

The Application Of Expert Systems In Accounting¹

David C. Yang and Miklos A. Vasarhelyi

Abstract

This paper summarizes the current application of expert systems in accounting. A extensive search of the application of expert systems in accounting was performed and results are reported in this paper. The areas of emphasis covered are: (a) Auditing, (b) Taxation, (c) Financial Accounting, (d) Personal Financial Planning, and (e) Management Accounting.

Introduction

Computers have been in existence for some time. Personal computers have emerged in the early eighties and changed substantially the way corporations perform their functions. Large quantity of application software, tools making the computer more useful, have been developed over the years. Different classes that describe application software, such as "Spreadsheets", "Word Processors" and "Data Bases", are now as much a part of our vocabulary as "fax" and "cellular phone" machines. Application software has been traditionally rated as "dumb." This attribute is to be contrasted with software with intelligence, that starts to appear in many places. While this differentiation is sometimes not obvious an entire category of more intelligent pieces of software is appearing. Among these we find often mentioned expert systems and intelligent agents.

Expert systems are software programs, that store knowledge extracted from human experts . Expert systems thus appear to mimic human experts in a particular field or domain such as tax or auditing. Early expert systems focused on expert emulation, attempting to replicate the behavior and decisions of human experts. In contrast to artificial intelligence, ES systems do not try to develop basic postulates and evolve these into intelligent behavior, but accept human knowledge / experience as its basics and attempt to formulate form of aggregate behavior. Most early expert systems captured knowledge in the form of **rules** and used algorithms to put these rules together into a set of decision systems. Most more recent systems are pragmatic in nature and combine rules from experts, to organized diffuse knowledge, and other form of knowledge representation.

We can define an agent *as anyone or anything that acts as a representative for another party, for the express purpose of performing specific acts* that are seen to be beneficial to the represented party. Norman², defines **Intelligent agents** as software entities that carry out some set of operations on behalf of a user or another program with some degree of independence or autonomy, and in doing so, employ some knowledge or representation of the user's goals or desires.

Expert systems are increasingly used in accounting. Intelligent agents are an emerging area still with little observable presence in the accounting area. They will be of great importance to the realization of accounting functions and will expand the current domain of expert systems. Expert systems are not only effective in responding to questions from a wide domain of knowledge and that have more than one answer but also effective in handling repetitive tasks in fuzzy domain of knowledge. The use of expert systems has become an important part of the overall strategy of larger firms and several organizations use expert systems in their attempt to achieve strategic competitive advantage.

¹ The authors gratefully acknowledge the helpful assistance of Susan Iwanaga.

² Norman, "Agents of Change."

Expert systems in accounting were not available until 1977 when McCarthy (McCarthy, 1977) developed the earliest tax application of an expert system called TAXMAN. Since then larger accounting firms have progressively recognized the importance of expert systems as a competitive tool in the accounting profession. During the last fifteen years there have been other applications of expert systems in accounting in the areas of auditing, financial accounting, personal financial planning, and management accounting.

This paper contains a series of tables listing currently available expert systems in accounting. Systems listed are grouped based on their accounting applications. References are provided for each application, including the names of the expert systems, and language(s), if available, used for developing the systems. Reference is also made to articles that mention / discuss / compare the research with other effort.

The purpose of this study is evaluate the status of current research in expert systems as of applied to the different areas in accounting. The reader can also use this paper as a guide to obtaining more direct information on a particular expert system or in a particular area of interest.

The Application Of Expert Systems In Accounting

The tables present lists of expert systems as applied to the different areas of accounting. It gives the reader a visual picture, in tabular form, of what is currently available on the market. The table makes it easier to locate specific application areas or specific expert systems for further studies. This table consists of a variety of accounting expert systems based on the area of their use and is comprehensive to serve as a guide for accountants or consultants in the selection of the most effective system(s) to meet their needs. A detailed reference is available at the end of this paper for the reader who is interested in particular expert systems listed in the table.

The application of expert systems in Accounting can be classified under the following headings: (A) Auditing, (B) Taxation, (C) Financial Accounting, (D) Personal Financial Planning and (E) Management Accounting.

Auditing

Expert systems incorporate the knowledge of single or multiple human experts and are able to help accountants improve the quality of their service in the areas of audit planning, internal control evaluation and identification of audit risk. Going-concern judgments and control in advanced EDP environments are other areas where expert systems may be applied.

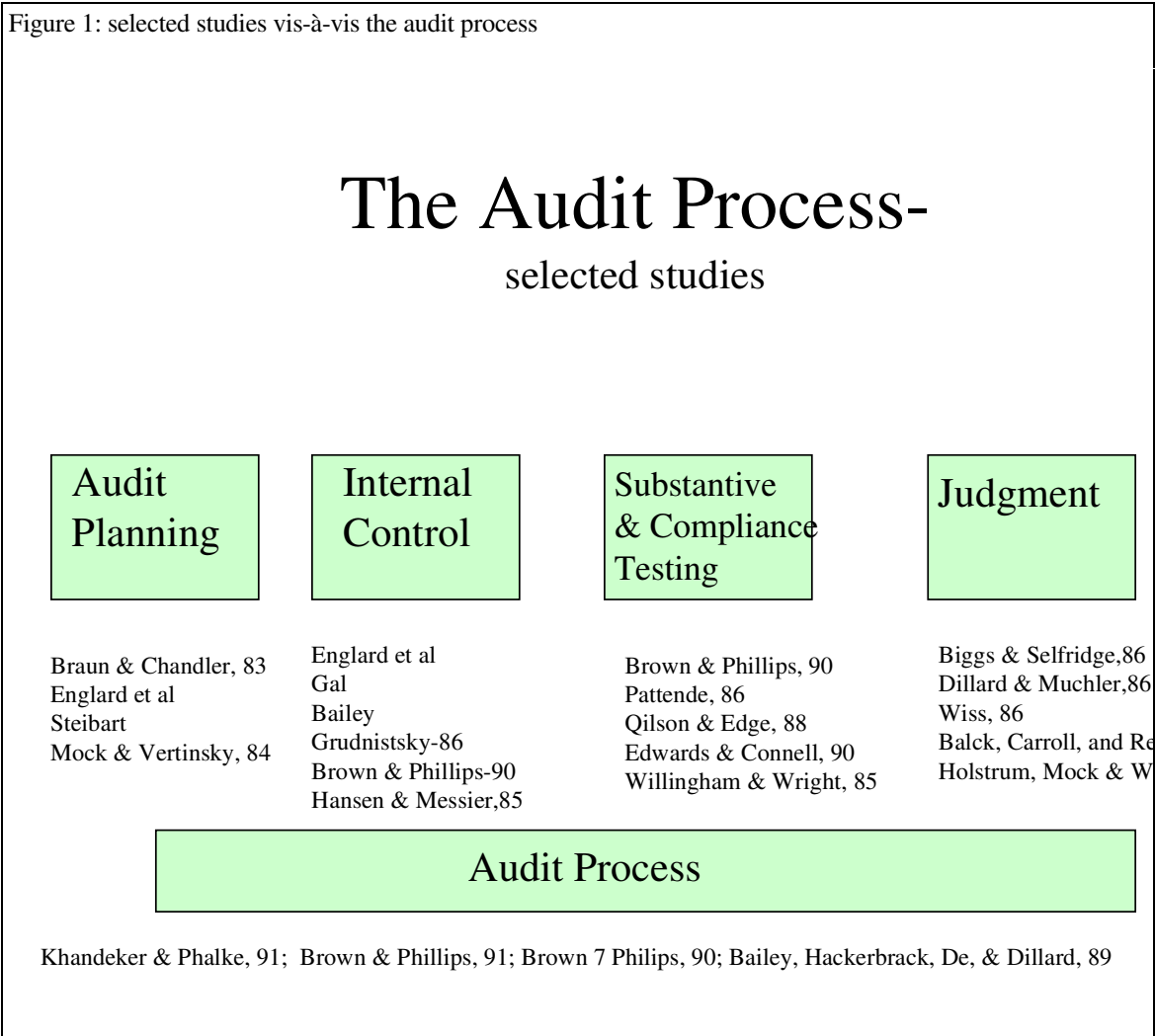
In the field of internal audit, expert systems are used for screening and verifying transactions susceptible to fraud. Airline and auto industries also use expert systems to verify the correct value of transactions prior to execution. In addition, authorization and processing of claims are subjects covered by the expert systems.

