ACCOUNTING REGULATION-BASED EXPERT SYSTEMS

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ABSTRACT

Expert systems are being used to solve accounting regulation problems. The tasks performed by these systems include developing financial statements, examining proxy statement information as in EDGAR (Electronic Data Gathering Analysis and Reporting), developing financial ratios from EDGAR and assisting in the computation of the provision for income tax for financial reporting. This paper discusses those systems and some extensions to those systems as well as some of the advantages and limitations of expert systems in accounting regulation.

Expert Systems have been receiving increasing attention from accounting academics and professionals. Recent symposiums and research papers have addressed the relationship between accounting and auditing judgement and expert systems. Some prototype expert systems have been built

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to demonstrate the feasibility of the use of expert systems in accounting [O'Leary, 1987] and some accounting firms have begun to develop expert systems in auditing. However, much less attention has been directed towards regulation-based expert systems.

Accordingly, the purpose of this paper is to provide an understanding of expert systems in general and their interface with accounting regulation in particular. In order to accomplish this purpose, this paper will:

- discuss some of the key elements of expert systems,
- analyze accounting regulation as an area for expert system development,
- review and analyze what has been done in expert systems as they relate to accounting regulation,
- analyze some potential extensions in accounting regulation-based expert systems,
- discuss some of the advantages and limitations of the use of expert systems in regulation.

ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS

The term artificial intelligence (AI) is an umbrella term that includes a number of activities: expert systems (ES), pattern recognition by computers, learning and reasoning by computers, natural language use by computers, and other topics. Barr and Feigenbaum [1981], Rich [1983], and Winston [1984] provide comprehensive surveys.

Winston [1984, p. 1] defined AI as "the study of ideas that enable computers to be intelligent." Barr and Feigenbaum [1981, p. 1] have defined AI as "the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics associated with intelligence in human behavior." These definitions indicate that AI is concerned with developing computer systems that perform tasks and do analysis that humans currently use knowledge and reasoning to carry out.

Currently, the most frequently applied branch of AI in accounting is expert systems. ES perform tasks normally done by knowledgeable human experts [Rich, 1983]. Accordingly, ES are developed by programming the computer to make decisions using the knowledge and a representation of the decision-making processes of the expert.

ES Structure

Structurally, ES usually have four major components: database, knowledge base, inference engine, and user interface. The data base contains the data used by the expert system. The data may come from the user or may be part of the system or may be part of a computer database. This is normally the same data that a human expert would use to solve the problem. However, the system may use more or less data to solve the problem. For example, the human expert may use additional equivocal information for ill-defined problems that is not easily incorporated into the system, whereas the expert system may exploit the data processing capabilities of the computer and include unequivocal data that a human would not have time to process.

The knowledge base provides the set of knowledge that the system uses to process the data. Typically, this is the domain-specific knowledge that the expert would use to solve the problem. Knowledge can be represented a number of ways. One of the most frequently used methods is the rule-based approach. Rule-based knowledge representation takes the form of "if. . . (condition) then. . . (consequence/goal)." The rules may or may not include a numeric level of confidence or probability of occurrence. Alternatively, knowledge may be represented as a "frame" to capture the characteristics associated with a given entity. The characteristics define the knowledge about the entity that is of interest in the application. Typically, frames describe a class of objects. The frame generally consists of a collection of "slots" that describe characteristics of the objects. These slots may then be filled with other frames describing other objects, [Rich, 1983].

The inference engine provides the basis for using the knowledge base to process the database. In a rule-based system, the inference engine normally uses either a forward or backward chaining approach (or some combination). Forward chaining reasons toward a goal. Backward chaining reasons backward from the goal to determine if or how the goal can be accomplished. In frame-based systems, the inference engine processes frames. The information within the frames then guides the choice of the next frame. Other approaches may be used depending on the knowledge representation and the problem solving approach used in the system.

The user interface provides the communication between the user and the system. Generally, the interface is user friendly, particularly in those situations where data is generated by the user. The user interface may include an analysis of the reasoning of the system in developing its decisions.

AI Languages and ES Shells

Developing ES requires a means to communicate with the computer. This means is usually provided by procedural languages, artificial intelligence languages and/or ES shells.

Procedural languages, such as BASIC, allow the user to define a sequenced set of operations to solve a specific problem. Some ES and some ES shells have been developed using procedural languages. Fortran, Pascal and most recently C are among the most frequently used procedural languages in the development of ES or ES shells. Two primary generic AI languages are in use: List Programing or LISP [Winston and Horn, 1984], and Programming in Logic or PROLOG [Clocksin and Mellish, 1984]. The primary AI programming applications that have been developed in the United States have used LISP, whereas the Japanese have chosen PROLOG for their fifth generation project [Feigenbaum and McCorduck, 1983].

