THE IMPACT OF EXPERT SYSTEMS ON AUDITING FIRMS

An Investigation Using the Delphi Technique and a Case Study Approach

by

Amelia Annette Baldwin-Morgan

Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of
Doctor of Philosophy in Business Administration with a major
in
Accounting and Information Systems

APPROVED:

James O. Hicks, Jr. chairman

Robert M. Brown

Tarun K. Sen

Dirk S. Baldwin

Roseanne J. Poti

September 17, 1991
Blackburg, Virginia
ABSTRACT

The increasing effort to develop auditing expert systems raises many questions about their impact on public accounting firms. This research examines the status of expert systems in auditing and investigates the possible future impacts of expert systems on auditing firms. The research involved two separate studies.

First, a Delphi study involving auditing and expert-systems experts investigated the likelihood of the proposed future impacts of expert systems on auditing firms. The purpose of the Delphi study was not only to identify the most and least likely impacts, but also to explore the reasons why respondents felt they were the most or least likely. The Delphi panel suggests that expert systems will very likely have an impact on auditing firms in the next decade.

The most likely impact identified was that use of an expert system for an audit task provides documentation references for audit judgements and reasoning. Other specific impacts that were identified as very likely include distribution of expertise, increased ability to handle complex analyses, and improved decision consistency and quality. The panel also indicated that use of expert systems in auditing is very likely to impact the education of auditors.

Second, a case study of an auditing firm using an audit
planning expert system provided evidence concerning the impact of an expert system in use. The case study confirmed that, even today, expert systems may be used to provide documentation references and enhance decision consistency and quality. In the situation studied, the impacts were most evident for the less experienced users.

The primary contribution of the research is to address questions and concerns about the impact of expert systems on the auditing profession. The pool of potential impacts of expert systems that has been discussed in the literature can now be narrowed to focus on the most likely impacts.

This research is the first step in developing a theory of expert systems impacts. It provides (1) the impetus for further research addressing more specific areas of potential expert systems impact and (2) case study evidence about expert systems impacts that are occurring today. Reasons for the most probable impacts of expert systems on auditing in the future are identified.
ACKNOWLEDGEMENTS

The preparation of a dissertation can be a long and lonely endeavor. However, I have been most fortunate. Friends and colleagues have made this process more pleasant, interesting, and insightful than most people imagine. Many have contributed in their own ways to the completion of this project.

First, I would like to thank my dissertation committee for their guidance and support. Jim Hicks provided direction and insight into the possibilities of the topic. Bob Brown dispensed helpful comments and encouragement. Roseanne Poti introduced me to the field of information technology impacts research which sowed the seed for the idea for the dissertation. Tarun Sen got me started on my first major research project. Throughout the progress of this research, Dirk Baldwin, despite the handicap of that surname, generously reviewed and discussed numerous research ideas and manuscripts.

Many thanks are owed to the participants in the Delphi study and case study, whose names and affiliations remain anonymous.

Thanks are also appropriate for the encouragement and assistance of Phyllis, Arnita, and Angie, who have answered my questions and solved my problems continuously for over three years. Others who have provided encouragement are the group of accounting doctoral students at VPI and the folks at Grace Covenant Presbyterian Church.

Much appreciation goes to Mary Frances Harsh, Sharon Burton and Graciela Baldwin for helping me think about things other than this project from time to time.

Many thanks are due to both the Baldwin and Morgan families who have provided encouragement and support through the entire project.
Finally, I want to thank Johnny, my husband, for his love and support.
CONTENTS

Abstract ii
Acknowledgements iv
List of Figures viii
List of Tables ix

Chapter 1 - INTRODUCTION 1

Overview of Results 1
Motivation 2
What is an expert system? 3
Why are expert systems developed and used? 4
When are expert systems appropriate? 7
Who is developing auditing expert systems? 8
Why study the strategic impact of expert systems? 11
Research Question 14
Overview 15

Chapter 2 - LITERATURE REVIEW 16

Information Technology Impacts Literature 16
Decision Support & Expert Systems Impact Literature 19
Organizational Programs 20
Information Processing Framework 21
Case Studies of Expert Systems Impacts 23

Chapter 3 - A PRELIMINARY FRAMEWORK AND PROPOSITIONS 25

The Elemental Proposition 29
The Efficiency Propositions 30
Personnel Productivity 31
Decision Unit Characteristics 34
The Effectiveness Propositions 35
Professional Judgement and Decision Quality 37
Quality Control 38
The Expertise Propositions 39
The Education Propositions 43
The External Propositions 45
Summary 50

Chapter 4 - RESEARCH METHODOLOGY 53

The Delphi Study 54
Accuracy and Reliability in Delphi Studies 56
Delphi Questionnaires 59
The Case Study 60
Auditing Firms 179
The Framework of Propositions and Future Research 180
Contributions and Limitations 187
Bibliography 190
Appendix A - Round One Delphi Questionnaire 202
Appendix B - Delphi Study Rationales 208
Appendix C - Case Study Questionnaire 240
Vita 244
**LIST OF FIGURES**

1-1 Information technology and audit firm strategy 12  
3-1 Major categories of propositions 28  
3-2 The efficiency propositions 32  
3-3 The effectiveness propositions 36  
3-4 The expertise propositions 40  
3-5 The education propositions 44  
3-6 The external propositions 46  
6-1 Task Programs for Audit Approach Planning 159  
6-2 Task Programs for Audit Approach Planning 160  
7-1 Refined Framework of Propositions: Major Categories 181  
7-2 Refined Framework of Propositions: Efficiency 182  
7-3 Refined Framework of Propositions: Effectiveness 183  
7-4 Refined Framework of Propositions: Expertise 184  
7-5 Refined Framework of Propositions: Education 185  
7-6 Refined Framework of Propositions: External 186
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1</td>
<td>Attributes of computerized systems</td>
<td>5</td>
</tr>
<tr>
<td>1-2</td>
<td>Expert systems in auditing</td>
<td>10</td>
</tr>
<tr>
<td>3-1</td>
<td>List of propositions of the preliminary framework</td>
<td>51-52</td>
</tr>
<tr>
<td>4-1</td>
<td>Case study measures</td>
<td>66</td>
</tr>
<tr>
<td>5-1</td>
<td>ANOVA results by profession, round one</td>
<td>78</td>
</tr>
<tr>
<td>5-2</td>
<td>Delphi Statements with significant differences</td>
<td>79</td>
</tr>
<tr>
<td>5-3</td>
<td>Comparison of descriptive statistics for propositions showing significant differences by profession</td>
<td>80</td>
</tr>
<tr>
<td>5-4</td>
<td>Descriptive statistics for round one</td>
<td>84</td>
</tr>
<tr>
<td>5-5</td>
<td>Descriptive statistics by profession for round one</td>
<td>85</td>
</tr>
<tr>
<td>5-6</td>
<td>Descriptive statistics for round two</td>
<td>88</td>
</tr>
<tr>
<td>5-7</td>
<td>Descriptive statistics by profession for round two</td>
<td>89</td>
</tr>
<tr>
<td>5-8</td>
<td>Descriptive statistics for round three</td>
<td>90</td>
</tr>
<tr>
<td>5-9</td>
<td>Descriptive statistics by profession for round 3</td>
<td>91</td>
</tr>
<tr>
<td>5-10</td>
<td>Comparison of consensus measures, standard dev.</td>
<td>92</td>
</tr>
<tr>
<td>5-11</td>
<td>Comparison of consensus measures, range of response</td>
<td>93</td>
</tr>
<tr>
<td>5-12</td>
<td>Comparison of consensus meas., interquartile ranges</td>
<td>94</td>
</tr>
<tr>
<td>5-13</td>
<td>Round three descriptive statistics sorted by mean</td>
<td>98</td>
</tr>
<tr>
<td>5-14</td>
<td>Round three descriptive statistics sorted by standard deviation</td>
<td>99</td>
</tr>
<tr>
<td>5-15</td>
<td>Round three descriptive statistics sorted by range</td>
<td>100</td>
</tr>
<tr>
<td>5-16</td>
<td>Efficiency propositions</td>
<td>108</td>
</tr>
<tr>
<td>5-17</td>
<td>Round 3: Efficiency results</td>
<td>109</td>
</tr>
<tr>
<td>5-18</td>
<td>ANOVA results by profession, round three</td>
<td>111</td>
</tr>
<tr>
<td>5-19</td>
<td>Effectiveness propositions</td>
<td>115</td>
</tr>
<tr>
<td>5-20</td>
<td>Round 3: Effectiveness results</td>
<td>116</td>
</tr>
<tr>
<td>5-21</td>
<td>Expertise propositions</td>
<td>122</td>
</tr>
<tr>
<td>5-22</td>
<td>Round 3 Expertise results</td>
<td>123</td>
</tr>
<tr>
<td>5-23</td>
<td>Education propositions</td>
<td>132</td>
</tr>
<tr>
<td>5-24</td>
<td>Round 3: Education results</td>
<td>133</td>
</tr>
<tr>
<td>5-25</td>
<td>External propositions</td>
<td>139</td>
</tr>
<tr>
<td>5-26</td>
<td>Round 3: External results</td>
<td>140</td>
</tr>
<tr>
<td>6-1</td>
<td>Case study hypotheses and results</td>
<td>152</td>
</tr>
<tr>
<td>6-2</td>
<td>Description of case study questionnaire responses</td>
<td>164</td>
</tr>
<tr>
<td>7-1</td>
<td>Summary of Results</td>
<td>174-176</td>
</tr>
</tbody>
</table>
Chapter 1: INTRODUCTION

The 1980s witnessed an increasing effort to develop expert systems with applications in auditing. This movement is the result of the increasing complexity of the auditing environment, growing specialization within the auditing profession, lower audit fees, and the successful development of expert systems in other professions [Messier & Hansen, 1989]. The application of expert systems technology to auditing becomes increasingly important as public accounting firms face expanding competition that requires audits conducted with increased efficiency without reducing audit effectiveness [Messier, 1986].