The audit knowledge domain has two main forms of systems: (1) supporting the audit process itself such as audit planning, analytical review, internal control evaluation and (2) supporting estimates to be made by corporations and being reviewed by auditors such as bad debt estimation, loan loss estimation or even in the tax area with tax accrual verification.

The progressive development of audit support tools, formalizing parts of the audit process has aimed to decrease the variance of quality among audit practices, and the improvement of the formalization of parts of the audit process. Behavioral research has found substantial difference in decision making between experienced and inexperienced auditors. This lends support to the assumption that audit is a heuristic knowledge rich domain where the extraction / quantification / inter-linkage / and formalization of experience. It is reasonable also to expect that well definable areas where an individual auditor may have had substantive experience over the years offer the greatest potential for success. The process of development and implementation of expert

systems in the large audit firms has been slow and sputtering but even ten years after the first systems were proposed work continues and systems are being developed.

Many of the important studies, serving as the base of evaluation of feasibility of particular approaches were performed in the five years 1985-1990. A symbolic chart placing studies in relation to the step in the audit process is described in Figure 1.



A more comprehensive listing of audit related expert system studies can be seen in Table 1.

Table 1: Auditing

Expert Domain	Reference	System Used	Tool
Evaluation of adequacy of allowance for Bad Debts	Dungan(1983)	Auditor	AL/X
	Wolfe and Viator(1986)		
	Bailey, Hackenbrack, De, and Dillard(1989)		
	Englard, Kiss, McCombs, and Schwartz(1989)		

	Edwards and Connell(1990)		
Allowance for Bad Debts in the Health Care Industry	Braun and Chandler(1983)	name unknown	AL/X
	Bailey, Hackenbrack, , De, and Dillard(1989)		
Analytic Review	Braun and Chandler(1983)	name unknown	
	Bailey, Hackenbrack, , De, and Dillard(1989)		
Materiality Judgments in Audit Planning	Steinbart(1984)	AUDIT PLANNER	EMYCIN
	Wolfe and Viator(1986)		
	Englard, Kiss, McCombs, and Schwartz(1989)		
	Bailey, Hackenbrack, , De, and Dillard(1989)		
	Edwards and Connell(1990)		
Internal Control Evaluation Process in Purchasing / Accounts Payable Cycle	Englard, Kiss, McCombs, and Schwartz(1989)	ARISC	
Audit Planning at Arthur Young	Englard, Kiss, McCombs, and Schwartz(1989)	AY/Decision Support	
Audit Planning at Ernst & Young	Brown and Phillips(1991)	EY/Decision Support	
Audit Planning at Deloitte & Touche	Brown and Phillips(1991)	Audit Planning Advisor	
Identification and Quantification of Audit Risk	Brown and Phillips(1991) Risk Advisor		
	Mock and Vertinsky(1984)	name unknown	
	Bailey, Hackenbrack, , De, and Dillard(1989)		
Choice of Audit Opinion			
Collectibility of Bank Loans	Willingham and Wright(1985)	CFILE	NEXPERT
	Bailey, Hackenbrack, , De, and Dillard(1989)		
	Edwards and Connell (1990)		
Internal Control in the Revenue Cycle	Gal(1985)	INTERNAL CONTROL ANALYZER	EMYCIN
	Bailey, Hackenbrack, , De, and Dillard(1989)		
Reliability of Control in Advanced Environment	Hansen and Messier(1985)	EDP-XPERT	AL/X
	Wolfe and Viator(1986)		
	Englard, Kiss, McCombs, and Schwartz(1989)		
	Edwards and Connell(1990)		
Review of Internal Control Procedures	Bailey(1985)	TICOM	PASCAL
	Wolfe and Viator(1986)		
	Englard, Kiss, McCombs, and Schwartz(1989)		

