, 1986 for examples of this approach). The use of LISP allowed us greater flexibility (see Dhar & Pople, 1987 and Koton, 1985 for a discussion of the relative flexibility of rule based versus model based reasoning systems).

The choice of LISP was also driven by hardware considerations. The system was implemented on a COMPAQ II portable microcomputer which, because of its compact size and portability, facilitated frequent demonstration of the system to subjects. When this research project was started, there were no inexpensive development tools available for portable microcomputers that supported a combination of rule and network data structures.

6.1.1 OBJECT ORIENTED LANGUAGE

An object oriented language was developed on top of LISP in order to add structure to the system's architecture while retaining maximum flexibility (see Stefik & Bobrow, 1986 for a discussion of object oriented programming).

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[18] Expert systems shells are software development tools that contain editors to facilitate the creation, modification and deletion of data structures (rules in this case) and predefined inferencing algorithms to draw conclusions from sets of data structures.

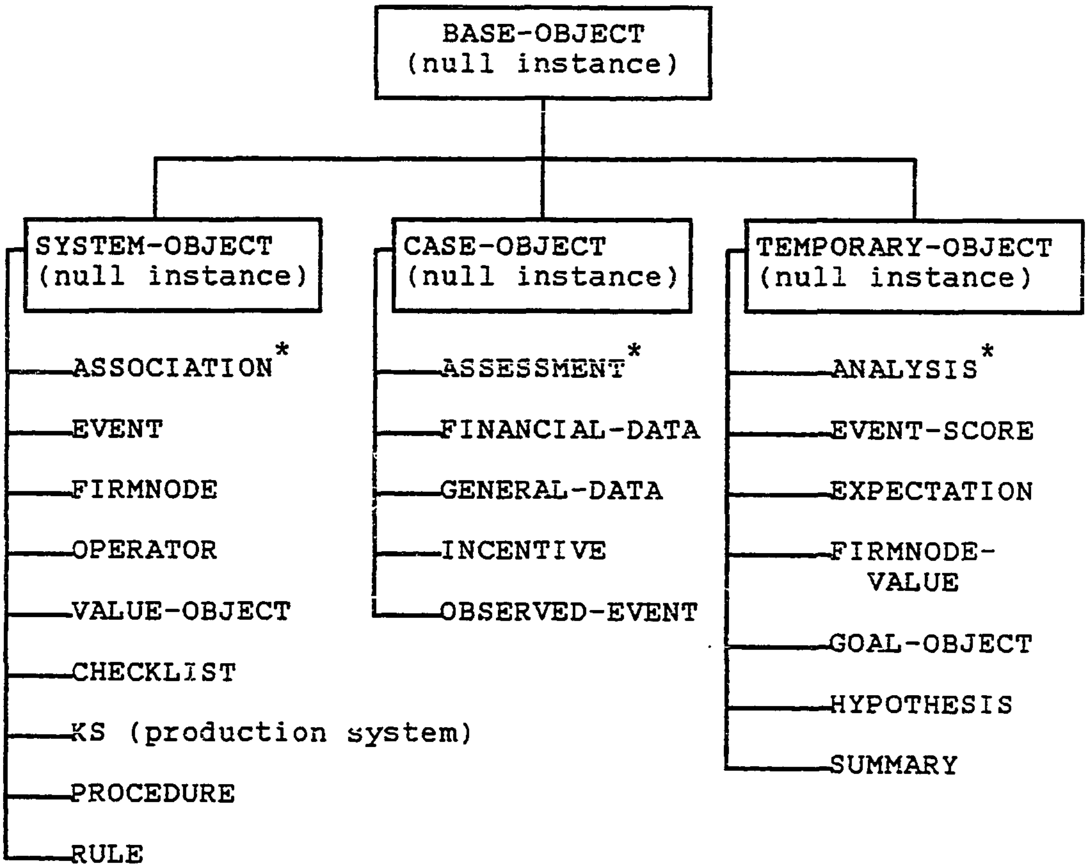
Structured objects are a very general data structure that can be specialized to include any or all of the three main data representational formalisms used in artificial intelligence programming: rules, propositions, or node and link networks. Since the language was custom built, only those features of typical object oriented languages needed for the system were included. By selecting a subset of standard structured object features, the overhead dedicated to the language could be minimized. This improved the system's operating speed and increased the memory available for the system's program code and data structures. The following discussion describes the object oriented features that were included in the language. Summary system statistics are presented in Section 6.6.

6.1.1.1 DEFINITION OF AN OBJECT

Simply stated, structured objects are merely a set of value attribute pairs (i.e. slots) that have been assigned a name. The power of structured object programming comes from the range of values that can be included in the slots. Values can include LISP functions and pointers to other structures as well as symbols and numbers. An object is defined by specifying a set of slots and assigning a name to them.

The system uses three basic types of objects: **null instance**, **class definitions** and **instances**. **Class definitions** contain information needed to create instances of the class as well as methods (i.e. specialized LISP functions) and values that are common to all members of the class. **Null instance** objects differ from class definitions only in that they do not contain the information necessary to define instances of classes of objects. Null instance and class definition objects are defined manually within the system with a function call to MAKE-OBJECT. This function builds an object based on its input.

Instances differ from null instances and class definitions in that they do not have children (see Section 6.1.1.2 for a discussion of the hierarchical nature of object organization). There is nothing in the language that precludes them from having children, but this feature was not needed and therefore not implemented and tested. Instances of object classes are created, modified or deleted in one of two ways: with the use of the system's editor for case and system objects (see Section 6.1.2 for a discussion of the editor) or under program control for temporary objects. Figure 8 below shows all the objects currently included in the system, how they are organized and their types.



*Remaining objects are all class definitions.

Figure 8 Overview of Object Organization

6.1.1.2 HIERARCHICAL ORGANIZATION

All objects within the system are organized in an "isa" hierarchy where each object "is a" member of a class. Children of an object are members of the object's class. Children can be either null instances, class definitions or instances. Null instances and class definitions typically have children, instances do not.

The top level object in the system is the BASE-OBJECT. This object contains information that is common to all objects in the system. It is a null instance as are its immediate children: SYSTEM-OBJECT, CASE-OBJECT and TEMPORARY OBJECT. These three objects contain information common to the three main classes of objects used by the system. Their children are the class definitions for those classes of objects. See FIGURE 8 for a complete overview of the system's object organization.

The system incorporates multiple inheritance with left to right precedence for the purposes of retrieving information and setting values. This means that an object can be a member of more that one hierarchy and inherit values and methods from more than one parent in each hierarchy. It also means that, when given a list of hierarchies to search, the system will start with the first member of the list and search it thoroughly until it either finds the slot name it is looking for or hits the top of the hierarchy without finding that slot name. Only if it hits the top of one hierarchy will it proceed to the next hierarchy. There are currently only two hierarchies used by the system, the static CLASS hierarchy described in Figure 8 and a dynamic PARENT hierarchy described in the discussion of procedural objects below (see Section 6.2.1).

The inheritance is implemented with a flexible value retrieval function, GETS which can climb hierarchies in a variety of ways. First, if it is not given specific instructions, it will chose a default hierarchy to climb. It uses two different defaults in two different contexts. In most cases, it will use the CLASS hierarchy described in Figure 8. However, when looking for variable bindings in procedural objects during system execution, it will use the dynamic PARENT hierarchy described in Section 6.2.1. Second, GETS can be directed to follow any hierarchy or set of hierarchies as a part of its function call. And finally, GETS can be told not to climb any hierarchy. GETS either returns the value it finds or FAIL which indicates that the slot name for which it was looking was not found in the hierarchy it was searching. Value setting is implemented using GETS so setting and retrieving operate in the same way.

6.1.1.3 MESSAGE PASSING

Communication between objects is achieved by sending messages. Messages tell an object to execute its version of a named function and return the value. The syntax of a message includes: 1) name of the object to which the message is directed, slot name where the desired function will be found, and an optional list of arguments. Message passing allows system flexibility to be achieved simply because information is stored locally. That is, each object "knows" the correct function to use to achieve a particular result. The sending object does not have to know the correct function name for the object it is sending to, it can merely request a generic value name and let the receiving object determine the correct function. For example, each object class definition contains a DISPLAY slot whose value is the name of the function designed to display the contents of that class of objects. To get an object to display its contents in a natural language format, one merely sends the object a message with a slot name of DISPLAY.

6.1.1.4 PATTERN MATCHING

The system incorporates a relatively simple pattern matching feature that replaces variable names with their current values in certain data structures prior to evaluating those structures. In general, variable names are slot names and the variable replacement function uses GETS and its inheritance rules described above to locate variable values. Variable names are designated with a (*VAR* x)[19] list structure where the "x" would be a variable name.

---

[19] Actually, the user or programmer enters "?x" and the "?" expands internally to (*VAR* x).

Currently, this variable replacement occurs in four places: FIRMNODE and ASSOCIATION formulae, condition and action elements of rules, variable parameters of events and default structures in class definition objects (see Section 6.1.2.2). The variable replacement function builds a list of variable bindings as it goes and looks first in that list for variable names to insure consistency within a data structure.

6.1.2 SYSTEM EDITOR

The system contains a menu driven editor which is used to create, delete and modify instances of classes. The editor also includes options for printing out recognition patterns for classes and running a case analysis. The editor itself is implemented in the system's object oriented language so it is possible to use the editor to change the editor's behavior.

6.1.2.1 DESCRIPTION OF EDITOR MENUS

A session begins with the top level menu as presented in Figure 9.

```
                    Main Menu
           Inherent Risk Evaluation System

(A)nalyze, review or update case information.

(R)eview or update system elements.

(Q)uit and return to the operating system

Enter your choice:
```

Figure 9 Main System Menu

Instances of system object classes can be edited with option **R** and case classes with option **A**. The system menu allows the user to either edit system instances or print recognition patterns for a class of objects. In order to access an instance, the system first needs to know the class of object and then the instance name. It looks up the instance name entered by the user in the recognition list for the object class and then executes the appropriate task on the instance. A recognition list is made up of a series of string, object name pairs. Strings are included for the object name itself, its print name and any additional recognition strings entered by the user. This recognition system is a simple way to provide some flexibility in identifying instances within the system.

Figure 10 presents the system menu which is followed by Figure 11 which is a prompt screen used by the system to identify the object class desired. The object class selection menu is dynamic in that whenever a new system object class definition is added to the system, the system automatically adds a response line to the menu based on the first letter of the new object class' name. This means that no two object class names may start with the same letter. Responses to these menus are key sensitive. That is, the user merely hits the key that matches the letter in parentheses on the screen to indicate his/her choice.

```
                    System Menu

You may perform the following activities on system
objects:

 (A)dd an instance of an object.

 (M)odify an instance.

 (D)elete an instance.

 (R)eview an instance.

 (P)rint recognition patterns.

 Add a (S)pecific slot to an instance.

 (E)rase a specific slot from an instance.

 (Q)uit and return to the main menu.

Enter your choice:
```

Figure 10 System Menu

```
Enter class of object or Q to quit.

Existing classes are:

   (A)SSOCIATION
   (C)HECK-LIST
   (E)VENT
   (F)IRMNODE
   (K)S
   (O)PERATOR
   (P)ROCEDURE
   (R)ULE
   (V)ALUE-OBJECT

Enter your choice:
```

Figure 11 Object Class Selection Menu

Once the system has the object class name, it prompts the user for an instance name (except for add operations) and takes appropriate action. The case menu is quite similar to the system menu and is presented in Figure 12.

```
                    Case Menu

   (A)dd an instance of a case object.

   (M)odify an instance.

   (D)elete an instance.

   (R)eview contents of an instance.

   (P)roduce an analysis of case information.

   (C)hange to a new case.

   (Q)uit and return to the main menu.

Enter your choice:
```

Figure 12 Case Menu

6.1.2.2 ADD AND MODIFY OPERATIONS

The system uses information stored in a class definition object to prompt the user for information necessary to create a new instance of that class. Each class definition object contains a list of multivalued slots, a list of user accessible slots and a series of descriptive structures called default fields which are used in the creation process. Default structures comprise the template which determines what slots an instance of the class should have. The "user-accessible" list in the class definition tells the editor which slots need user input. The "multi-valued" list tells the editor which slots can contain multiple values and therefore which ones should be entered as lists. For fields that are not user accessible, the default value is used.

A default structure contains five items: the slot name, the default value, LISP code to be executed when a new value is entered (an "if-added" demon), LISP code to be executed when a value is deleted (an "if-deleted" demon) and a print name. The LISP code can contain variables which are represented as a "(*var* x)" structure. The structure is replaced by the current value for "x" before the LISP code is executed. "If-added" and "if-deleted" demons are used both to edit incoming data and make sure that it complies with preset standards and to maintain fixed linkages between objects within the knowledge base.

The creation process consists of prompting the user for values for each slot name in the "user-accessible" list and testing each user entry by performing a variable replacement on the "if-added" demon associated with the slot and then executing that demon. Demons return "t" or "nil" where "nil" indicates a restriction failure. The user is prompted to reenter any data that creates a restriction failure. The user may also hit "enter" and the system will pick up the default value associated with that slot and use it.

The modification process consists of identifying the desired instances as described above, selecting the slot to change and then entering a new value. Both "if-added" and "if-deleted" demons are triggered in this process since it involves deleting an old value and entering a new one. Appendix C contains sample add and modify screens for case objects. The screens and procedures are identical for system objects.

6.2 REPRESENTATION OF PROCEDURAL KNOWLEDGE

6.2.1 COMMON FEATURES OF PROCEDURAL OBJECTS

Procedural knowledge in the system was represented in four different ways: as rules, productions systems, checklists and procedures. Each representation method was implement as a class of structured objects. There are three slots that are common to all four classes: trace message, explanation and variables. The trace message allows the system to display relevant information when a procedural object executes. This is useful for program debugging and for matching the model's process behavior against a human subject's verbal protocol. The explanation field is used like a comment line and facilitates debugging the system. Variables are the procedural object's local working memory. The values for these variables can be set by passing the procedural object information when it is called or by action of procedural objects. Since these fields are common to all procedural objects they will not be discussed further.

The procedural objects can be linked together dynamically in call chains similar to function calls in LISP which means the system has great flexibility. However, they are data structures that conform to certain standards of explicit knowledge representation which gives the system access to its own knowledge. This feature will be useful in future enhancements of the system that deal with improved explanation and learning.

Execution of procedural objects is achieved with the specialized slot name EXECUTE. An EXECUTE message triggers an appropriate evaluation function for a given procedural object. In all cases, the first step for EXECUTE is to store any local variable bindings associated with the object and reinitialize those bindings to values passed as part of the message or to default values if no values are passed. Then an execution procedure is triggered and its value returned after local variable bindings are reset to their original values. For example, an EXECUTE message to a CHECKLIST object would trigger the variable binding activity described above and then send an execution message to each procedural object included in the checklist's procedures slot until either the local STOP or SKIP variables were set to a non-nil value. If STOP is set, the function resets local variable bindings and returns the value to which STOP was set. If SKIP is set to a non-nil value, it resets SKIP to nil and skips the next procedure in the list. If all procedural objects are executed and STOP is never set, the function will reset variable bindings and return FAIL.

When procedural objects are executed, a record is kept of the name of the calling object. This creates a call chain or dynamic hierarchy which is used for purposes of retrieving variable values. For example, if there is a variable in the condition of a rule, the system will begin looking for that variable name in that rule's variable list. If it can't find it there, it will check the variable list of the calling object or PARENT. It will continue up the dynamically formed PARENT hierarchy until the variable name is found and will then return that variable's current value. The effect of this dynamic hierarchy is to simulate dynamic scoping within a push down stack. The system also contains a mechanism to allow for recursive execution messages to procedural objects.

6.2.2 RULES

Rules primarily reside inside production systems but can also be included in checklists. Rule objects contain five fields that are currently used by the system: condition, action, variables, trace message, and explanation. The condition and action fields are straightforward and represent the "if" and "then" clauses of "if ... then" rules. In keeping with the structured object approach, rules are allowed to have local variables. However, this feature is seldom used. Two additional fields show in the printout in Appendix D but are not currently used by the system: abductive and deductive strength. These fields were initially included because of the common use of certainty factors and other probabilistic measures in expert systems shells but no use was found for them in this implementation.

6.2.3 PRODUCTION SYSTEMS

The KS object class instances are production systems which contain rule packets that are interpreted sequentially until one fires and then the process begins at the beginning of the packet again. The processing terminates when no rules fire or when a rule tells the production system to stop. The KS name was used as an abbreviation for Knowledge Source. Production systems contain four fields: rule list, trace message, variables and explanation. The rule list is a list of rules that are checked sequentially until one fires.

6.2.4 CHECKLISTS

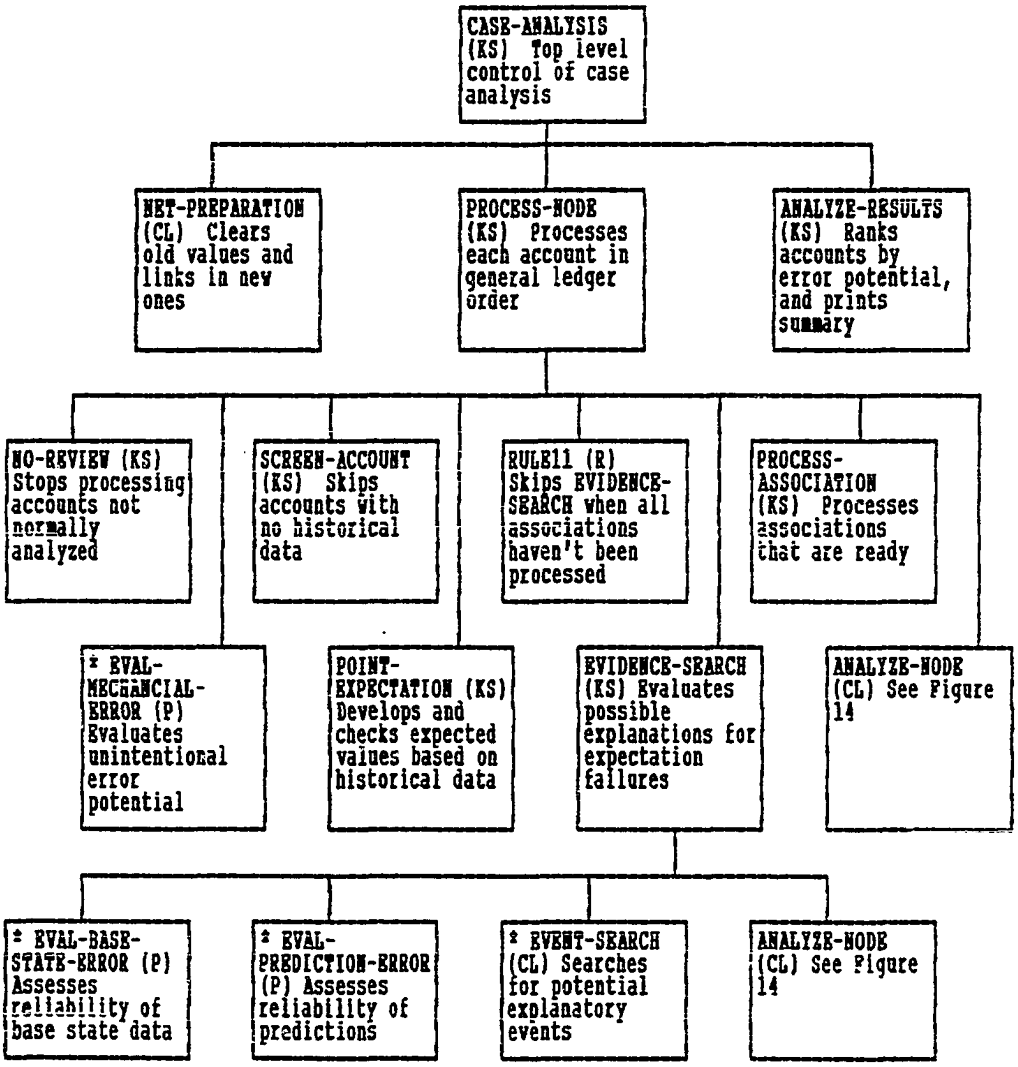
Checklists represent a specialized form of production system. They execute a list of procedural objects (rules, other checklists, production systems or procedures) sequentially until all have completed their activity or one of them tells the checklist to stop. In addition, procedural objects can tell the checklist to skip other procedural objects. Checklists contain four fields: list of procedural objects, variables, trace message and explanation.