Auditors and their firms must prepare for the impact of expert systems on their profession. However, speculation abounds as to the nature and extent of the impact of expert systems. The purpose of this research is to examine the present status of expert systems in auditing and to investigate the potential impacts of expert systems on the auditing profession.

Overview of Results

The research described involves two studies. First, a Delphi investigation was undertaken to determine the most and least likely impacts of expert systems on auditing firms in the next decade. As a result, the Delphi panel suggests
expert systems are very likely to have an impact on auditing firms in the next decade. Specific impacts identified as very likely include documentation references, distribution of expertise, increased ability to handle complex analyses, and improved decision consistency and quality. The panel also indicated that use of expert systems in auditing is very likely to impact the education of auditors.

Second, a case study was performed to determine what impact use of an expert system has on a firm presently using one. As expected, the use of the expert system does have an impact on the firm. However, the impact was smaller than expected. The effect of using the system was moderated by the level of experience of the person completing the task, and the status of the client. The impacts were most evident when the user of the system was a novice at the task, and/or the client was a first-time client.

The rest of this document reveals the motivation behind this research, the related literature, the research methodology, the results, and conclusions.

Motivation

In order to gain an understanding of reasons for the development and use of expert systems for auditing tasks and the motivation for the research, some important questions need to be addressed including: What is an expert system? Why are expert systems developed and used? When are expert
systems appropriate? Who is developing auditing expert systems? Why study the strategic implications of expert systems?

**What is an expert system?**

Many authors have penned their own definitions of an expert system. Some examples illustrate that they are often similar.

An expert system is

- a computer program that embodies the expertise of one or more experts in some domain and applies this knowledge to make useful inferences for the user of the system [Waterman & Hayes-Roth, 1983, p.169].

- a computer system that achieves a high degree of performance in task areas that, for human beings, require training and education, and which is able to explain its conclusions at any time [Savory, 1988, p.234].

- a computer program that uses specialized knowledge about a particular problem area rather than just general knowledge, uses symbolic reasoning rather than only numerical calculations, and performs at a level of competence that is better than nonexpert humans [Iuconi et al., 1986].

The British Computer Society has proposed this detailed definition:

An expert system is regarded as the embodiment within a computer of a knowledge-based component, from an expert skill, in such form that the system can offer intelligent advice or make an intelligent decision about a processing function. A desirable additional characteristic, which many would consider fundamental, is the capability of the system, on demand, to justify its own line of reasoning in a manner directly intelligible to the enquirer [Forsyth, 1984, p.10].

While there are more similarities than dissimilarities
between the many definitions of expert systems found in the literature, the AICPA [1987] definition is used for the purposes of this research endeavor.

Expert systems are computer programs that emulate the thinking processes of human experts to attain a level of performance comparable to those experts in a specific task [p.33].

Why are expert systems developed and used?

Expert systems, unlike traditional information systems, are not limited to the mere automation of a task. The attributes of expert systems, such as focus and application, differ from those of other types of computerized systems, e.g. transaction processing systems, management information systems, and decision support systems [Turban, 1990]. Table 1-1 illustrates some of these different attributes of computerized systems. Expert systems are built for different applications, have different decision capabilities and focus, and are intended to provide a different type of information than decision support systems and management information systems. Expert systems do much more than automate data retrieval, integrate models, or supply the user with general information. Expert systems attempt to mimic the judgments of experts.

Expert systems focus on inferencing and transferring expertise, whereas decision support systems focus on
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Management Information Systems</th>
<th>Decision Support Systems</th>
<th>Expert Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Applications</strong></td>
<td>Production control, sales forecasting, monitoring</td>
<td>Long-range strategic planning, complex integrated problem areas</td>
<td>Diagnoses, strategic planning, internal control planning, maintenance strategies, narrow domain</td>
</tr>
<tr>
<td><strong>Focus</strong></td>
<td>Information</td>
<td>Decisions, flexibility, user-friendliness</td>
<td>Inferencing, transfer of expertise</td>
</tr>
<tr>
<td><strong>Decision Capabilities</strong></td>
<td>Structured routine problems using conventional operations research tools</td>
<td>Semi-structured problems, integrated OR models, blend of judgment and structured support capabilities</td>
<td>The system makes complex decisions, unstructured; use of rules (heuristics)</td>
</tr>
<tr>
<td><strong>Type of Information</strong></td>
<td>Scheduled and demand reports, structured flow, exception reporting</td>
<td>Information to support specific decisions</td>
<td>Advice and explanations</td>
</tr>
<tr>
<td><strong>Highest Organizational Level Served</strong></td>
<td>Middle Management</td>
<td>Top Management</td>
<td>Top management and specialists</td>
</tr>
<tr>
<td><strong>Impetus</strong></td>
<td>Efficiency</td>
<td>Effectiveness</td>
<td>Effectiveness and expediency</td>
</tr>
</tbody>
</table>

Adapted from Turban [1990], Figure 1.5, page 18.
flexibility in supporting decision making. Expert systems provide a different type of information than decision support systems or management information systems. Advice and explanations are provided rather than information to support specific decisions or predefined reports.

Expert systems are developed for two main reasons. First, expert systems are discovery systems. They can be used to explore semi- or ill-structured decision processes. Successful expert systems may provide benefits including

- better understanding of a task process,
- better control,
- more knowledge,
- transportability of knowledge,
- leverage of knowledge.

Second, expert systems can alter competitive forces [Bakos and Treacy, 1986]. Smart management of expert systems development and use can provide a comparative advantage [Sviokla, 1986]. This ability to create advantages in a competitive market illustrates an important link between information technology and corporate strategy.

Firms develop expert systems because they believe such systems will provide a comparative advantage in a competitive market. Expert systems are expected to have strategic implications on effectiveness and efficiency, to help differentiate, and help lower cost [Sviokla, 1986]. Whether any or all of these potential impacts of expert systems will occur for firms using auditing expert systems is uncertain. The goal of this research is to investigate
these strategic implications of expert systems.

When are expert systems appropriate?

The best problem domains for expert systems are those which are small but important, and have human experts, data, and test cases available for development and validation. Expert systems will be successful if (1) the problem area is well bounded and understood, and (2) human experts are available to explain the knowledge needed for the system. In addition, any or all of the following conditions will make the development of an expert system worthwhile [Hu, 1987].

- Shortage of human experts/specialists
- Need to preserve experts' expertise
- High cost of expert advice or wrong decisions
- Critical requirement of expert advice
- Routine, detail-dependent decision making

Many auditing tasks meet several of these conditions. First, wrong audit decisions have particularly high costs. External auditors can reasonably expect their actions to be questioned in a court of law, with the possibility of substantial damage awards [Guy et al., 1990]. Second, the critical requirement of expert advice is highlighted by examining the definition of auditing.

**auditing** a systematic process of objectively obtaining and evaluating evidence regarding assertions about economic actions and events to ascertain the degree of correspondence between those assertions and established criteria and communicating the results to interested users [American Accounting Association Committee on Basic Auditing Concepts,
quoted in Guy et al., 1990].

Third, auditors are expected to assimilate a lot of detailed information. Fourth, the knowledge and critical experience of the expert auditor cannot be replaced easily, even by well-educated college graduates with newly obtained CPA certifications. A good education and a passing grade on the CPA exam does not instantly provide the auditing profession with new experts.

Based on the conditions and characteristics of the auditing environment, the increasing interest in auditing expert systems and the number of auditing systems that are being developed and implemented is not surprising.

Who is developing auditing expert systems?

Auditing expert systems development is taking place in academia and in large public accounting firms. In some cases, the distinction between these two groups grows cloudy. Not only is in-house expert systems development undertaken by public accounting firms, but expert systems related research in academia is being funded by public accounting firms. For example, the KPMG Peat Marwick Foundation [1990], through its Research Opportunities in Auditing program, has funded a number of expert systems projects, including seven which are in progress at this time.

More than a dozen prototype expert systems with
applications to auditing exist. Existing auditing expert systems are listed in Table 1-2. At least two of these expert systems are known to be in use at this time, KPMG Peat Marwick's LoanProbe and Coopers and Lybrand's ExperTax. Coopers and Lybrand has also begun implementing a second expert system, ExempTax, and training is underway for use of a third system, RiskAdvisor. A number of developmental systems are in various stages of formation [Graham et al., 1990; Srivastava & Shenoy, 1990; Boritz et al., 1986; Lewis & Dhar, 1985; Meservy et al., 1986].