	Edwards and Connell(1990)		
Going-Concern Judgments Formulation	Biggs and Selfridge(1986)	GC/X	LISP
	Wolfe and Viator(1986)		
	Bailey, Hackenbrack, De, and Dillard(1989)		
	Mutchler(1986)	name unknown	
Checklist of Audit Report	Pattenden(1986)	CheckGaap	C
	Wilson and Edge (1988)		
	Edwards and Connell(1990)		
Internal Control on Sales/Accounts Receivable Transactions	Grudnitski(1986)	ICES	EMYCIN
	Wolfe and Viator(1986)		
	Edwards and Connell(1990)		
Audit Opinion Decisions	Dillard and Mutchler(1986)	AOD	XINFO
	Bailey, Hackenbrack, De, and Dillard(1989)		
Evaluation of Adequacy of Loan Loss Reserves	Weiss(1987)	Loan Probe	
	Black, Carroll, and Rex(1990)		
	Holstrum, Mock, and West(1990)		
	Brown and Phillips(1990)		
	Brown and Phillips(1991)		
Internal Audit System for Planning, Execution, and Automatic Generation of Work Papers and Audit Report			
	Brown and Phillips(1990)	AShell	
	Brown and Phillips(1991)		
Internal Audit Planning	Brown and Phillips(1990)	audit-MASTERPLAN	(AMP)
	Brown and Phillips(1991)		
Internal Quality Evaluation	Khandeker and Phalke(1991)	Audit Quality Expert	VP-EXPERT (AQX)
Fraud Detection and Prevention	Brown and Phillips(1991)	DISCOVERY	
Verification of the Correct Value of a Transaction Prior to Its Execution	Brown and Phillips(1991)	PRA ESCAPE	COBOL
Continuous Process auditing	Vasarhelyi & Halper (1991, 1994)	CPAS	C, C++, UNIX tools
Application Controls in EDP Systems	Brown and Phillips(1991)	Expert Auditor	

Auditing has been the key area of expert systems studies. Recent work has expanded work scope into areas such as taxation, management accounting, personal financial planning and financial accounting.

Taxation

In addition to McCarthy's TAXMAN, there are various expert systems currently used in the tax area. Tax treatment on stocks, investments and dividends are part of the domain of these systems. Guidance for corporate tax accrual and the planning process, value-added tax, tax preparation system, and corporate tax planning for the oil and gas industry are provided by expert systems created to assist those involved in tax. In international taxation there are expert systems available for international tax planning and optimization of international corporation tax position.

In its utilization of expert systems, the IRS has developed thirteen expert systems in taxation (see Hicks, 1990). Some of these systems are used for criminal tax investigation, finding faulty returns and general auditing. Others are used in the areas of collection, taxpayer services and tax return processing. Allocation of income and expenses between multi-national corporations is also another area covered by an expert system in the IRS laboratory. These systems do much of the prescreening and routine work.

The ExperTax effort (Shpilberg & Graham , 1986) illustrates the potential and issues with applications to the tax area. Coopers & Lybrand attempted to automate the process of Tax Accrual Planning. The extensive manual questionnaire was impounded into an expert system that captured the knowledge of many tax experts. While audit staff could apply the questionnaire, the maintenance of the knowledge in the system was delegated to Tax Partners. In this manner the system's tax knowledge was constantly updated and usage could be widespread to many practices and engagements.

Tax knowledge as well as legal knowledge is often fuzzy with logical links between cases and rules obfuscated by contradictory rulings and confusing legal interpretation. Unlike other expert systems, these systems will tend as being fact rich and heuristic poor as fact as plentiful in the tax and legal arena, and expertise often is the understanding and finding of rules as opposed to extensive experiential basis of events like the auditing arena.

An interesting series of events is evolving through personal financial tax packages. Packages such as Intuit's (ChipSoft) TurboTax and managing Your Money have evolved from the simple manipulation of tax forms, and eventually linkages between forms and numbers, to some form of tax advising, a la expert systems. They offer yearly tax rule updates, and the "de luxe" version are CD-based with a multitude of tax advise and tax-management features. Figure 2 shows the linkages of the suite of personal-financial management programs and some of its expert-like features.

Figure 2: Personal Financial Packages and Expert-like Functions

Expert System-like features in Personal Financial Management

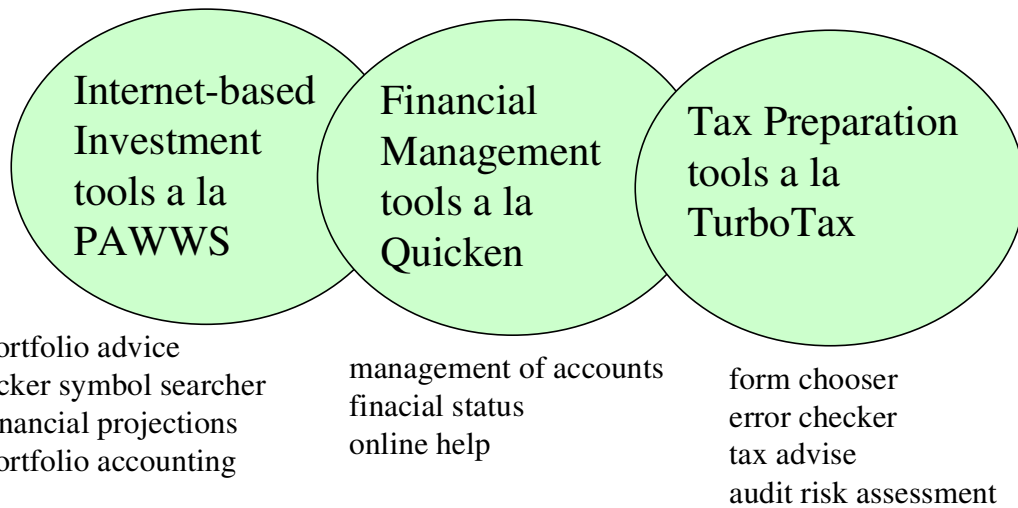


Table 2 describes a series of studies and systems performed since the ground breaking McCarthy study. They deal from specialized tax matters as “estate planing” to generic issues as legal reasoning. The cross-fertilization of fields is obvious in these studies. For example, while the tax accrual planning topic is a tax topic, its utilization is clearly part of the tax process.

