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TAX-BASED EXPERT SYSTEMS: A FIRST PRINCIPLES APPROACH

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Expert systems research recently has focused on the importance of theory-based "first principles." The term first principles refers to understanding the structure and function of problem solving. To date, research in tax-based expert systems has focused on developing prototypes of observed empirical relationships or models of the tax law.

This paper focuses on applying first principles to expert systems in taxation based on an expert systems paradigm. Those first principles are used to elicit some of the major research issues faced in developing expert systems in taxation. Research in tax-based expert systems is examined to determine the extent to which some of these issues have been previously addressed.

1. 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 (Meservy, Bailey and Johnson [1986] and Hansen and Messier [1986], for example) 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, some academics (Michaelsen [1982, 1984, and 1987] and Michaelsen and Messier [1987]), as well as international accounting firms like 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 the tax law. Not as much research has been done on the feasibility, appropriateness, and potential problems of applying ES to taxes. Michaelsen and Messier [1987, p. 19] point out that "it will be necessary to conduct more basic research on the tax professional's judgment 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. These two quotes are indicative of the need for first principles that this paper examines. First principles refers to understanding the structure and function of a problem and its solution. It is a theory-based approach.

Our current paper uses an analysis of the "first principles" to address the feasibility and appropriateness of applying ES to taxation, to discuss some potential problems in applying ES to the tax area and to establish research issues that need to be faced in developing tax-based expert systems. Previous expert tax systems research is examined to ascertain the extent to which researchers have examined the first principles. The expert systems paradigm is used to elicit the first principles.

The next section provides an overview of expert systems as they apply to the tax area. The following section presents the artificial intelligence notion of "first principles." Then these concepts are applied to taxation problem solving. Within that section, the resulting research issues in tax-based expert systems are elicited and examined, including to what extent previous expert systems tax research has analyzed these issues. The last section presents some conclusions. An Appendix is provided to give the reader background information and additional resources in the ES area.

2. OVERVIEW OF EXPERT SYSTEMS

Before applying first principles to tax-based ES research, establishing common terms may be helpful. Expert systems is a branch of artificial intelligence (AI). Essentially, artificial AI is concerned with designing intelligent computer systems; that is, systems that exhibit the characteristics associated with human intelligence.

Expert systems are programs that are designed to perform tasks normally done by human experts, which usually encompasses the application of judgment. Accordingly, ES's are developed by programming the computer to make decisions using the knowledge and possibly a representation of the 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's and

knowledge-based system (KBS). KBS's is a more "basic" expert system that would include knowledge, but not necessarily complex heuristics of a human expert. For example, knowledge is information that is available in text books 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 gray areas of the law, reading between the lines, and applying Congressional intent to a fact pattern.

Components of Expert Systems

Structurally, ES's have four major components: database, knowledge base, inference engine and user interface.

Database

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.

Knowledge Base

The knowledge base is the set of knowledge which 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, heuristics, etc.

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 system (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, which are discussed below. 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 tax-based expert system is typically more difficult than if the

information was deterministic. Although there are multiple methods of representing uncertainty, there is no generally accepted "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 a system's theoretical method of representing uncertainty corresponds to the way experts handle it.

Inference Engine

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 conditions that may lead to the goal.

In the If-Then statement cited above, 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.

User Interface

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 coming to a conclusion. An expert system may provide an educational function by furnishing on-line feedback or furnish information about the logic on which the system is based. This could allow more inexperienced personnel to solve problems generally requiring experienced personnel.

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, the firm would have increased 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 learn 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 somewhat unique relative to applying ES to other disciplines. Tax applications require both the need to manipulate numeric and symbolic information. Some existing AI languages and ES shells have some inherent problems in processing numeric information, while other computer languages are not as efficient at processing symbolic information.

Knowledge bases of tax expert systems are likely to be 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, minor changes in the knowledge base 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. Likewise, Financial Accounting Standard #96 required substantial efforts to update the knowledge base.

In general, expert systems work best with small, decomposable problems that need to be solved often. This is because they can be solved independent of unrelated problems, and because large or integrated problems require more than proportional effort and resources than smaller problems. Tax problems are often nondecomposable from business and personal decisions as well as other tax factors.

