TAX-BASED EXPERT SYSTEMS: IDENTIFYING OPPORTUNITIES AND PITFALLS

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ABSTRACT

This paper focuses on identifying potential opportunities and problems that may arise in applying expert systems technology to the taxation area. To date, research in tax-based expert systems has focused on developing prototypes of observed empirical relationships or modeling the tax law. Our approach is to go back to the basics and discuss the major issues faced in developing expert systems in taxation. This should be helpful to integrate the efforts of tax experts, tax researchers and knowledge engineers in developing effective tax expert systems. The current tax-based expert systems literature is examined to determine which issues have been addressed.

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INTRODUCTION

Expert systems (ES) have received increased attention from accounting academics and professionals. Several recent symposiums (e.g., the University of Southern California Audit Judgment Conference) and research papers [e.g., Meservy, Bailey, and Johnson, 1986; Hansen and Messier, 1986] have addressed the relationship between audit judgment and expert systems. Some prototype expert systems have been built to demonstrate the feasibility of applying expert systems to auditing [Dungan and Chandler, 1985], and some accounting firms have begun to develop auditing expert systems [Willingham and Wright 1985].

More recently, academics [Michaelsen, 1982, 1984, 1987, and 1988] and Michaelsen and Messier, 1987, as well as international accounting firms such as Coopers and Lybrand [Shpilberg, Graham, and Schatz, 1986] have applied expert systems to the taxation area. Much of this attention has centered on developing tax-based expert system prototypes based on observed empirical relationships or modeling the tax law [Brown and Streit, 1988]. Not as much research has been done on the feasibility, appropriateness, and potential problems of applying ES to taxation. Michaelsen and Messier [1987, p. 19] point out that "it will be necessary to conduct more basic research on the tax professional's judgement process," and "an examination of the task characteristics of the judgment process in taxation and a better understanding of the tax professional's expertise" will be required in the future. In commenting on the failure of a personal financial planning expert system, McDermott [1986] noted that the failure was largely due to a lack of theory in the particular task domain. These three comments are indicative of the need for increased academic awareness of the benefits and limitations of working in the tax based ES area as well as the importance of examining the fundamental building blocks of taxation.

Most of the early expert systems (e.g., MYCIN) were based on the collection of a large number of rules that tried to capture empirical associations in their domain. A limitation of the purely empirical approach is that gathering associations can lead to a system that is not all inclusive, may reflect conditions that are not generalizable, may not capture exceptions to the rule, and may not include specific conditions that the experts did not confront in the knowledge acquisition process. Also the empirical approach assumes a relatively stable knowledge base. The tax literature has also followed this historical path. Most of the published research on ES applied to taxation has mapped the law or captured empirical associations.

Recent research in expert systems and artificial intelligence has focused on "back to basics." This approach requires an understanding of the underlying basic building blocks of a domain, as well as the interrelationships between various factors to solve a problem. This approach leads to specification, understanding, and organization of factors, and of their interaction to solve a problem in the context of an intelligent expert system. Undertanding the basic building blocks is also necessary to allow the various members of the system building team to communicate with each other and work more effectively.

This paper addresses the feasibility and appropriateness of applying ES to taxation, discusses potential opportunities and problems in applying ES to the tax area, and identifies research issues that need to be faced in developing tax-based expert systems. Current expert tax systems research is examined to ascertain the extent to which researchers have addressed these issues. It is hoped that by going back to basics, the knowledge engineer and the tax expert will be able to produce a better system.

The next section provides an overview of expert systems applicable to the tax area. The following section identifies issues in applying ES to the tax domain. The resulting research issues are examined, including to what extent previous expert systems tax research has dealt with them. The last section presents certain conclusions. An extensive bibliography in ES in general and tax ES in particular is provided in the References to this paper.

OVERVIEW OF EXPERT SYSTEMS

Before applying first principles to tax-based ES research, establishing common terms is helpful. Expert systems is a branch of artificial intelligence (AI). Essentially, AI is concerned with designing computer systems, that exhibit the characteristics associated with human intelligence. AI includes expert systems, pattern recognition, learning and reasoning, and natural language. Comprehensive AI surveys are included in Barr and Feigenbaum [1981] and Rich [1983].[1]

Expert systems are programs designed to perform tasks normally done by human experts that usually encompass the application of judgment. Accordingly, ES are developed by programming the computer to make decisions using the knowledge and possibly a representation of the decision making processes of the expert.

Because the "classic" definition of an expert system includes the expert's heuristics in the system, a distinction is sometimes made between ES and knowledge-based systems (KBS). KBS are more "basic" expert systems that include knowledge, but not necessarily the complex heuristics of a human expert. For example, knowledge is information that is available in textbooks or the tax law, while heuristics may reflect the added understanding, judgment, or experience of the expert. The former would encompass the black letter of the law while the latter would include working with the law's grey areas, reading between the lines, and applying congressional intent, firm-wide experience, and so on, to a particular fact pattern.

Components of Expert Systems

Structurally, ES have four major components: database, knowledge base, inference engine, and user interface. The database contains the information used by the expert system. The data may be generated by the user, may be part of the system, or may be part of an internal or external database. Taxation-based expert systems may use financial data of an individual or a firm, or the user may supply the information.