Table 2: Taxation

Expert Domain	Reference	System Used	Tool
Rudimentary Legal Reasoning	McCarthy(1977)	TAXMAN	LISP
	Black, Carroll, and Rex(1990)		
	Edwards and Connell(1990)		
Tax Treatment on Stock Redemption	Hellawell(1980)	CORPTAX	BASIC
	Englard, Kiss, McCombs, and Schwartz(1989)		
	Edwards and Connell(1990)		
Estate Tax Planning	Michaelsen(1984)	TAXADVISOR	EMYCIN
	Wolfe and Viator(1986)		

	Englard, Kiss, McCombs, and Schwartz(1989)		
	Bailey, Hackenbrack, De, and Dillard(1989)		
	Black, Carroll, and Rex(1990)		
	Edwards and Connell(1990)		
Tax Shelter Investments for Individuals	Black, Carroll, and Rex(1990)		
	Michaelsen(1984)	INVESTOR	EMYCIN
Avoid Payment of Tax on Dividends	Roycroft and Loucopoulous (1984)	ACCI	ADVISER
	Edwards and Connell(1990)		
	Schlobohm(1985)	TA	PROLOG
Actual or Constructive Ownership of Stock	Edwards and Connell(1990)		
Legality of Loans to Directors	Evens(1986)	DIRECTORS	CRYSTAL TRANSACTIONS
	Edwards and Connell(1990)		
Guidance for Corporate Tax Accrual Planning Process	Shpilberg and Graham(1986)	ExperTax	LISP
	Wolfe and Viator(1986)		
	Englard, Kiss, McCombs, and Schwartz(1989)		
	Black, Carroll, and Rex(1990)		
	Holstrum, Mock, and West(1990)		
	Lyons and Fabiano(1990)		
	Edwards and Connell(1990)		
	Brown and Phillips(1990)		
	Brown and Phillips(1991)		
Tax Rules	Torsun(1986)	PAYE	PROLOG
	Edwards and Connell(1990)		
Selection of Tax Shelters	Michaelson(1987)	INVESTOR	
Value-added Tax	Susskind and Tindall(1988)	VATIA	C
	Edwards and Connell(1990)		
International Tax Planning	Brown(1988)	WORLD TAX PLANNER	
	Black, Carroll, and Rex(1990)		
Income Tax Compliance	Brown(1988)	name unknown	
	Black, Carroll, and Rex(1990)		
Constructive Stock Ownership	Black and Grudnitski(1990)	COTES	VP-EXPERT
		VP-INFO	
	Black, Carroll, and Rex(1990)	TaXpert	database
Optimization of International Corporation Tax Position	Brown and Phillips(1990)	name unknown	
Corporate Tax Planning System for Insurance Industry	Brown & Phillips (1990)		
Corporate Tax Planning	Brown & Phillips (1990)		

System for Oil and Gas Industry			
Finding Faulty Returns	Hicks(1990)	Tax Return Issue	
	Anthes(1991)	Identification Expert System	
Collection and Taxpayer Service and Returns Processing	Hicks(1990)	Reasonable Cause Determination Expert System	
Managing all Computer and Print System Workloads in Service Centers	Hicks(1990)	Automated Workload Management Expert System	
Perfection and Estate Tax	Hicks(1990)		
Classification of Estate Tax Return	Michaelsen (1988)		
Returns Processing, Collections, Taxpayer Assistance, and Auditing	Hicks(1990)	Correspondex	
Criminal Tax Investigation	Hicks(1990)	Link Analysis System	
	Anthes(1991)	Expert System Interface	
Manual Data Generation Process	Hicks(1990)	SAT Automated Data Preparation Expert System	
Information Systems Development	Hicks(1990)	Automated Under-reporter Expert System	
Taxpayer Service and Returns Processing	Hicks(1990)	Taxpayer Service Assistant	
Returns Processing Under S or C Corporate Systems	Jih & Paterson (1992)	Stax	
Performance of Waiver Determinations on Tax Returns	Hicks(1990)	Magnetic Media Waivers Expert System	
Employee Plans and Exempt Organizations	Hicks(1990)	Employee Plan Actuarial Examination Expert System	
Allocation of Income and Expenses Between Multinational Corporations	Hicks(1990)	International Code Sec. 482 Expert System	
Tax Preparation System	Brown and Phillips(1991)	TaxCut	
	McDuffie, Flory & Humphreys(1993)		
Determination of Correct Place to Enter Information on the Return by Identifying the Data Source	Brown and Phillips(1991)	Shoebox	

Financial Accounting

The population of financial accounting expert systems is sparser in the period of study. It strikes the researchers that this field is under-explored and great potential of research exists and has not been fully harvested. Most FASB statements can be positioned as a form of influence diagram, industry effects can be posted as branches or exceptions, other statement idiosyncrasies can be stated in the body of the net, and disclosure decisions can be the conditional variables for guiding financial managers and statement preparers. Early research in accounting has represented financial statements as sets of interconnected equations. Expert systems technology can greatly enrich this axiom and provide the basis for many different types of metaphors.

Table 3 shows that in financial accounting, expert systems are available for cash flow evaluation, analysis of mergers, acquisitions and other investment decisions. Determination of financial status by ratios, leases, and analysis of financial reports filed with the SEC are other areas in financial accounting where expert systems exist.

Table 3: Financial Accounting

Expert Domain	Reference	System Used	Tool
Cash Flow, Project Valuation and Risk Evaluation	Ash(1985)	CASHVALUE	BASIC
	Wilson and Edge (1988)		
	Edwards and Connell(1990)		
Analysis of Mergers, Acquisitions, and Other Business Opportunities	Bernstein(1985)	FINANCIAL ADVISOR	LISP
	Wilson and Edge (1988)		
	Edwards and Connell(1990)		
Determination of Financial Status by Ratios	Wilson and Edge (1988)	FINEX	
Accounting Treatment for Leases by Lessee	Boer and Livnat(1990)	name unknown	VP-EXPERT
	Smith, McDuffie, and Flory(1991)		
Accounting Treatment for Business, Combination	McDuffie(1990)	PURPOOL	VP-EXPERT
	Smith, McDuffie and Flory(1991)		
Analysis of Reports, such as Proxy Statements, Filed with SEC	Sweeney(1989)	ELOISE	
Automatic Selection and Analysis of Corporate Mergers and Acquisitions from an On-line Financial Service	Sweeney(1989)	SCISOR	

Personal Financial Planning

Personal financial Planning systems have evolved to a very sophisticated set of procedures. It allowed for the development of many packages sold independently or as part of a financial advisor's services. While stated separately, as it deserves a section of its own, these packages, mainly of commercial (not research) nature are heavily interconnected with the other types. Actually, they could be considered as part of the first circle in figure 2. Carol Brown's research extensively compares and evaluates these packages.

Due to the constant change in tax laws and regulations, financial planners have developed various types of expert systems to aid in financial planning for individuals. Most of the systems are based on the range of

income of each individual. Some expert systems even give advice on taxation, investment, and estate and retirement planning.