6.2.5 PROCEDURES

Procedures are ways for the system to call LISP functions directly while maintaining the features of other procedural objects. They contain four fields: variables, trace message, explanation and procedure definition. Use of procedures has been minimized because knowledge is not as explicitly represented as it is in the other procedural objects and their use was limited to complex mathematical calculations.

6.2.6 DISCUSSION OF PROCEDURAL OBJECT BEHAVIOR

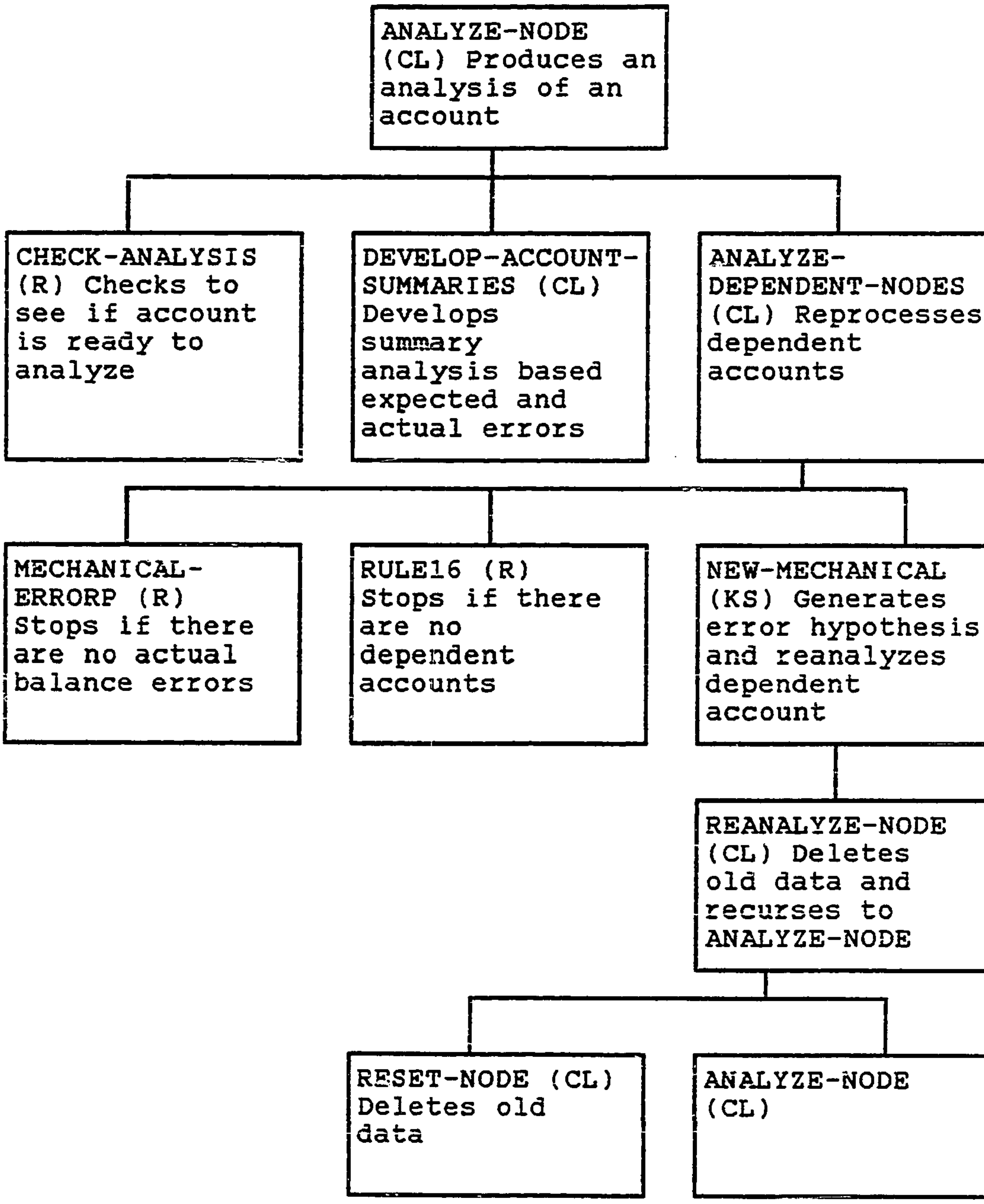
The following discussion is presented in order to assist the reader in gaining a clearer picture of how procedural objects function during a typical case analysis. Figures 13 and 14 present an overview of a typical call chain developed during a case analysis. Each box in the Figures represents a procedural object and contains the object's name, class and activity description. Flow of control in these Figures proceeds from top to bottom, left to right. The following discussion describes how a case is analyzed by "walking through" Figures 13 and 14. Figure 4 in Section 4.2 also presents an overview of the system's functioning in the form of a flowchart and can be used by the reader in conjunction with this description to help enhance clarity.



Object Class Key: CL = Checklist
KS = Production System
P = Procedure
R = Rule

* These procedural objects generate hypotheses

Figure 13 Main Procedural Control Structure



Object Class Keys: CL = Checklist
KS = Production System
R = Rule

Figure 14 Summary Account Analysis Control Structure

A case analysis begins when an EXECUTE message is sent to the CASE-ANALYSIS production system. CASE-ANALYSIS first initializes the internal firm model by sending an EXECUTE message to NET-PREPARATION which clears the model of any old values, expands all OBSERVED-EVENTs and links all case specific data to the appropriate model element (i.e. account). Next CASE-ANALYSIS produces an ordered list of account names that have current financial data associated with them. The list is in standard general ledger order (i.e. assets, liabilities, equity, revenues and expenses). CASE-ANALYSIS sends an EXECUTE message to PROCESS-NODE and passes the name of each account in turn. Once all accounts have been processed, it executes ANALYZE-RESULTS which produces a summary analysis of the case.

PROCESS-NODE first processes an account by executing NO-REVIEW to screen out accounts which are not normally analyzed separately by auditors (e.g. accumulate depreciation or stockholder's equity for a wholly owned subsidiary). Next, PROCESS-NODE determines the mechanical error potential for an account by executing EVAL-MECHANICAL-ERROR. EVAL-MECHANICAL-ERROR first determines if any account specific assessments (i.e. assessment objects that refer to a specific account) are related to the account and stops its processing if there are no specific assessments related to the account. If there are specific assessments, it executes production systems which are linked to the factor names in each assessment object to determine an error potential score. Both account specific and general assessments are included in the process. Each production system linked to a factor produces a score which is based on the level field of the assessment object and is either positive or negative depending on the knowledge of whether the factor would increase error potential or not, which is embedded in the production system. The total score is a sum of all individual scores.

Next, PROCESS-NODE executes SCREEN-ACCOUNT to determine if expected values should be generated for the account. If the account has no historical data on which to base an expected value or if an expected value has already been developed, SCREEN-ACCOUNT skips execution of POINT-EXPECTATION.

Next, PROCESS-NODE executes POINT-EXPECTATION to develop and test expected values for the account based on historical data. If there are significant differences between expected and actual balances, POINT-EXPECTATION will generate an expectation object for the current account. This expectation object represents an expectation failure. Then PROCESS-NODE executes RULE11 to determine if an expectation failure has been created and if all the association objects involving the current account have been processed. If all associations have not been processed, RULE11 creates a goal to execute an evidence search when all related association objects have been processed and tells PROCESS-NODE to skip the next operation. Since all existing goal objects have their conditions tested before any procedural object (except a rule) is executed, as soon as the PROCESS-ASSOCIATION production system completes its processing of the last association object related to the current account, the EVIDENCE-SEARCH checklist will be executed on that account.

Next, PROCESS-NODE executes EVIDENCE-SEARCH to look for alternative explanations of expectation failures. If no expectation failures have been created, EVIDENCE-SEARCH ceases execution. If there are expectation failures, it will check the variability of historical data that generated the expected balance, will check the confidence level of any predictions used to generate the expected balance and will look for any events in the event network that could explain the expectation failure. Once all three possibilities have been checked, it will execute ANALYZE-NODE to produce an analysis of the evidence related to the current account being processed.

The PROCESS-ASSOCIATION production system retrieves a list of all associations related to the current account being processed and checks each one to see if it has not already been processed. If an association has not been processed, PROCESS-ASSOCIATION determines if all the arguments have been processed. If all arguments have not been processed, it sets a goal to execute PROCESS-ASSOCIATION on the given association object when all arguments have been processed. If the arguments have been processed, it processes an association object by executing

POINT-EXPECTATION on the association. If POINT-EXPECTATION generates an expectation failure for the association, PROCESS-ASSOCIATION uses the expected value of the association to develop expectation failures for any of its arguments that depend on another argument. For example, an expectation failure for accounts receivable as a percent of sales would create an expectation failure for accounts receivable but not sales since the receivable balance depends on sales. PROCESS-ASSOCIATION uses the firm model and event networks to determine dependency.

The final step in processing an account is performed by the ANALYZE-NODE checklist. ANALYZE-NODE executes CHECK-ANALYSIS to determine if an account is ready to be analyzed, i.e. has not already been analyzed, has at least one expectation failure or hypothesis and has had all related association objects analyzed. CHECK-ANALYSIS terminates the execution of ANALYZE-NODE if all these are not met.

Next, ANALYZE-NODE executes DEVELOP-ACCOUNT-SUMMARIES to create an analysis object for the current account (see Section 6.5.1 for a description of analysis objects). The main function of analysis objects is to segregate all the accumulated evidence into two categories: evidence that supports the hypothesis that there is an error in the actual account balance and evidence that supports the hypothesis that there is an error in the expected account balance. The "evidence" analyzed by ANALYZE-NODE are all expectation failures and hypotheses that have been generated during the system's analysis of an account. Hypotheses can be generated by four procedural objects: EVAL-MECHANICAL-ERROR, EVAL-BASE-STATE-ERROR, EVAL-PREDICTION-ERROR and EVENT-SEARCH. Each one of these objects checks for duplicate hypotheses before it completes its processing and combines any duplicates (See Section 6.5.6 for a discussion of hypothesis combination).

Once an analysis object is developed and displayed on the screen, ANALYZE-NODE executes ANALYZE-DEPENDENT-NODES to determine if any account should be reanalyzed based on the results of the analysis of the current account. Since the system defers analysis of related accounts when that relationship is evidenced by an association object, ANALYZE-DEPENDENT-NODES searches the firm model and event network looking for dependencies between accounts that are not represented by association objects and executes a reanalysis of any account that depends on the current account. This is how the system differentiates between the **compiled causal**, i.e. represented by an association object and **causal** relationships discussed in section 4.2.2.1.2. In addition, since ANALYZE-DEPENDENT-NODES executes ANALYZE-NODE after it clears old data, its activity is an example of the use of recursion by the system.

6.3 PERMANENT DECLARATIVE KNOWLEDGE

6.3.1 BASIC RELATIONSHIPS BETWEEN OBJECTS

The declarative knowledge of the system is made up of five object classes: **association, event, firmnode, operator** and **value-object. Firmnode** and **operator** objects combine to form a node and link network where the nodes are firmnode objects and the links are operator objects. The network is created by the use of formulas in firmnode objects that show how values for the firmnode can be calculated from other firmnodes. These formulas include an operator object name and arguments. The arguments can be numbers or other firmnode names. Associations represent the compiled causal relationships mention in Section 4.2.2.1.2 and are very similar to firmnodes in that the main piece of information included in them is a formula which contains an operator and firmnode or number arguments. Causal relationships are represented by a combination of events and firmnodes. The "triggers" slots of firmnodes indicate which events are caused or enabled by changes in the firmnode's value. The "cause", "caused-by", "enabled", "enabled-by", "blocks" and "blocked-by" slots in events indicate which firmnodes or events have a causal relationship with the given event. Generally, causal relationships can occur between events directly or indirectly through state changes in firmnodes.

6.3.2 ASSOCIATION

Associations contain a variety of slots which serve two main purposes: calculating and storing various values for the association and recording any case specific or temporary data objects that relate to the association. The heart of the association is its formula which describes a relationship between two firmnodes. The operator object embedded in the formula is capable of calculating all the values needed for the association. These values include two percentage change values (**t-change** and **s-change**) and seven absolute values (**current, prior, past, history, quarterly, base-state** and **base-test**). The **t-change** and **s-change** values are expected change values for the association. The **t-change** value is an expected change in the trend or rate of change for the historic values while the **s-change** is an expected change in the current period's value from a base state value which is calculated using historical data. **Current, prior, past, history,** and **quarterly** values are absolute values based on general ledger data. The **prior** value is for the preceding year and the **past** value is for the year prior to that. **History** is the list of all historical data excluding the current year.

6.3.3 EVENTS

Events describe patterns of changes in firmnode objects and can be linked in a variety of causal chains. The pattern of change can be described through the use of the **nodes-affected** slot or the **parameters** slot. The **nodes-affected** slot provides a set of firmnodes and change directions that indicate a fixed pattern of change caused by an occurrence of the event. The **parameter** slot contains variables that allow the event's impact on firmnodes to vary with context. The **on-occurrence** slot contains LISP code that is executed whenever an observed-event case data structure indicates that the event has occurred. This Lisp code can contain variables and is currently used to generate prediction and assessment objects that indicate how account balances should change and sources of potential error in account balances. Events are also classified in two ways: by level of management influence and by type (i.e. normal recurring, infrequent or unacceptable). Unacceptable events are those that auditors feel should not occur in the normal course of business activity.

6.3.4 FIRMNODES

Firmnodes contain the same data fields as associations as described in Section 6.3.2. They also include some additional quarterly and budget data not included in associations. Since firmnodes can be included in the formulas of other firmnodes, they also contain an **outnode** list which includes back pointers to firmnodes that include the given firmnode as an argument in their formulas. This list allows the system to move in both directions in the network formed by formulas and firmnodes. A firmnode also contains descriptive information that tells whether it is a general ledger account, total or subtotal; whether it is an asset, liability, revenue or expense; the normal level of substantive auditing effort associated with the node and whether the balance is based on a large set of recurring transactions or small set of infrequently occurring transactions.

6.3.5 OPERATORS

Operator objects can perform a variety of quantitative and qualitative calculations for a standard set of mathematical functions: addition, subtraction, multiplication, division and per cent. There are also operators for standard mathematical comparison: greater than or equal to, less than or equal to, minimum and maximum. Operators can deal with these functions and comparisons on an absolute value bases, a percentage change basis or on a qualitative basis. The set of qualitative values with which operators deal are increase, decrease and no change. Operators can also solve for missing values. That is, given the fact that $x + 2 = 4$, the +! operator can solve for "x" and return 2.

6.3.6 VALUE-OBJECTS

Value objects are employed mainly to provide print names for various concepts used in the system.

6.4 CASE SPECIFIC DATA STRUCTURES

Case specific data structures are those that are entered by the user to describe a specific case. These data structures were thoroughly discussed in Chapter 5 and will not be discussed further here.

6.5 TEMPORARY DATA STRUCTURES

Temporary data structures are created by the system as it analyzes a case and contain inferences or summaries based on the case data. The structures include **analysis, event-score, expectation, firmnode-value, goal-object, hypothesis** and **summary**.

6.5.1 ANALYSIS

An analysis object contains classified and summarized data concerning a given firmnode object. Since procedural knowledge within the system targets firmnode elements that are general ledger accounts, analyses will only be created for firmnodes that represent general ledger accounts. An analysis is created if there are either expectations or hypotheses developed for the account. The hypothesis information is classified as to whether it supports the assertion that there is an error in the actual account balance or an error in the expected account balance. The analysis maintains history information on how hypothesis and expectation information was developed as well as a list of hypotheses and expectations that are summarized by the analysis.

6.5.2 EVENT-SCORE

Event score objects are created when an event is asked to determine the level of management incentive and ability to trigger an event occurrence. The level of incentive is based on how the occurrence of the given event would affect incentive objects associated with the case being processed. For example, in the test case a PREDATE-INVOICES event would have caused both sales and receivables to increase thus explaining expectation failures noted by the system in these accounts. Since gross profit was close to the incentive boundary established by the gross profit bonus incentive object and an increase in sales would cause an increase in gross profit (all other things equal), management's incentives to trigger a PREDATE-INVOICES event are positive. The predate invoice event was also rated as highly subject to management influence. These facts combined created a reasonably high score for the PREDATE-INVOICES event in the context of the test case. The event-score object records this score and a list of the data structures used to arrive at the score so that if the information is requested again, it will not have to be recalculated.

6.5.3 EXPECTATIONS

Expectation objects contain a record of mismatches between system generated expected account balances and actual account balances. The information contained in the expectation object includes the account affected, the actual account balance, the expected account balance and a history of how it was calculated, and a list of any hypotheses that are subsequently generated to explain the expectation mismatch.

6.5.4 FIRMNODE-VALUES

Firmnode-value objects contain an expected change value for a firmnode, the type of value (trend or point estimate) and a history of how that value was calculated. They are created whenever a firmnode is asked to calculate an expected value and are stored so that the calculation does not have to be repeated.

6.5.5 GOAL-OBJECTS

Goals can be set by any procedural data structure and are created whenever a procedural structure wants to defer its reasoning or the reasoning of some other procedural structure to some future point. Goals are similar to rules in that they contain conditions and actions. The conditions of each goal are checked prior to execution of checklists, procedures or production systems. A push down stack is used to order goals so the most recent goal is checked first. The first goal whose conditions are satisfied is executed (i.e. has its action slot evaluated). Goal execution involves establishing a context or set of variable bindings and then executing a procedural object. The context must be included in the action slot by the procedural object that created the goal. Bindings are returned to their preexecution values once the action is completed. The value returned by the action clause is returned by the goal execution function. Goals are not checked prior to the execution of each rule and the goal checking process is suspended while a goal is being executed in order to avoid highly disjointed behavior.

6.5.6 HYPOTHESES

Hypotheses are created by the system whenever it establishes that there is some evidence that either an expected or actual account balance may be in error. Since the mechanical error checking process described in Section 4.2.1.1 is performed independently of the expectation generation process, hypotheses can be created even though there is no expectation failure. A hypothesis contains five slots: **expectations, assertions, assertion support, weight** and **weight support.** The **expectations** slot contains a list of any expectations that the hypothesis attempts to explain, if any.

The **assertion** characterizes the hypothesis in that it contains the name of the firmnode or association to which the hypothesis applies and the nature of the hypothesized change to that data structure. A typical assertion might be:

(replace f-inventory current-value 99282 diff)

"Replace" indicates that the system has some evidence that there may be an error in an account or association. In this case, the error is in the current actual value of inventory. The assertion contains the current value of inventory (99282) to facilitate explanation. "Diff" indicates that the system has no evidence as to the direction of the error; that is, whether the balance should be higher or lower.

The **assertion-support** slot indicates which procedural object produced the hypothesis. In the above example it would be the mechanical error checking procedure.

The **weight** slot indicates the level of support for the assertion. The weighting logic in the system was discussed in some depth in Chapter 4. Generally, weights are determined by the procedural object that creates the hypothesis and are based on simple additive algorithms.

The **weight-support** slot contains a history of how the weight was calculated. In essence, this slot contains a trace of the system's reasoning in generating the hypothesis. A history contains the name of the procedural object that added to or subtracted from the weight and the variable bindings used by that object.

Hypotheses can be merged by the system in two ways. First, if at any point during processing, two different procedural objects create hypotheses with the same assertion, the expectations, assertion-support, weight and weight-support slots of these two hypothesis will be combined into one hypothesis and the other will be deleted. Only hypotheses with identical assertions are merged when they are created. Second, hypotheses with differing assertions about the same account are merged into a new summary hypothesis when the system creates its analysis of an account. These summary hypotheses have two possible assertions: an error in the expected balance or an error in the actual balance. They are used by the system to classify all evidence into those two categories.

The system does not attempt to resolve conflicting evidence within each category. For example, if the system expected the cost of goods sold balance to be higher based on historical trends but lower based on its relationship to sales the system would not attempt to resolve the conflict but merely note both facts and consider both as evidence for potential errors in the cost of goods sold balance. The system does not attempt to resolve these conflicts because auditors tend to be conservative and defer judgment until more evidence was gathered.