The knowledge base is 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 may be based on "facts," prior experience, tax laws, heuristics, and so on.

Knowledge can be acquired for or by the system in a number of ways. Typically current generation knowledge is acquired *for* the ES by a system developer through methods such as interview, questionnaires, observations, or protocol analysis. When the system acquires the knowledge *by* itself, you have machine learning. When the system analyzes data and derives the relationships, this characteristics is present.

Knowledge can be represented in a number of ways. The most frequently used method in tax-based expert systems is the rule-based approach. This may be because some areas of taxation-based knowledge are particularly well-suited to expression in rule form [MacRae, 1985]. Rule-based knowledge representation generally takes the form of "If . . . (condition) Then . . . (consequence/goal)." For example, a taxation-based expert sytem [Michaelsen, 1982, p. 202] uses the rule

If: The client's taxable estate is known

Then: It is definite that the client's death tax before credits is the estate tax calculation using the client's taxable estate.

This example assumes a deterministic relationship between the condition and the consequence. However, in the tax area knowledge frequently is not deterministic. Instead, it is often probabilistic or uncertain. Uncertainty in the tax domain derives from multiple sources. For example, the interpretation of a tax provision may be uncertain or the effective date of a law change may be probabilistic over a range of time during the legislative process.

Because the tax domain includes probabilities or uncertain knowledge, developing a knowledge base is typically more difficult than if the information were deterministic. Although there are multiple methods of representing uncertainty, there is no generally acceped "best" means. In a rule-based system, uncertainty can be represented by using weights on the rules to indicate a numeric level of confidence or probability of occurrence. Unfortunately, there is little empirical work that indicates whether a system's theoretical method of representing uncertainty corresponds to the way experts handle it.

Another method of representing knowledge is with "frames." This approach uses "slots" or "characteristics" to parsimoniously describe an element or object's properties. For example, to characterize a chair, the system developer might include such features as four legs, a seat, a back, wood, and inanimate. However, this methodology has some limitation. For instance, the chair may be made of leather, plastic or metal, or the object under scrutiny may not have a back.

The inference engine provides the means to use the knowledge base to process the database. In a rule-based system, the inference engine normally is either forward or backward chaining (or some combination of both). Forward chaining reasons toward a goal and is generally used when the conditions but not the consequences are known. Backward chaining reasons from the goal to determine if or how the goal can be accomplished and is usually employed when the desired consequences are known, but there are a number of methods for reaching the goal.

In the If-Then statement just cited, a forward chaining inference engine was used to move from the client's taxable federal estate to compute the taxpayer's gross estate tax liability. If the statement computed the taxable estate given the estate tax liability, it would be backward chaining.

The user interface provides the communication between the user and the system. Generally, the interface is intended to be user-friendly, particularly in those situations where data is user-generated. The interface also provides feedback and motivation to the user, as well as allowing for verification of inputs. Generally, the interface includes an explanation facility that typically traces through the rules used in reaching a conclusion. An expert system may provide an educational function by furnishing on-line feedback or information about the logic on which the system is based. This could allow less experienced personnel to solve problems generally requiring seasoned users.

AI Languages and ES Shells

Whether developing, modifying, using, or critiquing an expert system, understanding how the program communicates with the computer is important. Communication is effected in one of three ways: (1) procedural languages, (2) AI languages, or (3) expert system shells.

Procedural languages allow the user to define a sequenced set of operations to solve a specific problem. BASIC, FORTRAN, Pascal and most recently C are among the most frequently used procedural languages.

There are two primary generic AI languages in use, LISP [Whinston and Horn, 1984]and Prolog [Clocksin and Mellish, 1984]. In the United States, LISP is the primary AI programming language, whereas, in Japan, Prolog is used for the Japanese's fifth-generation project [Feigenbaum and McCorduck, 1983].

AI languages differ from procedural languages in two primary ways. First, procedural languages are dependent on the order of the statements, while AI languages generally are not. AI languages' greater flexibility allows development of a knowledge base in response to environmental changes. This is particularly important in taxation where frequent changes in the tax law occur. Second, in contrast to other computer languages that are designed to process variables with numeric values, AI languages are designed to process variables with symbolic values (e.g., words, sentences, or concepts). This is important for taxation-based expert systems because much of the tax law is presented in English language rules, that is, symbolic information. Unfortunately, this also can be a limitation of AI languages. For example, the generic Prolog discussed in Clocksin and Mellish [1984, p. 25] only allows variables to take integer values that range from 0 to 16383. This range is inadequate to perform tax calculations and represent financial information where decimals and larger numbers are frequently encountered.

There are several ways in which AI and procedural language limitations can be overcome. In some cases the expert system designer can use both languages. For example, some versions of LISP and Prolog allow the user to access procedural languages. Also, interfacing with a database may circumvent the numeric range limitation, by allowing computations to be done within the database system.

ES shells are computer software that can simplify the development of an expert system by providing many user-friendly features [Turbin, 1985]. The inference engine is specified and, thus, does not need to be developed. The knowledge base may be easy to specify to the computer. The ES shells also may allow the user to access existing databases such as dBase III, and AI languages. Unfortunately, the same limitations that are inherent in AI languages are also present in the ES shells developed in those languages. In addition, the shells are still computer software and, accordingly, nonprogrammers find it difficult to use the ES shells to develop an expert system.