ES are easier to develop 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 then only limited human expert consultation may be required (e.g., Schlobohm [1984, 1986]). Where court determined outcomes, for example, 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.

3. FIRST PRINCIPLES APPROACH

Most of the early expert systems (e.g., MYCIN) were developed 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 simply 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 or else the relationships gathered may change. 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.

Recent research in expert systems and artificial intelligence has focused on an alternative theory-based or "first principles" approach. This refers to understanding the underlying basic building blocks of a domain, as well as the interrelationship between various factors to solve a problem. As noted by Davis [1983, p. 403], first principles refer to "... an understanding of the structure and function of the devices they are examining." Thus, the first principles approach leads to specification, understanding and organization of factors, and their interaction to solve a problem in the context of an intelligent expert system.

4. FIRST PRINCIPLES APPLIED TO TAXATION

This paper uses the expert system paradigm to elicit the first principles of using expert systems in tax decision making problems. Throughout, it is assumed that there is a computer-based system to assist or perform the process of finding a solution to a stated problem. In our context, that paradigm employs 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 to assist them then there is a *user interface* between the person and the system.

Development of First Principles for Taxation Based Expert Systems

The taxpayer is an artifact of the tax law. How an entity is defined as a taxpayer (for example, individual or corporation) is a function of the law.

What is an event also is an artifact of the tax law. Tax events are not necessarily the same as accounting or economic events.

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 that is 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 sections of Code, as well as considering state corporate law, and financial accounting considerations.

The knowledge is provided, in large part, by the tax law. The relevant tax law is based on the particular legal system (U.S. income or estate tax law), that derive from multiple sources (statutory or case law) and interpretations (Treasury regulations and rulings).

The 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 *goals of the legal system*, and must take into account the goals of the taxpayers. The *goals of the individual taxpayer* may include financial accounting factors, 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* likely is a part of the way tax problems are solved. The interface between the user and the system 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.

Taxpayer

The fundamental question in almost any tax problem is "who is the taxpayer?" The answer defines the appropriate portion of the law. It can include domestic or foreign corporations, resident and non-resident individuals, partnerships, complex or simple trusts, and estates. Within each of these models of a taxpayer, there may be sub-categories. For example, a domestic corporation may be part of a consolidated group, be a personal services corporation (PSC) or an S Corporation. There are even subcategories within these subcategories. For example, IRC Section 269A, 441, and 448 each define a PSC differently. The tax law often applies different rules for each of these groups.

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

Status. As noted in Michaelsen and Messier [1987], a number of knowledge based systems have been developed for different taxpayers. For example, Taxman I and II (McCarty [1977 and 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 Section 318 includes the constructive ownership of partnerships, corporations, trusts and estates, as well as individual shareholders.

Type of Tax Event

This type of tax event can lead to different tax consequences. For example, there is a different tax treatment for ordinary versus capital losses. An event may give rise to a realized but not a recognized gain or loss. Also, consumer interest expense is non-deductible (subject to a phase-out) while business or residential interest expense may be fully deductible.

Research Questions. What are different types of tax events? How can such events be characterized? How does a tax event differ from an accounting or an economic event or a legal event?

Status. Michaelsen 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.

Legal Systems

Another fundamental aspect of the tax domain is the existence of various legal and tax systems, that often interact. Not only is there the federal income tax law, but there are state and local income and property tax laws. Estate and gift tax rules may interface with income tax rules, 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 impact the tax consequences.

Research Questions. What are the different models of legal systems that need to be considered? How do the structures of these models differ? How do the models interact? What issues can be decomposed easily?

Status. Most of the systems developed to date appear to focus on the United States legal system. Accordingly, there is little room to comment on the relationship between different models of legal systems. The other research questions have received little attention.

Problems Being Solved by the System

Compliance vs. Planning

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 enumeration of a complete planning decision tree. Planning answers questions 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 contrast with planning, compliance would involve a pruned version of the planning decision tree. Compliance answers questions such as "Given the following scenario, what is my tax liability?" or "What is my constructive stock ownership?"