6.5.7 SUMMARIES

Summary objects are created during the development of the final summary for the case. They are used to rank the analysis of individual accounts by importance level. This importance level does not just depend on the sum of hypothesis weights associated with the account but also depends on dependence relationships. That is, if the value of account A depends on account B, a problem with the account B is more important than a problem with account A. For example, a problem with inventory is more important than a problem with cost of goods sold since inventory is used to calculate cost of goods sold. When ranking accounts for final presentation, the system checks for dependencies and increases the weight of accounts on which others depend.

A summary object contains four slots: firmnode, weight, analysis and dominance. The firmnode slot contains the name of the account involved, the analysis slot the name of the analysis object associated with that account, the weight slot the final weight developed during the ranking processes and the dominance slot is not currently being used.

6.6 SUMMARY INFORMATION

The system runs on a COMPAQ II portable microcomputer that has been enhanced to include a 5 megabyte extended memory board. The enhancement was necessary to accommodate GoldHill Computer, Inc.'s Golden Common LISP 286 development package which was the software used to implement the system. The system does not take advantage of any special features of the hardware or software and should run in most Common LISP environments. Table 3 contains descriptive statistics of the system.

Table 3 System Statistics

Source code (commented and uncompiled)	275 kbytes
Compiled source code	292 kbytes
System data structures	427 kbytes
Test case data structures (includes general ledger)	10 kbytes
Item counts:	
Associations	6
Check lists	44
Events	41
Firmnodes	107
Operators	11
Procedures	44
Production systems	45
Rules	360
Value objects	45

CHAPTER 7

EVALUATION OF SYSTEM PERFORMANCE

7.1 DESCRIPTION OF THE EVALUATION PROCEDURE

7.1.1 GOALS OF THE EVALUATION PROCEDURE

The evaluation portion of this research was designed to obtain answers to five main questions:

1. Was the form of the system's analysis and the evaluation context realistic?

2. How accurate and reasonable were the system's account level analyses?

3. Were the conceptual model assertions supported by the evidence?

4. Were the case descriptions accurate and complete?

5. Were there any potential uses for the system in actual practice?

7.1.2 DESCRIPTION OF THE EVALUATION PROCESS

Two questionnaires were designed to obtain information from the two auditor subjects who had helped develop cases for this research project. Copies of these questionnaires are included in Appendix E. The questions on the questionnaires were general and open ended in order to give the subjects maximum opportunity to express their opinions freely and to avoid prejudicing their responses.

Two packets of materials were mailed to each subject. The first packet included a cover letter which contained general instructions, a copy of Questionnaire #1 (see Appendix E), a case description for the case that the particular subject had helped develop and an annotated printout of the system's analysis of that case (see Appendix B for an example of a case description and system analysis). The second packet was similar to the first but included a copy of Questionnaire #2 and the case descriptions and system analyses for two cases which were unfamiliar to the subject. Questionnaire #2 did not contain questions pertaining to the completeness and accuracy of the case description and overall evaluation of the research project which were included in Questionnaire #1.

The subjects were asked to evaluate the system's analyses within the following context:

> Assume the analysis produced by the system was developed by a junior accountant who had been given the case materials and asked to identify potential risk areas based on the case information.

The context was selected to be as realistic as possible given the anticipated level of the system's performance and the author's understanding of how inherent risk assessments are made within the subjects' audit firm. The system's performance was quite simplistic given the preliminary nature of this research and, in the author's opinion, approximated the analysis an inexperienced junior accountant might produce. However, junior accountants don't normally prepare inherent risk analyses. Therefore, a training context for a junior accountant was selected with the assumption that such a training exercise might be used to prepare the junior for a more responsible position.

Analysis of the subjects' responses primarily involved reviewing their detailed critiques of the system's analyses looking for areas where the subjects disagreed with the system and the reason for the disagreement. The reasons were then classified into categories to identify more general changes and extensions that were needed in the system. In addition, the critiques were reviewed for evidence concerning the validity of the conceptual model assertions. Finally, a count was taken of the total number of accounts involved in each case, the number of times the subjects disagreed with the system's analysis of an account and the number of times the subjects disagreed with each other on the analysis of an account.

The analysis of the subjects' responses was subjective due to the open ended nature of the questions asked. Support for conceptual model assertions and system design assumptions often had to be inferred from the subjects' responses since the subjects' evaluation of these items was not directly solicited. In general, subject #2 agreed with the system's analysis more often and had a more complementary opinion of the system than subject #1. This is probably because Subject #2 was involved in the research project early in the data gathering stage and was instrumental in developing the first test case. A summary of the results of this analysis and examples of inferences made is included in the following sections of this chapter. Each of the questions presented in 7.1.1 are dealt with in turn except number 4. This question was only asked subjects on cases they helped develop and was included as a double check on the completeness and accuracy of the case descriptions. Since this question had been asked several times during case development meetings, significant deficiencies should not have, and did not, come up.

7.2 EVALUATION CONTEXT AND SYSTEM OUTPUT

This portion of the analysis of subjects' responses involved determining if the context used to evaluate the system was realistic and if the system's output represented a realistic risk evaluation given that context. The realism of the context was evaluated based on the subjects' responses to question I.C. in Questionnaire #1. The realism of the system's analysis given the context was more complex and involved drawing inferences from both the subjects' detailed critique of the system's performance and the overall evaluation of that performance.

7.2.1 REALISM OF EVALUATION CONTEXT

Subject #1 felt that the evaluation context was not realistic because risk assessments are typically developed by partner and manager level personnel. Subject #2 felt that the context was realistic in that such an exercise could be used to help train future in-charge accountants. (see Appendix F, question I.C.).

7.2.2 REALISM OF THE SYSTEM OUTPUT

Both subjects felt that the system's overall performance was adequate given the limited case material (Appendix F, question II.C.). However, subject #1 felt that the system was too "numbers oriented" and did not deal adequately with qualitative factors such as management integrity and pressures on management, changes in the business environment and quality of internal controls (Appendix F, questions I.C. and III.A.). Subject #1 felt that the analysis generated looked more like a Financial Performance Review[20] than a General Risk Assessment[21].

The strongest evidence supporting the realism of the output is indirect. Although Subject #1 felt it was inappropriate to have junior accountants evaluating inherent risks, neither subject had difficulty in evaluating the system's analysis in that context. The problems mentioned in both questions A. and B., Section III of Appendix F can be characterized as problems in coverage as opposed to problems of approach. For example, Subject #1's main

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[20] A Financial Performance Review is a subject CPA firm procedure that uses historical financial data and ratio and trend analysis to identify potential audit risks.

[21] A General Risk Assessment is a subject CPA firm procedure that combines the results of the Financial Performance Review with qualitative assessments to produce a detailed analysis of potential audit risks. It is this procedure that most closely represents an inherent risk evaluation.

criticisms of the system were that it did not deal with a broad enough range of financial ratios and qualitative issues. The system does deal with these issues, but to a very limited degree. Subject #1 did not indicate that the system's basic approach was flawed, just that it didn't go far enough in several areas.

7.3 ACCURACY OF THE SYSTEM'S ACCOUNT LEVEL ANALYSES

To determine the overall accuracy of the system's analyses, counts were made of the total line items in all three cases, the number of times the auditors disagreed with the system and the number of times the auditors disagreed with each other. "Disagreement" was broadly defined and included situations where auditors differed with the system on whether an account was risky or not as well as situations where the auditors agreed that an account was risky but for reasons different from those expressed by the system. "Disagreement" between auditors was defined in the same way. The only difference between system/auditor comparisons and auditor/auditor comparisons is that the auditors were criticizing the system's analysis but did not see each other's comments. Therefore, disagreements between auditors were determined by differences in their criticisms of the system's analysis and not by direct criticism of each other's comments. No statistical tests were run on these data because the observations were not independent. The results of these comparisons are summarized in Tables 4 and 5 below.

Table 4 Summary of Subject/System Disagreement

	Subject #1	Subject #2	Total
Agreement	75	78	153
Disagreement[22]	14	11	25
Total	89	89	178

Table 5 - Proportion of Assessment Disagreements

	Subject/ System	Subject/ Subject
Agreement	.86	.88
Disagreement	.14	.12
Total	1.00	1.00

In quantitative terms, the system performed nearly as well as the experienced audit managers that were used as subjects in that the audit managers disagreed with each other nearly as much as they did with the system. However, these simple statistics do not reflect different levels of disagreement. The disagreements between the subjects were usually based on detailed points and fine interpretations. However, the subjects' disagreements with the system usually

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[22]In two cases the subjects disagreed with the system's analysis of a line item because the system had not considered information that was available to the subject but had not been mentioned during the development of the case and therefore was not available to the system. These disagreements were considered indications of an incomplete case and not a disagreement in analysis.

reflected more basic weaknesses in the system's analysis. The following discussion of the subjects' critique of the system's analysis of Test Case #3 is presented to highlight these qualitative differences.

7.3.1 DISCUSSION OF SUBJECTS' COMMENTS ON CASE #3

7.3.1.1 INVENTORY

Subject #1 identified several problems with the system's analysis of the inventory account. That analysis was as follows (author supplied annotations are in boxes):

> **Inventory may be more risky because the account balance is higher than would be expected based on a projection of prior years' values and its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.**

The "low level of supervision" observation is based on the fact that there was a problem last year that was cleaned up by the client. The system feels that in cases like this, management may feel the problem has been resolved and be less attentive this year.

Subject #1 took issue with the decision rule the system applied concerning management's possible reaction to a prior year accounting problem. Subject #1 also felt that inventory should be evaluated based on turnovers in relationship to anticipated sales whereas the system used its historical data extrapolation mechanism and the ratio of inventory to sales as a basis for expectation generation. Finally, Subject #1 indicated that the system did not take the problem of determining how much software cost should be capitalized in inventory into consideration in its analysis of inventory risk.

Subject #2 had no criticism of the system's analysis of inventory. The differences in the two subjects' reactions to the system's analysis of the inventory account can probably be explained by the differences in the subjects' familiarity with the system. As previously mentioned, Subject #2 had been involved in the early development of the system. Subject #2 was the source of the decision rule with which Subject #1 took issue. Also, because of his familiarity with the system, Subject #2 tended to focus his criticism on the system's performance given the case material while Subject #1 tended to bring in more general auditing considerations. Therefore, Subject #2 did not consider using inventory turnover data based on projected sales to evaluate inventory because projected sales data was not in the case. Finally, the system did consider the capitalization issue in its analysis as evidenced by the "calculation complexity" comment in its analysis although this was not very clear from the analysis or author's annotations. Subject #2 was familiar enough with the system's mode of expression to pick up on this subtlety while Subject #1 was not.

7.3.1.2 SALES AND DEFERRED REVENUE

The system expressed concern for a pattern of data that included higher than expected sales and accounts receivable balances. The system's analysis of these related accounts is as follows:

> The "predating of invoices" observation is coming from the fact that there is a pattern of data that suggests management is manipulating sales and receivables by altering invoice dates. The pattern of data includes the fact that both sales and receivables are higher than expected and that the gross profit of the company is near the bonus cutoff giving management an incentive to inflate sales.

> Sales may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to predating of invoices.
>
> Reevaluating the risk assessment of deferred revenue based on new evidence.
>
> Deferred revenue may be more risky because there is some evidence that there may be an error in this account due to a potential error in sales.

Both subjects took issue with the system's narrow view of the potential cause of the sales/receivable overstatement problem. Both felt that there were other potential management activities that could have accounted for the data as easily as predating invoices. However, neither of them criticized the system's identification of the problem and its linkage of the pattern of overstatements to the status of the bonus plan.

Subject #1's criticism was more specific in that he felt the greatest potential risk for manipulation would be in the deferred revenue account. Management could inflate sales by shifting amounts from deferred revenue to sales. Subject #1 felt this manipulation would be more difficult to detect than predating of invoices which would probably show up in a standard sales cutoff test. However, manipulation of deferred revenues would not account for the increase in receivables noted by the system. In addition, it would create a lower than expected deferred revenue balance which was not the case here.

Again, these differences between the subjects' criticisms could probably be explained by differences in familiarity with the system. In general, Subject #2 focused his criticism more narrowly on the system's analysis of the specific data in the case while Subject #1 tended to bring in more general auditing considerations. Because Subject #2 had been involved more system refinement meetings, he had probably become used to dealing with the system's analysis in a more focused fashion.

7.3.1.3 ADMINISTRATIVE EXPENSES

Both subjects took issue with the system's analysis of administrative expenses for fundamentally the same reason: the system flagged this account solely because of a change in pension reporting standard. The system's analysis is as follows:

> **Administrative expenses may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for administrative expenses. This error may have occurred in spite of a high level of internal controls for the firm.**

The system has determined that the other side of the pension accrual transaction normally affects administrative expenses.

The main difference in the subjects' criticisms of the system's analysis was the nature of its errors in reasoning. Subject #1 felt that the problem lay in the system's inability to determine the potential magnitude of the effect of the reporting standard change on administrative expenses by referring to the proportion of salaries and wages that were included in administrative expenses versus those that were included in production costs. Subject #2 was more concerned about changes in total operating expenses which had remained constant despite the significant increase in sales activity.

7.3.2 SUMMARY OF SUBJECTS' ACCOUNT LEVEL CRITICISMS

While the subjects' criticism of the system's analysis differed considerably in the details they chose to highlight, there were several underlying themes that were common to both.

7.3.2.1 HIGHER ORDER RELATIONSHIPS

Both subjects criticized the system's analysis of several accounts based on the system's limited ability to identify and reason with higher order relationships. Higher order relationships include standard ratios and relationships between accounts, e.g. Subject #2's concern for the system's inability to recognized total operating costs as a percent of sales had dropped in Case #3 (see

7.3.1.3). The system does have limited capabilities to identify and reason with these relationships, but the subjects both felt that its capacity to deal with these relationships was far too limited.

7.3.2.2 MANAGEMENT INCENTIVES

Both subjects felt that the system's ability to identify the potential impact of management incentive issues was too limited. The specific criticism came in the system's focus on predating of invoices in its analysis of sales in Case #3 discussed in 7.3.1.2 above. In addition, Subject #1 mentioned the system's inability to deal with management incentive issues as a major qualitative area in which the system was deficient.

7.3.2.3 WEIGHTING EVIDENCE

The problem of weighting evidence comes up in two general areas. First, the system has no ability to determine the magnitude of the effect qualitative changes will have on account balances (e.g. how much a pension reporting standard will alter administrative expenses). Second, the system has only limited ability to weight qualitative evidence when combining it with both other qualitative evidence as well as quantitative evidence (e.g. how great an impact does a strong overall control system have on the risk of error in inventory when there is evidence that management's specific concern for inventory controls may be lower and the inventory balance is out of line with expectations).

7.4 SUPPORT FOR ASSERTIONS

The subjects' responses to the questionnaires were reviewed for evidence on the validity of the five assertions underlying the conceptual model discussed in 3.4.2. Since the subjects were not asked to assess these assertions directly, the evidence on their validity is indirect. Each assertion is discussed below.

7.4.1 ACCOUNT BY ACCOUNT BASIS

Assertion 1 states that inherent risk assessment are generated on an account by account basis. The subjects seem to agree that account level assessments are a part of inherent risk assessment in that they did not fault the system for analyzing risks at the account level. Subject #1 did fault the system on its inability to take such firm-wide factors as audit history, management integrity and pressures on management to achieve certain results, and changes in the firm's business environment into consideration in its analysis. This implies that there is a firm-wide component to risk analysis as well as an account level component.

The system does consider these firm-wide factors to a limited extent but only in the context of how they affect the risk associated with a specific account. Since audit tests and procedures are applied at the account level, how these firm-wide factors fit into the inherent risk assessment process remains unclear.

7.4.2 EXPECTATION GENERATION

Assertion 2 states that auditors use expectation failures to focus their inherent risk assessment. The support for this assertion is indirect. The system employed an expectation generation process to focus its analysis and seemed to do a reasonably good job of not only identifying risky accounts but also skipping over less risky ones (see Tables 4 and 5). In addition, the subjects' criticism were focused on how their own expectations differed from the system's and did not fault the system for generating expectations.

7.4.3 EXPECTATIONS BASED ON CHANGES FROM PRIOR YEARS

Assertion 3 refines assertion 2 by stating that the expectation generation process is based on changes in events or circumstances from previous years. Again much of the support for this assertion is indirect in that the system employed a historical data driven expectation generation module and the subjects' generally agreed with its analysis. However, both subjects' indicated that the system was too strict in its adherence to historical data and did not place enough emphasis on current relationships between accounts in generating expectations and identifying risks.

7.4.4 MANAGEMENT INCENTIVE

Assertion 4 states that management incentives are of special importance in assessing risk. While the system did consider incentives in its analysis of the sales account in Case #3, this was the only place the issue arose. Subject

#1 specifically faulted the system on its limited ability to deal with management integrity and pressures on management to achieve certain results. Subject #1's criticism supports the assertion by faulting the system for not placing enough emphasis on management incentives.

7.4.5 EXPLANATION OF RISK

Assertion 5 states that risk assessments should involve explanations of risk factors rather that mere quantifications of risk levels. The system did not produce any point assessment of risks but only ranked risky accounts relative to each other. It did provide an explanation of its reasoning in identifying an account as risky. Neither subject faulted the system for this approach nor did either indicate the need for a point estimate of risk. In addition, both subjects characterized the system's analysis as adequate given the data. Finally, much of the detailed criticism of the system's account by account analysis concerned either lack of clarity in the system's explanations or differences in opinion concerning the reasoning process the system employed. These criticisms provide indirect evidence that a risk assessment should include an explanation of the causal chain used to identify an account as risky but need not include a point estimate of that risk.

7.5 USEFULNESS OF THE SYSTEM

The final question addressed by the evaluation portion of this research was the issue of ultimate usefulness of the system to practicing auditors. Although the purpose of this research was to build a descriptive, psychologically valid model of an auditor's inherent risk evaluation and not to build a functioning decision support system, the subjects' impressions of the usefulness of the system provide evidence on the overall accuracy of the psychological model. That is, if the system is a good model of an auditor performing a common audit task then subjects should find that system useful in actual practice.

Both subjects felt the system could have some use given it was refined. Subject #1 did not see much future for the system as a risk evaluation system due to his belief that computer systems could never handle the qualitative issues involved with risk assessments but could see some potential for using the system for automating Financial Performance Reviews. Subject #2 saw broader potential for the system. He felt it could be used as a training tool for both staff accountants and college students to help them prepare for the risk identification task they would perform as in-charge auditors and ultimately audit managers. He also felt the system might be useful in providing a second opinion on risk issues.

7.6 SUMMARY OF EVALUATION RESULTS

The analysis of the evaluation questionnaire responses identified several basic strengths and weakness of both the conceptual and computational models (computer system) of inherent risk assessment presented in this thesis. The major strengths are that the system can produce inherent risk analyses on limited but realistic cases that experienced auditors feel is adequate given the case data. These auditors felt comfortable in evaluating the system's performance in a context that characterized the system's output as an analysis produced by a junior accountant. An analysis of the auditor subjects' criticisms of the system's analysis provided some support for the overall conceptual model and the specific assertions underlying that model. Finally, the subjects see potential use for the system in applied auditing and academic settings. In general, the conceptual and computational models appear to capture most of the critical elements of inherent risk assessment and the computational model is capable of bringing these elements together to provide reasonable risk assessments.

The major weaknesses lie in the incompleteness of the computational model. Specifically:

1) The system does not deal adequately with the issue of using qualitative information to merge with quantitative information to produce risk assessments. There are two main facets to this weakness: a) the limited ability to assess the impact of qualitative factors by linking them into causal chains that relate to risk areas and b) the limited ability to properly assess the relative degrees of impact of both qualitative and quantitative factors.

2) The system is not sensitive enough to higher order relationships between accounts, such as standard financial ratios, and classes of accounts. Its analysis is too account level driven in that it does not "pop up" to the next level of aggregation and look for trends and relationships in groups of accounts.

3) The system lacks the ability to assess the relative impact of various events on the firm. For example, it was not able to determine how significant a change in pension reporting standards would be to administrative expenses, cost of goods sold and inventory valuation.