The expert systems in Table 1-2 represent a number of auditing applications including audit planning [Srivastava & Shenoy, 1990; Shafer et al., 1988; Kelly et al., 1986], audit risk assessment [Graham et al., 1990], going concern evaluation [Dillard & Mutchler, 1986; Biggs & Selfridge, 1986], internal control evaluation [Grudnitski, 1986; Gal, 1985; Bailey et al., 1985], materiality determination [Steinbart, 1987, 1984], loan loss reserve evaluation [Willingham & Ribar, 1988; Willingham & Wright, 1985], advanced EDP environment control reliability [Hansen & Messier, 1986a, 1986b], and tax accrual [Shpilberg & Graham, 1986; Shpilberg et al., 1986]. As these expert systems are developed and implemented, auditing firms must consider the potential consequences of expert system use.
<table>
<thead>
<tr>
<th>System</th>
<th>Technology</th>
<th>Audit Context</th>
<th>Reference</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOD</td>
<td>XINFO</td>
<td>Going concern</td>
<td>Dillard &amp; Mutchler</td>
<td>1986</td>
</tr>
<tr>
<td>Auditor</td>
<td>AL/X</td>
<td>Bad debt expense</td>
<td>Dungan &amp; Chandler</td>
<td>1983</td>
</tr>
<tr>
<td></td>
<td></td>
<td>same (hospitals)</td>
<td>Dungan &amp; Chandler</td>
<td>1983</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Braun &amp; Chandler</td>
<td>1983</td>
</tr>
<tr>
<td>Auditor's</td>
<td>Apple</td>
<td>Audit planning &amp; evidence aggregation</td>
<td>Srivastava &amp; Shenoy</td>
<td>1988</td>
</tr>
<tr>
<td>Assistant</td>
<td>Macintosh</td>
<td></td>
<td>Shafer, et al.</td>
<td></td>
</tr>
<tr>
<td>AUDIT-PLANNER</td>
<td>EWCIN</td>
<td>Materiality</td>
<td>Steinbart &amp; Shafer</td>
<td>1984</td>
</tr>
<tr>
<td></td>
<td></td>
<td>judgments</td>
<td>Shafer, et al.</td>
<td></td>
</tr>
<tr>
<td>CFILE</td>
<td>NEcPERT</td>
<td>Audit planning</td>
<td>Kelly, et al.</td>
<td>1986</td>
</tr>
<tr>
<td>CHECKGAAP</td>
<td>Browse</td>
<td>compliance</td>
<td>Pattenden</td>
<td></td>
</tr>
<tr>
<td>EDP-</td>
<td>AL/X</td>
<td>Reliability of computer systems</td>
<td>Hansen &amp; Messier</td>
<td>1986</td>
</tr>
<tr>
<td>XPERT</td>
<td></td>
<td></td>
<td>Hansen &amp; Messier</td>
<td></td>
</tr>
<tr>
<td>ExemTax</td>
<td>LISP</td>
<td>Tax considerations of not-for-profits</td>
<td>Shpilberg &amp; Graham</td>
<td>1986</td>
</tr>
<tr>
<td>ExperTax</td>
<td>LISP</td>
<td>Corporate tax</td>
<td>Shpilberg, et al.</td>
<td>1986</td>
</tr>
<tr>
<td>Experttest</td>
<td>LISP, GCLISP</td>
<td>choosing appropriate audit tests</td>
<td>Morris</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>QSHHELL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC-X</td>
<td>LISP, VAX11/780</td>
<td>Going concern</td>
<td>Biggs &amp; Selfridge</td>
<td>1986</td>
</tr>
<tr>
<td></td>
<td></td>
<td>judgments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICES</td>
<td></td>
<td>Internal controls</td>
<td>Grudnitski</td>
<td>1986</td>
</tr>
<tr>
<td>INTERNAL-</td>
<td>EWCIN</td>
<td>Internal controls in revenue cycle</td>
<td>Gal</td>
<td>1985</td>
</tr>
<tr>
<td>CONTROL-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ANALYZER</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LoanProbe</td>
<td></td>
<td>Collectibility of commercial loans</td>
<td>Willingham &amp; Ribar</td>
<td>1988</td>
</tr>
<tr>
<td>Risk Advisor</td>
<td>IBM pc, ART, FFAST</td>
<td>Assessment of audit risk</td>
<td>Willingham &amp; Wright</td>
<td>1985</td>
</tr>
<tr>
<td>TICOM</td>
<td>CDC, Cyber 720</td>
<td>Internal accounting controls</td>
<td>Bailey, et al.</td>
<td>1985</td>
</tr>
</tbody>
</table>
Why study the strategic implications of expert systems?

Information technology and corporate strategy are linked. More specifically, expert systems are expected to have certain strategic implications that contribute to competitive advantage. Firms use various types of information technology because they believe the use of the technology will have strategic implications such as providing a comparative advantage within the industry (competitive strategy) or improving the efficiency and effectiveness of the organization (internal strategy) [Bakos and Treacy, 1986]. These expectations shape the corporate strategy that includes expert systems development.

Think of the link between corporate internal strategy and information technology (in this specific case, expert systems) as a triangle (see Figure 1-1). The development of corporate strategy involves assessing the state of the firm. Assuming the firm is not perfect, the corporate strategy is designed to change the state of the firm, i.e. to improve its strategic position. Information technologies are included in corporate strategy. Specifically, expert systems are developed because they are expected to impact the state of the firm. However, the cycle of corporate strategy is not complete. The impacts of expert systems (the bottom link in the figure) are, for the most part, unknown. These impacts are the focus of the research.
Figure 1-1: Information technology and audit firm strategy
discussed here.

These impacts of expert systems are of concern to members of the accounting profession. As new expert systems are developed and implemented, the impact of new technology on the auditing profession is a major issue for auditors and auditing educators. Professional associations and conferences consider this topic most important [AICPA, 1987]. The AICPA [1985] Future Issues Committee identified artificial intelligence and expert systems as a significant issue with rapidly emerging future implications. Even small and medium-sized firms are aware of the possibility of using expert system technology in the not-too-distant future [Coppage, 1988; McKee, 1988; Bagranoff & Simkin, 1987]. One conference that addressed this issue was the 11th annual Arthur Young Professors' Roundtable, where the theme was "helping the auditor of the year 2000 achieve maximum productivity." Because the auditors of the future may be surrounded by technology, preparing the auditor for technological change and the impact of technology used to support human judgement in auditing were discussed [Gambino, 1988].

Despite the fact that expert systems development appears to be growing rapidly, there are few reported cases and research studies that focus on the effect on organizations of using expert systems [Sviokla, 1989]. Most of the research that focuses on the effects of using any
kind of decision support system has evaluated the impact on the single user only. However, very little research has concerned the effects of expert system use on organizations or their divisions [Benbasat & Nault, 1990].

Abdollomahmadi [1987] reviewed the literature concerning decision support and expert systems in auditing. He provided interesting questions as avenues for future research, including those addressing the impact of expert systems and decision support systems on the organizational structure of accounting firms and the implications of these systems for educational institutions educating the auditors of tomorrow. Amer et al. [1987] suggest that behavioral research tied to accounting and auditing is an important area of potential growth. Because advances in auditing expert systems are expected in the not-too-distant future [Amer et al., 1987], the assessment of long-run effects of using expert systems is an important research question [Gal & Steinbart, 1987]. In response to this need, the next section presents a preliminary framework and propositions for investigating the impact of expert systems on auditing firms.

**Research Question**

Because of the increasing development and use of expert systems in auditing the following research question is of interest:
What impacts will expert systems have on auditing firms?

**Overview**

This dissertation is organized as follows: the following literature review chapter provides a brief overview of the information technology impacts literature and related research and theories, followed by a discussion in chapter three of potential impacts of expert systems on auditing, including identification of the propositions of the preliminary framework. An explanation of the research methodology is found in chapter four. The results of the Delphi study are explained in chapter five, while chapter six sets forth the implications of the case study. Finally, a discussion of the conclusions, contributions and limitations of the research appears in chapter seven.
Chapter 2: Literature Review

The following two chapters survey the literature concerning the impacts of information technology and expert systems. First, the information technology impacts literature is overviewed in this chapter. Additionally, existing theories relating to the impacts of advanced information technology on organizations are examined. Second, the potential impacts of expert systems on auditing firms are described in chapter three. As impacts identified in the literature are discussed, the preliminary framework and propositions are explained. The literature reviewed includes accounting and auditing literature, academic as well as practitioner-oriented journals; and information systems and artificial intelligence literature.

Information Technology Impacts Literature

Information technology implies a broad range of tasks involving the processing of data and information. The rise of computer information systems has provided a rich area of research endeavor. Few researchers doubt that information technology has an impact on organizations. However, the exact nature of the impact is a matter of contention in the literature.
"It is no secret that research on information technology and organizational change has produced conflicting results and few reliable generalizations [Markus and Robey, 1988, p. 596]." For example, consider the centralization versus decentralization of decision making argument. Leavitt and Whisler [1958] linked computerization to increased centralization of decision-making because fewer persons can control authority and decision making through expanded data collection and processing abilities. Conversely, Anshein [1960] and Burlingame [1961] linked computerization with decentralization of decision-making because advanced technology allows information to flow downward so that better decisions can be made further down the organization's hierarchy. Studies and theoretical papers providing some support for either or both sides of the centralization/decentralization debate include Schultz and Whisler [1960], Gallagher [1961], Siegman and Karsh [1962], Wagner [1966], Reif [1968], Delehanty [1967], Rourke and Brooks [1967], Whisler [1970], Klatzky [1970], Stewart [1971], Blau and Schoenherr [1971], Pfeffer and Leblebici [1977], Ein-Dor and Segev [1978], Carter [1984], and Leifer and McDonough [1985].