Purpose of Expert Systems

Expert systems serve three primary purposes: (1) educational, (2) advisory, and (3) replacement mode [O'Leary, 1986]. Often, systems will perform more than one of these function. For example, although Coopers & Lybrand's expert system ExperTAX was designed to advise auditors in computing deferred income tax liability, it also provides and educational function by providing feedback to the auditor on the relationsship between financial and tax accounting.

Expert systems are being used for training. STEAMER [Williams, Hollan, and Stevens, 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. Some of the taxation-based expert system prototypes developed to date contain educational featurnes.

Most expert systems developed are designed to function in an advisory manner. The human experts review the recommendation, as well as the logic behind the decision before the decision is implemented. One method of implementing an advisory expert systems is to use a "smart questionnaire." This format, which allows the system to guide the user, makes it feasible for the inexperienced person to use the system successfully. To date, most of the prototype taxation-based expert systems use an advisory mode and a smart questionnaire format.

A system may be designed to replace the decision maker. Glover, McMillan, and Glover [1984] designed a system that they indicated should be called a "managerial robot" because it was designed to replace the manager. The system scheduled employee's work loads in a decision making environment with weekly fluctuations. Systems designed to replace the decision maker also may be used in an advisory manner. This is probably the layman's biggest fear about ES, but probably the most rare application of the three.

Advantages of Tax-Based Expert Systems

There are several potential advantages to tax-based expert systems. Tax knowledge and expertise is often a scarce resource. An expert system representing that knowledge can be used to make the tax experts' resources more widely available. The use of the same knowledge base also can lead to consistent decisions throughout a firm. Thus, an organization using ES could increase uniformity in its position on a given issue. In these litigious times, this may be quite beneficial. Inexperienced staff might use the educational mode of the system to become more proficient and arrive at expert decisions. Experienced staff could sharpen their skills and develop better solutions. A still unexplored area is the cost/benefit tradeoff of a tax-based expert system.

Limitations of Expert Systems

There are a number of limitations of "current generation" tax-based expert systems which may be unique relative to applying ES to other disciplines. Tax applications often require the manipulation of both numeric and symbolic information. Since some existing AI languages and ES shells have inherent problems in processing numeric information, and other computer languages are not as efficient at processing symbolic information, a language or shell that can handle both types of information may be required.

Knowledge bases of tax expert systems are subject to substantial periodic revision. Some of these changes may be minor while others may require wholesale revision. For example, ExperTAX [Shpilberg and Graham, 1986, p. 24] had no provision for using LIFO inventory in accounting for long-term contracts. When a recent court case held that LIFO was permissible, a minor knowledge base change was required. The Tax Reform Act of 1986 enacted a corporate alternative minimum tax. Its impact on deferred income tax accounting involved major changes in ExperTAX's knowledge base. Similarly, Financial Accounting Standard #96 required substantial efforts to update the knowledge base, as did the uniform capitalization rules of IRC Section 263A.

In general, expert systems work best with small, isolated problems that need to be solved often. This is because such problems can be solved independently of related problems, and because large or integrated problems require proportionally greater programming effort and computer resources than smaller problems. An income tax problem is often not decomposable from operational business and personal decisions as well as other tax system factors. This is a potential problem in applying current generation ES to the tax domain. However, if the various isolated ES programs were linked into a more integrated system, this limitation could be overcome.

ES are best developed when the knowledge base can be elicited easily. In the tax area, the knowledge base may be difficult to elicit. If the knowledge is based on clear-cut rules from the law, only limited human expert consultation may be required [e.g., Schlobohm, 1984, 1985]. For example, when court determined outcomes are used there may be substantial difficulty in constructing a knowledge base. This is because an expert may have difficulty in determining and communicating the knowledge, heuristics, or probability factors involved.

ISSUE IDENTIFICATION

This paper identifies the basic building blocks necessary for using expert systems in tax decision-making problems. The italicized words are key factors that will be examined. Throughout, it is assumed that there is a computer-based system to assist in or perform the process of finding a solution to a stated problem. The problem solving process involves a *taxpayer* who encounters a *tax event* that results in a *tax-based problem* to solve and a tax expert to solve that problem. That tax expert has a *knowledge base* about tax law and *reasons* through that knowledge in an effort to solve tax problems. If the expert (or the taxpayer) uses a computer system for assistance, then there is a *user interface* between the person and the system.

The *taxpayer* is an artifact of the tax law. How an entity is defined (e.g., individual or corporation, taxable or tax-exempt) is a function of the law. A *tax event* also is specially defined in the tax law. Tax events are not necessarily the same as accounting or economic events. Thus, if the fair market value of an asset increases, but is not sold, an economic event but not a tax event has occurred. Similarly, if a personal-use assets is sold for a loss, an accounting but not a tax event has occurred.

The *tax-based problem* is a function of the tax event and can be characterized as either a *compliance problem* or a *planning problem*. That problem may be an independent tax problem or a tax problem embedded in a larger business problem. For example, a model of the Internal Revenue Code [IRC] Section 318 stock attribution rules is readily separated from the rest of Subchapter C, while modeling corporate tax-free and taxable reorganizations involves the interaction of multiple Code section, as well as state corporate law and financial accounting considerations.