In general, the conceptual and computational models appear to provide a solid beginning to the study of inherent risk evaluation during audit planning but the computation model needs considerable refining before auditors would consider its performance comparable to an experienced audit manager's.

CHAPTER 8

CONCLUSIONS

This research project resulted in both conceptual and computational models of inherent risk assessment during audit planning. These models capture some of the expertise used by auditors when assessing potential risks of error and irregularities during audit planning. The project included both discovery and evaluation phases. The discovery phase consisted of data acquisition and model building. The performance of the computational model was then evaluated by experienced auditors who judged its performance to be adequate given the limitations of the case data.

8.1 SUMMARY OF THE RESEARCH PROJECT

This research project began with three related questions:

1. What is the nature of an inherent risk assessment?

2. How do auditors assess inherent risk during audit planning?

3. How are inherent risk assessments used in audit planning?

An analysis of the inherent risk assessment task was conducted utilizing professional and academic literature, structured and unstructured interviews, simulation exercises and observations of risk assessment meetings. A conceptual model of inherent risk assessment was developed from the results of this task analysis. A computational model (computer program) was developed that captured most of the features of the conceptual model. A single experienced auditor was used to help refine the model by developing a case based on one of the auditor's clients. The author gradually refined and extended the computational model by using the case as a focal point for the evaluation of the model's performance until the model reached conclusions and provided explanations that the auditor felt were reasonable and accurate.

In order to provide data that would make the model more general in scope and capabilities, a second experienced auditor was used to develop a second case based on one of his clients. In both cases, the model refinement process was iterative and involved making a series of extensions and corrections to the model based on repeated evaluation sessions with the auditors. The refinement process also resulted in changes to the original conceptual model.

A third case was developed by the author for validation purposes. The computational model's performance was evaluated by having each auditor critique the model's evaluation of all three cases. The results of the evaluation process provided support for the conceptual and computational models while also indicating major areas where the computation model needed improvement and extension.

8.2 CONTRIBUTIONS

While this research project has not provided complete answers to the questions listed above, it has provided insight into several issues involving inherent risk assessment during audit planning.

1. Inherent risk assessments are not made in isolation. Inherent risk is closely linked to control risk and auditors tend to assess them jointly. The primary role of risk assessment during planning is to target the auditor's detection efforts. The nature and level of auditor detection efforts is a joint function of the inherent risk of error in an account and the quality of the client's efforts to detect that error.

2. Inherent risk is assessed at both general and specific levels. The general level refers to firm-wide factors that might influence error rates in account balances while the specific level refers to factors that affect the error potential in a given account. Ultimately, general risk appear to be translated into specific risk effects because audit tests are carried out at the account level. However, how general risks affect specific risks remains unclear.

3. Inherent risk assessments need to contain references to causal linkages between risk factors and potential errors. These causal linkages help the auditor determine which specific procedures (s)he needs to employ to effectively and efficiently deal with the risk. Point estimates of risk levels provide very limited information for making audit procedure selections.

4. Inherent risk assessments are performed in a systematic manner and involve a thorough review of all accounts.

5. Expectation failures play in important role in focusing the auditors attention on potentially risky accounts.

6. The expectation generation process is a complex one that involves consideration of historical financial data and the occurrence or

lack of occurrence of economic events whose impact may or may not be quantifiable.

7. The joint inherent/control risk assessment process is complex and involves combining qualitative and quantitative evidence to identify the most likely causal linkage between risk factors and potential errors. The nature of the evidence combination process remains unclear but the evidence indicates that a simple combination rule based on equal weighting of cues is an inadequate model of the process.

8. Management incentives play an important role in the inherent risk assessment process but how incentive issues impact on the risk assessment remains unclear.

In general, inherent risk evaluation involves bringing together large amounts of historical and current information about the client firm, its management, its industry, its economic environment, and general business management knowledge to determine what accounts may be more likely to contain material errors.

8.3 STRENGTHS AND LIMITATIONS

The major strength of the research project is that a comprehensive model of a complex decision process was developed and tested in a realistic environment. However, the research project is incomplete and this thesis really represents a progress report on a continuing research effort. The major limitations are related to the incomplete status of the project. First, the results were based on a small sample of auditors from two international CPA firms. The model refinement and evaluation process was limited to two auditors from one international CPA firm. Therefore, the conclusions may not be generalizable to all auditors.

Second, because of the complexity of the inherent risk assessment process and related complexity of the computational model, evaluation data tended to be subjective and subject to alternative interpretations. Finally, only the conclusions of the computational model and not the processes it used to achieve those conclusions were evaluated.

8.4 REMAINING QUESTIONS

Several elements of the inherent risk assessment process remain unclear. These elements involve the expectations generation process, the role of management incentives, and the nature of the auditors' knowledge representation and inferencing processes. Extending the research to more auditors, more cases and different CPA firms as well as gathering concurrent verbal protocol data based on existing and new cases would be most useful in attempting to answer these remaining questions. In addition, the computational model developed in this research project would provide a valuable tool for testing alternative answers to these remaining questions.

8.4.1 EXPECTATION GENERATION

Expectation generation has proven to be a key attention directing mechanism. However, this process is extremely complex and involves much more than merely extrapolating from historical data. Auditors generate expectations based on quantitative and qualitative data. The specific data used and methods used to combine data vary from account to account as well as from client to client. More information is needed on how auditors alter the expectation generation process based on account, firm and industry specific factors; what level of precision they use in developing expectations; what role relationships between accounts play in the process; and how they combine qualitative and quantitative factors when developing expectations.

8.4.2 MANAGEMENT INCENTIVES

Although both professional literature and practicing auditors indicated the special importance of incentives in evaluating inherent risk, only the author generated case raised the issue of incentives. Consequently, data on how auditors deal with incentive issues are very limited. More information is needed on when incentives issues become a concern for auditors. The computational model discussed in this thesis assumed that incentive issues only became a concern when a pattern of expectation failures existed that could be explained by unacceptable management behavior and when there was evidence of outside pressure on management to produce a given result (e.g. earnings near a bonus plan threshold). One subject felt that these assumptions were too restrictive thus leaving the question open concerning what circumstances must exist before incentives become an issue. More information is also needed on how incentive issues are combined by auditors with other evidence in producing an inherent risk assessment.

8.4.3 KNOWLEDGE REPRESENTATION

The are two related knowledge representation issues that need more exploration: how should relationships between accounts noted by the subjects be incorporated into the exiting firm model and how can both permanent and temporary data structures be altered to provide clearer natural language generation for explanation purposes. The computational model currently contains a limited set of these account relationships; however, it would be easy to expand the set. These relationships are not currently linked into the event network. An analysis of the auditors' comments concerning account relationships implies that they are linked to economic events. The question remains as to how these linkages should be represented and what impact those linkages should have on the structure of the event network.

The computational model contains a natural language generation feature that is stilted and incomplete. These problems reflect weaknesses in the structure of the underlying data structures that produce the translations. Further analysis of the weaknesses in the current approach is needed to improve in the underlying data structures.

8.4.4 PROCESS DETAILS

Most of the evidence gathered in this research project dealt with the inputs and outputs of the inherent risk assessment procedure. Concurrent verbal protocols were not used because the nature of the task and task context were not clearly defined enough to permit the development of cases that accurately captured the task in its natural context. The auditors evaluation of existing cases and the ease with which they were able to evaluate the computation model's analyses implies that a sufficient understanding of the inherent risk assessment task has been achieved and that development of cases for detailed protocol analysis would now be appropriate. Protocol data would provide valuable evidence on the accuracy of the assumptions used in determining the computational model's flow of control, on the nature of the processes used to combine qualitative and quantitative evidence and on the complete set of factors that the auditor considers when assessing inherent risk.

8.5 EXTENSIONS

The preceding section discussed specific questions that remain concerning the inherent risk assessment task. This research project could also be extended beyond the inherent risk assessment task. One extension would be to determine how inherent risk assessment and analytical review are related and extend the model to include the analytical review task.

A second extension would be to explore the relationship between risk assessments, internal control evaluations and audit procedures and extend the model to produce specific audit procedure recommendations based on its risk assessments and either auditor supplied or model developed internal control evaluations. Eventually, the model could be extended to evaluate the results of its recommended audit procedures, evaluate the effectiveness of its risk and internal control evaluations based on those results and suggest modifications to its procedural recommendations.

APPENDICES

APPENDIX A

OUTLINE OF INHERENT RISK FACTORS

This appendix contains an outline of all the factors identified from interviews that subjects felt influenced their assessment of inherent risk. The factors are presented in outline format and broken into three main classes: **general client factors, account specific factors** and **audit firm factors. General client factors** affect the overall riskiness of all or large groups of account balances but do not have a direct impact on a specific account. **Account specific factors** affect an account or small group of accounts directly. **Audit firm factors** represent an interaction between characteristics of the audit firm and audit team and client risk factors. Each class of factors is further subdivided into those that are internal to or external to the client.

I. General firm factors

A. External

1. Economic environment

a) Rates of inflation
b) Status of the local economy
c) Changes in the value of the dollar

2. Political environment (typically in a foreign country

a) Local political instability
b) Social unrest
c) Potential for nationalization

3. Local legal requirements, whether certain audit procedures are required by local laws

4. Nature of client's industry

a) Location of product in life cycle
b) Current level of demand for product
c) Special problems faced by the industry

B. Internal factors

1. Background and training of key management and staff

2. Turnover or changes in top management

3. Debt covenants

4. Existence of budgets and plans and how close the client is to achieving them.

5. Existence of management compensation plans tied to accounting numbers

6. Expectations created by the client in the financial markets

7. Management's reactions to any existing general problems

8. Perceived level of management integrity

9. Concern shown by client for the audit

10. Degree to which judgmental procedures are specified by company policy

11. Degree to which judgmental procedures are scrutinized by higher levels of management

12. Size of audited unit relative to total client size if audit is of only part of client's total operations

13. Overall health of the client

14. Nature of the client

    a) Size and sophistication
    b) Form of ownership (public or private)
    c) Multinational
    d) Multilocation
    e) Conservative or liberal corporate culture
    f) Degree of centralized control

II. Account specific factors

A. External

1. Reduction in demand for one of the client's products

2. Loss of major customers

3. Nature of customer base

    a) Number of customers and degree of concentration
    b) Financial health of major customer
    c) Consumer versus industrial

4. Nature of the product (i.e. essential or convenience)

5. Decline in the price of raw materials

B. Internal

1. Materiality of account balance

2. Degree of management judgment involved in account valuation

3. Degree of management judgment involved in selecting between alternative accounting treatments

4. Level of standardization of underlying transactions to make up account balance

(i.e. large number of similar transactions with little exceptions or several unusual and large transactions)

5. Degree of technical complexity involve in calculating account balance

6. Complexity of administrative procedures involved in determining account balance

7. Level of management or staff turnover in departments responsible for individual account balances

8. Management's response to an account specific problem

9. Introduction of a new product

10. Major changes in ownership

11. Special problems (e.g. history of workmen's compensation insurance problems

12. Client's liquidity status

13. Age of client assets and level of maintenance required

14. Existence of long term contracts

III. Audit firm factors

A. Level of audit team turnover, both too little and too much

B. Experience of team members with client's industry

C. Existence of close, personal relationships between team members and client.

APPENDIX B

TEST CASE

This appendix contains a complete case description. This case was created by the author and used for system evaluation and demonstration. Two other cases whose contents and structure were similar to this one were used in the design of the system. These other cases could not be presented because they describe actual client data and confidentiality agreements with the CPA firm involved precluded making any of that data public.

Description of Sample Company #3

Sample Company #3 manufactures, markets and services local area networks, multifunction workstations and dispersed computing and office systems worldwide. Management is considered to be competent and concerned with maintaining a strong and reliable internal control environment. Accounting personnel are well trained and capable. Sample Firm #3 is publicly traded.

More specific items of background information include:

1. Controls over accounts payable and receivable are considered strong. There have been no material audit adjustments for either of these accounts in the past.

2. Inventory calculations are relatively complex primarily due to difficulties in properly assigning costs to software products included in inventory. The company personnel did discover a major error in inventory valuation last year but all corrections were handled by company personnel and no audit adjustments were necessary.

3. One outstanding long term debt instrument is subject to a covenant that requires that the current ratio stay at or above 2.0.

4. The company has a management compensation package for top management that includes a bonus if gross profit equals or exceeds 120% of the prior year's gross profit.

5. The company has an employee stock purchase plan that usually leads to small amounts of common stock being issued each year.

6. Earnings per share were up sharply last year and management has made public statements that have created an expectation within the financial community that earnings per share should double this year.

The most significant events that occurred during the past year were:

1. The company changed its method for calculating a major component of other assets. This change should not have a direct impact on the balance other assets.

Description of Sample Company #3 (Continued)

2. There was a change in the reporting standards for pensions that became effective this year. This change should lead to increased liabilities and expenses associated with pension activity.

3. A major long term debt instrument was retired during the year.

4. The company executed a new type of short term line of credit with its primary bank.

5. The company sold a South American affiliate and has withdrawn temporarily from that market.

6. Changes in the value of the dollar should cause the cumulative translation adjustment account to increase by 50 to 70%.

CONSOLIDATED BALANCE SHEETS

	1988 (Unaudited)	1987	1986	1985	1984
	(In thousands)				
Assets:					
Current Assets:					
Cash	$ 12,405	$ 6,236	$ 7,043	$ 4,754	$ 1,549
Temporary investments	120,047	98,962	45,359	199,503	1,003
Accounts receivable	149,734	135,523	132,445	110,467	71,021
Inventories	99,282	77,823	97,318	74,422	68,506
Prepaid expenses	6,782	3,346	3,495	2,049	989
Total Current Assets	388,250	323,890	285,660	391,195	143,068
Property, plant and equipment, net	137,137	137,587	153,242	124,730	78,139
Investments in affiliates	97,761	101,123	105,858	18,765	478
Other assets	16,619	24,074	26,990	7,415	1,938
	$639,767	$586,674	$571,750	$542,105	$223,623
Liabilities and Stockholders' Equity					
Current liabilities:					
Notes payable - banks	$ 18,482	$ 8,138	$ 14,597	$ 7,776	---
Current maturities	7,575	8,299	5,479	4,487	163
Accounts payable	36,202	28,020	21,053	23,408	16,139
Accrued expenses	63,865	57,358	60,726	42,208	26,674
Deferred revenue	18,445	16,616	9,204	4,700	834
Income taxes payable	6,187	3,987	2,479	8,763	5,466
Total Current Liabilities	150,756	122,438	113,538	91,342	45,276
Long term debt	110,720	123,737	131,603	129,603	3,934
Deferred income taxes	3,529	8,723	---	2,737	1,281
Other liabilities	3,901	1,833	459	---	---
Stockholders' equity					
Common stock	5,063	5,026	4,992	4,880	4,248
Paid in capital	189,781	187,227	185,253	173,919	74,021
Foreign currency translation adjustment	(18,242)	(11,541)	(5,269)	---	---
Retained earnings	194,433	149,251	141,174	139,624	90,863
Treasury stock	(174)	---	---	---	---
Total stockholders' equity	370,861	329,963	326,150	318,423	169,132
	$639,767	$586,674	$571,750	$542,105	$223,623

CONSOLIDATED STATEMENTS OF EARNINGS

(In thousands, except for earnings per share data)

	1988 (Unaudited)	1987	1986	1985	1984
Sales	$617,154	$540,192	$508,486	$449,490	$318,826
Cost of sales	314,900	295,098	277,205	226,318	160,953
Gross Profit	302,254	245,094	231,281	223,172	157,873
Operating expenses:					
Product development	46,945	47,267	44,637	36,532	27,858
Marketing	168,029	165,081	163,870	94,729	63,410
Administrative	18,827	18,855	16,369	14,348	9,776
Total operating expenses	233,801	231,203	224,876	145,609	101,044
Operating income	68,453	13,891	6,405	77,563	56,829
Interest income (expense)	(2,532)	(8,194)	(2,377)	7,595	(389)
Earnings before taxes & extraordinary items	65,921	5,697	4,028	85,158	56,440
Income tax expense (credit)	22,503	(2,380)	1,623	36,397	22,962
Earnings before extraordinary items	43,418	8,077	2,405	48,761	33,478
Extraordinary items	1,764	---	---	---	---
Net earnings	$ 45,182	$ 8,077	$ 2,405	$ 48,761	$ 33,478
Earnings per share	$ 2.20	$ .39	$ .12	$ 2.50	$ 1.97

Additional explanations of the system's analysis are included in boxes following the system printout to which the explanatory material pertains. Material not in boxes is the system's actual printout for the case.

There are several messages below that refer to differences between expected and actual account balances. The system generates the expected balances that are compared to actual financial data in four ways depending on the nature of the account, its relationship to other accounts and the existence of any case specific predictions. First, if the given account's balance is normally the result of high volumes of recurring transactions, the system will develop an expectation based on the trend in historical values. It indicates use of this method with the phrase "based on a projection of prior year's values". Second, if the account's balance is normally the result of large infrequent transactions, the system uses the prior year's balance as a current year's expected balance. The system indicates choice of this method with the phrase "based on" a change from last year's balance". Third, if any case specific predictions or events have been entered that would effect the expected balance, they are merged with the initial expected balance as calculated based on the above description. The system indicates use of predictions by a phrase that begins with "based on" and ends with a paraphrase of the prediction involved. Finally, the system can also develop expected balances based on a given account's relationship to other accounts. It indicates the use of this method with the phrase "based on its relationship to".

> The system uses a reasonable range in determining whether an actual balance is different from an expected one. For accounts whose expected balances are based on historical trends, the width of the range is based on the average variability in the historical data as long as that variability is not greater or less than preset bounds. For accounts whose expected balances are base on the prior year's balance, the range is based on a case specific materiality level. These ranges can be modified further based on the level of normal substantive audit test done on the account. For accounts like long term debt where each individual item is usually confirmed with an outside party, the system will tolerate a larger difference between expected and actual balances before it gets concerned.

Short term investments may be more risky because the account balance is higher than would be expected based on a change from last year's balance.

Prepaid expenses may be more risky because the account balance is higher than would be expected based on a projection of prior years' values.

Other other assets may be more risky because the account balance is lower than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to significantly different calculation methods for other other assets. This error may have occurred in spite of a high level of internal controls for the firm. However, there is some evidence that there may be an error in developing expected values due to a potential error in a prediction of no change in the current period's other other assets with a high confidence based on calculation method change.

> The "significantly different calculation methods" refers the statement in the case concerning a change in calculation method for a major component of other assets. The system feels that such changes inherently increase risk of error. It is mitigating its conclusion by the existence of a generally strong internal control environment but weights this observation lower than the specific observation of a calculation method change for the given account. I also notes that its expected balance is based on a prediction which, because it is a prediction, could be in error. It has separated evidence that supports the conclusion that there is an error in the actual account balance from evidence that supports the conclusion that there is an error in the expected balance.

Notes payable - banks may be more risky because there is some evidence that there may be an error in this account due to moderately different types of transactions for notes payable - banks. This error may have occurred in spite of a high level of internal controls for the firm.

> The system can identify risks strictly based on qualitative evidence. That is, even when there is not violation of expected balances. The "moderately different types of transactions" refers to the new line of credit arrangement indicated in the case.

Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory.

Accrued liabilities may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for accrued liabilities. This error may have occurred in spite of a high level of internal controls for the firm.

> The system has recognized that a reporting standard change that effect pension accruals will typically effect accrued liabilities as the credit side of a pension accrual transaction. It implies that if there is a reporting standard change, the accounts involved will have a higher risk of error.

Other liabilities may be more risky because the account balance is higher than would be expected based on a change from last year's balance.

Inventory may be more risky because the account balance is higher than would be expected based on a projection of prior years' values and its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

> The "low level of supervision" observation is based on the fact that there was a problem last year that was cleaned up by the client. The system feels that in cases like this, management may feel the problem has been resolved and be less attentive this year.

Reevaluating the risk assessment of accounts payable based on new evidence.

Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory. There is some evidence that there may be an error in this account due to a potential error in inventory.

> The system is aware that accounts payable and inventory share a common cutoff and is saying that if there is a possibility of an error in one, that creates a possibility of error in the other. It can go back and reassess earlier conclusions based on new evidence.

Receivables may be more risky because the account balance is higher than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to predating of invoices.