Research Questions. To what extent does the nature of the tax problem (compliance vs. planning) impact the nature of knowledge acquisition and use? Does their smaller search tree imply the compliance systems are relatively easier to develop and implement?

Status. There apparently has been little effort devoted to ascertaining the difference between the requirements for a planning system as opposed to a compliance system.

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, there may be multiple taxpayer entities 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 may vary greatly.

Second, there may be multiple factors or considerations in solving the problem. For example, tax factors are only a part of the overall decision of whether to lease or buy an asset. Because there are other issues such as financial statement implications, return on investment criteria, bond covenant restrictions, AMT and regular tax accounting considerations and other management concerns, this tax problem is interdependent.

Third, there may be the need to employ multiple experts. Thus, a problem may require a tax expert on corporate taxation (Subchapter C), but other situations require a consolidations expert. Alternative, corporate tax problems may involve foreign questions or state and local issue that additional experts may be called in to help solve.

Research Questions. Generally, expert systems are developed with greater ease if the problem being analyzed can be decomposed from other problems. This allows specialization of the knowledge base. THe existence of decomposed, yet related problems suggests there is a need to study how such problems can be recoupled, and what are the costs of decoupling the problem. Other development questions include, how does the degree of independence of the problem impact the ease development of the system?

Status. Most prototype systems have dealt with systems that are largely independent, except ExperTAX (Shpilberg [1986] and Shpilberg and Graham [1986]). Although the current technology suggests focusing on small, independent problems, if the focus is too narrow then the system is in danger of losing value or utility by neglecting interaction with other problems.

Source and Interpretation of the Law

Each of the above legal systems has various sources and interpretations that must be considered by tax experts. Thus, expert systems that are developed to solve problems within the context of those legal 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. For example, in Section 1502, "the Secretary shall prescribe such regulations as he may deem necessary .... " Further, some of the rules derive from court cases (judicial law). Often, court decisions relate to the interpretation of specific instances, which sometimes are generalizable.

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

Research Questions. How do we 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 accounts 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.

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

Complexity of the Tax Law

One of the primary characteristics of the tax domain is that the tax laws are complex and constantly changing. The architects of a taxed based expert 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 in the tax domain.

Constantly Changing

Many aspects of the tax law are constantly changing, and interpretations 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 et al. [1988].

Research Questions. How critical are changes in the law? What types of cost-beneficial and timely methods of knowledge acquisition can be used? How can machine learning be used to mitigate the task of updating systems knowledge bases.

Status. 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 based on pre- Tax Reform Act of 1986 law, does not include the major changes made in that legislation, and the resulting impact on decision making.

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 there are frequent interpretations issued, there is a need to develop systems that can update their own knowledge base. 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 Provisions

Some provisions of the law are interrelated with other non-adjacent sections of the law. Sometimes the interactions are implicit rather than explicit. Thus, in practice, 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. This would be necessary to ensure that parts of the law are not ignored in the development of the systems.

Research Questions. How can expert systems take into account provisions of the law that are implicitly or explicitly related to other provisions? How can the interrelations between the provisions be found, so that these rela-tionships are not ignored?

Status. 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 more critical in tax systems.

Incomplete or Vague Rules

Some portions of the tax law are incomplete while, other portions of the law are vague and very general. Thus, the expert is required to interpret the missing

portions of the law 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 conflicting interests that must be met in the development of the law (Bellord [1981]).

Research Questions. What reasoning processes can be used to mitigate missing portions and vagueness of the law? How does the expert account for conflicting goals and interest in taxation?

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

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 (or semantic) 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. See, for example Code Section 341(e), which contains the longest and possibly the most complex sentence in the tax law.

Research Questions. 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 mitigate syntactical and semantic complexity in expert systems. What kinds of knowledge representation schemes can be best used to mitigate complexity.

Status. There has been little research aimed at understanding how to mitigate the difficulties associated with semantic difficulty in expert systems in tax. However, as noted by Allen [1980, p.75], "... syntactic uncertainties within and between sentences are regarded as being the structural problems of legal drafting." Research coming from legal drafting may be integrated into expert systems.