The *knowledge base* is provided, in a large part, by the tax law. The relevant tax law is based on the particular legal system (Federal income or estate tax law), and is derived from multiple sources (statutory or case law) and interpretations (Treasury regulations and rulings).

The ES knowledge base is searched by an *inference* or *reasoning process*. Unfortunately, reasoning through a tax knowledge base requires *interpretation of complexities* in the tax law deriving from ambiguous terms, as well as syntactical and conceptual complexity. The search for a solution must interpret the law in light of the *legal system and its goals*, and must take into account the goals of the taxpayer. The *goals of the taxpayer* may include financial accounting factors and political sensitivity factors, as well as other business and personal considerations. Since tax problems employ a knowledge base promulgated by the legal system, *legal reasoning* is a part of the way tax problems are solved.

The *user interface* is critical. The existence of different users (experts and nonexperts) suggests that no one user interface or explanation facility would be appropriate for all applications.

DISCUSSION OF BUILDING BLOCKS

Developing a Taxpayer Model

An initial issue in almost any tax problem is; "Who is the taxpayer?" The answer helps delineate the applicable portion of the tax law. The term "taxpayer" can include domestic or foreign corporations, resident and nonresident individuals, partnerships, complex or simple trusts, estates, and taxable and nontaxable entities. Within each of these models, there are subcategories. For example, a domestic corporation may be a member of a consolidated group, a personal services corporation (PSC), or an S Corporation. There are even subcategories within these subcategories. Thus, IRC Section 269A, 441, and 448 each define PSC differently. The tax law applies different rules for each of these groups. In developing an expert system as applied to the tax domain, certain questions must be addressed.

Is there a generic taxpayer model that can be developed? How do the models of taxpayers differ? What are those fundamental differences? Can expert systems be built that take into account the varied tax treatments of different taxpayers?

The academic literature was examined relative to the taxpayer identification issue. Michaelsen and Messier [1987], note a number of knowledge based systems have been developed for different taxpayers. For example, Taxman I and II [McCarty, 1977, 1980] were models of corporations, and TAXADVISOR [Michaelsen, 1984] was a model used for individuals. Others have been more focused in scope, but have dealt with different taxpayers. For example, a system developed for the application of IRC Section 318 models the constructive ownership of partnerships, corporations, trusts and estates, as well as individual shareholders [Schlobohm, 1985].

Identifying the Tax Event

Different tax events or characteristics can lead to different tax consequences and the system must be able to identify these differences. Thus, ordinary versus capital loss status is crucial for proper analysis of a tax problem. This characteristic must be combined with taxpayer identification, to determine the proper treatment. An event may give rise to a realized but not a recognized gain or loss. Like kind exchanges, tax free reorganizations, wash sales rules, and so forth, would fall in this category. Consumer interest expense is nondeductible (subject to a phase out) while business or residential interest may be fully deductible. A taxpayer's degree of involvement in an activity can be crucial to an expense or loss treatment (IRC Section 469).

The ES developer must identify what the different types of tax events are and how such events can be characterized. If a database uses financial or economic information, discriminating between a tax event and an economic or accounting event is crucial.

Michaelson and Messier [1987] note that there have been systems developed for a number of different applications. For example, INVESTOR [Michaelsen, 1987] assists in the selection of an appropriate tax shelter, while ExperTAX supports the tax accrual process. Gardner [1984] provides a preliminary structure to a legal event by characterizing an abstraction hierarchy of events. Most of those implicitly identify a taxable event, to some extent.

Identifying the Appropriate Legal System

Another fundamental aspect of the tax domain is the existence of various legal and tax systems that interact. The decision maker must consider the federal income tax law as well as state and local income and property tax rules. Thus, estate and gift tax rules may interface with income tax rule, while local property law significantly impacts estate and gift tax rules. Even broader than the federal tax law are international tax considerations, where treaties between various countries affect the tax consequences.

In developing a tax-based ES, the tax and ES experts must identify what the different models of legal systems that need to be considered are and how the structures of these models differ. They must also consider what issues can be easily isolated and how the models interact.

The systems developed to date focus on the Federal income tax system. The interactions with other legal systems has received little attention. This is probably true because current generation ES systsems work best on small, isolated problems.

Type of Problem to be Solved

There are generally two categories of problem solving: (1) compliance or (2) planning. A framework for understanding the difference between a compliance and planning problem is modelled and discussed in Karlinsky and O'Leary [1988]. Planning is the set of activities related to structuring an event in order to attain tax goal(s). It generally involves an ex ante analysis. Potentially, this involves the development of a complete planning decision tree. Planning answers a question such as: "How do I minimize my tax liability?" As a result, planning-based problems generally search for the conditions that lead to a particular consequence.

Compliance is the set of activities related to preparing a return or complying with a provision of the law. Compliance generally involves an ex-post analysis. In constrast with planning, compliance involves a scaled down version of the decision tree since many of the branches are unnecessary when you already know the taxpayer, and so on. Compliance answers questions such as: "Given the following ownership, what is my constructive stock ownership?"