The conflicting results are not limited to the issue of centralized/decentralized decision making. According to Markus and Robey [1988, pp.585-586],

"...empirical research has generated contradictory
findings on almost every dimension of hypothesized computer impact [Robey, 1977; Kling, 1980; Attewei and Rule, 1984]. Information systems have been found to both enrich and routinize jobs [Kling, 1978; Bjorn-Andersen et al., 1986], both centralize and decentralize authority [Klatzky, 1970; Whisler, 1970; Stewart, 1971; Blau et al., 1976; Carter, 1984; Foster and Flynn, 1984; Dawson and McLaughlin, 1986], and to produce no changes where changes were expected [Robey, 1981; Franz et al., 1986].

The conflicting results in this body of literature suggest two underlying important principles [Baldwin and Baldwin, 1991]:

1. The nature of the causation between information technology and organizations is complex [Markus and Robey, 1988; Majchrzak et al., 1990].

2. Numerous factors affect the impact of information technology on organizations [Cooper & Zmud, 1990; DeSanctis & Courtney, 1983; Keen, 1980; and Sanders, 1985].

In light of the complexity of the information technology/organization relationship, some of the problems with prior information technology research include a lack of consideration for differences in task, industry, environment, and size.

If differences in the purpose of computer use [task] affect the impact of computers on organizations, future studies should examine the impact of particular types of information systems used for similar tasks. Transaction systems and expert systems, for example, may have totally distinct impacts on organizations due to the differences inherent in the type and use of information systems.

Studies of many firms within an information technology
dominated industry will add to the knowledge of information technology impacts important for the tasks that are natural to that industry. Future studies should also consider the role of other moderator variables such as size and environment. Bakos [1987] suggested that controlling or compensating for the effect of contextual variables, such as size, technology and environment, will better isolate the impacts being studied. Bakos also called for the study of organizations that are information technology intensive, including service industries.

This study attempts to control for size, task and industry by investigating the use of a specific type of information technology for similar tasks by large firms in a single industry. One industry that is information technology intensive is public accounting. This study investigates the impact of expert systems used for auditing-related tasks on the auditing divisions of large public accounting firms.

Decision Support & Expert Systems Impact Research

In 1984, Scott-Morton reviewed several hundred articles concerning management support systems. He cited the complete lack of impact research into management support systems. Scott-Morton [1967, 1971] is one of the few who have undertaken an in-depth study of the use of a management support system. He examined the decision processes of a
manufacturing firm before and after the implementation of a management support system. He found that decision processes had changed significantly with the use of the management support system. Specific effects of the system included faster cycle time, more flexibility, and more confidence.

Although the impacts of decision support systems and expert systems have rarely been studied, the subject has been touched upon in survey research. Alter [1980] conducted a survey of users of fifty-six decision support systems. He identified five common benefits of decision support systems.

1. improved personnel efficiency
2. expedited problem solving
3. improved communication
4. more learning and training
5. increased organizational control

Unfortunately, specific effects of the fifty-six systems studied cannot be determined from Alter's study.

Organizational Programs

Often in studies of decision support systems, the focus is on the individual. This focus provides information about decision making but little insight into the effects of the system on the firm [Sviokla, 1986]. Scott-Morton [1967] attempted to link individuals to the firm by using process flow diagrams to examine the behavior of executives before and after system use. This was the first use of organizational programs for identifying how technology
changed the task process.

March and Simon [1958] provide an example of a task program by describing what happens in a fire station when the alarm bell goes off. Generically speaking, a stimulus (e.g. the need to do a task) starts off a complex and organized set of responses, the "program" for that particular task. An expert system, then, is the incarnation of a task program. The use of organizational programs to describe a task process, such as an expert system task, is linked to the concept of information processing.

**Information Processing Framework**

Unfortunately, there are no recognized theories concerning the impact of expert systems on an organization. However, there are useful measures for addressing aspects of the impact of expert systems. One set of useful measures, Galbraith's information processing framework was used by Sviokla [1986] in a related expert systems impact study.

Galbraith [1977, 1973] believed that an organization's information processing capacity is an organizational variable to be managed. The information processing approach to the firm is based on two assumptions [Sviokla, 1986].

1. A given task has a required amount of information. Presumably, if the task can be described (using organizational programs), the information processing requirements of the task can be assessed.
2. Once the information processing needs are identified, the information processing capacity of the firm can be identified, measured, and managed.

The measure of information processing capacity is defined as

the diversity of the outputs, the number of different input resources, and the level of task performance.

Galbraith argued that a firm manages the balance between information processing need and information processing capacity. Tushman [1979] asserts that organizational information processing is more important than organizational structure. Bakos [1987] also identified information processing capacity as an important organizational level process variable in information technology impacts studies. Other studies that have used the information processing framework include Van de Ven et al. [1976], Galbraith [1977], Tushman and Nadler [1978], Daft and MacIntosh [1981], Kmetz [1984], McKenney [1986], and Sviokla [1986].

The lack of a recognized framework to guide research has been a central difficulty in investigating the impact of information technology or expert systems on firms. However, the information processing framework can provide a central starting point for this kind of research [Sviokla, 1986]. This framework will be used to guide the collection of data in the case study discussed in the methodology section.
Case Studies of Expert Systems Impacts

Recent studies of the impact of expert systems in non-accounting environments have been undertaken using an information processing framework. Sviokla [1990, 1989, 1986] conducted case studies of three expert systems in use in three different organizations: 1) an expert system used for mud engineering in an oil-service company, 2) an expert system used for configuring computer systems for a computer manufacturer, and 3) an expert system used by a financial planning firm to provide financial planning services. These studies provide insight into the effects on the organizations of using such systems.

Sviokla [1989] studied the effect of using MUDMAN, an expert system for drilling mud analysis, on NL Baroid, the leading supplier of drilling mud to major oil companies. Use of MUDMAN increased the information-processing capacity of the organization performing the tasks of mud planning, mud management, and mud reporting. Reports were more consistent compared to pre-MUDMAN reports. Diagnosis of well problems was improved and the time required to compile and complete the mud report for the client was drastically reduced.

Sviokla [1990] presents another case study of the use of an expert system, XCON, used by Digital Equipment Corporation for configuring PDP and VAX computer systems. The management and execution of the computer configuration task was changed by the use of the expert system. By using
XCON the firm's information processing capacity increased, expertise was more quickly dispersed, and faster, higher quality decisions resulted. In addition, post-XCON control and application of task-related knowledge was more consistent and correct than pre-XCON.

These studies provide insight into how expert systems effect organizations. Whether similar conclusions will be reached in case studies of auditing expert systems remains to be seen.
Chapter 3: A PRELIMINARY FRAMEWORK AND PROPOSITIONS

The information processing framework provides a guide for measuring the impacts of expert systems. However, more specific impacts may be associated with the auditing environment. The following propositions are not meant to be testable hypotheses, but rather they provide a starting point for a richer study that augments the information processing framework.

The following research question has been identified:

What impacts will expert systems have on auditing firms?

Although no study has specifically focused on this question, aspects of this question have been addressed in both the academic and practitioner accounting, auditing and artificial intelligence literature. This rather broad research question can be divided into more specific research questions concerning the strategic internal impacts of expert systems on auditing firms.

What impacts will expert systems have on the efficiency of auditing firms?

What impacts will expert systems have on the effectiveness of auditing firms?

What impacts will expert systems have on the expertise of auditing firms?

What impacts will expert systems have on the education of auditors?

What impacts will expert systems have on external
factors affecting auditing firms, such as competition, capital, employees, and risk?

These questions are basic elements of the preliminary framework that is developed in this section. As specific parts of the preliminary framework are identified, related information from the literature is discussed. The theories of Huber and Weitz serve as a starting point for the following discussion.

Huber [1990] set forth a related theory, as yet untested. Although not referring specifically to expert systems in auditing, Huber's theory explores the effects of advanced information technologies on organizational design, intelligence, and decision making. Huber [1990] focused on changes that affect the quality and timeliness of intelligence and decision making and set forth fourteen related propositions. Some of the proposed effects include less time in decision-related meetings, reduced decision time, and higher quality decisions.

Weitz [1990] also addressed the impact of expert systems. He examined the near-term impact of expert system technology on work and the organization by focusing on general tendencies. Unfortunately, his broad framework does not provide testable propositions or hypotheses.

In the accounting and auditing literature, many authors have speculated on the impacts of expert systems. For example, Elliott and Kielich [1985] suggested that expert
systems will result in a reduced need for staff time, greater capital investment, and the creation of non-accounting competition in services presently monopolized by the accounting profession. Some beneficial effects of expert systems that have been suggested include augmented professional judgement, shorter decision time, and knowledge sharing [Elliott & Kielich, 1985; Messier & Hansen, 1989].