Table 4: Personal Financial Planning

Expert Domain	Reference	System Used	Tool
Providing Financial Planning for Those with Income Over \$60,000	Kempin(1983)	AYCO	
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		
Advice in Taxation, Investment, Estate, and Retirement Planning	Apex(1986)	PLANPOWER	LISP
	Edwards and Connell(1990)		
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		
Providing Financial Planning for Those with Income Between \$25,000 and \$200,000	Mowatt(1987)	CLIENT PROFILING SYSTEM	
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		
Providing Financial Planning for Those with Income over \$50,000	Niswander(1987)	OBJECTIVE FINANCIAL SYSTEM	
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		
Providing Financial Planning for All Taxpayers	Barbee(1987)	PERSONAL FINANCIAL ANALYSIS	
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		
Providing Financial Planning for Those with Income Between \$25,000 and \$500,000	Cann(1987)	PERSONAL FINANCIAL PLANNING SYSTEM	
	Phillips, Brown, and Nielson(1990) (PFPS)		
	Phillips, Brown, and Nielson(1991)		
Providing Financial Planning for All Taxpayers	Whittenburg (1987)	PLANMAN	
	Head(1989)	AAFINPLAN	
	Phillips, Brown, and Nielson(1990)		
	Phillips, Brown, and Nielson(1991)		

	Nielson(1991)		
	McDuffie, Flory, Humphreys (1993)		

Management Accounting

At this time, expert systems are also widely used in the management accounting area. International Business Machines' FAME is an example of such a system. FAME is used to assist customers with mainframe capacity decisions and financial planning for the acquisition of mainframe computers by purchase, conditional purchase or lease. Texas Instruments' capital investment system and Exxon's revenue recognition, transfer pricing, cost flow and accumulation, and evaluation of credit worthiness are other examples of the expert system developed for management accounting purposes. Extensive surveys of applications in management accounting can be found in Brownxxxx and Alan xxxx work. Alan display a series of applications of management accounting in the United Kingdom, proving great international penetration of the filed.

Analysis of variances for cost control, budgeting and future planning, and division evaluation are also part of the application of expert systems in management accounting. Expert systems in the management accounting area cover asset allocation and performance attribution, and also design and development of management information systems.

(e) MANAGEMENT ACCOUNTING

Expert Domain	Reference	System Used	Tool
Financial Planning for the Acquisition of Mainframe Computers by Purchase, Conditional Purchase, or Lease	Brown and Phillips(1990)	FAME	
Preparation of the Investment Decision	Brown and Phillips(1990)	Capital Investment System Reports	
Revenue Integrated Recognition Transfer, Pricing, Cost Flow and Accumulation, and Evaluation of Credit Worthiness	Brown and Phillips(1990)	Capital Reporting and Operations (ICOR)	COBOL
Assistance in Buying, Pricing, Promotion Planning, and Retail Space Allocation	Phillips(1990)	Grocers' Buyer's Workbench	
Analysis of Variances for Cost Control, Budgeting and, Future Planning	Brown & Phillips(1990)	NEXPERT	Arthur D Little's Expert System
Division Evaluation Program	Brown and Phillips(1990)	BUCKS	
Design and Development of Management Information Systems	Englard, Kiss, McCombs, and Schwartz(1989)	name unknown	
Asset Allocation and Performance Attribution	Valentine(1988)	name unknown	

Conclusion

During the past fifteen years, expert systems have made a tremendous contribution to the accounting profession. Because of the high cost of developing such systems, only large accounting firms were actively involved in the development of most expert systems for accounting purposes. Expert systems will continue to

play an increasingly important role in the work of accountants in the future. They can assist less skilled practitioners in handling routine as well as complex tasks; they can easily handle routine screening and categorizing tasks; and they can be used as decision aids by financial analysts, auditors and individual companies. As with personal computers, today's accountants will need to understand the application of expert systems to be able to perform effectively and efficiently in the workplace.

While much research has been performed in the audit field, its deployment in practice has been limited and is still in pre-paradigmatic stage. The applications in tax are very promising and have been deployed for widespread usage by the IRS and in personal tax packages. The applications in financial accounting are very promising but require much research and study. The same is true for management accounting and costs. Finally, personal financial planning packages are here and widely deployed for profit. These show that proper choice of domain and investments can pay off and benefit large portions of the economy.

Another dimension of the phenomenon however makes us much more optimistic. The expert systems paradigm has deeply influenced information systems design and implementation. Features such as the separation of the knowledge engine from the data engine, the why? Help feature, integrated designs of expert systems shells, have seriously influenced information systems design and are progressively appearing in the ubiquitous personal financial management tools. We expect these effects to route back to research and to guide us to an entire new set of paradigms in systems design and implementation.

References

- Anthes, G. H., "IRS Tries Expert System for Fewer Errors", Computerworld, June 3, 1991, p. 33.
- Apex, Technical Overview of PLANPOWER in Applied Expert Systems, Five Cambridge Center, Cambridge, MA 02142, 1986.
- Ash, N., "How Cash Value Appraises Capital Projects", The Accountant, 1985.
- Bailey, A., G. Duke, and J. Gerlach, "TICOM and the Analysis of Internal Controls", Accounting Review, Vol. LX, No. 2, 1985.
- Bailey, A. D., K. Hackenbrack, P. De, and J. Dillard, "Artificial Intelligence, Cognitive Science, and Computational Modeling in Auditing Research: A Research Approach", Artificial Intelligence in Accounting and Auditing, Ed. Miklos Vasarhelyi, New York: Markus Wiener, 1989, p. 4.
- Barbee, G., Executive Director of Personal Financial Services, Price Waterhouse, 51 Sawyer Road, Waltham, MA 02154, 1987.
- Bernstein, A., "Money Experts", Business Computer Systems, 1985.
- Biggs, S. and M. Selfridge, "GC-X: A Prototype Expert System for the Auditor's Going-concern Judgment", Proceedings of the Symposium on Expert Systems and Audit Judgment, University of Southern California, 1986.
- Black, R. L., T. W. Carroll, and S. K. Rex, "Expert Systems a New Tool to Enhance a Tax Practice", The Tax Adviser, Jan. 1990, pp. 3-17.
- Black, R. and G. Grudnitski, "Expert Systems in Complex Tax Environments: An Application for Determining Constructive Stock Ownership Under Subchapter C", Advances in Taxation, 1990.
- Boer, G. and J. Livnat, "Using Expert Systems to Teach Complex Accounting Issues", Issues in Accounting Education, Spring 1990, pp. 108-119.

Braun, H. and J. Chandler, Development of an Expert System to Assist Auditors in the Investigation of Analytic Review Fluctuations, Research Project for Peat Marwick Main & Co., 1983.