This brings up questions such as: To what extent does the nature of the tax problem (compliance vs. planning) affect the nature of knowledge acquisition and use? Does the smaller search tree imply that compliance systems are relatively easier to develop and implement? To date, there has been little effort devoted to ascertaining the difference between the requirements for a planning system as opposed to a compliance system.

Identifying a Problem's Degree of Independence

Tax problems can occur as independent subproblems that are fairly autonomous from other factors, as highly interdependent problems embedded in other business decisions, or somewhere in between. The dependence factor primarily arises in three ways.

First, multiple taxpayer entities may be involved. For example, a corporation may distribute property to its shareholders in a partial liquidation. Depending on whether the shareholder is a corporation or individual, the tax consequences would vary greatly.

Second, there may be multiple factors to be considered in solving the problem. For example, tax factors are only a part of the overall decision of whether to lease or buy an asset. Issues such as financial statement implication, return on investment criteria, bond covenant restriction, regular accounting considerations and other management concerns must also be considered. Thus, this tax problem is very interdependent.

Third, there may be the need to employ multiple experts. Thus, an extraordinary dividend rule problem (IRC. Sec. 1059) may require only one tax specialist, but planning a viable 'mirror' transaction require several experts (consolidation, Sub C., and so forth). Alternatively, corporate tax problems may involve foreign questions, or state and local considerations that require additional experts.

Important questions that need to be addressed include: Can the problem being analyzed be isolated from other problems? How is it best to isolate a problem so that it is doable and still usable? How can decomposed yet related problems be recoupled? What are the costs of recoupling them? Also, how does the degree of independence of the problem affect the ease of system development?

Most prototypes developed to date have dealt with problems that are largely independent. The major exception is ExperTAX [Shpilberg, 1986 and Shpilberg and Graham, 1986]. Although the current technology suggests focusing on small, independent problems, if the focus is too narrow, the system is in danger of losing value or utility by neglecting interaction with reality.

Source and Interpretation of The Law

Each legal system has various sources and interpretations that must be considered by tax experts. Thus, expert systems need to reflect those alternative interpretations. The importance of the source and interpretation is compounded in those situations where there are interactions between legal systems.

The federal income tax law primarily derives from Congress (statutory law). However, there are times where Congress empowers the Treasury to make law

(statutory regulations). For example, in IRC Section 1502, "the Secretary shall prescribe such regulations as he may deem necessary." Unfortunately, this delegation to Treasury of lawmaking powers has become more frequent (see IRC Sections 385, 337(e), 346, and so on) Further, some rules derive from court decision (judicial law).

In addition, as noted in Kovach [1982], there are a number of sources of alternative interpretations, each with a different "weight of authority." He indicates that many of the interpretive expression in tax fit into the category of "disregardable authority." For example, letter rulings technically apply only to the taxpayer requesting the ruling. However, the fact that "interpretive promulgations may be disregarded by higher authorities does not mean that such promulgations are useless, or even minimally useful" [Kovach, 1982, p. 726]. Instead, these ruling still provide valuable information which should be embedded in the knowledge base.

The developer of an ES must decide how to account for the weight of authority of different, possibly contradictory, interpretations, in the development of tax-based expert systems. Weights on rules in expert systems account for the strength of association, not for the reliability of the knowledge. What role should different interpretations play in tax-based expert systems? How can we build the knowledge of multiple interpretations into an expert system in a workable manner?

The role of different authoritative interpretations has received only preliminary investigation [Michaelsen and Messier, 1987]. If the different interpretations arrive at similar conclusions, the interpretations might be treated with higher reliability. If the different interpretations arrive at dissimilar conclusions, the interpretations would have lower reliability. Unfortunately, reliability is different than the strength of association that weights on rules are designed to capture. The remaining questions have received little attention.

Complexity of the Tax Law

One of the primary tax domain characteristics is that the tax laws are complex and constantly changing. The architects of a tax-based system must be aware of this factor in designing a system. There are a number of characteristics that create complexity. These characteristics require and help define expertise.

Constantly Changing

The tax law is constantly changing and interpretation of the law are constantly being refined and redefined. Thus, for some parts of the law, knowledge must be continually updated. Machine learning in tax expert systems is being investigated by Garrison and Michaelsen [1988] and in auditing systems by Greene, Mesrvy, and Smith [1988] as a means of updating knowledge bases.

The knowledge engineers and tax researchers need to discuss how critical changes in the law are to the specific ES being developed. They must also discuss what cost-benefit tradeoff is involved, what timely methods of knowledge acquisition can be used and how machine learning be used to mitigate the task of updating system knowledge bases.

The importance of the impact of changes in the knowledge base is exemplified in the tax-based expert system Investor [Michaelsen, 1987]. That system, developed prior to the Tax Reform Act of 1986, does not include the IRC Section 469 changes and the resulting impact on decision making. Nor does it reflect the revised alternative maximum tax rule changes.

Inventive means of knowledge acquisition have been developed and used in tax expert systems [e.g., ExperTAX—Shpilberg, Graham, and Schatz, 1986]. However, because there are frequent changes in the tax law and because continuous interpretations are issued, there is a need to develop systems that can update their own knowledge bases. DeJong [1979] developed a system that could read and understand news stories. That approach might be used to develop a system that could update its own knowledge base. Such an approach is being used by Biggs and Selfridge [1986] in a system designed for going concern decisions.