> The system's conclusions on receivables and inventory may seem out of place. The system has deferred its analysis on these two accounts until it has completed its evaluation of sales since they are so closely tied to sales. The "predating of invoices" observation is coming from the fact that there is a pattern of data that suggests management is manipulating sales and receivables by altering invoice dates. The pattern of data includes the fact that both sales and receivables are higher than expected and that the gross profit of the company is near the bonus cutoff giving management an incentive to inflate sales.

Sales may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to predating of invoices.

Reevaluating the risk assessment of deferred revenue based on new evidence.

Deferred revenue may be more risky because there is some evidence that there may be an error in this account due to a potential error in sales.

Cost of goods sold may be more risky because the account balance is lower than would be expected based on its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

Administrative expenses may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for administrative expenses. This error may have occurred in spite of a high level of internal controls for the firm.

> The system has determined that the other side of the pension accrual transaction normally effects administrative expenses.

Interest expenses may be more risky because the account balance is lower than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to moderately different types of transactions for interest expenses. This error may have occurred in spite of a high level of internal controls for the firm. However, there is some evidence that there may be an error in developing expected values due to a potential error in a prediction of an increase in the current period's interest expenses with a high confidence based on new debt issuance and a potential error in a prediction of a decrease in the current period's interest expenses with a high confidence based on debt retirement.

> The system is inferring that if there is a new type of note issued, the calculation of interest associated with that note may also be different and therefore create an error potential in interest expense.

Income tax expense may be more risky because the account balance is considerably higher than would be expected based on a projection of prior years' values. However, there is some evidence that there may be an error in developing expected values due to the variability of historical data.

> The system is tempering its belief in its expected value because of the variability of historical data. As mentioned earlier, the variability effected its acceptance range but if the variability gets too high, it also effects the system's confidence in its expected account balance.

Presenting a summary of my analysis:

> To produce a summary analysis, the system ranks accounts that it has identified as risky by risk level and redisplays its analysis of each account. It has a arbitrary cutoff value so that accounts with risk levels below a certain point will not be displayed. In addition, it summarizes the balance of its analysis by listing accounts that were with unexpected balances but for which there was no explanatory evidence, accounts with unexpected balances where there was evidence of errors in generating the expected balance, accounts that were passed over because there were no problems with them and accounts that were not analyzed for one reason or another.

The most serious problem is that Inventory may be more risky because the account balance is higher than would be expected based on a projection of prior years' values and its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Sales may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to predating of invoices.

A less serious problem is that Cost of goods sold may be more risky because the account balance is lower than would be expected based on its relationship to sales. There is some evidence that there may be an error in this account due to a low level of supervision for inventory and significantly complex calculations for inventory. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Receivables may be more risky because the account balance is higher than would be expected based on a change from last year's balance. There is some evidence that there may be an error in this account due to predating of invoices.

A less serious problem is that Accounts payable may be more risky because the account balance is lower than would be expected based on its relationship to inventory. There is some evidence that there may be an error in this account due to a potential error in inventory.

A less serious problem is that Accrued liabilities may be more risky because the account balance is higher than would be expected based on a projection of prior years' values. There is some evidence that there may be an error in this account due to significantly different reporting standards for accrued liabilities. This error may have occurred in spite of a high level of internal controls for the firm.

A less serious problem is that Deferred revenue may be more risky because there is some evidence that there may be an error in this account due to a potential error in sales.

A less serious problem is that Administrative expenses may be more risky because there is some evidence that there may be an error in this account due to significantly different reporting standards for administrative expenses. This error may have occurred in spite of a high level of internal controls for the firm.

There may also be problems with the account balances of interest expenses, notes payable - banks, and other other assets.

In addition, the account balances of other liabilities, prepaid expenses, and short term investments are not what I expected them to be. However, I don't have enough evidence to determine whether my expectations are at fault or not.

There are differences between my expectations and the account balances of income tax expense but my expectations appear to be in error.

I did not find any problems with cash, common stock, cumulative translation adjustment, current portion of long term debt, deferred income taxes - long term, federal income taxes payable, investment in affiliates, long term debt, net property, plant and equipment, paid in capital, product development, and selling expenses.

I ignored treasury stock and unusual charges because their balances were immaterial.

I did not analyze average shares outstanding and retained earnings because these items are usually not a concern in this case.

APPENDIX C

SAMPLE DATA INPUT SCREENS

This appendix contains samples of data input screens used to enter case specific qualitative data into the system. Case specific quantitative data (i.e. general ledger data) is read directly by the system from a standard ASCII file. User input is in **bold type** and explanatory comments are in boxes.

When the system is asked to display an object's name it will use a print name if one has been assigned to that object and the object's internal name otherwise. Print names appear in the screens as lower case words enclosed in quotation marks. Internal names appear as uppercase words.

The non-modifiable slots are slots that contain pertinent identification information for the object being presented but can not be changed by the user.

Two screens are presented for each object, the screen used to add the object and the one used to modify it. In the addition screen, values in the prompt line in "[]" are default values.

```
Adding a new instance of the ASSESSMENT class of objects.

Values will be needed for the following fields:

("assessment (H M L)" "factor name" "firm model element")

assessment (H M L) [NIL]: "high"
factor name [NIL]: "calculation complexity"
firm model element [NIL]: "inventory"
```

```
Modifying ASSESSMENT11

Non-modifiable slots and values:

1. NAME: ASSESSMENT11
2. CLASS: (ASSESSMENT)

Modifiable slots and values:

1. assessment (H M L): "high"
2. factor name: "complex calculations"
3. firm model element: "inventory"

Enter the number of the slot or Q to quit: q
```

Case specific data objects do not have natural names so the system provides automatic internal names for them, in this case ASSESSMENT11.

```
Adding a new instance of the GENERAL-DATA class of objects.

Values will be needed for the following fields:

("case name" "audit period" "number of quarters covered by
current data" "default materiality base and level" "account
specific materiality bases and levels" "type of ownership")

Name for new instance is CASE-DATA

case name: TEST3
audit period [YEAR]: year
number of quarters covered by current data [4]:
default materiality base and level
[(F-INCOME-BEFORE-EXTRAORDINARY-AND-TAXES 0.05)]: ("sales"
.003)
account specific materiality bases and levels {multi-valued}
[NIL]:
type of ownership [NIL]: public
```

```
Modifying CASE-DATA

Non-modifiable slots and values:

1. NAME: CASE-DATA
2. CLASS: (GENERAL-DATA)

Modifiable slots and values:

1. case name: TEST3
2. audit period: "year"
3. number of quarters covered by current data: 4
4. default materiality base and level: (F-SALES 0.003)
5. account specific materiality bases and levels: NIL
6. type of ownership: "public"

Enter the number of the slot or Q to quit: q
```

Three editor features are demonstrated above. First, blank responses in the entry screen indicate that the user hit the "enter" key and the default value was automatically picked up. Second, the editor replaces various recognition strings for the same object with the object's name internally. This occurred in the entry of the materiality value where "sales" was replaced with F-SALES. Finally, the "{multi-valued}" prompt indicates that the field can contain mulitple values in which case it expects a list of values.

Adding a new instance of the INCENTIVE class of objects.

Values will be needed for the following fields:

("estimated impact strength on management" "incentive formula" "print name")

estimated impact strength on management [MEDIUM]: **high**
incentive formula [NIL]: **("times" 1.2 ("gross profit" prior))**
print name [NIL]: **"gross profit bonus"**

Modifying gross profit bonus

Non-modifiable slots and values:

1. NAME: "gross profit bonus"
2. CLASS: (INCENTIVE)

Modifiable slots and values:

1. estimated impact strength on management: "high"
2. incentive formula: (*! 1.2 (F-GROSS-PROFIT PRIOR))
3. print name: "gross profit bonus"

Enter the number of the slot or Q to quit: q

Note the replacement in the incentive formula.

```
Adding a new instance of the OBSERVED-EVENT class of
objects.

event [NIL]: "reporting standard change"
transaction name [NIL]: "pension accrual"
firm model element [NIL]:
direction of expected change on above [NIL]: "increase"
```

```
Modifying OBSERVED-EVENT13

Non-modifiable slots and values:

1. NAME: OBSERVED-EVENT13
2. CLASS: (OBSERVED-EVENT)

Modifiable slots and values:

1. event: "reporting standard change"
2. TRANSACTION: "pension accrual"
3. FIRMNODE: NIL
4. DIRECTION: "an increase"

Enter the number of the slot or Q to quit: q
```

> Because observed-event objects are variable (i.e. the editor does not know what fields will be needed until it knows what event has occurred), the is no section in this screen that informs the user in advance what fields will need to be filled.

Adding a new instance of the PREDICTION class of objects.

Values will be needed for the following fields:

("firm model element or relationship" "percentage change" "change type (S or T)" "confidence (H M L)" "source")

firm model element or relationship [NIL]: **"cumulative translation adjustment"**
percentage change [0]: **-6**
change type (S or T) [S]: **s**
confidence (H M L) [LOW]: **"high"**
source [NIL]: **"change in the value of the dollar"**

Modifying PREDICTION14

Non-modifiable slots and values:
1. NAME: PREDICTION14
2. CLASS: (PREDICTION)

Modifiable slots and values:

1. firm model element or relationship: "cumulative translation adjustment"
2. percentage change: -0.06
3. change type (S or T): S
4. confidence (H M L): "high"
5. source: "change in the value of the dollar"

Enter the number of the slot or Q to quit: q

> The source field in a prediction object is not a print name but a description field that is not used by the system except for displaying explanations.

Displaying financial data for sales:

financial data flag: T
budget amount: NIL
quarterly budgeted amounts: NIL
current year's quarterly data: NIL
prior year's quarterly data: NIL
current year's: 617154
list of prior values: (540192 508486 449490 318826)

Although financial data are not input into the system from a screen, I have included a sample of the display information that the user can obtain for each account. This screen also illustrates the breadth of information that can be used by the system if available.

APPENDIX D

SAMPLES OF DATA STRUCTURES

This appendix contains a set of sample printouts for all data objects used in the system. The printouts were produced after the test case was processed and contain data from the analysis of that case. The printouts are blocked by major class, i.e. **general, system, case specific** and **temporary**. All data structures in the system are organized in a single hierarchy with BASE-OBJECT at the top. **General** data structures are BASE-OBJECT and its immediate child objects which define the remaining three classes of objects. **System** objects contain the general system knowledge base. **Case specific** objects contain user supplied data for each case. **Temporary** objects are built by the system as it does its analysis. Within each class, object printouts are presented in pairs with the class definition object first followed by an example instance printout. Objects are ordered alphabetically within classes. An index is included on the first page of the appendix. All author supplied explanatory comments are in boxes.

INDEX TO DATA STRUCTURE PRINTOUTS

GENERAL DESCRIPTIVE COMMENTS

Each class definition object contains a list of multivalued slots, a list of user accessible slots and series of descriptive structures called default fields. The editor uses these three items to create an instance of an object class. Default fields represent the template used to create an instance of an class of objects. The "user-accessible" list in the class definition tells the editor which fields need user input. The "multi-valued" list tells the editor which slots can contain multiple values and therefore which ones should be entered as lists. For fields that are not user accessible, the default value is used. A default structure contains five items: the slot name, the default value, lisp code to be executed when a new value is entered (an "if-added" demon), lisp code to be executed when a value is deleted (an "if-deleted" demon) and a print name. The "(*var* x)" structure in the lisp code represents a variable that is replace by the current value for "x" before the lisp code is executed. "If-added" and "if-deleted" demons are used both to edit incoming data and make sure that it complies with preset standards and to maintain fixed linkages within the knowledge base.

In general, slots with single values are methods used by that class of objects to respond to a given request.

Each class definition object contains a "recon-list" slot that lists all the patterns linked to instances of the class and a "children" slot that lists all the instances. In order to reduce the size of this appendix, most of these slots have been edited to include only the information pertaining to the instance used as an example.

For the sake of readability, the some of the system printouts have been condensed by taking out blank lines and the default slot names have been converted to **bold type**.

GENERAL DATA STRUCTURES

Printing contents of BASE-OBJECT

NON-ACCESSIBLE-DISPLAY: (NAME CLASS)

DELETE-SPECIFIC-SLOT: DELETE-SPECIFIC-SLOT

ADD-SPECIFIC-SLOT: ADD-SPECIFIC-SLOT

PRINT-NAME: "base object"

ADD: ADD-OBJECT

DELETE: DELETE-OBJECT

MATCH: MATCH

MODIFY: MODIFY-OBJECT

ADD-CHILD: ADD-CHILD

SAVE: SAVE-OBJECT

DISPLAY-CONTENTS: DISPLAY-OBJECT-CONTENTS

GET-INSTANCE: GET-INSTANCE

GET-NEW-NAME: GET-NEW-NAME

REVIEW: REVIEW-OBJECT

CHILDREN: (TEMPORARY-OBJECT CASE-OBJECT SYSTEM-OBJECT)

Printing contents of CASE-OBJECT

CLASS: (BASE-OBJECT)

ASSESSMENTS: (ASSESSMENT1)

TRACEABLE-OBJECTS: (KS RULE PROCEDURE CHECK-LIST)

Templates contain the structural definitions for setting up the case objects for new cases. The information contained in the templates is identical to that displayed in the case object section of this appendix. The inclusion of the template information in the CASE-OBJECT is a matter of programming convenience.

TEMPLATES: ((**INCENTIVE** ((NAME INCENTIVE) (CLASS (CASE-OBJECT)) (MULTI-VALUE NIL) (CALCULATE-BOUND-VALUE CAL-INCENTIVE-BOUND-VALUE) (CHECK-BOUND CHECK-INCENTIVE-BOUND) (COUNT 0) (DISPLAY DISPLAY-INCENTIVE) (CALCULATE-DIRECTION CALCULATE-INCENTIVE-DIRECTION) (USER-ACCESSIBLE (IMPACT FORMULA PRINT-NAME)) (GET-NEW-NAME GET-NEW-NAME1) (GET-INSTANCE GET-INSTANCE2) (DEFAULT ((IMPACT MEDIUM (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (HIGH MEDIUM LOW))) NIL "estimated impact strength on management") (FORMULA NIL (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3) (FORMULAP (*VAR* NEW-VALUE))) NIL |incentive formula|) (PRINT-NAME NIL (STRINGP (*VAR* NEW-VALUE)) NIL |print name|))) (RECON-LIST NIL) (CHILDREN NIL)))

(**GENERAL-DATA** ((NAME GENERAL-DATA) (CLASS (CASE-OBJECT)) (ADD ADD-GENERAL-DATA) (GET-INSTANCE GET-GENERAL-DATA) (MULTI-VALUE (SPECIFIC-MATERIALITY)) (USER-ACCESSIBLE (CASE-NAME AUDIT-PERIOD QUARTERS-COVERED DEFAULT-MATERIALITY SPECIFIC-MATERIALITY OWNERSHIP)) (DEFAULT ((DELETE DELETE-OBJECT1 NIL NIL NIL) (CASE-NAME NIL NIL NIL |case name|) (AUDIT-PERIOD YEAR (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (YEAR Q1 Q2 Q3 Q4))) NIL |audit period|) (QUARTERS-COVERED 4 (MEMBER (*VAR* NEW-VALUE) (QUOTE (0 1 2 3 4))) NIL |number of quarters covered by current data|) (OWNERSHIP NIL (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (PUBLIC WHOLELY-OWNED CLOSELY-HELD))) NIL "type of ownership") (DEFAULT-MATERIALITY (F-INCOME-BEFORE-EXTRAORDIN-ARY-AND-TAXES 0.05) (MATERIALITY-MATCH (*VAR* NEW-VALUE)) NIL "default materiality base and level") (SPECIFIC-MATERIALITY NIL (MATERIALITY-MATCH1 (*VAR* NEW-VALUE)) NIL "account specific materiality bases and levels"))) (CHILDREN NIL)))

```
(OBSERVED-EVENT ((NAME OBSERVED-EVENT) (CLASS (CASE-OBJECT))
(MULTI-VALUE NIL) (ADD ADD-OBSERVED-EVENT) (EXPAND-SLOT
EVENT-NAME) (DISPLAY DISPLAY-OBSERVED-EVENT) (COUNT 0)
(GET-INSTANCE GET-INSTANCE2) (GET-NEW-NAME GET-NEW-NAME1)
(USER-ACCESSIBLE (EVENT-NAME)) (DEFAULT ((EVENT-NAME NIL
(MATCH-TEST (QUOTE EVENT) (*VAR* NEW-VALUE)) NIL "event")))
(CHILDREN NIL)))

(PREDICTION ((NAME PREDICTION) (CLASS (CASE-OBJECT))
(MULTI-VALUE NIL) (DISPLAY DISPLAY-PREDICTION) (COUNT 0)
(GET-INSTANCE GET-INSTANCE2) (GET-NEW-NAME GET-NEW-NAME1)
(USER-ACCESSIBLE (FIRMNODE CHANGE TYPE CONFIDENCE SOURCE))
(DEFAULT ((FIRMNODE NIL (OR (MATCH-TEST (QUOTE FIRMNODE)-
 (*VAR* NEW-VALUE)) (MATCH-TEST (QUOTE ASSOCIATION) (*VAR*
NEW-VALUE))) NIL "firm model element or relationship")
(CHANGE 0 (TEST-PREDICTION-CHANGE (*VAR* NEW-VALUE)) NIL
"percentage change") (TYPE S (OR (EQ (*VAR* NEW-VALUE)
(QUOTE S)) (EQ (*VAR* NEW-VALUE) (QUOTE T))) NIL "change
type (S or T)") (CONFIDENCE LOW (MATCH-TEST (QUOTE
VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL "confidence (H M L)")
(SOURCE NIL (STRINGP (*VAR* NEW-VALUE)) NIL "source")
(PROCESSED NIL NIL NIL "processed flag"))) (CHILDREN NIL)))

(ASSESSMENT ((NAME ASSESSMENT) (CLASS (CASE-OBJECT))
(USER-ACCESSIBLE (ASSESSMENT FACTOR FIRMNODE)) (MULTI-VALUE
NIL) (COUNT 0) (DISPLAY DISPLAY-ASSESSMENT) (GET-INSTANCE
GET-INSTANCE2) (GET-NEW-NAME GET-NEW-NAME1) (DEFAULT ((-
FACTOR NIL (MATCH-TEST (QUOTE CHECK-LIST) (*VAR* NEW-VALUE))
NIL "factor name") (ASSESSMENT NIL (MATCH-TEST (QUOTE
VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL "assessment (H M L)")
(FIRMNODE NIL (MATCH-TEST (QUOTE FIRMNODE) (*VAR*
NEW-VALUE)) NIL "firm model element"))) (CHILDREN NIL)))
(FINANCIAL-DATA ((NAME FINANCIAL-DATA) (CLASS (CASE-OBJECT))
(PRINT-NAME "general ledger data") (GL-DATA NIL) (ADD
GL-ACCESS-ERROR) (DELETE GL-ACCESS-ERROR) (MODIFY
GL-ACCESS-ERROR) (GET-INSTANCE GL-INSTANCE) (REVIEW
DISPLAY-GL) (CHILDREN NIL))))

PRINT-NAME: "case object"

CHILDREN: (GENERAL-DATA OBSERVED-EVENT PREDICTION ASSESSMENT
FINANCIAL-DATA INCENTIVE)
```

Printing contents of SYSTEM-OBJECT

CLASS: (BASE-OBJECT)

PERCENT-FIELDS: (S-DEFAULT T-DEFAULT S-CHANGE T-CHANGE BASE-TEST)

PRINT-NAME: "system object"

VARIABLES: ((ASSOCIATION-BOUND 0.025) (ALPHA 0.95) (CHANGE-BOUND 0.05) (CONSTRAINT-BOUND 0.03))

TERMINALS: NIL

CHILDREN: (ASSOCIATION VALUE-OBJECT EVENT PROCEDURE CHECK-LIST RULE KS FIRMNODE OPERATOR)

Printing contents of TEMPORARY-OBJECT

CLASS: (BASE-OBJECT)

USER-ACCESSIBLE: NIL

RECON-LIST: (("event-score" EVENT-SCORE) ("summary" SUMMARY) ("analysis" ANALYSIS))