Brown, C. E. and M. E. Phillips, "Need an Expert? Ask a Computer" Journal of Accountancy, Nov. 1991, pp. 91-93.

Brown, C. E. and M. E. Phillips, "Expert Systems for Internal Auditing", Internal Auditor, Aug. 1991, pp. 23-27.

Brown, C. E. and M. E. Phillips, "Expert Systems for Management Accountants", Management Accounting, Jan. 1990.

Brown, "Tax Expert Systems in Industry and Accounting", 1 Expert Systems Review for Business and Accounting 9, Sept. 1988.

Cann, Ross S., Chase Lincoln First Bank, MC-5, Rochester, NY 14643, 1987.

Dillard, J. and J. Mutchler, "A Knowledge-Based Expert System for the Auditor's Going Concern Decisions", working paper, The Ohio State University, 1986.

Dungan, C., "A Model of an Audit Judgment in the Form of an Expert System", Ph.D. dissertation, University of Illinois, 1983.

Edwards, A. and N.A.D. Connell, "Expert Systems Research and Development in Accounting", Expert Systems in Accounting, Prentice Hall International(UK) Ltd., p. 55-74.

Englard, B., M. Kiss, G. B. McCombs, and H. Schwartz, "Expert Systems in Accounting", The CPA Journal, April 1989, pp. 58-61.

Evens, M., "Expert Systems in the Accountancy Profession", Proceedings of the London Expert Systems Conference, Mackintosh International, 1986.

Gal, G., "Using Auditor Knowledge to Formulate Data Model Constraints: Expert Systems for Internal Control Evaluation", Ph.D. dissertation, Michigan State University, 1985.

Grudnitski, G., "A Prototype of an Internal Control Expert System for the Sales/Accounts Receivable Application", Proceedings of the Symposium on Expert Systems and Audit Judgment, University of Southern California, 1986.

Hansen, J. V. and W. F. Messier, "Auditing: A Journal of Practice and Theory", A Preliminary investigation of EDP-XPert, Vol. 6, No. 1, 1985.

Head, Wallace, Arthur Anderson & Co., 69 West Washington St., Chicago, IL 60602, 1989.

Hellawell, R. "A Computer Program for Legal Planning and Analysis: Taxation of Stock Redemptions", Columbia Law Review, Vol. 80, No. 7, 1980.

Hicks, S. A., "Computers in Taxation", The Tax Adviser, January 1990, pp. 51-54.

Holstrum, G. L., T. J. Mock, and R. N. West, "Information Systems in the 1990s", Internal Auditor, Feb. 1990, pp. 32-37.

Jih, W. and S. Paterson, "An Expert Prototype That Determines Corporate Tax Status and Liabilities", Financial & Accounting Systems, Winter 1992, pp. 15-19.

Kempin, Linda, The Ayco Corporation, One Wall Street, Albany, NY 12205, 1983.

Khandeker, J. G. and A. A. Phalke, "Evaluating Audit Quality with Expert Systems", Internal Auditor, Oct. 1991.

Lyons, P. and A. Fabiano, "Using Expert System Technology to Foster Innovation", Review of Business, Fall 1990, pp. 33-37.

McCarthy, L. T., "Reflections on TAXMAN: An Experiment in Artificial Intelligence and Legal Reasoning", 90 Harvard Law Review 837, March 1977.

McDuffie, S., "Construction and Validation of an Expert System Prototype to Determine the Accounting Treatment for Business Combinations", Vol. 67, Issue 3, Massachusetts CPA Review, Summer 1993, pp. 11-13.

McDuffie, S., S. M. Flory, N. J. Humphreys, "Using Expert Systems to Expand Your Accounting Practice", Massachusetts CPA Review, Louisiana Tech University, 1990.

Michaelsen, R. H., "An Expert System for Federal Tax Planning", 1 Expert Systems 149, Oct. 1984.

Michaelsen, R. H., "An Expert System for Selecting Tax Shelters", 9 The Journal of the American Taxation Association 35, Fall 1987.

Michaelsen, R. H., "Development of an Expert Computer System to Assist in the Classification of Estate Tax Returns", Accounting Horizons, Dec. 1988, pp. 63-70.

Mock, T. and I. Vertinsky, "DSS-RAA: Design Highlights", Summary paper presented at the Symposium on Decision Support Systems for Auditing, Sponsored by the University of Southern California and the Deloitte, Haskins & Sells Foundation, 1984. Mowatt, Tyrone, APEX, Applied Expert Systems, Five Cambridge Center, Cambridge, MA 02142, 1987.

Niswander, Bruce, Objective Financial Systems, 245 West Cooke Rd., Columbus, OH, 43214, 1987.

Pattenden, N. quoted in Expert Systems User, June 1986.

Phillips, M. E., C. E. Brown, and N. L. Nielson, "Personal Financial Planning with Expert Systems", Management Accounting, Sept. 1990, pp. 29-33.

Phillips, M. E., C. E. Brown, and N. L. Nielson, "Expert Systems to Provide Financial Planning Benefits", Benefits Quarterly, First Quarter 1991, pp. 41-50.

Roycroft, A. E. and P. Loucopoulos, "ACCI: An Expert System for the Apportionment of close companies' income", Proceedings of Fourth Technical Conference of the British Computer Society Specialist Group on Expert Systems, Cambridge University Press, 1984.

Schlobohm, D., "Tax Advisor: A PROLOG Program Analyzing Income Tax Issues", Dr. Dobbs Journal, 1985.

Shpilberg, D. and L. Graham, "Developing ExperTax: An Expert System for Corporate Tax Accrual and Planning", Proceedings of the Symposium on Expert Systems and Audit Judgment, University of Southern California, 1986.

Smith, M. L., S. R. McDuffie, and S. M. Flory, "Here's An Expert System-Based Support Tool for Making Accounting Decisions", The CPA Journal, Oct. 1991, pp. 83-87.

Steinbart, P., "The Construction of an Expert System to Make Materiality Judgments", Ph.D. dissertation, Michigan State University, 1984.

Susskind, R. and C. Tindall, "VATIA: Ernst & Whinney's VAT Expert System", Ernst & Whinney Working Paper, London, 1988.

Sweeney, R. B., "PC: What did We Earn Last Year?", Management Accounting, Oct. 1989, pp. 31-35.

Torsun, I. S., Proceedings of the Sixth Technical Conference of the British Computer Society Specialist Group on Expert Systems, Cambridge University Press, 1986.