Interrelated Tax Provisions

Another contributor to the tax law's complexity is the fact that some provisions of the law are interrelated with other nonadjacent sections of the law. Sometimes the interactions are implicit rather than explicit. For example, the depreciation recapture provisions of IRC Sections 291, 1245 and 1250 affect almost all sales or exchanges. Thus, the expert must be aware of and search for related provisions. Also, some Treasury regulations may no longer apply because of subsequent revisions to the Code. For example, Treasury Regulation 1.542-2 still reflects pre-1964 law. In addition, case law decisions are not as directly accessible as statutory law. The knowledge base must reflect these related Code and court provisions. This is essential to ensure that factors are not ignored in the development of the systems.

To develop a viable tax-based expert system, the experts must determine how the system can take into account provisions of the law that are implicitly or explicitly related to other provisions. They must also determine how the interrelations between the provisions can be found, in order that these relationships are not ignored, and how the systems engineer can best work with the expert to reflect the interrelated provisions.

The need to take into account interrelated provisions suggests that models of tax knowledge will require substantial validation efforts to ensure that all the appropriate knowledge is in the knowledge base. Accordingly, developing validation tests of completeness may be even more critical in tax than in other areas of AI.

Imprecise Language

Another factor in tax law complexity is that some portions of the tax law are incomplete, while other portions are vague and very general. For example, Section 385 may be viewed as incomplete since Congress and Treasury have not defined debt versus equity for over 20 years, and it has been left to the courts to decide the issue. Also, the law will use terms like intent, trade or business or E. & P. which are vague, general or ill-defined. Thus, the expert is required to interpret the imprecise language and try to eliminate the vagueness. Often this requires that the law be interpreted in light of the intent of Congress and its underlying goals. This is confounded by the fact that there are conflicting goals of taxation and that various interests must be met in the development of the law [Bellord, 1980].

The researchers must identify what reasoning processes can be used to mitigate missing portions and vagueness of the law and how the expert accounts for conflicting goals and interest in taxation. They must also identify what types of knowledge representations can best capture ill-defined concepts such as "arms length," what processes experts use to characterize such concepts, and how we acquire knowledge of the existence of such terms.

It is likely that experts employ heuristics or make assumptions to fill the gap of missing or vague law. However, there is little research that indicates the generic structure of the assumptions or heuristics.

Ill-defined concepts such as "arms length" may best be represented as frames. Frames would allow the summarization of a number of characteristics of the concepts as was done in ELOISE [Arthur Andersen, 1985]. Alternatively, Taxman I and II [McCarty, 1977, 1980] used semantic networks to link characteristics of different concepts.

Syntactical and Conceptual Complexity

Some parts of the law are more difficult to understand because of syntactical complexity [Allen, 1980 and Karlinsky and Koch, 1987]. As a result, there may be more than one interpretation of the text [Niblett, 1980]. Also, the conceptual complexity of various portions of the law differs [Karlinsky and Andrews, 1986]. As a result, Bellord [1980] noted that some tax law is at best difficult to understand. For example, IRC Section 341(e) contains the longest and possibly the most complex sentence in the tax law. The aggregation and segregation rules of IRC Section 382 are also very complex.

The researcher must ask: What is the impact of syntactical and semantic complexity on the development of expert systems? How do experts mitigate the impact of these types of complexity? What methodologies can be used to reduce syntactical and conceptual complexity in expert systems and what kinds of knowledge representation schemes can be best used to mitigate complexity?

There has been little research aimed at understanding how to reduce the problems associated with semantic complexity. However, as noted by Allen [1980, p. 75], "syntactic uncertainties within and between sentences are regarded as being the structural problems of legal drafting." Current legal drafting research might be integrated into expert systems.

Tax law complexity is exacerbated by the fact that the same word may take alternative meanings in different provisions of the tax law. For example, the use of "solely" in IRC Section 351(a) has a different meaning than in IRC Section 368(a)(1)(B). Similarly, the definition of "control" for IRC Section 368(c) is different than for IRC Sections 269(a) or 1504(a)(2).

An important issue that the designer of a tax expert system faces is identifying words, like "solely," that have different interpretations in the knowledge base and treating them properly. Is the definition context dependent or is there some other set of cues that indicate which definition should be used? What are efficient forms of knowledge representation for issues of this type? Should frames be used?

There has been little research to investigate these questions. All of these "dimensions of complexity" engender uncertainty and make interpretation of the law difficult. This compleixty issue must be considered when designing, implementing, or critiquing a tax-based expert system.

Goals and Intent of The Legal System

The interpretation of the law, in part, is a function of the goals and intent of the legal system. If the goal is to achieve equity, the law and interpretation of the law is likely to be different than if the goal is to motivate economic behavior. Over time, goals and congressional intent behind the development of particular laws may change. The drifting behavior of policy makers can make it difficult to interpret the law especially when future law changes are being integrated into the knowledge base. Thus, it is critical that the expert system or its developers monitor and understand changes in the environment and make appropriate modifications. A good case in point is today's climate in which much of the tax law and Treasury Regulations are being driven by revenue considerations, rather than by equity or simplicity goals.