SAVE: SAVE-TEMPORARY

CHILDREN: (EVENT-SCORE SUMMARY ANALYSIS HYPOTHESIS EXPECTATION GOAL-OBJECT FIRMNODE-VALUE)

SYSTEM DATA STRUCTURES

Declarative Data Structures

Printing contents of ASSOCIATION

CLASS: (SYSTEM-OBJECT) GET-VALUE: GET-FIRMNODE-VALUE

RE-RUN: (HYPOTHESES EVALUATION-FLAG PREDICTIONS EXPECTATIONS S-CHANGE T-CHANGE)

WEIGHT-METHOD: GET-F-WEIGHT GET-ASSESSMENTS: GET-ASSOCIATION-ASSESSMENTS

CLEAR-FIELDS: (PREDICTIONS HYPOTHESES CURRENT-QUARTERS PRIOR-QUARTERS EVALUATION-FLAG BASE-TEST S-CHANGE T-CHANGE PRIOR-VALUE CURRENT-VALUE BASE-STATE BUDGET PAST-VALUE HISTORY-VALUE)

DELETE: DELETE-OBJECT1 PRINT-NAME: "association between firm model elements" CALCULATE-CHANGE: EVALUATE-ASSOCIATION CALCULATE-VALUE: CALCULATE-ASSOCIATION-VALUE GET-INSTANCE: GET-INSTANCE2 GET-NEW-NAME: GET-NEW-NAME1 COUNT: 14

USER-ACCESSIBLE: (FORMULA T-DEFAULT S-DEFAULT RECOGNITION-PATTERNS PRINT-NAME)

MULTI-VALUE: (RECOGNITION-PATTERNS) DISPLAY: DISPLAY-ASSOCIATION

Default fields -

(**HYPOTHESES** NIL NIL NIL hypotheses)
(**CURRENT-QUARTERS** NIL NIL NIL current year's quarterly data)
(**PRIOR-QUARTERS** NIL NIL NIL prior year's quarterly data)
(**WEIGHT-VALUE** NIL NIL NIL weight)

(**WEIGHT-BASE** F-SALES (EQ T (SEND-MESSAGE (QUOTE GL-NODEP) (QUOTE EXECUTE) NIL (LIST (QUOTE NODE) (*VAR* NEW-VALUE)))) NIL weight base)

(**EVALUATION-FLAG** NIL NIL NIL evaluation flag)
(**PREDICTIONS** NIL NIL NIL predictions)
(**EXPECTATIONS** NIL NIL NIL expectations)
(**SAVE** SAVE-OBJECT NIL NIL save function)

(**FORMULA** NIL (TEST-ASSOCIATION-FORMULA (*VAR* NEW-VALUE) (*VAR* NAME)) (DELETE-ASSOCIATION-FORMULA (*VAR* NEW-VALUE) (*VAR* NAME)) formula)

(**S-DEFAULT** 0 (TEST-PREDICTION-CHANGE (*VAR* NEW-VALUE)) NIL single period default change value)

(**T-DEFAULT** 0 (TEST-PREDICTION-CHANGE (*VAR* NEW-VALUE)) NIL trend default change value)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**BASE-TEST** NIL NIL NIL base state test statistic)
(**S-CHANGE** NIL NIL NIL single period change value)
(**T-CHANGE** NIL NIL NIL trend change value)
(**PRIOR-VALUE** NIL NIL NIL prior value)
(**CURRENT-VALUE** NIL NIL NIL current year's)
(**BASE-STATE** NIL NIL NIL base state)
(**BUDGET** NIL NIL NIL budget)
(**PAST-VALUE** NIL NIL NIL past value)
(**HISTORY-VALUE** NIL NIL NIL history-value)
(**QUARTERLY-VALUE** NIL NIL NIL quarterly values)

End of default fields, returning to class definition object slots.

RECON-LIST: (("association3" ASSOCIATION3) ("accounts payable as a percent of inventory" ASSOCIATION3))

CHILDREN: (ASSOCIATION3)

Printing an example of an instance of the association class of objects, accounts receivable as a percent of inventory (ASSOCIATION3).

Printing contents of ASSOCIATION3

```
CLASS: (ASSOCIATION)
HYPOTHESES: NIL
CURRENT-QUARTERS: NIL
PRIOR-QUARTERS: NIL
WEIGHT-VALUE: NIL
WEIGHT-BASE: F-SALES
EVALUATION-FLAG: T
PREDICTIONS: NIL
EXPECTATIONS: (EXPECTATION5)
SAVE: SAVE-OBJECT
BASE-TEST: 0.33271
S-CHANGE: (VALUE12)
T-CHANGE: NIL
PRIOR-VALUE: NIL
CURRENT-VALUE: NIL
BASE-STATE: 48.0862
BUDGET: NIL
PAST-VALUE: NIL
HISTORY-VALUE: (36.0048 21.6332 31.4531 23.5585)
FORMULA: (% F-ACCOUNTS-PAYABLE F-INVENTORY)
T-DEFAULT: 0
S-DEFAULT: 0
RECOGNITION-PATTERNS: NIL
PRINT-NAME: "accounts payable as a percent of inventory"
CHILDREN: NIL
```

<u>Printing contents of EVENT</u>

CLASS: (SYSTEM-OBJECT)
NODE-LIST: LIST-NODES
AFFECTED-NODES: GET-EVENT-NODES
CLEAR-FIELDS: (SCORE OCCURED-EVENTS OCCURANCE-DATA)
DELETE: DELETE-OBJECT1

USER-ACCESSIBLE: (TYPE PARAMETERS NODES-AFFECTED ENABLES ENABLED-BY CAUSES CAUSED-BY BLOCKS BLOCKED-BY PARENTS MANAGEMENT-INFLUENCE ON-OCCURANCE RECOGNITION-PATTERNS PRINT-NAME)

MULTI-VALUE: (BLOCKED-BY PARAMETERS NODES-AFFECTED ENABLES ENABLED-BY CAUSES CAUSED-BY BLOCKS PARENTS RECOGNITION-PATTERNS DESCENDANTS)

CLEAR-OCCURANCE: CLEAR-EVENT-OCCURANCE
OCCURANCE: EVENT-OCCURANCE

<u>Default fields -</u>

(**SCORE** NIL NIL NIL event score)

(**TYPE** NORMAL-RECURRING (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (NORMAL-RECURRING NORMAL-INFREQUENT UNACCEPTIBLE))) NIL event type)

(**OCCURED-EVENTS** NIL NIL NIL occured events) (**SAVE** SAVE-OBJECT NIL NIL NIL)

(**PARAMETERS** NIL (ADD-EVENT-PARAMETER (*VAR* NAME) (*VAR* NEW-VALUE)) (REMOVE-VALUE (QUOTE FIRMNODE) (QUOTE VARIABLE-EVENTS) (*VAR* NAME)) event parameters)

(**NODES-AFFECTED** NIL (ADD-FIRMNODE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME)) (DELETE-FIRMNODE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME)) firm model elements affected)

(**ENABLES** NIL (ADD-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE ENABLED-BY)) (DELETE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE ENABLED-BY)) this event enables)

(**ENABLED-BY** NIL (ADD-ENABLED-BY (*VAR* NEW-VALUE) (*VAR* NAME)) (DELETE-ENABLED-BY (*VAR* NEW-VALUE) (*VAR* NAME)) this event is enabled)

(**CAUSES** NIL (ADD-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE CAUSED-BY)) (DELETE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE CAUSED-BY)) this event causes)

(**CAUSED-BY** NIL (ADD-CAUSE (*VAR* NEW-VALUE) (*VAR* NAME)) (DELETE-CAUSE (*VAR* NEW-VALUE) (*VAR* NAME)) this event is caused by)

(**BLOCKS** NIL (ADD-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE BLOCKED-BY)) (DELETE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE BLOCKED-BY)) this event blocks)

(**BLOCKED-BY** NIL (ADD-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE BLOCKS)) (DELETE-EVENT (*VAR* NEW-VALUE) (*VAR* NAME) (QUOTE BLOCKS)) this event is blocked by)

(**PARENTS** NIL (ADD-PARENT (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PARENT (*VAR* NEW-VALUE) (*VAR* NAME)) parents)

(**MANAGEMENT-INFLUENCE** NIL (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL degree of management influence)

(**ON-OCCURANCE** NIL (AND (LISTP (*VAR* NEW-VALUE)) (FBOUNDP (CAR (*VAR* NEW-VALUE)))) NIL action triggered on event occurrence)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**DESCENDANTS** NIL NIL NIL descendants)

(**OCCURANCE-DATA** NIL NIL NIL data structures created by event occurrence)

End of default fields, returning to class definition object slots.

RECON-LIST: (("reporting-standard-change" REPORTING-STANDARD-CHANGE) ("reporting standard change" REPORTING-STANDARD-CHANGE))

CHILDREN: (REPORTING-STANDARD-CHANGE)

Printing an example of an instance of the event class of objects, reporting standard change.

Printing contents of REPORTING-STANDARD-CHANGE

CLASS: (EVENT) SCORE: NIL TYPE: NORMAL-INFREQUENT OCCURED-EVENTS: (OBSERVED-EVENT8) SAVE: SAVE-OBJECT DESCENDANTS: NIL OCCURANCE-DATA: NIL

PARAMETERS: ((TRANSACTION NIL (MATCH-TEST (QUOTE EVENT) (*VAR* NEW-VALUE)) NIL "transaction name") (FIRMNODE NIL (MATCH-TEST (QUOTE FIRMNODE) (*VAR* NEW-VALUE)) NIL "firm model element") (DIRECTION NIL (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL "direction of expected change on above"))

NODES-AFFECTED: NIL ENABLES: NIL ENABLED-BY: NIL CAUSES: NIL CAUSED-BY: NIL BLOCKS: NIL BLOCKED-BY: NIL PARENTS: NIL MANAGEMENT-INFLUENCE: LOW

ON-OCCURANCE: (COND ((*VAR* FIRMNODE) (LIST (BUILD-ASSESSMENT (QUOTE REPORTING-STANDARD-VOLITILITY) (QUOTE HIGH) (*VAR* FIRMNODE)) (BUILD-PREDICTION (*VAR* FIRMNODE) (*VAR* DIRECTION) (QUOTE S) (QUOTE HIGH) (CHECK-PRINTNAME (*VAR* EVENT-NAME))))) ((*VAR* TRANSACTION) (APPEND (SETS (*VAR* TRANSACTION) (QUOTE OCCURED-EVENTS) (GETS (QUOTE REPORTING-STANDARD-CHANGE) (QUOTE OCCURED-EVENTS))) (EVENT-ASSESSMENT (QUOTE REPORTING-STANDARD-VOLITILITY) (QUOTE HIGH) (*VAR* TRANSACTION)) (EVENT-PREDICTION (*VAR* TRANSACTION) (*VAR* EVENT-NAME) (*VAR* DIRECTION)))))

RECOGNITION-PATTERNS: NIL PRINT-NAME: "reporting standard change" CHILDREN: NIL

CHILDREN: NIL

Printing contents of FIRMNODE

```
CLASS: (SYSTEM-OBJECT)
NORMAL-SUBSTANTIVE-EFFORT: LOW
GET-EVENTS: GET-FIRMNODE-EVENTS
GL-DEPENDENT: GL-DEPENDENT
EVENT-PARTNERS: EVENT-PARTNERS
SAVE: SAVE-FIRMNODE
MATERIALITY-VALUE: CALCULATE-MATERIALITY

SPECIFIC-SLOTS: ((NORMAL-SUBSTANTIVE-EFFORT LOW (MEMBER
(MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE
(HIGH MEDIUM LOW))) NIL "normal substantive audit effort"))

VARIABLE-EVENTS: (DEBT-RETIREMENT INCUR-DEBT)

RE-RUN: (ANALYZED SUMMARY CHECKED-EVENTS HYPOTHESES
EVALUATION-FLAG T-CHANGE S-CHANGE EXPECTATIONS ASSESSMENTS
PREDICTIONS)

GL-DISPLAY-FIELDS: (GL-DATA BUDGET QUARTERLY-BUDGET
CURRENT-QUARTERS PRIOR-QUARTERS CURRENT-VALUE HISTORY-VALUE)

GL-INNODES: GET-GL-INNODES

CLEAR-FIELDS: (SOURCE-TYPE SUMMARY ANALYZED CHECKED-EVENTS
HYPOTHESES QUARTERLY-BUDGET CURRENT-QUARTERS PRIOR-QUARTERS
EVALUATION-FLAG T-CHANGE S-CHANGE BASE-TEST EXPECTATIONS
ASSESSMENTS GL-DATA PAST-VALUE PRIOR-VALUE HISTORY-VALUE
PREDICTIONS WEIGHT-VALUE CURRENT-VALUE BASE-STATE BUDGET)

GET-ASSESSMENTS: GET-ASSESSMENTS
NON-ACCESSIBLE-DISPLAY: (CLASS NAME OUTNODE)

NO-ANALYZE: (F-AVERAGE-SHARES-OUTSTANDING
F-ACCUMULATED-DEPRECIATION F-RETAINED-EARNINGS)

GET-VALUE: GET-FIRMNODE-VALUE
DELETE: DELETE-OBJECT1
PRINT-NAME: "firm model node"
CALCULATE-CHANGE: EVALUATE-FIRMNODE
CALCULATE-VALUE: GET-F-HISTORY
WEIGHT-METHOD: GET-F-WEIGHT
LIST-CHILDREN: GET-FIRMNODE-CHILDREN
INNODES: GET-INNODE-SETS

USER-ACCESSIBLE: (TYPE ACCOUNT-TYPE FORMULA WEIGHT-BASE
RECOGNITION-PATTERNS PRINT-NAME)

MULTI-VALUE: (TRIGGERS CHECKED-EVENTS FORMULA
RECOGNITION-PATTERNS)
```

DISPLAY: DISPLAY-FIRMNODE
CALCULATE-DIRECTION: CALCULATE-FNODE-DIRECTION

Default fields -

(**TYPE** ACCOUNT (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL element type)

(**ENABLES** NIL NIL NIL enables events)
(**SOURCE-TYPE** NIL NIL NIL source type)
(**TRIGGERS** NIL NIL NIL triggers)
(**SUMMARY** NIL NIL NIL summary analysis object)
(**ANALYZED** NIL NIL NIL analyzed flag)
(**CHECKED-EVENTS** NIL NIL NIL checked events)
(**HYPOTHESES** NIL NIL NIL hypotheses)

(**ACCOUNT-TYPE** NIL (OR (NULL (*VAR* NEW-VALUE)) (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (NIL AS LI RE EX)))) NIL account type)

(**PRIOR-QUARTERS** NIL NIL NIL prior year's quarterly data)
(**CURRENT-QUARTERS** NIL NIL NIL current year's quarterly data)
(**QUARTERLY-BUDGET** NIL NIL NIL quarterly budgeted amounts)
(**T-CHANGE** NIL NIL NIL trend change value)
(**S-CHANGE** NIL NIL NIL single period change value)

(**ASSOCIATIONS** NIL NIL (SEND-MESSAGE (*VAR* NEW-VALUE) (QUOTE DELETE)) relationships)

(**BASE-TEST** NIL NIL NIL base state test statistic)
(**SAVE** SAVE-OBJECT NIL NIL NIL)
(**EXPECTATIONS** NIL NIL NIL expectations)
(**ASSESSMENTS** NIL NIL NIL assessments)

(**EVENTS** NIL NIL (REMOVE-VALUE (*VAR* NEW-VALUE) (QUOTE NODES-AFFECTED) (*VAR* NAME)) events)

(**FORMULA** NIL (TEST-FIRMNODE-FORMULA (*VAR* NEW-VALUE) (*VAR* NAME)) (DELETE-FIRMNODE-FORMULA1 (*VAR* NAME) (*VAR* NEW-VALUE)) formula)

(**OUTNODE** NIL NIL (DELETE-FIRMNODE-FORMULA (*VAR* NEW-VALUE) (*VAR* NAME)) NIL)

(**HISTORY-VALUE** NIL NIL NIL list of prior values)
(**GL-DATA** NIL NIL NIL financial data flag)
(**PAST-VALUE** NIL NIL NIL year before last's value)
(**PRIOR-VALUE** NIL NIL NIL last year's value)
(**PREDICTIONS** NIL NIL NIL NIL)
(**WEIGHT-VALUE** NIL NIL NIL NIL)

(**WEIGHT-BASE** F-SALES (OR (NULL (*VAR* NEW-VALUE)) (VALIDP (SEND-MESSAGE (QUOTE GL-NODEP) (QUOTE EXECUTE) NIL (LIST (QUOTE NODE) (*VAR* NEW-VALUE))))) NIL weight base)

(**EVALUATION-FLAG** NIL NIL NIL NIL)
(**CURRENT-VALUE** NIL NIL NIL current year's)

(**RECOGNITION-PATTERNS** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**BASE-STATE** NIL NIL NIL base state)
(**BUDGET** NIL NIL NIL budget amount)

End of default fields, returning to class definition object slots.

RECON-LIST: (("gross sales" F-SALES) ("f-sales" F-SALES) ("sales" F-SALES))

CHILDREN: (F-SALES)

Printing an example of an instance of the firmnode class of objects, F-SALES.

Printing contents of F-SALES

```
CLASS: (FIRMNODE)
TYPE: ACCOUNT
ENABLES: NIL
SOURCE-TYPE: NORMAL-RECURRING
TRIGGERS: NIL
SUMMARY: SUMMARY4
ANALYZED: ANALYSIS10

CHECKED-EVENTS: (SHIPMENT-OF-PRODUCT PREDATE-INVOICES
SALE-OF-PRODUCT DEFER-REVENUE)

HYPOTHESES: (HYPOTHESIS16 HYPOTHESIS15)
ACCOUNT-TYPE: RE
PRIOR-QUARTERS: (NIL)
CURRENT-QUARTERS: NIL
QUARTERLY-BUDGET: NIL
T-CHANGE: NIL
S-CHANGE: (VALUE20)

ASSOCIATIONS: (ASSOCIATION13 ASSOCIATION4 ASSOCIATION5
ASSOCIATION2)

BASE-TEST: 7.12615F-02
SAVE: SAVE-OBJECT
EXPECTATIONS: (EXPECTATION8)
ASSESSMENTS: NIL
EVENTS: (DEFER-REVENUE SALE-OF-PRODUCT PREDATE-INVOICES)

FORMULA: ((+! F-SALES-SEARS F-SALES-OTHER) (*! F-UNITS-SOLD
F-FIRM-PRICE) (*! F-MARKET-SHARE F-MARKET-DEMAND))

OUTNODE: (F-GROSS-PROFIT-RATE F-GROSS-PROFIT)
HISTORY-VALUE: (540192 508486 449490 318826)
GL-DATA: T
PAST-VALUE: 508486
PRIOR-VALUE: 540192
PREDICTIONS: NIL
WEIGHT-VALUE: NIL
WEIGHT-BASE: F-SALES
EVALUATION-FLAG: T
CURRENT-VALUE: 617154
RECOGNITION-PATTERNS: ("gross sales")
PRINT-NAME: "sales"
BASE-STATE: 5.751F+05
BUDGET: NIL
CHILDREN: NIL
```

Printing contents of OPERATOR

CLASS: (SYSTEM-OBJECT)

CALCULATE-VALUE: CONVERT-OPERATOR

PRINT-NAME: "operator"

DISPLAY: DISPLAY-OPERATOR

USER-ACCESSIBLE: (PRINT-NAME CALCULATE-CHANGE CALCULATE-CHANGE-ARGUMENT EVALUATE-CHANGE RECOGNITION-PATTERNS)

MULTI-VALUE: (RECOGNITION-PATTERNS)

Default fields -

(**SAVE** SAVE-OBJECT NIL NIL NIL)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**CALCULATE-CHANGE** NIL (GETD (*VAR* NEW-VALUE)) NIL change value calculation function)

(**CALCULATE-CHANGE-ARGUMENT** NIL (GETD (*VAR* NEW-VALUE)) NIL method to calculate value of missing change argument)

(**EVALUATE-CHANGE** NIL (GETD (*VAR* NEW-VALUE)) NIL change direction function)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

RECON-LIST: (("+!" +!) ("plus" +!))

CHILDREN: (+!)

Printing contents of +!