Others have suggested that auditors of the future will be surrounded with electronic technology and that expert systems will enhance the quality of audits [Gambino, 1988; Coopers & Lybrand, 1987]. On the contrary, some academicians and practitioners assert that expert systems will have no impact in the foreseeable future [Gambino, 1988; Buckley, 1988].

The possible impacts of expert systems on auditing firms are complex and interrelated. However, for better understanding and ease of explanation, the possible effects can be categorized into a preliminary framework of expert systems implications for auditing firms. Figure 3-1 illustrates the five main categories of propositions. The propositions of this framework include potential impacts on auditing firms at the firm, group, and individual auditor level. Note that lower level propositions (e.g. 1.1.1 staff time) are set forth as possible areas to investigate when attempting to quantify the general effect represented by the
Figure 3-1: Major categories of propositions.
higher level impacts (e.g. 1. efficiency). As the propositions are discussed examples of impacts and reasons for them are given from the few existing studies of expert systems and decision support systems impacts.

The Elemental Proposition

The elemental proposition is the one proposition that, if false, will negate all the subsequent propositions.

Proposition 0  Expert systems used for auditing tasks will have an impact on auditing firms in the next decade.

Sviokla [1986] found that three expert systems (used for non-audit tasks) did, in fact, impact their respective firms. The task processes were changed by the introduction of the expert systems, and the information processing capacities of the firms were increased, including number of inputs, diversity of outputs, and level of task performance.

Some academicians and practitioners have expressed the opinion that expert systems will not impact the auditing profession, particularly in the short term [Summers, 1988]. One academician expressed his opinion at the 1987 Arthur Young Professors' Roundtable (where the topic was "Auditor Productivity in the Year 2000").

Expert systems will not have a major impact on auditing during the life-time of the vast majority of auditors currently in practice... [Buckley, 1988].
The tension between long- and short-run time frames is one reason for using a one decade time frame in this study. Ten years is a long-run time frame. Determining the short-run effects, one to three years for example, of any phenomena would be of relatively little value to the auditing profession, because these firms are already planning for the short-term. Large public accounting firms often operate according to five-year strategic plans, three-year financial plans, and one-year operating plans.

However, the ten year horizon is suitably long to provide information useful to auditing firms for use in planning for the impact of expert systems. Also, such a horizon does not have the magnitude of error associated with much longer time frames, e.g. fifty years. The use of a longer time horizon would greatly increase the level of uncertainty, not least because of the rapidity of change in expert systems technology development.

The Efficiency Propositions

Numerous authors have stated that expert systems will increase the efficiency of audits [Englard et al., 1989; Shafer et al., 1988; Borthick, 1987; Connell, 1987]. Therefore, proposition 1 is given.

Proposition 1 The use of an expert system for an auditing task improves the overall efficiency of the performance of the task.
One indication that efficiency is positively impacted is an increase in the number of inputs used for a task. This is an element of Galbraith's information processing capacity concept. Sviokla [1986] measured the number of inputs used both before and after the implementation of expert systems for three firms. Sviokla found that the number of inputs increased for all three firms.

The specific propositions concerning efficiency relate to particular areas that expert systems will affect, such as personnel productivity and decision unit characteristics (see Figure 3-2).

**Personnel Productivity**

In reducing the amount of time needed for a specific task, expert systems will result in an improvement of personnel productivity [AICPA, 1987; Borthick & West, 1987]. In a very broad sense this impact is captured in Proposition 1.1.

**Proposition 1.1** The use of expert systems in auditing improves personnel productivity.

Efficiency, in many respects, is measured by the amount of time required to complete a specific task. Huber [1990] presented a number of related propositions that concern specific aspects of personnel productivity that will be affected by advanced information technologies. Elliott and
Figure 3-2: The efficiency propositions
Kielich [1985] and Juras [1989] suggest similar effects on staff time. These proposed impacts are reflected in the following propositions.

**Proposition 1.1.1** The use of an expert system for an audit task reduces the need for staff time on the task.

Alter [1980] found improved personnel efficiency was one of the most common benefits cited by users of fifty-six decision support systems. The primary reason for improved efficiency is faster and better processing of relevant information. Additionally, expert systems may improve efficiency by providing advice and explanations that are not available through the conventional task process.

Using expert systems to help plan audits, collect and evaluate evidence, and form opinions will reduce the time required to make audit decisions [Sriram & Srinivasan, 1989; Juras, 1989].

**Proposition 1.1.2** The use of an expert system for an audit task reduces the time required to make audit decisions related to the task.

Expert systems will also reduce the amount of time needed to authorize proposed actions and the amount of time spent in audit decision-related meetings [Huber, 1990].

**Proposition 1.1.3** The use of an expert system for an audit task reduces the time required to authorize proposed actions relevant to the task.

**Proposition 1.1.4** The use of an expert system for an audit task results in less of the auditing division's time being absorbed in decision-related meetings.
Scott Morton [1967, 1971] described a quicker cycle time for decisions and decision processes due to the use of a management support system. Sviokla [1986] described similar faster cycle times due to the use of PlanPower (a financial planning expert system). Another expert system, MUDMAN, drastically reduced the time required to compile and complete the client's mud report [Sviokla, 1989].

**Decision Unit Characteristics**

Other efficiency gains that are not related specifically to time saved concern the number and variety of individuals involved in aspects of decision-making. These impacts suggest that the use of expert systems will affect the characteristics of the auditing decision unit.

**Proposition 1.2** The use of expert systems in auditing affects the characteristics of the auditing decision unit.

Concerning specific changes in decision unit characteristics, two of Huber's [1990] propositions may be restated as Propositions 1.2.1 and 1.2.2.

**Proposition 1.2.1** The use of an expert system for an audit task reduces the number of organizational levels involved in authorizing proposed task-related actions.

**Proposition 1.2.2** The use of an expert system for an audit task reduces the number and variety of members comprising the traditional face-to-face task decision unit.
The Effectiveness Propositions

The effectiveness propositions concern the impact of expert systems on decision quality and quality control. Borthick [1987] and Shafer et al. [1988], among others, suggest that the use of expert systems will improve the effectiveness of auditing (see Figure 3-3).

Expert systems may be used to provide a "second opinion" when faced with unique and complex judgments, a common situation for most auditors [Elliott & Kielich, 1985]. By capturing the expert's specialized knowledge, this expertise becomes available to more staff members. Furthermore, expert systems may allow the user to focus on the issues of most importance [Messier & Hansen, 1989]. This impact is reflected in Proposition 2.

Proposition 2 The use of expert systems improves the effectiveness of auditing.

One indication that effectiveness is increased is an increase in the diversity of outputs of the task process. This is the second element of Galbraith's information processing capacity concept. Sviokla [1986] measured the outputs both before and after the implementation of expert systems for three firms. Sviokla found that the number and diversity of outputs increased for all three firms. Additionally, expert systems may improve effectiveness by providing advice and explanations that are not available
Figure 3-3: The effectiveness propositions
through the conventional task process. The user is able to use information that would not otherwise be available.

**Professional Judgement and Decision Quality**

Other authors have identified more specific impacts of expert systems on audit effectiveness that concern aspects of decision quality. Augmented professional judgement is an impact suggested by Elliott and Kielich [1985] and Gambino [1988].

**Proposition 2.1** The use of expert systems in auditing results in augmented professional judgement.

As professional judgement is improved, decision quality will also improve, resulting in better decisions [Huber, 1990; Gal & Steinbart, 1987; Borthick, 1987; Coopers & Lybrand, 1987].

**Proposition 2.2** The use of an expert system for an audit task improves audit task decision quality.

Analogous to task decision quality is the third element of Galbraith's information processing capacity concept, level of task performance. Sviokla [1966] found that the level of task performance increased after the implementation of expert systems for three firms. The expert systems made the keeping of consistent records easier. One particular system (XCON) was notable not only for increased quality of decisions but also for increased correctness, 95-98% for the
expert system versus 65% or better for personnel before the system was implemented. One possible reason for this marked improvement is the system provided more detailed information about the task than before. Another expert system, MUDMAN, improved task decision quality. Post-MUDMAN diagnosis of oil well problems was improved compared to pre-MUDMAN diagnosis.

**Quality Control**

Expert systems can provide assistance in quality control [AICPA, 1987].

**Proposition 2.3** The use of expert systems in auditing improves quality control.

Expert systems may be used to encourage consistent and uniform performance of auditing tasks [Englard et al., 1989; Juras, 1989]. Expert systems built encompassing the auditing firm's standards for specific auditing tasks will ensure that key aspects of the task or decision have been considered [AICPA, 1987]. Proposition 2.3.1 concerns consistency.

**Proposition 2.3.1** The use of an expert system for an audit task improves decision consistency for that particular task.

Not only will expert systems affect quality control by improving the consistency of decisions across audits and auditors, but they will also cause the identification of exceptional circumstances warranting further investigation.
control effect is reflected in the following proposition.

Proposition 2.3.2 The use of an expert system for an audit task assists in identifying exceptional circumstances for the task warranting further investigation.