AI languages differ from procedural languages. Procedural languages are dependent on the order of the statements, whereas AI languages may not have that constraint. This allows the development of a knowledge base independent from the rest of the system and facilitates changing that knowledge base in response to environmental changes. Second, in contrast to other computer languages that are designed to process numeric information, AI languages process symbolic information.

ES shells can simplify the development of an expert system by providing many user friendly features [Turbin, 1985]. The inference engine can be specified and does not need to be developed. The knowledge base is easy to specify to the computer. The ES shells also may allow the user to access existing databases, such as dBase II, procedural languages, and AI languages. Recently, many shells have been criticized for being computationally slow and for providing little beyond some versions of AI languages. In addition, the shells are still computer software and, accordingly, nonprogrammers still find it difficult to use the ES shells to develop an expert system.

Understanding and Learning by ES

The notion of "understanding" by ES generally is dependent on the particular context. For example, in a discussion of a program, SAM, that is intended to model a human story understander, Schank [1978, p. 133], notes that "by 'understand' we mean that SAM can create a linked causal chain of conceptualizations that represent what took place in each story."

Learning by ES refers to the acquisition of new knowledge by the ES. In virtually all the business and accounting systems developed to date this means that the knowledge base of the expert system is updated manually or via interactive transfer of expertise. The systems do not have the capability to learn by themselves.

Purpose of the System

ES can be used in a number of ways: an educational mode, an advisory mode, and a replacement mode [O'Leary, 1986].

AI/ES are being used to model educational functions that previously would not have been placed in a computer model. STEAMER [Williams et al., 1981] is an example of a simulation program that uses concepts from AI to serve as a tutor; training students in the principles of propulsion engineering.

Most ES developed to date are designed to function in an advisory manner. These systems make a recommendation. A human expert reviews the decision and the logic behind the decision, before the decision is implemented.

There are some systems designed to replace the decision maker. Glover et al. [1984] designed a system that they indicated should be called a "managerial robot" because it was designed to replace the manager. The system was designed to schedule employees in a decision-making environment of weekly fluctuations. However, systems designed to replace the decision maker do not have to be implemented in that manner but instead can be used in an advisory manner.

Knowledge and Decision Characteristics

There are a number of characteristics of successful expert systems. First, the knowledge is in short supply [Fox, 1984], not readily accessible, or an expensive resource. This ensures that the system that is developed will be a benefit to the company. Second, the knowledge is not easily acquired, otherwise, there would not be a need for the ES. Third, the decision should require short reaction time or the processing of a substantial amount of information. Fourth, McDermott (1984) adds that the decision should be a high value decision. Fifth, the knowledge required for the decision is structured and limited. These last two characteristics contribute to the likelihood of a high cost-benefit ratio.

ACCOUNTING REGULATION AS AN AREA FOR EXPERT SYSTEM DEVELOPMENT

Accounting regulation is beginning to draw interest as a domain for ES development. This section defines accounting regulation-based systems and relates those systems to the knowledge and decision characteristics of the previous section.

Definition

An accounting regulation-based expert system is an expert system that incorporates accounting regulation knowledge into the system or allows the user to respond to changes in accounting regulation; the set of expert systems driven by accounting regulation. The focus of regulation in this paper excludes taxation, except to the extent that such methods involve financial statement issues.

Knowledge and Decision Characteristics

The knowledge and decision characteristics of successful ES suggest that accounting regulation is an environment that can benefit from the application of ES. First, the number of accountants with a high degree of technical knowledge about accounting regulation is limited. Second, such knowledge is not easily acquired and is expensive to maintain. Third, there is a substantial body of regulation knowledge that is not easily accessed. Fourth, regulation has a substantial impact on the "accounting behavior" of firms. Thus, there is a high value associated with regulation. Fifth, some of the knowledge of accounting regulation is structured. For example, there are rules on disclosure of financial information. In addition, some knowledge in accounting regulation is only loosely coupled with other knowledge.

ACCOUNTING REGULATION-BASED EXPERT SYSTEMS

There have been at least five prototype expert systems that have been developed in accounting regulation. These systems reflect a number of design approaches and types of accounting regulation knowledge.