CLASS: (OPERATOR)
SAVE: SAVE-OBJECT
PRINT-NAME: "plus"
CALCULATE-CHANGE: PLUS
CALCULATE-CHANGE-ARGUMENT: PLUS-CHANGE-ARG
RECOGNITION-PATTERNS: NIL
CHILDREN: NIL

Printing contents of VALUE-OBJECT

The primary use of value objects is to provide nice display and print features for various concepts used by the system.

CLASS: (SYSTEM-OBJECT)

DISPLAY: CHECK-PRINTNAME

SPECIFIC-SLOTS: ((DISPLAY DISPLAY-VALUE-OBJECT (FBOUNDP (*VAR* NEW-VALUE)) NIL "display function name"))

USER-ACCESSIBLE: (PRINT-NAME RECOGNITION-PATTERNS)

MULTI-VALUE: (RECOGNITION-PATTERNS)

Default fields -

(**SAVE** SAVE-OBJECT NIL NIL NIL)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

RECON-LIST: (("more" MORE) ("more than" MORE) ("greater than it is" MORE))

CHILDREN: (MORE)

Printing contents of MORE

CLASS: (VALUE-OBJECT)
SAVE: SAVE-OBJECT
PRINT-NAME: "greater than it is"
RECOGNITION-PATTERNS: ("more than")
CHILDREN: NIL

Procedural Data Structures

<u>Printing contents of CHECK-LIST</u>

CLASS: (SYSTEM-OBJECT) PRINT-NAME: "check list" EXECUTE: EXECUTE-CHECKLIST EXPLAIN: NIL

USER-ACCESSIBLE: (DISPLAY TRACE-MESSAGE VARIABLES PROCEDURES PRINT-NAME RECOGNITION-PATTERNS EXPLANATION)

MULTI-VALUE: (VARIABLES PROCEDURES RECOGNITION-PATTERNS)

<u>Default fields -</u>

(**DISPLAY** NIL (AND (SYMBOLP (*VAR* NEW-VALUE)) (FBOUNDP (*VAR* NEW-VALUE))) NIL display procedure name)

(**DISPLAY** NIL NIL NIL display function) (**SAVE** SAVE-OBJECT1 NIL NIL NIL)

(**VARIABLES** ((PARENT NIL NIL) (STOP NIL NIL) (SKIP NIL NIL)) (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3)) NIL variables)

(**EXPLANATION** NIL (STRINGP (*VAR* NEW-VALUE)) NIL explanation)

(**PROCEDURES** NIL (OR (OBJECT-TYPE (QUOTE PROCEDURE) (*VAR* NEW-VALUE)) (OBJECT-TYPE (QUOTE CHECK-LIST) (*VAR* NEW-VALUE)) (OBJECT-TYPE (QUOTE RULE) (*VAR* NEW-VALUE)) (OBJECT-TYPE (QUOTE KS) (*VAR* NEW-VALUE))) NIL operations)

(**TRACE-MESSAGE** NIL (LISTP (*VAR* NEW-VALUE)) NIL trace message)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

End of default fields, returning to class definition object slots.

RECON-LIST: (("event-search" EVENT-SEARCH) ("event search" EVENT-SEARCH))

CHILDREN: (EVENT-SEARCH)

Printing an example of an instance of the Checklist class of objects, event search.

Printing contents of EVENT-SEARCH

CLASS: (CHECK-LIST)

DISPLAY: NIL

DISPLAY: DISPLAY-ASSESSMENT-CHECKLIST

SAVE: SAVE-OBJECT1

VARIABLES: ((PARENT NIL NIL) (STOP NIL NIL) (SKIP NIL NIL) (EVENTS NIL NIL) (DIRECTION NIL NIL) (FINAL-EVENTS NIL NIL) (TEMP-EVENTS NIL NIL) (TEMP-EVENT NIL NIL))

EXPLANATION: "triggers a search for events that would explain an expectation mismatch and then cleans up any duplicate hypotheses"

PROCEDURES: (SEARCH-MISSING-EVENTS EOE2 MERGE-HYPOTHESES)

TRACE-MESSAGE: NIL

PRINT-NAME: "event search"

RECOGNITION-PATTERNS: NIL

CHILDREN: NIL

Printing contents of KS

CLASS: (SYSTEM-OBJECT) PRINT-NAME: "knowledge source"
EXECUTE: RUN-KS

USER-ACCESSIBLE: (DISPLAY TRACE-MESSAGE RULES VARIABLES PRINT-NAME RECOGNITION-PATTERNS ACTIVITY-DESCRIPTION)

MULTI-VALUE: (RULES VARIABLES RECOGNITION-PATTERNS)

Default fields -

(**DISPLAY** NIL (FBOUNDP (*VAR* NEW-VALUE)) NIL display procedure name)

(**SAVE** SAVE-OBJECT1 NIL NIL NIL)

(**RULES** NIL (OBJECT-TYPE (QUOTE RULE) (*VAR* NEW-VALUE)) NIL rules)

(**VARIABLES** ((PARENT NIL NIL) (STOP NIL NIL)) (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3)) NIL local variables)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**TRACE-MESSAGE** NIL (LISTP (*VAR* NEW-VALUE)) NIL trace message)

(**ACTIVITY-DESCRIPTION** NIL NIL NIL activity description)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

End of default fields, returning to class definition object slots.

RECON-LIST: (("check-base" CHECK-BASE) ("check base" CHECK-BASE)

CHILDREN: (CHECK-BASE)

Printing an example of an instance of the KS class of objects, check base. KS is an abbreviation for Knowledge Source. These are the objects referred to as production systems throughout this dissertation

Printing contents of CHECK-BASE

CLASS: (KS)

DISPLAY: NIL

SAVE: SAVE-OBJECT1

RULES: (CHB1 CHB2 CHB3 CHB4 CHB5)

VARIABLES: ((START NIL NIL) (EXPECTS NIL NIL) (EXPECT NIL NIL) (PARENT NIL NIL) (STOP NIL NIL))

PRINT-NAME: "check base"

TRACE-MESSAGE: NIL

ACTIVITY-DESCRIPTION: "screens out firm model elements who don't need to have their base states checked"

RECOGNITION-PATTERNS: NIL

CHILDREN: NIL

Printing contents of PROCEDURE

CLASS: (SYSTEM-OBJECT) PRINT-NAME: "procedure" EXECUTE: EXECUTE-OPERATION EXPLAIN: NIL

USER-ACCESSIBLE: (DISPLAY TRACE-MESSAGE EXPLANATION VARIABLES PRINT-NAME RECOGNITION-PATTERNS)

MULTI-VALUE: (RECOGNITION-PATTERNS VARIABLES)

Default fields -

(**DISPLAY** NIL (FBOUNDP (*VAR* NEW-VALUE)) NIL display procedure name)

(**SAVE** SAVE-OBJECT1 NIL NIL NIL)

(**VARIABLES** ((PARENT NIL NIL)) (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3)) NIL variables)

(**TRACE-MESSAGE** NIL (LISTP (*VAR* NEW-VALUE)) NIL trace message)

(**PRINT-NAME** NIL (TEST-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) print name)

(**RECOGNITION-PATTERNS** NIL (TEST-RECON-PATTERN (*VAR* NEW-VALUE) (*VAR* NAME) (*VAR* CLASS)) (DELETE-PRINTNAME (*VAR* NEW-VALUE) (*VAR* NAME)) recognition patterns)

(**EXPLANATION** NIL (STRINGP (*VAR* NEW-VALUE)) NIL explanation)

RECON-LIST: (("build-event-score" BUILD-EVENT-SCORE) ("build event score" BUILD-EVENT-SCORE))

CHILDREN: (BUILD-EVENT-SCORE)

Printing contents of BUILD-EVENT-SCORE

CLASS: (PROCEDURE)
DISPLAY: NIL
SAVE: SAVE-OBJECT1
VARIABLES: ((PARENT NIL NIL))
TRACE-MESSAGE: NIL
PRINT-NAME: "build event score"
RECOGNITION-PATTERNS: NIL
EXPLANATION: "builds an event score object"
CHILDREN: NIL

Printing contents of RULE

CLASS: (SYSTEM-OBJECT) DISPLAY: DISPLAY-RULE-PARENT
PRINT-NAME: "rule" CHECK-CONDITIONS: CHECK-RULE-CONDITIONS
EXECUTE: EXECUTE-RULE EXECUTE-ACTION: EXECUTE-RULE-ACTION
PROVE-CONDITIONS: PROVE-RULE-CONDITIONS
DISPLAY-INSTANTIATION: DISPLAY-INSTANTIATED-RULE

USER-ACCESSIBLE: (TRACE-MESSAGE VARIABLES CONDITIONS ACTION DESCRIPTION DEDUCTIVE-STRENGTH ABDUCTIVE-STRENGTH)

MULTI-VALUE: (VARIABLES)

Default fields -

(**SAVE** SAVE-OBJECT1 NIL NIL NIL)

(**CONDITIONS** NIL (LISTP (*VAR* NEW-VALUE)) NIL rule conditions)

(**ACTION** NIL (LISTP (*VAR* NEW-VALUE)) NIL rule action)

(**DESCRIPTION** NIL (STRINGP (*VAR* NEW-VALUE)) NIL description of rule activity)

(**TRACE-MESSAGE** NIL (LISTP (*VAR* NEW-VALUE)) NIL trace message)

(**DEDUCTIVE-STRENGTH** NIL (NUMBERP (*VAR* NEW-VALUE)) NIL deductive weight)

(**ABDUCTIVE-STRENGTH** NIL (NUMBERP (*VAR* NEW-VALUE)) NIL abductive weight)

(**VARIABLES** ((PARENT NIL NIL)) (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3)) NIL local variables)

> End of default fields, returning to class definition object slots.

RECON-LIST: (("case5" CASE5))

CHILDREN: (CASE5)

Printing an example of an instance of the Rule class of objects, CASE5.

Printing contents of CASE5

CLASS: (RULE)

SAVE: SAVE-OBJECT1

CONDITIONS: (EQ (*VAR* KIND) (QUOTE Q))

ACTION: (SETS (*VAR* PARENT) (QUOTE RESPONSE) NIL (QUOTE (PARENT)))

DESCRIPTION: "calls for a new response if the user enters a 'Q class"

TRACE-MESSAGE: NIL

DEDUCTIVE-STRENGTH: NIL

ABDUCTIVE-STRENGTH: NIL

VARIABLES: ((PARENT NIL NIL))

CHILDREN: NIL

CASE SPECIFIC DATA STRUCTURES

> The data structures presented in this section duplicate those presented in the previous appendix that dealt with input screens. This duplication should help the reader relate input screens to internal data structures.

Printing contents of ASSESSMENT

CLASS: (CASE-OBJECT)

USER-ACCESSIBLE: (ASSESSMENT FACTOR FIRMNODE)

MULTI-VALUE: NIL

COUNT: 18

DISPLAY: DISPLAY-ASSESSMENT

GET-INSTANCE: GET-INSTANCE2

GET-NEW-NAME: GET-NEW-NAME1

Default fields -

(**FACTOR** NIL (MATCH-TEST (QUOTE CHECK-LIST) (*VAR* NEW-VALUE)) NIL factor name)

(**ASSESSMENT** NIL (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL assessment (H M L))

(**FIRMNODE** NIL (MATCH-TEST (QUOTE FIRMNODE) (*VAR* NEW-VALUE)) NIL firm model element)

CHILDREN: (ASSESSMENT17 ASSESSMENT16 ASSESSMENT15 ASSESSMENT14 ASSESSMENT13 ASSESSMENT12 ASSESSMENT11 ASSESSMENT3 ASSESSMENT2 ASSESSMENT1 ASSESSMENT0)

Printing contents of ASSESSMENT11

CLASS: (ASSESSMENT)
FACTOR: REPORTING-STANDARD-VOLITILITY
ASSESSMENT: HIGH
FIRMNODE: F-ACCRUED-LIABILITIES
CHILDREN: NIL

Printing contents of FINANCIAL-DATA

CLASS: (CASE-OBJECT)

PRINT-NAME: "general ledger data"

The GL-DATA slot of the FINANCIAL-DATA object contains a copy of the general ledger data read in to the system with each case. It is used to facilitate displaying this information when requested by the user. Only on field is shown here to reduce the size of this appendix.

GL-DATA: ((F-SALES NIL NIL NIL NIL NIL NIL NIL NIL NIL NIL NIL NIL NIL 617154 540192 508486 449490 318826))

ADD: GL-ACCESS-ERROR

DELETE: GL-ACCESS-ERROR

MODIFY: GL-ACCESS-ERROR

GET-INSTANCE: GL-INSTANCE

REVIEW: DISPLAY-GL

CHILDREN: NIL

Printing contents of GENERAL-DATA

CLASS: (CASE-OBJECT)

ADD: ADD-GENERAL-DATA

GET-INSTANCE: GET-GENERAL-DATA

MULTI-VALUE: (SPECIFIC-MATERIALITY)

USER-ACCESSIBLE: (CASE-NAME AUDIT-PERIOD QUARTERS-COVERED DEFAULT-MATERIALITY SPECIFIC-MATERIALITY OWNERSHIP)

Default fields -

(**DELETE** DELETE-OBJECT1 NIL NIL NIL)

(**CASE-NAME** NIL NIL NIL case name)

(**AUDIT-PERIOD** YEAR (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (YEAR Q1 Q2 Q3 Q4))) NIL audit period)

(**QUARTERS-COVERED** 4 (MEMBER (*VAR* NEW-VALUE) (QUOTE (0 1 2 3 4))) NIL number of quarters covered by current data)

(**OWNERSHIP** NIL (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (PUBLIC WHOLELY-OWNED CLOSELY-HELD))) NIL type of ownership)

(**DEFAULT-MATERIALITY** (F-INCOME-BEFORE-EXTRAORDINARY-AND-TAXES 0.05) (MATERIALITY-MATCH (*VAR* NEW-VALUE)) NIL default materiality base and level)

(**SPECIFIC-MATERIALITY** NIL (MATERIALITY-MATCH1 (*VAR* NEW-VALUE)) NIL account specific materiality bases and levels)

CHILDREN: (CASE-DATA)

Printing contents of CASE-DATA

CLASS: (GENERAL-DATA)
DELETE: DELETE-OBJECT1
CASE-NAME: TEST3
AUDIT-PERIOD: YEAR
QUARTERS-COVERED: 4
OWNERSHIP: PUBLIC
DEFAULT-MATERIALITY: (F-SALES 0.003)
SPECIFIC-MATERIALITY: NIL
CHILDREN: NIL

Printing contents of INCENTIVE

CLASS: (CASE-OBJECT)

MULTI-VALUE: NIL

CALCULATE-BOUND-VALUE: CALC-INCENTIVE-BOUND-VALUE

CHECK-BOUND: CHECK-INCENTIVE-BOUND

COUNT: 3

DISPLAY: DISPLAY-INCENTIVE

CALCULATE-DIRECTION: CALCULATE-INCENTIVE-DIRECTION

USER-ACCESSIBLE: (IMPACT FORMULA PRINT-NAME)

GET-NEW-NAME: GET-NEW-NAME1

GET-INSTANCE: GET-INSTANCE2

Default fields -

(**IMPACT** MEDIUM (MEMBER (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) (QUOTE (HIGH MEDIUM LOW))) NIL estimated impact strength on management)

(**FORMULA** NIL (AND (LISTP (*VAR* NEW-VALUE)) (EQ (LENGTH (*VAR* NEW-VALUE)) 3) (FORMULAP (*VAR* NEW-VALUE))) NIL incentive formula)

(**PRINT-NAME** NIL (STRINGP (*VAR* NEW-VALUE)) NIL print name)

RECON-LIST: (("incentive2" INCENTIVE2) ("incentive1" INCENTIVE1) ("incentive0" INCENTIVE0))

CHILDREN: (INCENTIVE2 INCENTIVE1 INCENTIVE0)

Printing contents of INCENTIVE1

CLASS: (INCENTIVE)
IMPACT: HIGH
FORMULA: (> F-GROSS-PROFIT (*! 1.2 (F-GROSS-PROFIT PRIOR)))
PRINT-NAME: "gross profit bonus"
CHILDREN: NIL

Printing contents of OBSERVED-EVENT

CLASS: (CASE-OBJECT)

MULTI-VALUE: NIL

ADD: ADD-OBSERVED-EVENT

EXPAND-SLOT: EVENT-NAME

DISPLAY: DISPLAY-OBSERVED-EVENT

COUNT: 13

GET-INSTANCE: GET-INSTANCE2

GET-NEW-NAME: GET-NEW-NAME1

USER-ACCESSIBLE: (EVENT-NAME)

Default fields -

(**EVENT-NAME** NIL (MATCH-TEST (QUOTE EVENT) (*VAR* NEW-VALUE)) NIL event)

CHILDREN: (OBSERVED-EVENT12 OBSERVED-EVENT11 OBSERVED-EVENT10 OBSERVED-EVENT7 OBSERVED-EVENT5 OBSERVED-EVENT2 OBSERVED-EVENT1)

Printing contents of OBSERVED-EVENT12

CLASS: (OBSERVED-EVENT)
EVENT-NAME: REPORTING-STANDARD-CHANGE
TRANSACTION: PENSION-ACCRUAL
FIRMNODE: NIL
DIRECTION: INC
USER-ACCESSIBLE: (EVENT-NAME TRANSACTION FIRMNODE DIRECTION)
CHILDREN: NIL

Printing contents of PREDICTION

CLASS: (CASE-OBJECT)

MULTI-VALUE: NIL

DISPLAY: DISPLAY-PREDICTION

COUNT: 26

GET-INSTANCE: GET-INSTANCE2

GET-NEW-NAME: GET-NEW-NAME1

USER-ACCESSIBLE: (FIRMNODE CHANGE TYPE CONFIDENCE SOURCE)

Default fields -

(**FIRMNODE** NIL (OR (MATCH-TEST (QUOTE FIRMNODE) (*VAR* NEW-VALUE)) (MATCH-TEST (QUOTE ASSOCIATION) (*VAR* NEW-VALUE))) NIL firm model element or relationship)

(**CHANGE** 0 (TEST-PREDICTION-CHANGE (*VAR* NEW-VALUE)) NIL percentage change)

(**TYPE** S (OR (EQ (*VAR* NEW-VALUE) (QUOTE S)) (EQ (*VAR* NEW-VALUE) (QUOTE T))) NIL change type (S or T))

(**CONFIDENCE** LOW (MATCH-TEST (QUOTE VALUE-OBJECT) (*VAR* NEW-VALUE)) NIL confidence (H M L))

(**SOURCE** NIL (STRINGP (*VAR* NEW-VALUE)) NIL source)

(**PROCESSED** NIL NIL NIL processed flag)

CHILDREN: (PREDICTION25 PREDICTION24 PREDICTION23 PREDICTION22 PREDICTION21 PREDICTION20 PREDICTION19 PREDICTION18 PREDICTION17 PREDICTION16 PREDICTION15 PREDICTION14 PREDICTION0)

Printing contents of PREDICTION0

CLASS: (PREDICTION)
FIRMNODE: F-CUMMULATIVE-TRANS-ADJ
CHANGE: -0.6
TYPE: S
CONFIDENCE: HIGH
SOURCE: "change in the value of the dollar"
PROCESSED: NIL
CHILDREN: NIL

TEMPORARY DATA STRUCTURES

Printing contents of ANALYSIS

CLASS: (TEMPORARY-OBJECT)

COUNT: 16

DISPLAY: DISPLAY-ANALYSIS

Default fields -

(**SUPPORT-STRUCTURES** NIL NIL NIL support structures)

(**FIRMNODE** NIL NIL NIL firm model element)

(**EXPECTATION-INFORMATION** NIL NIL NIL expectation information)

(**HYPOTHESIS-INFORMATION** NIL NIL NIL hypothesis information)

CHILDREN: (ANALYSIS15 ANALYSIS14 ANALYSIS13 ANALYSIS12 ANALYSIS11 ANALYSIS10 ANALYSIS9 ANALYSIS8 ANALYSIS7 ANALYSIS6 ANALYSIS5 ANALYSIS3 ANALYSIS2 ANALYSIS1 ANALYSIS0)

Printing contents of ANALYSIS7

CLASS: (ANALYSIS)

SUPPORT-STRUCTURES: (EXPECTATION11 EXPECTATION2 HYPOTHESIS11 HYPOTHESIS0)