On the contrary, it is possible that the increasing use of expert systems will result in a standardization of the audit task. This outcome could be detrimental to the continuing usefulness of audits and the ability of creative human thinking and intervention to identify questionable areas for investigation that are not part of the standardized audit program that is part of an expert system driven audit.

Proposition 2.4 The development and use of expert systems for audit tasks leads to the standardization of audit tasks.

The Expertise Propositions

The expertise propositions concern the effect of expert systems use on the preservation, replication and distribution of expertise (see Figure 3-4).

Proposition 3 The use of expert systems in auditing impacts the nature of the expertise of the firm. The development of knowledge bases in auditing expert systems allows for the preservation and replication of expertise by collecting and preserving the knowledge of the firm's auditing experts in the knowledge base for later
Figure 3-4: The expertise propositions
retrieval [Juras, 1989; AICPA, 1987; Borthick & West, 1987].

Recording the knowledge of experts in an expert system allows the firm to save the current knowledge regardless of whether expert auditors retire or leave the firm [AICPA, 1987].

Proposition 3.1 The use of an expert system for an audit task results in the preservation of expertise related to the task.

The preservation of expertise means that expert systems' information provides documentation references for audit judgements, and maintains a record of the reasoning leading up to audit judgements [Borthick, 1987]. This documentation can be used not only as a record of audit decisions, but also for training purposes.

Proposition 3.2 The use of an expert system for an audit task provides documentation references for audit judgements and reasoning concerning the task.

One of the most discussed benefits of expert systems is the distribution of expertise, more commonly called knowledge sharing. Knowledge sharing implies that the firm's best expertise is accessible to all its auditors [Englard et al., 1989; AICPA, 1987; Borthick, 1987; Borthick & West, 1987; Coopers & Lybrand, 1987; Elliott & Kielich, 1987]. Perhaps the issue of knowledge sharing is best described by David Shpilberg:

Coopers & Lybrand's ExperTAX system is another case in point. We've taken the expertise of 40 senior auditors and tax planners and put it into the hands of every
single tax and audit professional the firm has. It's not that we've transformed them into instant experts, but we've given them access to the expertise in a very usable manner [Coopers & Lybrand, 1987, p.2].

The distribution of expertise (knowledge sharing) impacts of expert systems are reflected Proposition 3.3.

Proposition 3.3  The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.

As a result of the preservation, replication, and distribution of expertise, auditors will gain new insights into the audit decision process and will exhibit an increased ability to handle complex analyses and tasks [AICPA, 1987; Borthick & West, 1987].

Proposition 3.4  The use of an expert system for an audit task allows auditors to gain new insights into the task decision process.

Proposition 3.5  The use of an expert system for an audit task results in an increased ability to handle complex analyses in the task.

On the contrary, the use of an expert system for a particular audit task could inhibit the development of task related expertise. Users of the system may rely too heavily on its output and not develop the intuition for that audit task that grows with experience.

Proposition 3.6  The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.
The Education Propositions

The education propositions refer to the impact of expert systems on the training of new and lower level audit staff (see Figure 3-5). Because expert systems allow for the documentation of audit decisions and reasoning, they can be used as training aids, enhancing in-house training programs [McCarthy & Outslay, 1989; AICPA, 1987; Borthick, 1987; Borthick & West, 1987; Elliott & Kielich, 1985]. Developing auditors can sharpen their skills and test their judgement against expert systems that provide professional recommendations [Englard et al., 1989].

Proposition 4 The use of expert systems in auditing impacts the education of auditors.

Expert systems can be used as a decision training aid [Juras, 1989]. Expert systems have the capability to explain to the user how the solution is determined, can interact with the user, and trace the steps in the user's decision process. These are valuable characteristics of a training tool [Jancura & Overbey, 1988]. Expert systems can provide simulated on-the-job experience by exposing inexperienced auditors to more real-world situations in less time than actual auditing assignments [Jancura, 1987].

Proposition 4.1 The use of an expert system for an audit task enhances in-house training programs relating to that task.

Two specific ways the enhancement of the in-house
Figure 3-5: The education propositions
training program will be reflected are spelled out in the following two propositions.

Proposition 4.2 The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers completing the task.

As the learning curve is shortened, new auditors need less time to improve their decision making skills.

Proposition 4.3 The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.

The External Propositions

Although many of the proposed effects of expert systems on auditing firms are characterized as desirable, some, without doubt, will prove to be undesirable. Some of the external impacts of expert systems on auditing could prove to be less than desirable. The external propositions concern broader effects of the use of expert systems on the auditing firm's economics, employees, environment, and risk (see Figure 3-6).

Proposition 5 The use of expert systems in auditing will affect external factors such as capital, competition, hiring, and risk.

Capital. Traditionally, the accounting profession is a labor-intensive business. However, the development, introduction, and use of expert systems will result in a shift from labor to capital in order to cover the costs of
Figure 3-6: The external propositions
hardware, software, knowledge acquisition and expert system maintenance [Ashton & Willingham, 1988; Summers, 1988; Elliott & Kielich, 1985].

Proposition 5.1 The use of expert systems for auditing tasks results in greater capital investment by auditing firms.

Competition. The question of competition for auditing services from non-accounting firms has never been a serious concern.

Historically, the accounting profession has had a virtual monopoly on accounting and auditing services because of the expertise needed to provide the various services. However, as expert [systems] capture more and more of that expertise, anyone with the capital to develop or purchase such systems will become a potential competitor [Elliott & Kielich, 1985, p.134].

This possibility may be more of a threat in the tax and consulting areas, because of the state accountancy statutes that govern auditing. However, the profession must take advantage of any increases in efficiency and effectiveness that expert systems can provide, in order to prevent others from capturing segments of the accounting business [Ashton & Willingham, 1988; Elliott & Kielich, 1985].

Proposition 5.2 The development and use of expert systems results in increased non-accounting competition.

Employees. Technology change promotes transportability, not only of knowledge, but also of personnel. As auditing expert systems are developed, employees with particular expertise will be able to move
freely in the market for auditing jobs, changing positions, firms, or professions. Hiring and retention of superstars will become more difficult, a "draft system" may even be adopted in an attempt to get high quality expertise into the firm and to combat a free-agency type of hiring system [Summers, 1988].

Proposition 5.3 The development and use of expert systems result in an increasing difficulty in hiring and retaining the top auditing experts.

Risk. The last proposition concerns risk. The impact of expert systems on the risk of practice to auditing firms is not easily predicted. Some believe that technology will drive the risk of practice higher, forcing firms to consolidate (as they have been doing already). Consolidation will increase overhead and regulation, and decrease innovation. Firms will try to eliminate the high-risk portions of their practices or form "risk pools", to identify clients or services with particular levels of risk, in order to appropriately account for the costs of servicing higher risk clients [Summers, 1988].

Proposition 5.4 The development and use of expert systems for audit tasks causes auditing firms to identify and/or eliminate the highest-risk areas in their practice.

Conversely, others may argue that the use of expert systems will reduce the risk of practice. Expert systems will not only provide expert advice, but will also provide
documentation of audit decisions. Such documentation may be useful in reducing the amount of litigation from "audit failure."

Other Possible Adverse Impacts. Other possible adverse impacts of expert systems on auditing firms include legal liability, prestige, and dehumanization. The use of expert systems for auditing tasks may result in a dehumanization of auditing, that is, fewer humans will be used in the audit process. Reliance on expert systems for specific audit tasks could lead to less emphasis on the knowledge and expertise of the human auditor present for a particular audit (or audit task).

Proposition 5.5 The development and use of expert systems for audit tasks leads to the dehumanization of auditing.

The possibility of the dehumanization of auditing leads to speculation concerning a loss of prestige among auditing firms who rely too heavily on "computerized experts" rather than human experts.

Proposition 5.6 The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.

One final possible impact of expert systems on auditing concerns legal liability. Given that the environment exists for substantial damages and litigation surrounding "audit failure", the question arises: Who is liable for an audit failure that is dependent upon advice gained from an
auditing expert system? The uncertainty about such liability may increase the incidence of litigation in the audit environment.

Proposition 5.7 The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.