The system designer must decide to what extent it is necessary to build the goals of the legal system into the knowledge base, how to incorporate the goals of the legal system into the reasoning of expert systems, and how the system chooses which goals are currently important.

The goals of the legal system apparently have not been directly incorporated into any system. However, it is likely that empirical associations developed for many of the systems (e.g., TAX ADVISOR) implicitly incorporate an assessment of some of those goals. Goals of court-derived decisions have been implemented in Taxman I and II [McCarty, 1977; 1980]. Implicit inclusion may be misleading since the goals might change, while the knowledge base would stay the same.

Taxpayer Goals and Constraints

The problem of solving tax questions is further complicated by the taxpayer's own goals and objectives. Thus, if an estate planning expert system concluded that certain tax planning will save a significant amount of taxes, but the client, for personal reasons, does not want to take that course of action, the system will not provide a satisfactory answer because it failed to consider nontax motives of the taxpayer. Also, other client-based factors such as client aggressiveness, the probability of audit, and impact on earning per share or bond covenants may be necessary inputs in arriving at an optimal solution. Thus, just as the human tax expert would consider these factors, expert systems developed to solve tax problems must consider them.

For example, if an ES is choosing between various investments, there arde two sets of risks to consider: investment risk and tax risk [Seidler and Karlinsky, 1985]. In the first case, the question might be: What are the chances of meeting rate of return goals? In the second case, questions might be: What are the chances of getting capial gains as opposed to ordinary income treatment? What tax rates are going to be in effect in the future? Will I be able to deduct losses currently?

The developer of the tax-based ES must ask: How can taxpayer goals and constraints be represented in the expert system? How do tax experts evaluate the probability of such constraints or the importance of goals, for example, the probability of an audit?

Also, the way tax experts view uncertainty, compared to the way that expert systems use weights to represent uncertainty is as yet an unexplored area. If the two differ, alternative means of representing uncertainty may need to be established for use in tax expert systems. This may be critical in assessing the "probability" of an audit.

Michaelsen's [1987] expert system, INVESTOR, somewhat takes into account riskiness and certain other taxpayer goals and constraints. Taxpayer goals and contraints can be built into tax expert systems to enable the system to help choose which alternative is best.

Legal Reasoning

Analysis of statutory laws requires legal reasoning. Legal reasoning has been a source of investigation by AI researchers [e.g., Kovach, 1982; Gardner, 1985;

Dyer and Flowers, 1985; and Waterman, Paul, and Peterson, 1986]. Those investigations have yielded a number of characteristics of legal reasoning.

Episodic Reasoning

Legal reasoning is based on the ability to index and store information in a manner that allows implementation. Inexperienced and untrained users likely would have difficulty knowing where to find information to answer their questions because they do not know how legal information is organized. Thus, lawyers use conceptual "groups" of information which is called episodic reasoning. For example, the "Good Samaritan" issues [Dyer and Flowers, 1985] refer to situations such as "helpful mechanics" and "helpful doctors" where the individuals perform unrequested, yet necessary, services.

Research in AI has focused on retrieval and organization in conceptual memory [e.g., Kolodner, 1980]. Designers of expert system in the tax domain must address the following questions: What strategies do tax experts use in organizing conceptual memory for tax issues? What conceptual groups are used in taxation and what hierarchical relationships exist between the groups? How can such knowledge be acquired and represented?

Taxman I and II [McCarty, 1977, 1980] used semantic networks to model the way in which a person might categorize knowledge. However, that approach was "hard wired," since the concepts and the relations between the concepts were static. On the other hand, Kolodner [1980] specifies a general memory in tax expert systems, then develops retrieval and search strategies that can be used to build up and access that memory. If we are to have dynamic memory in tax expert systems, retrieval and search strategies for organizing tax knowledge need to be investigated.

Analogical Reasoning

Another logic methodology used in legal reasoning identified by jurisprudence research is analogical reasoning. " The way lawyers think about law, and in effect, interpret and apply the rules of law appears to be very different from the rule based theorem proving systems in AI" [Dyer and Flowers, 1985, p. 57]. Dyer and Flowers note that most law schools teach by the Socratic method of reasoning, which is example base. Lawyers and tax accountants make frequent reference to analogous cases. Sometimes the law itself is enacted based on this analogous reasoning. For example, the treatment of contributing unrealized loss property to a corporation for losses on small business stock (IRC Section 1244 (d)) was substantially adopted in new IRC Section 336 (d)(2).

Recent research in AI [Eliot, 1987] has concentrated on integrating analogical thinking into computer programs. The ES designer must decide how analogical thinking can be integrated into tax expert systems and what types of analogies tax experts use.

Tax-based expert systems currently being developed generally utilize rule-based logic. Unfortunately, one of the primary means of human expression, understanding and learning is using analogical and episodic reasoning. The capabilities of the currently developed tax-based expert systems are limited and thus, their use may be limited. There are systems that make limited use of analogical thinking [Eliot, 1987], but they have not as yet been applied to tax problem solving.