FIRMNODE: F-INVENTORY

EXPECTATION-INFORMATION: ((HIGHER LOW (HISTORICAL-VALUES ASSOCIATION5)))

HYPOTHESIS-INFORMATION: ((ACTUAL-VALUE 3.5 ((ERROR ((AFSL3 ((NODE F-INVENTORY) (ASSESSMENT LOW) (ADDED-WEIGHT 2))) (AFCC1 ((NODE F-INVENTORY) (ASSESSMENT HIGH) (ADDED-WEIGHT 2)))))) (NOT-ERROR ((AFGCE1 ((ASSESSMENT HIGH) (ADDED-WEIGHT -0.5))))))))

CHILDREN: NIL

<u>Printing contents of EVENT-SCORE</u>

CLASS: (TEMPORARY-OBJECT)

DELETE: DELETE-EVENT-SCORE

COUNT: 1

<u>Default fields -</u>

(**EVENT** NIL NIL NIL event)

(**OCCURRENCE** NIL NIL NIL event occurrence)

(**SCORE** NIL NIL NIL event score)

(**INCENTIVE-SCORE** NIL NIL NIL incentive score)

(**ABILITY-SCORE** NIL NIL NIL ability score)

(**HISTORY** NIL NIL NIL history)

CHILDREN: (EVENT-SCORE0)

<u>Printing contents of EVENT-SCORE0</u>

CLASS: (EVENT-SCORE)

EVENT: PREDATE-INVOICES

OCCURRENCE: T

SCORE: 3

INCENTIVE-SCORE: 2

ABILITY-SCORE: 1

HISTORY: ((INCENTIVE1 EXPECTATION1))

CHILDREN: NIL

Printing contents of EXPECTATION

CLASS: (TEMPORARY-OBJECT)

REMOVE-EFFECT: REMOVE-EXPECTATION

DELETE: DELETE-EXPECTATION

COUNT: 15

DISPLAY: DISPLAY-EXPECTATION

Default fields -

(**CHANGE-TYPE** NIL NIL NIL change type)

(**FIRMNODE** NIL NIL NIL firm model element)

(**EXPECTED-CHANGE** NIL NIL NIL expected change value object)

(**ACTUAL-CHANGE** NIL NIL NIL actual change value)

(**HYPOTHESES** NIL NIL NIL hypotheses)

CHILDREN: (EXPECTATION14 EXPECTATION13 EXPECTATION12
EXPECTATION11 EXPECTATION10 EXPECTATION9 EXPECTATION8
EXPECTATION7 EXPECTATION6 EXPECTATION5 EXPECTATION4
EXPECTATION3 EXPECTATION2 EXPECTATION1 EXPECTATION0)

Printing contents of EXPECTATION6

```
CLASS: (EXPECTATION)
CHANGE-TYPE: HISTORICAL-VALUES
FIRMNODE: F-ACCOUNTS-PAYABLE
EXPECTED-CHANGE: VALUE12
ACTUAL-CHANGE: 6.0916F-02
HYPOTHESES: NIL CHILDREN: NIL
```

> The following FIRMNODE-VALUE objects are included to demonstrate how the system maintains a complete history of the calculations supporting the expected-change slot of the expectation object.

Printing contents of VALUE12

```
CLASS: (FIRMNODE-VALUE)
TYPE: S
VALUE: 3.99069F-01
FIRMNODE: F-ACCOUNTS-PAYABLE
HISTORY: ((ASSOCIATION VALUE11))
SOURCES: NIL
CHILDREN: NIL
```

Printing contents of VALUE11

```
CLASS: (FIRMNODE-VALUE)
TYPE: S
VALUE: 0.0
FIRMNODE: ASSOCIATION3
HISTORY: ((% 0 VALUE4))
SOURCES: NIL
CHILDREN: NIL
```

Printing contents of VALUE4

```
CLASS: (FIRMNODE-VALUE)
TYPE: S
VALUE: 0
FIRMNODE: F-INVENTORY
HISTORY: NIL
SOURCES: NIL
CHILDREN: NIL
```

Printing contents of FIRMNODE-VALUE

CLASS: (TEMPORARY-OBJECT)

DELETE: DELETE-FIRMNODE-VALUE

COUNT: 34

Default fields -

(TYPE S NIL NIL type)

(VALUE NIL NIL NIL value)

(FIRMNODE NIL NIL NIL firm model element)

(HISTORY NIL NIL NIL value's calculation history)

(SOURCES NIL NIL NIL predictions that lead to value)

CHILDREN: (VALUE34 VALUE33 VALUE32 VALUE31 VALUE30 VALUE29 VALUE28 VALUE27 VALUE26 VALUE25 VALUE24 VALUE23 VALUE22 VALUE21 VALUE20 VALUE19 VALUE18 VALUE17 VALUE16 VALUE15 VALUE14 VALUE13 VALUE12 VALUE11 VALUE10 VALUE9 VALUE8 VALUE7 VALUE6 VALUE5 VALUE4 VALUE3 VALUE2 VALUE1)

Printing contents of VALUE28

CLASS: (FIRMNODE-VALUE)

TYPE: S

VALUE: 0

FIRMNODE: F-INTEREST

HISTORY: ((+! (PREDICTION PREDICTION21 "debt retirement") (PREDICTION PREDICTION23 "new debt issuance")))

SOURCES: (PREDICTION21 PREDICTION23)

CHILDREN: NIL

Printing contents of GOAL-OBJECT

CLASS: (TEMPORARY-OBJECT)

ACTIVE: NIL

COUNT: 7

PRINT-NAME: "goal structure"

SET-GOAL: SET-GOAL

EXECUTE-GOAL: EXECUTE-GOAL

Default fields -

(**CONDITIONS** NIL NIL NIL conditions)

(**ACTION** NIL NIL NIL action)

CHILDREN: NIL

Printing contents of GOAL3

> This goal causes the system to pickup the analysis of inventory where it left off (i.e. from the point that the expected balance and been compared to the actual balance) when both ASSOCIATION3 and ASSOCIATION5 have been processed. Both these associations involve inventory. Since goals are deleted as they are executed, this printout was made during the processing of the test case, not after.

CLASS: (GOAL-OBJECT)

CONDITIONS: (ALL-EVALUATEDP (QUOTE (ASSOCIATION3 ASSOCIATION5)))

ACTION: (DEFER (QUOTE RECHECK-EXPECTATIONS) (QUOTE PROCESS-NODE) (QUOTE (CURRENT-NODE F-INVENTORY)) (QUOTE (OLD-EXPECTATIONS NIL)) (QUOTE (CURRENT-HYPOTHESES NIL)) (QUOTE (CURRENT-EXPECTATIONS NIL)))

CHILDREN: NIL

Printing contents of HYPOTHESIS

CLASS: (TEMPORARY-OBJECT)

DISPLAY: DISPLAY-HYPOTHESIS

SPECIFIC-ASSESSMENTP: SPECIFIC-ASSESSMENTP

DELETE: DELETE-HYPOTHESIS

GET-FIRMNODES: GET-HYPOTHESIS-FIRMNODES

COUNT: 29

Default fields -

(**EXPECTATIONS** NIL NIL NIL expectations)

(**ASSERTION** NIL NIL NIL assertion)

(**ASSERTION-SUPPORT** NIL NIL NIL assertion support)

(**WEIGHT** 0 NIL NIL weight)

(**WEIGHT-SUPPORT** NIL NIL NIL weight support)

CHILDREN: (HYPOTHESIS28 HYPOTHESIS27 HYPOTHESIS26 HYPOTHESIS25 HYPOTHESIS24 HYPOTHESIS23 HYPOTHESIS22 HYPOTHESIS21 HYPOTHESIS20 HYPOTHESIS19 HYPOTHESIS18 HYPOTHESIS17 HYPOTHESIS16 HYPOTHESIS15 HYPOTHESIS14 HYPOTHESIS13 HYPOTHESIS12 HYPOTHESIS11 HYPOTHESIS10 HYPOTHESIS9 HYPOTHESIS8 HYPOTHESIS7 HYPOTHESIS6 HYPOTHESIS5 HYPOTHESIS4 HYPOTHESIS3 HYPOTHESIS2 HYPOTHESIS1 HYPOTHESIS0)

Printing contents of HYPOTHESIS0

CLASS: (HYPOTHESIS)

EXPECTATIONS: NIL

ASSERTION: (REPLACE F-INVENTORY CURRENT-VALUE 99282 DIFF)

ASSERTION-SUPPORT: MECHANICAL-ERROR

WEIGHT: 3.5

WEIGHT-SUPPORT: ((AFSL3 ((NODE F-INVENTORY) (ASSESSMENT LOW) (ADDED-WEIGHT 2))) (AFCC1 ((NODE F-INVENTORY) (ASSESSMENT HIGH) (ADDED-WEIGHT 2))) (AFGCE1 ((ASSESSMENT HIGH) (ADDED-WEIGHT -0.5))))

CHILDREN: NIL

Printing contents of SUMMARY

CLASS: (TEMPORARY-OBJECT)

COUNT: 11

DISPLAY: DISPLAY-SUMMARY

Default fields -

(FIRMNODE NIL NIL NIL firm model element)

(WEIGHT 0 NIL NIL summary weight)

(ANALYSIS NIL NIL NIL related analysis object)

(DOMINANCE NIL NIL NIL dominance relationships)

CHILDREN: (SUMMARY10 SUMMARY9 SUMMARY8 SUMMARY7 SUMMARY6 SUMMARY5 SUMMARY4 SUMMARY3 SUMMARY2 SUMMARY1 SUMMARY0)

Printing contents of SUMMARY8

CLASS: (SUMMARY)

FIRMNODE: F-INVENTORY

WEIGHT: 8.5

ANALYSIS: ANALYSIS7

DOMINANCE: NIL

CHILDREN: NIL

APPENDIX E

EVALUATION QUESTIONNAIRES

This appendix contains copies of the two questionnaires used to evaluate the system's performance on three cases. The questionnaires were sent to each subject with a cover letter. That letter included the following paragraph that further defined the nature of the expected responses to the questionnaire:

> "I would like you to answer the questions on a separate sheet of paper but with a clear reference back to the question number. If you feel it is more appropriate for a given question, you may also reference the case materials or make marginal comments on these materials. In general, I am not concerned with the form of your answers just so long as I can relate your comments to a given question."

Questionnaire 1 was given to the subject with the first of three cases to evaluated and it includes general questions about the research project as a whole. Questionnaire 2 was given to the subject along with the second and third cases and includes only questions concerning a specific case.

Evaluation Questionnaire 1

I would like you to answer the following questions concerning the enclosed test case and system analysis. I have blocked series of questions on major issues together in an outline format. I appreciate your taking to time to review the case materials and provide me with this feedback.

In responding to the following questions, assume the following scenario. The case is designed to be used as a training exercise for junior accountants. Its purpose is to help expose them to issues of general risk assessment during audit planning. Assume the analysis produced by the system was developed by a junior accountant who had been given the case materials and asked to identify potential risk areas based on the information. The trace of the system's analysis has been annotated to avoid the difficult problem of creating complex natural language explanations that are not rigid. Your review of the analysis should include the annotations since these represent expanded explanations of the system's reasoning processes.

I. Evaluation of the case

A. Is the case complete in that it covers the major relevant issues for the audit period being planned? If not, what items should be included?

B. Is the information contained in the case accurate? If not, what items need to be corrected?

C. Is the scenario realistic? That is, would a case like this have potential value as a training exercise for junior accountants?

II. Evaluation of the system's analysis

A. Please identify any specific problems you find in the analysis. That is, identify any issues the system raised that you feel shouldn't have been raised, were given too much attention or weighed too heavily, or were raised for the wrong reasons. Also indicate why you feel the system's treatment of the issue was in error.

B. In addition, please identify issues that you feel the system should have raised but didn't and why you feel the issue was important.

C. In general, how would you characterize the system's analysis? I am looking for comments on the system's overall performance as well as the appropriateness of its analysis given the scenario.

III. Evaluation of the research project

A. Do you see any potential value to a system like this one? Do not limit you comments to the scenario that I have described above (i.e. training of junior accountants). What role(s), if any, could you envision a system like this playing in either audit training or on an engagement?

B. What basic changes or improvements need to be made to the system before it could fulfill any roles you identified above at an acceptable level of performance?

Evaluation Questionnaire 2

I would like you to answer the following questions concerning the enclosed system analyses. I appreciate your taking to time to review the case materials and provide me with this feedback.

In responding to the following questions, assume the same scenario as in the previous case I asked you to evaluate. That is, assume the case is designed to be used as a training exercise for junior accountants. Its purpose is to help expose them to issues of general risk assessment during audit planning. Assume the analysis produced by the system was developed by a junior accountant who had been given the case materials and asked to identify potential risk areas based on the information. As before, the trace of the system's analysis has been annotated. Your review of the analysis should include the annotations since these represent expanded explanations of the system's reasoning processes.

Evaluation of the system's analysis

IV. Please identify any specific problems you find in the analysis. That is, identify any issues the system raised that you feel shouldn't have been raised, were given too much attention or weighed too heavily, or were raised for the wrong reasons. Also indicate why you feel the system's treatment of the issue was in error.

V. In addition, please identify issues that you feel the system should have raised but didn't and why you feel the issue was important.

VI. In general, how would you characterize the system's analysis? I am looking for comments on the system's overall performance as well as the appropriateness of its analysis given the scenario.

APPENDIX F

EVALUATION RESULTS

This appendix contains the two evaluation subjects' responses to the two evaluation questionnaires presented in Appendix E. Only the detailed analysis of the case used in Chapter 5 to demonstrate the system's behavior is presented in order to maintain client confidentiality agreements with the participating CPA firm. The subjects' responses are presented in **bold type** after the each question and are labeled S1 or S2 for subject 1 and subject 2. Since the case the subjects are responding to was developed by the author, the subjects' could not judge the completeness and accuracy of the case and so these questions are not considered here.

Evaluation Questionnaire 1

I would like you to answer the following questions concerning the enclosed test case and system analysis. I have blocked series of questions on major issues together in an outline format. I appreciate your taking to time to review the case materials and provide me with this feedback.

In responding to the following questions, assume the following scenario. The case is designed to be used as a training exercise for junior accountants. Its purpose is to help expose them to issues of general risk assessment during audit planning. Assume the analysis produced by the system was developed by a junior accountant who had been given the case materials and asked to identify potential risk areas based on the information. The trace of the system's analysis has been annotated to avoid the difficult problem of creating complex natural language explanations that are not rigid. Your review of the analysis should include the annotations since these represent expanded explanations of the system's reasoning processes.

I. Evaluation of the case

C. Is the scenario realistic? That is, would a case like this have potential value as a training exercise for junior accountants?

S1 - It may have some value, but not as a primary risk assessment tool. That process must be driven from the top down (primary input from the partner and manager), not from the bottom up as would be the case here. The value in this case might be in the area of a financial performance review or assessment of financial factors which could indicate potential future problems. However, the case analysis does not display any of the financial ratios so that the analysis developed by the system (i.e. amount of risk) can be validated. I understand it may be cumbersome to incorporate additional ratios and financial performance indicators in the system, but believe some are needed in addition to the 3 factors presently used.

S2 - Yes. Such a training exercise would not be appropriate for a first year person but would be useful in training a person heading for an in-charge position.

II. Evaluation of the system's analysis

A. Please identify any specific problems you find in the analysis. That is, identify any issues the system raised that you feel shouldn't have been raised, were given too much attention or weighed too heavily, or were raised for the wrong reasons. Also indicate why you feel the system's treatment of the issue was in error.

S1 - Inventory - I am not comfortable with the decision rule that management will not be as vigilant in an area that had a problem in the past. I believe that management is aware of the areas of greatest risk and in most cases will devote attention to those areas. I believe the inventory should be evaluated on the basis of how often the company turns it over, based on average inventory for the year. I am unable to determine whether this has been considered based on the phrase "relationship to sales". In addition, I believe that inventory levels are (hopefully, at least) built up and reduced based on anticipate future sales and manufacturing lead time considerations. I think the analysis should consider what projected sales look like during the first inventory turn compared to the prior year. Finally, the case intro mentions problems in determining how much software cost should be capitalized in inventory. This is not addressed in the system analysis.

Deferred revenue - If the risk is that sales are overstated, I would not expect that deferred revenue would be up. In fact, I would think this area is one where the manipulation could take place easier that predating invoices since the latter would also require some adjustment to inventory and cost of sales which might be easier to spot, particularly in a standard cutoff test.

Admin expenses - The potential error in this caption is related solely to the change in pension accounting according to the system analysis. However, not all the pension adjustment flows through this line item. The amount which flows through admin expenses is dependent on the employee mix (i.e. production vs. administrative employees) and other factors.

S2 - Sales - The system registered its concerns about the significant sales growth. I certainly agree with these concerns. One point of documentation warrants your consideration. The system focused on a "predating of invoices" as the source of a potential error of overstatement. Although this is most certainly one way for management to manipulate sales, there are several others (use of fictitious invoices, recording of sales with subsequent issuance of credit memos, etc.). I raise this point only for you consideration in evaluating the system's recommendation.

Administrative Expenses - Administrative expenses were flagged only because of the change in accounting standard. I would have been concerned about total operating expenses (not just administrative expenses) because they have

remained relatively constant despite the significant increase in sales activity. In other words, the system apparently did not focus on these costs in the total as a percentage of sales.

B. In addition, please identify issues that you feel the system should have raised but didn't and why you feel the issue was important.

S1 - Other than in the areas noted above, I found no areas that were worthy of further analysis or investigation.

S2 - (S2 left this question blank indicating no other areas worth noting).

C. In general, how would you characterize the system's analysis? I am looking for comments on the system's overall performance as well as the appropriateness of its analysis given the scenario.

S1 - Overall, I would characterize the system's performance as adequate given the design constraints it operates under. Refer to my comments at II.A. above for specific critique of the analysis.

S2 - In general, I thought that the system's evaluation and prioritization were sound given the evidence of this case.

III. Evaluation of the research project

A. Do you see any potential value to a system like this one? Do not limit you comments to the scenario that I have described above (i.e. training of junior accountants). What role(s), if any, could you envision a system like this playing in either audit training or on an engagement?

S1 - I can see potential value to the system as a validation tool. I think its greatest contribution would be to automate the financial performance review or ratio analysis to highlight any potential problems that do not surface as a result of identifying current year events that could impact the company.

The system may have some training value in alerting junior staff to the potential risks that may exist due to financial relationships being out of syc.

However, I think the system is too "numbers" driven in it evaluation. I believe that general risk analysis focuses to a larger extent on the audit history with the client, the

analysis of management's integrity and the pressures on them and on changes in the company's business environment (including competition, financing pressure, etc.). Specific risk analysis (that done at the account level) is based to a degree on materiality of the account and other factors the system analyzes, but also focuses on the internal controls, and the adequacy of those controls, to detect and correct a material error or irregularity. I was unable to note any differentiation in the analysis in those areas where strong internal controls were noted to be in operation.

S2 - I feel the system has value as a training tool, either in public accounting or in an academic setting. The system is good in that it gets you thinking about how you would evaluate risk. The system is also fun to work with, I enjoyed evaluating its analysis. The system may also be useful in the field but it would have to be refined somewhat. The auditor would never rely totally on the system's analysis but could provide a useful second opinion.

B. What basic changes or improvements need to be made to the system before it could fulfill any roles you identified above at an acceptable level of performance?

S1 - See earlier comments regarding displaying key financial ratios to validate the system analysis. I also found some of the nomenclature to be confusing, but that may be due to unfamiliarity with the system.

Overall: I am torn about how much a system such as this can contribute to the risk analysis process. There are so many intangibles, such as relationship with the client, historical problem areas, significant current events and assessments of management that I have reservations that a computer system, even an "intelligent" system, would be able to properly consider these variables. There may be some value from a "number crunching" stand point as a supplement to the analysis of intangible factors.

S2 - Initially I found the system's method of expression rather stilted and hard to interpret but I got used to it over time. However, smoother expression would help the user interpret the system's analysis. The system does a good job of identifying areas of risk but needs to have weighting factors refined, primarily in more subjective areas. It is also not clear how sensitive it is to industry specific factors. In general, I continue to be impressed with the system's evolution and capabilities.

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