Valentine, J. L., "Applying Expert Systems to Investment", Financial Analysts Journal, Nov.-Dec. 1988, pp. 48-53.

Vasarhelyi, M. A. and Sareen, V., Towards Intelligent Agents In Accounting: Background And Potential, working paper, Faculty of Management, Rutgers University, Newark, NJ, September 1996. Paper presented at the Second International Conference of Artificial Intelligence and Expert Systems, University of Huelva, Spain, 1996.

Weiss, "Turning an Art into a Science: Expert Tax Programs", MacWeek (January 31, 1989), at 24, Ribar, "Expert Systems Technology at Peat Marwick Main", 1 Expert Systems Review for Business and Accounting 1 (Sept./Oct. 1987).

Whittenburg, Daniel L., Sterling Wentworth Corporation, 57 West 200 South, Suite 510, Salt Lake City, UT 84101, 1987.

Willingham, J. and W. Wright, "Development of a Knowledge-Based System for Auditing and Collectability of a Commercial Loan", Research Proposal for Peat Marwick Main & Co., 1985.

Wilson, E. and W. Edge, "Knowledge Based Systems and the Future", Australian Accountant, Dec. 1988, pp. 73 and 76.

Wolfe, C. and R. Viator, "Expert Systems: An Accounting Perspective", Journal of Accounting and EDP, Summer 1986, pp. 47-51.

EXPERT SYSTEMS WITH APPLICATIONS, Vol. 3, pp. 99-107, 1991

Ching-Ding (Stephen) Hsu, "An Evolving Conceptual Organization Schema For Database Systems", unpublished working paper, University of Southern California.

William E. McCarthy and Stephen R. Rockwell, "The Integrated Use of First Order Theories, Reconstructive Expertise, and Implementation Heuristics in an Accounting Information Systems Design Tool", unpublished working paper, Michigan State University.

Anthony Wensley, and Efirm J. Boritz, "Validating Expert Systems with Complex Outputs: The Case of Audit Planning", unpublished working paper, University of Waterloo and the University of Toronto, Canada, 1991.

Leslie Richeson Winkler and Therese Grahn Massaad, "A Basic Introduction To Neural Networks For Accountants", Artificial Intelligence in Accounting and Auditing, Volume 2, 1995, pp. 131.

Carol E. Brown, "Expert Systems in Public Accounting: Current Practice and Future Directions", *EXPERT SYSTEMS WITH APPLICATIONS*, Vol. 3, pp. 3-18, 1991.

Miklos A. Vasarhelyi and Fern B. Halper, "The Continuous Audit of Online Systems", *AUDITING: A JOURNAL OF PRACTICE AND THEORY*, Vol. 10, No. 1, pp. 110-125, Spring 1991,

Miklos A. Vasarhelyi, Fern B. Halper and Kazuo J. Ezawa, "The Continuous Process Audit System: A UNIX-Based Auditing Tool", with the permission of the publisher *THE EDP AUDITOR JOURNAL*, Vol. 3, pp. 85-91, 1991.

William F. Messier and James V. Hansen, "Inducing Rules For Expert Systems Development: An Example Using Default and Bankruptcy Data", *MANAGEMENT SCIENCE*, pp. 1403-16, December 1988.

Niles A. Kandelin and Thomas W. Lin, "An Object-Oriented Programming Approach To Credit Decision Making", unpublished working paper, University of Maryland at College Park and University of Southern California, December 1991.

Jesse F. Dillard and Jane F. Mutchler, "Expertise in Assessing Solvency Problems", *EXPERT SYSTEMS: THE INTERNATIONAL JOURNAL OF KNOWLEDGE ENGINEERING*, Vol. 4, No. 3, August 1987.

Marinus A. Bouwman, "Knowledge Elicitation and Representation: An Example From Financial Analysis", unpublished working paper, University of North Carolina at Chapel Hill, January 1992.

Rajendra P. Srivastava, "A General Scheme For Aggregating Evidence in Auditing: Propagation of Beliefs in Networks", unpublished working paper, University of Kansas.

Daniel E. O'Leary, "Issues in Bayes Nets and Influence Diagrams: With Applications in Accounting and Auditing", unpublished working paper, University of Southern California, January 1992.

Saurav K. Dutta, "A Decision Support System For Planning An Efficient Audit", unpublished working paper, Rutgers University.

William E. McCarthy, Stephen R. Rockwell and Eugene Wallingford, "Design, Development and Deployment of Expert Systems Within An Operational Accounting Environment", unpublished working paper, Michigan State University, May 1989.

Jagdish Gangollym, "Some Thoughts on the Engineering of Financial Accounting Standards", unpublished working paper, State University of New York at Albany.

Glen L. Gray, Thomas E. McKee and Theodore J. Mock, "The Future Impact of Expert Systems and Decision Support Systems on Auditing", *ADVANCES IN ACCOUNTING*, Vol. 9, pp. 249-274.

Miklos A. Vasarhelyi and Fern B. Halper, "Auditing: A Day in the Life of Ivan Auditorvich in the Future: A View of Future Technology", unpublished working paper, Rutgers University and AT&T, September 1992.

Antonio Sanchez Tomas, "Expert Systems Applications In Accounting," unpublished working paper, Professor Titular de Escuela Universitaria, Departamento de Contabilidad, Universitat de Valencia.

David C. Yang and Miklos A. Vasarhelyi, "The Application Of Expert Systems In Accounting," unpublished working paper, September 1995.

John J. Cheh, Randy Weinberg, and Ken Yook, "A Framework for Evaluation of Neural Network Investment Systems for Prediction of Takeover Targets," unpublished working paper, September 1995

Susanne O'Callaghan, John Paul Walker and J. Timothy Sale, "Over and Under Reliance on Internal Controls: Neural Networks versus External Auditors," unpublished working paper.

Babro Back, Mikko Irjaja, Kaisa Sere & Hannu Vanharanta, "Competitive Financial Benchmarking Using Self-Organizing Maps," unpublished working paper.

Alan Sangster, "Bank Commercial Risk Assessment Using An Expert System," unpublished working paper, Department of Accountancy, University of Aberdeen.

Amelia A. Baldwin-Morgan, "Expert Systems for Audit Tasks - Applicability and Impacts," unpublished working paper, Associate Professor, Eastern Michigan University, November 1995.

Jesse F. Dillard & Kristi Yuthas, "Expert Judgment And Audit Expert Systems: Toward A Disclosure Ethic," unpublished working paper, October 1995.