Common Sense Reasoning

Another potential flaw in currently developed prototypes is that common sense reasoning [Waterman, Paul, and Peterson, 1986 and Dyer and Flowers, 1985] is not imbeded in the knowledge base or inference engine. "The vast majority of laws and rulings which cover every day situations are actually very 'natural' . . . in fact for every day non-technical situations, the law is simply an attempt to codify common sense notions of justice and fair play" [Dyer and Flowers, 1985, p. 58]. Unfortunately, because there is such a large base of knowledge underlying common sense and we are too close to it to differentiate it from other knowledge, common sense is difficult to capture in an expert system.

It appears that common sense reasoning permeates legal decision making and tax decision making. How can common sense reasoning be represented in tax expert systems and are there particular types of common sense reasoning involved in tax reasoning? Although most tax practitioners would likely agree that there are certain common ways of viewing the "tax world," there has been little analysis as to what constitutes that tax common sense.

Judicial Law

Another jurisprudence concept that should be applied to ES is how judges make decisions [Gardner, 1985] since some law is derived from their holdings. In order to understand the applications and motivations underlying case law, it is helpful to understand how judges make decisions. This analysis can be made using either a process or an output approach. A process approach might use protocol analysis to help understand the process that the judge uses to make a decision. Unfortunately, there has been little research aimed at understanding the process of tax judicial decisions. An output approach might use discriminant factor analysis to analyze, ex post, the rationale for the decision. An ancillary issue is analyzing Treasury's interpretation of tax laws since often it becomes de facto law.

Unanswered questions the ES engineers will encounter include: How do judges make decisions and when is judicial law created? What is the impact of other court decisions on similar issues on this judge's verdict? Should a process or output approach be taken? The same type of questions need to be asked of the Treasury's tax law interpretation.

In seeking answers, we may need to borrow from the political science literature about the legislative process to understand judges and Treasury behavior. There has been much tax research on the factors associated with judicial decisions, but it has only recently been applied to expert systems [Garrison and Michaelsen, 1988].

Heuristics

Experts use a number of heuristics or "rules of thumb," in decision making. One heuristic that has been analyzed in the legal decision-making literature is referred to as the "indispensable element." "When certain facts from the information at hand suggest the possible applicability of a particular provision, it becomes desirable to attempt to 'short circuit' a full analysis of that provision by finding its indispensable element that is most easily disproved" [Kovach, 1982, p. 718]. For example, individual taxpayers need not concern themselves with IRC Section 243 dividends received deduction or Section 1059 extraordinary dividends, because an indispensable element is that the shareholder must be a corporation. Similarly, a shareholder who is an S Corporation does not get the benefit of IRC Section 243, because the shareholder must be a C Corporation.

Alternatively, in the computer science literature, "one heuristic which determines the relevance of a difference (in facts) is that it results in a differential judgment" [Dyer and Flowers, 1985, p. 57]. This heuristic focuses on the exception, rather than the norm. It also can be used to establish conditions that make a situation different than an alternative scenario. This type of legal reasoning could be used to differentiate a previously decided court case from the present situation.

Remaining questions to be researched are: What heuristics are used by tax experts and how can these heuristics be acquired and represented in expert systems? There has been little research to date, developing generic classes of heuristics used by tax experts.

User Interface

The user interface depends to a large extent on whom the user is. A number of factors are critical to the success of the system, including the level of tax and computer competence of the user. If the system is designed to assist a tax expert by speeding processing capabilities, the level of responses of the system would likely be substantially different than a system designed to assist a staff accountant of a CPA firm. In addition, the explanation facilities of the system

designed for the expert would likely be substantially different because of their deeper understanding of the available support materials, such as case citation. Alternatively, if that tax expert is not a computer expert, then the system would need to provide friendly operations.

The ES developers must ask if the tax users and the tax context have any unique features that require study. It is likely that the nature of the legal reasoning process and the legal materials will create a need for unique explanatory facilities. Other more generic issues that could be studied in a tax context are analyzed by Reneau and Grabski [1987].

There has been virtually no research into the user interface of tax-based decision systems. In fact, the Reneau and Grabski [1987] survey on research in computer and human interface found no research in the interface and use of tax-based systems. Apparently, tax researchers have ignored the impact of the specificity of the tax content on user interfaces in tax decision systems.

CONCLUSION

This paper attempts to make tax experts, tax researchers, and knowledge engineers aware of the benefits and limitations of working in and with taxation based ES. In order to do this, the paper identifies basic building block issues that the various members of the development team must be aware of. Also, one who is critiquing a tax based expert system would need to be aware of these issues.

The issues identified include understanding models of the taxpayer, type of tax event, legal systems and their goals, sources and interpretations of the law, and complexities of the law. It also includes considering taxpayer's goals and constraints, various legal reasoning methodologies and heuristics, whether the tax task is a compliance or planning problem, as well as the degree of independence.

These issues were used to generate future research questions that need additional investigation. An analysis of current ES research was made to examine the extent that these issues were addressed.

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NOTE

1. For the reader who is interested in learning more about expert systems, a number of books have been written on this subject: Hayes-Roth, Waterman, and Lenat [1983], Buchanan and

Shortliffe [1985], Rauch-Hindin [1985, 1986], Holsapple and Whinston [1987], and Silverman [1987]. For a review of accounting, auditing, and management accounting expert systems, the following are suggested: Messier and Hansen [1984], O'Leary [1986, 1987], Borthick [1987], and Borthick and West [1987].

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