ELOISE

Two systems have been developed to interface with the Securities and Exchange Commission's (SEC) Electronic Data Gathering Analysis and Retrieval (EDGAR) project: ELOISE, and FSA. The EDGAR database places the actual filings of companies in a computer format [e.g., Goodman and Jayne, 1986].

ELOISE [Arthur Andersen, 1985a] stands for *E*nglish *L*anguage *O*riented *I*ndexing *S*ystem for *E*DGAR. ELOISE is a prototype expert system designed to analyze the proxy statements in EDGAR, in order to study antitakeover provisions. The system was designed using LISP.

ELOISE is based on Fast Reading Understanding and Memory Program or FRUMP [DeJong, 1979], an AI program that is designed to read and "understand" news stories. These systems are designed to identify a concept based on the identification of some key building words associated with those concepts. After a concept has been identified, the system can predict the content of the material. The system does an iterative matching between the predictions and the actual content to "understand" the material. These systems also use semantic information to determine where to look for the desired concepts. A sample of ELOISE-supported analysis is given in Exhibit 1.

ELOISE uses two kinds of knowledge: SEC knowledge and English language knowledge. ELOISE contains specific vocabulary found in proxy statements. ELOISE uses two aspects of the anti-takeover provisions:

- changes in by-laws to accommodate the acquisition or disposition of securities, and
- changes in by-laws to require a supermajority vote for mergers.

In addition, ELOISE uses knowledge about English grammar, sentence structure and possible meanings of the words.

ELOISE was developed as a stand-alone prototype application. At this point in time, ELOISE does not actually use the EDGAR database, but instead uses unaltered excerpts (provided by the developers to the system in American Standard Code Information Interchange (ASCII) from actual SEC proxy documents.

ELOISE is regarded as a regulation-based system because it was commissioned by the SEC, it is designed to interface with EDGAR and because it is designed to analyze proxy statements in order to study antitakeover provisions, an issue of importance in regulation.

FSA

FSA stands for *F*inancial *S*tatement *A*nalyzer. FSA (Arthur Andersen, 1985b) is a prototype expert system designed to develop financial ratios by locating, interpreting and analyzing financial information contained in nonstandardized financial statements. FSA was programmed using LISP.

Exhibit 1. ELOISE-Supported Document Retrieval

Concept: Amendment to the company's by-laws dealing with the authorization of securities.

Component Name	*Component Concept*
Base Concept:	Document Revision
Type of Document:	By-Laws
Action:	Change in Number
Effect of Action:	Increase
Target of Action:	Common Stock

Source: Arthur Andersen (1985a, p. 13)

FSA has a knowledge of ratios, financial report captions and footnotes. The system is designed for three ratios: quick ratio, debt-to-equity ratio and the times fixed charges earned ratio. Since the search for information for the components of these ratios is contained in the captions and the footnotes, the system must have appropriate knowledge to access that information.

Unlike ELOISE, FSA does not use the techniques employed in FRUMP. This is because the semantic structure of the captions and footnotes is irregular. Instead, a vocabulary of certain key words is used to identify where the information required for the ratios is located.

As in ELOISE, the EDGAR database is not used. Instead, the system uses database representations of the financial statement documents. The user interface in FSA is very friendly, with the system designed to be an analyst's workbench. The system is flexible and the analyst has substantial control over what the system does.

FSA is designed for the services industry. However, the knowledge required for other industries can be built into the system.

FSA is an accounting regulation system because it was commissioned by the SEC and it was designed to interface with the EDGAR database. Although there are other financial analysis ES [Blocher and Scalf, 1986], those systems are not included here as regulation systems, since general financial statement analysis is done in many areas of accounting and finance and is not always related to regulation.

FINSTA

FINSTA (O'Leary and Munakata, 1986) is a prototype expert system designed to take "natural language" input—an unordered set of accounting titles and dollar amounts and develop a financial statement (balance sheet). The system is designed to consolidate some of the accounts with other accounts, and to formulate, structure and label the statement according to accounting regulation requirements. FINSTA was programmed using PROLOG.

FINSTA uses a frame-based form of knowledge representation to structure the basic characteristics of accounting concepts. Concepts are differentiated by the time dimension and the liquidity dimension, each of which is necessary to develop the balance sheet. The system recognizes a number of concepts, including cash, prepaids, receivables, fixed assets and others. Certain accounting titles (vocabulary) were attributed to each of these concepts. For example, the system would find that "Net Electric Plant in Service" has a plant asset concept and "Cash" has a cash concept of a short term asset and the most liquid short term asset.

The system determines which concept to invoke based on an analysis of the account titles. FINSTA analyzes the words in the account titles in order to identify the concept associated with that title.