Marilyn M. Greenstein & Amelia A. Baldwin-Morgan, "Expert Systems and Audit Process Reengineering Applied to Audit Client Engagement Decisions," unpublished working paper.

Jia-Lin Chen, Dennis McLeod, & Daniel O'Leary, "REA Accounting Database Evolution," an earlier version of this paper was presented at the American Accounting Association National Meeting, New York, 1994.

Michelle McEacharn and Anwi Zebda, "Fuzzy Logic: Treating The Uncertainty In Expert Systems," unpublished working paper.

Thomas E. McKee, "Bankruptcy Prediction Via A Recursive Partitioning Model," unpublished working paper, Chairman and Professor of Department of Accountancy, East Tennessee State University.

Kathleen M. Swigger, Robert Michaelsen and Janet Trewin, "An Intelligent Interface For Tax Data Bases," unpublished working paper, December 1994.

William E. McCarthy and Stephen R. Rockwell, "The Integrated Use of First Order Theories, Reconstructive Expertise, and Implementation Heuristics in an Accounting Information Systems Design Tool", unpublished working paper, Michigan State University.

Anthony Wensley, and Efrim J. Boritz, "Validating Expert Systems with Complex Outputs: The Case of Audit Planning", unpublished working paper, University of Waterloo and the University of Toronto, Canada, 1991.

Leslie Richeson Winkler and Therese Grahn Massaad, "A Basic Introduction To Neural Networks For Accountants", *Artificial Intelligence in Accounting and Auditing*, Volume 2, 1995, pp. 131.

Carol E. Brown, "Expert Systems in Public Accounting: Current Practice and Future Directions", *EXPERT SYSTEMS WITH APPLICATIONS*, Vol. 3, pp. 3-18, 1991.

Miklos A. Vasarhelyi and Fern B. Halper, "The Continuous Audit of Online Systems", *AUDITING: A JOURNAL OF PRACTICE AND THEORY*, Vol. 10, No. 1, pp. 110-125, Spring 1991,

Miklos A. Vasarhelyi, Fern B. Halper and Kazuo J. Ezawa, "The Continuous Process Audit System: A UNIX-Based Auditing Tool", with the permission of the publisher *THE EDP AUDITOR JOURNAL*, Vol. 3, pp. 85-91, 1991.

William F. Messier and James V. Hansen, "Inducing Rules For Expert Systems Development: An Example Using Default and Bankruptcy Data", *MANAGEMENT SCIENCE*, pp. 1403-16, December 1988.

Niles A. Kandelin and Thomas W. Lin, "An Object-Oriented Programming Approach To Credit Decision Making", unpublished working paper, University of Maryland at College Park and University of Southern California, December 1991.

Jesse F. Dillard and Jane F. Mutchler, "Expertise in Assessing Solvency Problems", *EXPERT SYSTEMS: THE INTERNATIONAL JOURNAL OF KNOWLEDGE ENGINEERING*, Vol. 4, No. 3, August 1987.

Marinus A. Bouwman, "Knowledge Elicitation and Representation: An Example From Financial Analysis", unpublished working paper, University of North Carolina at Chapel Hill, January 1992.

Rajendra P. Srivastava, "A General Scheme For Aggregating Evidence in Auditing: Propagation of Beliefs in Networks", unpublished working paper, University of Kansas.

Daniel E. O'Leary, "Issues in Bayes Nets and Influence Diagrams: With Applications in Accounting and Auditing", unpublished working paper, University of Southern California, January 1992.

Saurav K. Dutta, "A Decision Support System For Planning An Efficient Audit", unpublished working paper, Rutgers University.

William E. McCarthy, Stephen R. Rockwell and Eugene Wallingford, "Design, Development and Deployment of Expert Systems Within An Operational Accounting Environment", unpublished working paper, Michigan State University, May 1989.

Jagdish Gangolly, "Some Thoughts on the Engineering of Financial Accounting Standards", unpublished working paper, State University of New York at Albany.

Glen L. Gray, Thomas E. McKee and Theodore J. Mock, "The Future Impact of Expert Systems and Decision Support Systems on Auditing", *ADVANCES IN ACCOUNTING*, Vol. 9, pp. 249-274.

Miklos A. Vasarhelyi and Fern B. Halper, "Auditing: A Day in the Life of Ivan Auditorvich in the Future: A View of Future Technology", unpublished working paper, Rutgers University and AT&T, September 1992.

Antonio Sanchez Tomas, "Expert Systems Applications In Accounting," unpublished working paper, Professor Titular de Escuela Universitaria, Departamento de Contabilidad, Universitat de Valencia.

David C. Yang and Miklos A. Vasarhelyi, "The Application Of Expert Systems In Accounting," unpublished working paper, September 1995.

John J. Cheh, Randy Weinberg, and Ken Yook, "A Framework for Evaluation of Neural Network Investment Systems for Prediction of Takeover Targets," unpublished working paper, September 1995

Susanne O'Callaghan, John Paul Walker and J. Timothy Sale, "Over and Under Reliance on Internal Controls: Neural Networks versus External Auditors," unpublished working paper.

Babro Back, Mikko Irjaja, Kaisa Sere & Hannu Vanharanta, "Competitive Financial Benchmarking Using Self-Organizing Maps," unpublished working paper.

Alan Sangster, "Bank Commercial Risk Assessment Using An Expert System," unpublished working paper, Department of Accountancy, University of Aberdeen.

Amelia A. Baldwin-Morgan, "Expert Systems for Audit Tasks - Applicability and Impacts," unpublished working paper, Associate Professor, Eastern Michigan University, November 1995.

Jesse F. Dillard & Kristi Yuthas, "Expert Judgment And Audit Expert Systems: Toward A Disclosure Ethic," unpublished working paper, October 1995.

Marilyn M. Greenstein & Amelia A. Baldwin-Morgan, "Expert Systems and Audit Process Reengineering Applied to Audit Client Engagement Decisions," unpublished working paper.

Jia-Lin Chen, Dennis McLeod, & Daniel O'Leary, "REA Accounting Database Evolution," an earlier version of this paper was presented at the American Accounting Association National Meeting, New York, 1994.

Michelle McEacharn and Anwi Zebda, "Fuzzy Logic: Treating The Uncertainty In Expert Systems," unpublished working paper.

Thomas E. McKee, "Bankruptcy Prediction Via A Recursive Partitioning Model," unpublished working paper, Chairman and Professor of Department of Accountancy, East Tennessee State University.