Summary

A number of propositions concerning the impact of expert systems on the auditing profession have been identified. The following two pages contain a complete listing of the propositions (Table 3-1). Specifically, these propositions deal with the auditing firms' efficiency, effectiveness, expertise, and in-house education. These propositions will be investigated using the Delphi technique to examine the perceptions of experts in auditing and expert systems development. The preliminary framework will be further investigated through multiple case studies of auditing firms using auditing expert systems.
Table 3-1: List of Propositions of the Preliminary Framework

<table>
<thead>
<tr>
<th>Proposition 0</th>
<th>Expert systems will have an impact on auditing firms in the next two decades.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proposition 1</td>
<td>The use of an expert system for an audit task improves the overall efficiency of the performance of the task.</td>
</tr>
<tr>
<td>Proposition 1.1</td>
<td>The use of expert systems in auditing improves personnel productivity.</td>
</tr>
<tr>
<td>Proposition 1.1.1</td>
<td>The use of an expert system for an audit task reduces the need for staff time on the task.</td>
</tr>
<tr>
<td>Proposition 1.1.2</td>
<td>The use of an expert system for an audit task reduces the time required to make audit decisions related to the task.</td>
</tr>
<tr>
<td>Proposition 1.1.3</td>
<td>The use of an expert system for an audit task reduces the time required to authorize proposed actions relevant to the task.</td>
</tr>
<tr>
<td>Proposition 1.1.4</td>
<td>The use of an expert system for an audit task results in less of the auditing division's time being absorbed in decision-related meetings.</td>
</tr>
<tr>
<td>Proposition 1.2</td>
<td>The use of expert systems in auditing affects the characteristics of the auditing decision unit.</td>
</tr>
<tr>
<td>Proposition 1.2.1</td>
<td>The use of an expert system for an audit task reduces the number of organizational levels involved in authorizing proposed task related actions.</td>
</tr>
<tr>
<td>Proposition 1.2.2</td>
<td>The use of an expert system for an audit task reduces the number and variety of members comprising the traditional face-to-face task decision unit.</td>
</tr>
<tr>
<td>Proposition 2</td>
<td>The use of expert systems improves the effectiveness of auditing.</td>
</tr>
<tr>
<td>Proposition 2.1</td>
<td>The use of expert systems in auditing results in augmented professional judgement.</td>
</tr>
<tr>
<td>Proposition 2.2</td>
<td>The use of an expert system for an audit task improves audit task decision quality.</td>
</tr>
<tr>
<td>Proposition 2.3</td>
<td>The use of expert systems in auditing improves quality control.</td>
</tr>
<tr>
<td>Proposition 2.3.1</td>
<td>The use of an expert system for an audit task improves decision consistency for that particular task.</td>
</tr>
<tr>
<td>Proposition 2.3.2</td>
<td>The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.</td>
</tr>
<tr>
<td>Proposition 2.4</td>
<td>The development and use of expert systems for audit tasks leads to the standardization of audit tasks.</td>
</tr>
</tbody>
</table>
Table 3-1: List of Propositions of the Preliminary Framework, continued

Proposition 3  The use of expert systems in auditing impacts the nature of the expertise of the firm.
Proposition 3.1  The use of an expert system for an audit task results in the preservation of expertise.
Proposition 3.2  The use of an expert system for an audit task provides documentation references for audit judgements and reasoning concerning the task.
Proposition 3.3  The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.
Proposition 3.4  The use of an expert system for an audit task allows auditors to gain new insights into the decision process.
Proposition 3.5  The use of an expert system for an audit task results in an increased ability to handle complex analyses.
Proposition 3.6  The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.

Proposition 4  The use of expert systems in auditing impacts the education of auditors.
Proposition 4.1  The use of an expert system for an audit task enhances the in-house training program related to that task.
Proposition 4.2  The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers.
Proposition 4.3  The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.

Proposition 5  The use of expert systems in auditing will effect external factors such as capital, competition, hiring, and risk.
Proposition 5.1  The use of expert systems will result in greater capital investment by auditing firms.
Proposition 5.2  The development and use of expert systems for audit tasks results in increased non-accounting competition for auditing services.
Proposition 5.3  The development and use of expert systems in auditing results in an increasing difficulty in hiring and retaining top auditing experts.
Proposition 5.4  The development and use of expert systems for audit tasks causes auditing firms to identify and/or eliminate the highest-risk areas in their practice.
Proposition 5.5  The development and use of expert systems for audit tasks leads to the dehumanization of auditing.
Proposition 5.6  The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.
Proposition 5.7  The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.
Chapter 4: RESEARCH METHODOLOGY

The research involved three steps:

1. A review of the literature to determine current and historical information about expert systems in accounting and to identify the probable status of expert systems technology in auditing in the next two decades.

2. A Delphi study of experts in auditing expert systems development to determine the likelihood of future technological events and trends. This study allows for the refinement of the preliminary framework.

3. A case study of one office of an auditing firm that has implemented an auditing expert system provides a before-and-after picture of the impact of the expert system on the audit firm.

The purpose of the Delphi study is to identify the most likely impacts of expert systems on auditing, and, more importantly, to gain a better understanding of why these effects may occur. The results of the Delphi study can be used to move from the preliminary propositions of expert systems' impacts on auditing toward developing a general framework of expert systems' impacts.

The case study utilized an information processing framework to investigate the impact of an expert system on a participating firm. The case study provides further evidence about how expert systems impact organizational information processing and task programs. The case study also provides evidence to support or refute the general framework of propositions.

The overall objective of these research steps is to
gain a better understanding of the potential and actual impacts of expert systems on auditing firms and in this manner to further develop and refine the framework of propositions. This is the first step in building a theory of expert systems' impacts. An overview of the results of the literature review was presented in an earlier section. A discussion of the subsequent research steps follows.

The Delphi Study

When identifying possible future technological events and trends, the most suitable methods are a review of the relevant literature and interviews with experts. Experts of special interest are those directly involved in research environments in which future implementation of technology is already being investigated. The Delphi technique is particularly suited for assessing the likelihood of future events and trends [Holstrum et al., 1986]. Further, the Delphi method has been suggested as an appropriate technological forecasting tool when considering the effect of technological changes on auditing [Garsombke & Cerrulo, 1984].

The most knowledgeable people about a given future event are those that are involved in the present events that are shaping the future. Therefore, people involved in
developing and using expert systems for auditing are the most knowledgeable about expert systems and the future impacts on the auditing profession. Several groups of subjects that fall into this category are included in the Delphi study: 1) directors of expert system development and implementation at Big Six accounting firms, 2) knowledge engineers (expert systems professionals involved in developing these systems for accounting firms), 3) auditing experts who are involved in the development of auditing expert systems, 4) information systems and computer science academicians with expertise in expert systems related impact research, 5) auditing academicians with expertise in expert systems, and 6) staff auditors who use auditing expert systems.

Subjects involved in developing auditing expert systems were identified and contacted through the Big Six accounting firms. Information systems and computer science academicians with expertise in expert systems were identified through a search of an information systems research database for respondents with the appropriate expertise. Auditing and information systems academicians were identified from the auditing and expert systems literature.

The Delphi technique involves asking a panel of experts for their subjective evaluation of the probability of occurrence of specified future events or trends. A summary
of the panel's evaluations serves as the basis for subsequent rounds of evaluation [Cundiff, 1985].

**Accuracy and Reliability in Delphi Studies**

As in all methodologies, sources for error exist in Delphi studies [Benarie, 1988]. The best advice, according to Linstone [1985], is to suit the method to the problem, not vice versa. The Delphi method is particularly useful when

1. The problem does not lend itself to precise analytical techniques but benefits from subjective judgments on a collective basis, and

2. The individuals who need to interact cannot be brought together in a face-to-face exchange because of time or cost constraints. Further, a conventional conference tends to be dominated by particularly strong personalities or to give rise to an undesirable bandwagon effect [Linstone, 1985].

The first point is important because the present study is essentially one of theory building. The question of expert systems impact does not lend itself to analytical techniques at this time due to the lack of theory in the area. That does not mean, of course, that analytical techniques cannot be used to address this question. Rather, given the preliminary stage of this line of research, a large volume of experimental research, for example, would be exploratory and perhaps counter-productive.

The second point is important to the present study
because bringing a large number of knowledge engineers, expert auditors, and academicians together for a face-to-face exchange is economically impractical. For this particular implementation of the Delphi technique, a major advantage is the elimination of the time and expense required of face-to-face meetings. Another advantage of the Delphi technique is that the experts in the panel remain unknown to each other throughout the study. The disadvantages of direct group contact, such as power and influence, and group pressure for conformity, are not a factor in Delphi studies.

One important tactic for combating sources of error in Delphi studies is the selection of an appropriate panel. The minimum panel size is seven. With smaller size panels, accuracy deteriorates quickly, while extremely large panels experience slow improvements in accuracy. A survey of published Delphi studies shows that typical panels have from fifteen to forty participants, although some have hundreds of respondents [Dalkey and Helmer, 1963].

Another question to be considered when forming a panel is that of illusory expertise. An alleged expert may prove to be a poor forecaster because his specialist nature causes him to view the forecast in an artificial setting [Linstone, 1985]. The tactic for combatting this problem is to form a panel of experts who are not all specialists in the same narrow field. As discussed above, the panel for the present
study includes experts from a number of areas related to auditing and expert systems. One limitation of the Delphi technique is that there are no tests to measure the expertness of the Delphi panel. Also, even "experts" are not free from bias and there are cases when the specialist in a field is not a good forecaster [Linstone, 1975].

Forecast accuracy is another important concern in Delphi studies. Forecasts tend to be pessimistic for long-range estimates and optimistic for short-range estimates. There should be a time span for obtaining the most accurate forecasts, presumably occurring at the time that forecasts shift from pessimistic to optimistic. However, there is no data to provide precise estimates for this kind of bias [Linstone, 1985]. This study utilizes a ten year time horizon. The accounting firms that use or will use auditing expert systems typically use one, three, and five year planning schemes. A ten year horizon removes the estimate from the short term but does not project too far into the future.

A final point about accuracy and reliability concerns the nature of the Delphi statements. Statements that are too concise lead to widely variant interpretations. Statements that are too lengthy require too much assimilation [Linstone, 1985]. According to Linstone [1975], "Excessive specification or vagueness in the statement reduces the information provided by the respondents."
Salancik et al. [1971] concluded that there is a "correct" length for Delphi statements that leads to the optimal amount of obtained information. Twenty to twenty-five word statements formed the peak of their distribution. The propositions used in the present study are constructed accordingly.