In addition, FINSTA incorporates other disclosure requirements. For example, rules such as the need to disclose expenses that are one percent or more of sales can be included in such ES.

The inference engine [as above] in FINSTA is the execution of a sequence of PROLOG procedures. The data base is included in the program. The user interface is limited to the output of the system: the original accounts and the financial statement.

FINSTA is designed for the electric power industry. However, the knowledge from industry guides in other industries can be built into the system. FINSTA is included as an accounting regulation-based expert system because it includes rules of regulation for financial statement presentation.

ExperTAX

ExperTAX was developed by Coopers and Lybrand [Shpilberg and Graham, 1986] and [Shpilberg et al., 1986] to assist their audit staff in analyzing and computing the income tax accrual for financial reporting purposes. ExperTAX was developed in LISP and runs on IBM and IBM compatible personal computers.

Tax accrual is an audit task that requires specialized training. Accounting firms have developed questionnaires and checklists to facilitate the gathering of the necessary information. These questionnaires are usually completed by staff accountants in the field and analyzed by audit and tax management in order to identify tax planning issues and opportunities. However, practical realities limit the efficiency of the process. Questionnaires are perceived as long and complicated documents. Some of the issues on the questionnaire require tax expertise while others require audit expertise. Analysis of the forms can be a long and complex task that may not meet the timeliness required by the situation.

ExperTAX was developed to mitigate these problems. ExperTAX improves the process by reducing the elapsed time from start to finish, maintaining the quality of the output and reducing time demands on personnel. The system incorporates over 1,000 rules and several hundred frames. There are two types of frames in the knowledge base, question frames and issue frames. The frame types differ in the number and type of attributes and the procedures and facts associated with them.

The inference engine for the rules is forward chaining. A frame "manager" program is used to execute the two different types of frames.

The user interface is operated through a system of nested menus that allows the user to control the process. The user friendly system employs multiple windows to communicate with the user on multiple levels, and includes information identifying the section being analyzed, the questions being asked and the explanation of system requests of the user.

EDAAS

EDAAS (*E*xpert *D*isclosure *A*nalysis and *A*voidance *S*ystem) is an expert system in use at the Environmental Protection Agency (EPA). EDAAS [Feinstein and Seims, 1985] is designed to advise on the disclosure of confidential business information (CBI). Although the system does not employ accounting information or make judgements that directly affect accounting information, it is included here as an example of an expert system in use by a regulatory agency. The system was developed using Fortran because of the availability of programmers and portability of the software.

Chemical manufacturers, importers and processors submit detailed information to the EPA on thousands of chemical substances in commerce. The EPA has instituted security procedures to prevent the direct release of that information. However, if there is a request for information that is not sensitive then EPA tries to honor the request unless the information can be combined with other nonsensitive information that "too closely" estimates sensitive data protected under Federal nondisclosure law. This indirect disclosure could be used to estimate corporate strategies or research and development plans.

The process of determining whether the information is sensitive can require substantial manpower. Because of the Agency's limited resources, the well-understood nature of the tests of the information and the rule-based structure of the procedures, an expert system was built.

EDAAS contains two separate knowledge bases, each represented different ways. One of the knowledge bases uses rules to represent the specific law concerning information release. Another knowledge base contains known relationships between "pieces" of company-related CBI and non-CBI data.

EDAAS includes about 60,000 chemicals in the database and has thirty categories of chemical data. For each class of chemical and category of data there are approximately eleven rules. This is equivalent to about 198,000 rules.

EXTENSIONS

In addition to some extensions of the above systems, there are at least two other areas for potential application of expert systems in accounting regulation: modeling the law and regulations, and interfacing with EDGAR.

Extensions of ELOISE, FSA and FINSTA

Both ELOISE and FSA can be extended to interface with the EDGAR database [Arthur Andersen, 1985a,b]. This could be accomplished by the use of a translation module that would allow those two systems to access EDGAR.

All three of these systems can be extended by providing additional knowledge. For example, FSA could be extended to other ratios [Arthur Andersen, 1985b]. All three systems could benefit from an increased vocabulary.

The FSA system could be provided with a memory that would allow it to only compute the ratios one time for each company and then store the results. The stored results would then be used to provide the information in later requests.

Each of the systems could be expanded beyond their current domains. For example, FSA and FINSTA could be expanded beyond their single industry orientation and ELOISE could be expanded to other concepts besides anti-takeover provisions in the proxies.