Subjective and Ill-Defined Terms

The tax law has a number of subjective or ill-defined concepts, such as "arms length," "intent," "trade or business," and "earnings and profits." Although an expert may be able to explain and implement these concepts, there may be multiple interpretations or conclusions.

Research Questions. What types of knowledge representations best capture ill-defined concepts such as "arms length?" What processes do experts use to characterize such concepts? How can we acquire knowledge of the existence of such terms?

Status. Ill-defined concepts such as "arms length" may best be repre-sented as a frame. The frame 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.

Alternative Meanings

The same word may take alternative meanings in different provisions in the tax law. For example, Section 351(a)'s use of "solely" has a different meaning than Section 368(a)(1)(B)'s. Similarly, the definition of "control" for Section 368(c) is different than for Section 269(a) or Section 1504(a)(2).

Research Issues. An important question that faces the designer of a tax expert system is are there any words, like "solely," that have different interpretations in the knowledge base? If there are, then how should they be treated? Is the definition context dependent, or is there some other set of cues that indicate which definition should be used? Further, what are efficient forms of knowledge representation for issues of this type? Should frames be used?

Status. There has been little research to investigate these issues. All of these "dimensions of complexity" of the law engender uncertainty and make interpretation of the law difficult. This complexity first principle 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 then the law and interpretation of the law is likely to be different then 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. Thus, it is critical that the expert system can monitor and understand changes in the environment. A good case in point is today's environment in which much of the law and Treasury Regulations are being driven by revenue considerations rather than by equity or simplicity goals.

Research Questions.

How do we incorporate the goals of the legal system into the reasoning of expert systems and how does the system choose which goals are currently important? To what extent is it necessary to build the knowledge of the goals of the legal system into the knowledge base?

Status. 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) incorporate implicitly an assessment of some of those goals. Goals of court derived decisions have been

implemented in Taxman I and II (McCarty [1977 and 1980]). Implicit inclusion can be dangerous since the goals change, but the knowledge base stays the same.

Taxpayer Goals and Constraints

The problem of reasoning about tax question is further compounded in that taxpayers have goals and objectives that must be considered. Thus, if an estate planning expert system concluded that certain tax planning will save significant taxes, but the client, for personal reasons, does not want to take that course of action, the system will not provide at a satisfactory answer because it failed to consider the taxpayer. Also, other client-based factors such as client aggressiveness, the probability of audit, impact on earnings per share 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 these factors.

For example, if an ES is choosing between various investments, there are two sets of risk problems: 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, the questions might be, what are the chances of getting capital 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?

Research Questions. 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, e.g., the probability of an audit constraint?

Another set of research issues deals with the relationship between the way tax experts view uncertainty, compared to the way that expert systems use weights to represent uncertainty. If the two differ then alternative means of representing uncertainty may need to be established for use in tax expert systems. This may be critical in assessing the "profitability" of an audit.

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

Legal Reasoning

Analysis of statutory laws requires legal reasoning. Legal reasoning has been the source of investigation by AI researchers (e.g., Kovach [1982], Gardner [1985] and Dyer and Flowers [1984] and Waterman, Paul and Peterson [1986]). These investigations have yielded a number of characteristics of legal reasoning.

Episodic Memory Organization (Dyer and Flowers [1984])

Legal reasoning is based on the ability to index and store information in a manner that allows implementation. An inexperienced and untrained user 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. For example, the "Good Samaritan" issues (Dyer and Flowers [1984]) refer to situations such as "helpful mechanics" and "helpful doctors" where the individuals perform unrequested, yet necessary services.

Research Questions. Recent research in AI has focused on retrieval and organization in conceptual memory (e.g., Kolodner [1980]). What strategies do tax experts use in organizing conceptual memory for tax issues? What conceptual groups are used in taxation? What hierarchical relationships exist between the groups? How can such knowledge be acquired and represented?

Status. Taxman I and II (McCarty [1977,1980]) used semantic networks to model the way in which a human 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 organization and 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, then retrieval and search strategies for organizing tax knowledge need to be investigated.

Analogical, Case-Based 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 [1984, p. 57]). Dyers and Flowers note that most law schools teach by the Socratic method of reasoning, which is example based. Lawyers 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 Section 1244 purposes was substantially adopted in new Section 336(d)(2).