Modeling Law and Regulations

Accounting regulation involves a substantial body of law and regulations. It has been demonstrated [Waterman and Peterson, 1981], that rule-based expert systems can be used to model various aspects of the law. Similarly, many regulations have a rule-based structure. Accordingly, to the extent that accounting regulation has such a structure, those problems may be amenable to the development of ES.

This could be beneficial because the complexities of the law can make it difficult to understand and because the frequent changes in the law can make it difficult to keep up with these changes. A computer program that fostered a use and understanding of the laws and regulations could make it easier for the user.

Interface with EDGAR

The purposes of EDGAR, as delineated in Goodman and Jayne [1986, p. 1], provide a basis for examining some of the other potential capabilities of expert systems. These purposes were to:

- provide investors, securities analysts and the public with access to corporate disclosure documents on computer screens,
- allow companies to make required filings via direct transmission, diskette or magnetic tape, and

- enable commission staff to process and analyze filings more efficiently at computer work stations.

FSA was aimed at aiding in the first purpose. However, FSA could be expanded beyond the development of financial ratios to include an analysis of the meaning of those financial ratios. This type of a system likely would focus on a particular industry, much as human experts (financial analysts, for example), focus on particular industries. In addition, the system also would likely be aimed at meeting the needs of a particular group of users.

Once the filings have been developed an expert system could be developed to translate the firm's filings into a format that meets the SEC's requirements.

The third purpose could also benefit from an ES approach. An expert system could be developed for the commission staff as an aid in analyzing the filings for accuracy and completeness.

ADVANTAGES AND LIMITATIONS OF ACCOUNTING REGULATION-BASED EXPERT SYSTEMS

Accounting Regulation-based Expert Systems

A recent national survey [Fried, 1986] cited a number of benefits of ES: improved decisions by nonexperts, more consistent decisions, reduced response time, reduced cost, and improved training. From the perspective of accounting regulation, these benefits suggest a number of implications.

The first benefit suggests a quasi-replacement mode of use for ES wherein experts could spend their time on more complex problems while nonexperts use ES to process the more routine decisions.

The second benefit indicates that by using the expert system, for example, the analysis of the filings may be done in a more consistent manner. The third benefit suggests that by using ES both the firm's filing and the SEC's analysis of the filings could be done in a more timely manner.

The fourth benefit arises because after an expert system has been built, it can be replicated without substantial additional cost (other than computer time and knowledge base updating). This is in contrast to human experts who require salaries, benefits, working space, etc.

Finally ES can be used to provide educational benefits. Using principles of AI and ES new systems can be used to provide education in areas that have been ignored previously in computer-aided education.

However, there also are some general limitations of ES [Messier and Hansen, 1983] and [McDermott, 1984]:

- a substantial effort is required to build an expert system,
- the development process requires an expert to spend time developing and debugging the systems,
- the size of the knowledge base is limited by current technology,
- the systems do not learn from their experience, and
- the systems do not have a general knowledge to fall back on if the specific knowledge is insufficient.

The regulation environment also limits the feasibility of the current generation of expert systems. Accounting regulation is in a state of constant change due to actions by rule-making bodies. This may induce obsolescence and/or lead to rapid changes in the knowledge base except at the most primitive levels.

In addition, although accounting regulation has a large body of formal rules that claim to define the domain, these rules are often contradictory, ambiguous and incomplete. In addition, the rules often employ complex and ill-defined concepts. This indicates the importance of chosing the right problems for the ES. If a decision-making problem includes many of these characteristics then it may be better to avoid it or to use a unique approach.

Human experts use many kinds of reasoning processes. The knowledge on which their decisions are based may require the judicious use of common sense, rather than domain-specific knowledge. However, ES do not easily incorporate common sense, which would require too broad a range of knowledge. Those problems for which common sense is used should likely be avoided in favor of those problems that are high in domain-specific knowledge.

CONCLUSION

This paper has introduced fundamental ES concepts and investigated the use of ES in accounting regulation. The paper has examined some actual ES and possible extensions to those systems. In addition, the paper has summarized some of the advantages and limitations of using ES in accounting regulation-based problems.

Two implemented and three prototype accounting regulation-based ES were discussed. These systems demonstrate the feasibility of using ES to model problems of concern in accounting regulation. These ES also demonstrate the range of accounting regulation problems that can be addressed using ES.

ES strengths are in the performance of structured activities with well defined problem domains. They can be used by decision makers to perform some of the "day-to-day" tasks, while humans focus on more complex problems. Because of the nature of accounting regulation and ES, it appears that accounting regulation can benefit from the application of ES.

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