Research Questions. Recent research in AI (Eliot [1987]), has concentrated on integrating analogical thinking into computer programs. How can analogical thinking be integrated into tax expert systems? What types of analogies do tax experts use?

Status. Tax-based expert systems being developed generally require, rule-based logic. Unfortunately, one of the primary means of human expression, understanding and learning is with analogies. Thus, the capabilities of the current systems is limited and their use may be limited. There are systems that make limited use of analogical thinking (Eliot [1987])--but not as of yet in taxation.

Common Sense Reasoning (Waterman, Paul and Peterson [1986] and Dyer and Flowers [1984])

As noted in Dyer and Flowers [1984, p. 58], "... the vast majority of laws and rulings which cover every day situations are actually very 'natural'." They continue, "in fact for every day non-technical situations, the law is simply an attempt to codify common sense notions of justice and fair play." 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, thus common sense is difficult to capture in expert systems.

Research Questions. It appears that common sense reasoning permeates legal decision making and tax decisions. Thus, are there particular types of common sense reasoning involved in tax reasoning? If it is so common, how can we acquire it for the system? How can common sense reasoning be represented in tax expert systems? To what extent can common sense reasoning be useful in tax based expert systems?

Status. Although most tax practitioners would likely agree that there are certain common ways of viewing the "tax world," there has been little analysis to determine what constitutes that tax common sense.

How Judges Make Decisions (Gardner [1985])

Judicial law derives from judges making decisions. In order to understand the application and motivations underlying case law it is necessary 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 discriminate factor analysis to ex post, analyze the rationale for the decision.

Research Questions. How do judges make decisions? 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?

Status. There apparently has been little research into how judicial tax law is made or how the interpretations that are issued are made. We may need to borrow from the political science literature about the legislative process. There has been much research on the factors associated with judicial tax decisions, but it has only recently been applied to expert systems (Garrison and Michaelsen [1988]).

Heuristics

Experts use a number of heuristics, "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, an individual taxpayer need not concern themselves (unfortunately) with IRC Section 243, dividends received deduction, because an indispensable element is that the shareholder must be a corporation. Likewise, a shareholder who is an S Corporation does not get the benefit of 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 [1984, 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 would be used to differentiate a past decided court case from the present situation.

Research Questions. What heuristics are used by tax experts? How can these heuristics acquired and represented in expert systems?

Status. There has been little research into developing generic classes of heuristics used by tax experts. Most of the heuristics that have been captured are situation specific. In addition, the heuristics likely are embedded in the representations of the knowledge that they are designed to process.

User Interface

The user interface depends to a large extent on who 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, then 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 and use of the system. Many systems are encountering a lack of use simply because they ask the user to "Hit Any Key" and the user sends back the software because the user's system does not have a key named "Any."

Research Questions. There are a number of research questions, but probably the most basic issue that needs resolution is whether or not the tax users and the tax context have any unique needs that require study. It is likely that the nature of the legal reasoning process and the legal materials will necessitate the need for unique explanatory facilities. Other more generic issues that could be studied in a tax context are analyzed by Reneau and Grabski [1987].

Status. There has been virtually no research into the user interfaces of tax-based decision systems. Reneau and Grabski [1987] survey the research in computer and human interface. That survey pointed to no research in the 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.

5. 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 uses a theory based approach.

First principles have begun to find use in artificial intelligence and expert systems by aiding developers in structuring the system. However, there has been little in tax-based expert systems in the way of understanding and structuring the implementation of the underlying theory to those systems. Instead, generally developers have used an empirical approach to eliciting knowledge for the systems.

The application of first principles to the taxation environment includes understanding models of the taxpayer, type of tax events, legal systems and their goals, sources and interpretations of the law and complexities of the law (e.g., conceptual complexity). It also includes taxpayer's goals and constraints, legal reasoning and heuristics, whether the tax task is a compliance or planning problem, as well as the degree of independence.

These first principles were used to generate research questions and analyze the previous research in tax-based expert systems. The analysis of that research indicates that there has been little investigation into most of the research questions generated by the first principles approach discussed in this paper.

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