Parente et al. [1984] conducted an examination of factors contributing to Delphi accuracy. They concluded that consensus-based forecasts are more accurate than 95 percent of forecasts obtained from individual panelists. They also suggested that iterative and feedback polling procedures reduce error in prediction.

Other important limitations of the Delphi technique should be noted, such as bias and pressure for conformity. First, individual experts may bias responses to be favorable toward areas of personal interest. Second, the possibility of submerging differences of opinion that evidence uncertainty for the sake of gaining convergence [Jones, 1975].

**Delphi Questionnaires**

The panel of experts are not only asked for their subjective evaluation of the probability of the occurrence of specified future events or trends; they are also asked for their rationale for these predictions.

The potential future events and trends included in the
questionnaires are contained in the propositions in chapter 3. The propositions appear in the questionnaire in random order. A round one questionnaire is presented in Appendix A. These propositions represent future events and trends. The second (and subsequent) round questionnaires ask for revisions and comments on previous round responses that fall outside of the inter-quartile range of responses of the experts consulted. Therefore, post round one response data is highly selective.

In all early Delphi forecasting studies, a point of diminishing returns is reached after a few rounds. Generally, three rounds have proved to attain stability in responses, and excessive repetition is generally unacceptable to participants [Linstone & Turoff, 1975]. Therefore, three rounds of Delphi questionnaires are conducted in this study.

Analysis of the Delphi survey responses includes descriptive statistics and frequency distributions. Additional statistical analyses was performed to determine whether differences exist between responses of experts with different backgrounds.

The Case Study

In instances where a body of knowledge is not sufficient to provide causal questions, and when it is
difficult to study a phenomenon outside of its natural context, case research is appropriate [Bonomo, 1985]. Further, Kaplan and Duchon [1988] stress the need for context dependent research in information systems. According to Yin [1981a, 1981b],

A case study is an empirical enquiry that
1. investigates a contemporary phenomenon within its real-life context; when
2. the boundaries between phenomenon and context are not clearly evident; and in which
3. multiple sources of evidence are used.

Case research is particularly suited for problems in which the research and theory are in the formative stages [Roethlisberger, 1977]. A specific research strategy can have a distinct advantage for a specific situation. A case study has a distinct advantage when:

A how or why question is being asked about a contemporary set of events, over which the investigator has little or no control [Yin, 1989, p.20].

Case studies are useful for capturing the knowledge of practitioners and developing theories from actual practice. In fact, due to the rapidity of change in the information systems arena, information systems researchers often learn much by studying the innovations of practitioners [Benbasat et al., 1987].

Case studies of auditing firms that implement expert systems for use in auditing tasks will provide evidence from the field about the impact of expert systems. A case study is not only a source of data about use of an expert system,
it is also a rich source of data about potential impacts that may have not been considered in the preliminary framework. The case study will serve to enrich and improve the framework and expand understanding of the different aspects of the auditing firm that may be affected by the use of expert systems.

As mentioned earlier, case studies of the impact of expert systems have been undertaken in other fields [Sviokla, 1990, 1989, 1986]. Clearly, properly conducted and reported case studies will add to the limited knowledge presently available about the impact of expert systems on auditing firms.

In summary, there are three reasons for using a case study as an information systems research strategy [Benbasat et al., 1987].

1. The researcher can study information systems in a natural setting, learn about the state of the art, and generate theories from practice.

2. The case method allows the researcher to answer "how" and "why" questions, to understand the complexity of the processes taking place.

3. A case approach is an appropriate way to research an area in which few previous studies have been carried out.

These reasons fit in well with the nature and purpose of this research project. The following section details the steps involved in the case study of an auditing expert system.
The Auditing Expert System Case Study

The case study involves one office of a Big Six firm that uses an expert system for an auditing task. The purpose of the case study is to gather and evaluate evidence concerning the propositions of the preliminary framework and, more specifically, the findings of the Delphi study, by describing and exploring the impact of a particular expert system. Whenever possible, multiple data collection procedures are used. Ideally, the multiple sources of data provide evidence that converges to support the research findings [Yin, 1989; Benbasat et al., 1987]. Triangulation involves the use of multiple methods of data collection when exploring a claim or issue [Bonoma, 1985; Jick, 1979]. Collecting the types of data identified below will allow triangulation, e.g. substantiating a fact or issue identified in the interviews with information obtained from the archival data. The goal of the case study is to obtain a rich set of data concerning the impact of the expert system on the auditing firm, especially information from before and after the introduction of the expert system that can be compared to identify any effects. Sources of evidence used include

1. interviews
2. archival records
3. direct observation

Interviewing auditors who have performed the audit task
with and without the expert systems provides compelling
information about the impact of the system. Studies of
expert systems in other areas have relied heavily on the use
of interviews [e.g. Sviokla, 1990, 1989, 1986]. Information
of particular interest will provide some comparable data
from before the implementation of the expert system and from
after the implementation of the expert system.
Documentation that is of interest includes the manuals that
explain the proper use of the expert system by the auditors
in the field.

The case study involves a pre-post design to
approximate the impact of expert system use. The basic
framework is to compare the pre-expert system use situation
with the post-expert system situation. The pre-expert
system situation is re-created largely through interviews.
The post-expert system situation is investigated through
interviews, archival data and direct observation.

Some examples of the type of data collected are given.
The most important information is data to be used in
building a before and after picture of the expert systems'
audit task (see the next section for a discussion of
organizational programs). Other data that will be of
interest includes the organizational context, the location
of the system, and the types of users (i.e. rank).

The most important information desired from the
collection of archival data is samples of the written part
of the task, before and after the expert system is implemented. Organizational information concerning the structure and size of the organization and the roles and responsibilities of the firm members was also sought. Information on the performance of the task, such as time required and firm members involved, was gathered. Information concerning how the task was performed prior to the implementation of the expert system is crucial to an understanding of the pre-expert system audit task.

Measures and Hypotheses. The difficulty of investigating the impact of expert systems on organizations is greatly associated with the lack of recognized frameworks to guide such research [Sviokla, 1986]. While there are no recognized frameworks for this research, there are useful measures for addressing aspects of the impact of expert systems.

Two measures that have been useful in other types of computer impacts research are information processing capacity and organizational programs (see Table 4-1). These measures have been used previously by Sviokla [1986] for studying the impact of expert systems on organizations. These measures are used to help measure effects of expert system use and to describe changes associated with the implementation of expert systems. These measures assist in identifying changes in the task and its related parts before and after expert system implementation. For example,
Table 4-1: Case Study Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Definition</th>
<th>Data to be Collected</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity of Outputs</td>
<td>The number of different versions of the task service</td>
<td>Representative samples of the output of the task</td>
<td>A categorization of the outputs, their number and diversity before ES use and after ES use as assessed by the researcher and reviewed by members of the firm</td>
</tr>
<tr>
<td>Level of Task Performance</td>
<td>A subjective assessment of level of performance by the researcher as informed by managers</td>
<td>Structured interviews of the users and their perception of the diversity of task output as it existed before ES use &amp; after ES use</td>
<td>Observation of the task, interviews with managers/users to assess standards and performance</td>
</tr>
<tr>
<td>Number of inputs</td>
<td>Number of data sources used &amp; people consulted in completing the task</td>
<td>Structured interviews with users to list their data sources and networks of individuals contacted in the process of completing the task</td>
<td>A review and comparison of performance data, an enumeration of the inputs to the task process</td>
</tr>
<tr>
<td>Task Process</td>
<td>The sequences of activities necessary to complete the task</td>
<td>Structured interviews of user’s and manager’s perception of the task output as it existed before and after ES use</td>
<td>Process flow diagrams showing subtasks, and their sequence, job descriptions, division of labor and other task related personnel data, review of task process flow diagrams with managers/users, follow a task through the task process</td>
</tr>
</tbody>
</table>
changes in information processing capacity may be a sign of more specific changes in efficiency, effectiveness, or firm expertise.

As these measures are explained below, several exploratory hypotheses are identified. These hypotheses are used as guidelines to organize questions, data collection and analyses. While these hypotheses are broader than the specific impacts of the preliminary framework, they will provide evidence about those more specific, but less easily operationalized, impacts identified in the propositions of the preliminary framework.

Information Processing Capacity. According to Galbraith [1973, 1977], an organization's information-processing capacity is the diversity of the outputs, the number of inputs, and level of task performance for a given task. Inputs are the number of data sources and people used in the process of the task. Outputs are the number of different versions of the service the task provides. The level of task performance is the management's assessment of performance and any available objective measures [Sviokla, 1986].

H1 Use of an expert system increases the information processing capacity of the firm.

Use of an expert system provides more information processing capacity to the organization because it
enumerates and automates an important task. These changes may be evident in any of Galbraith's three measures: diversity of outputs, number of inputs, and level of task performance. The expert system task may provide more outputs, use more inputs and elicit a higher level of task performance than the pre-expert system task. Therefore, these sub-hypotheses are identified:

**H1a** The use of an expert system results in more outputs from the task than before expert system use.

**H1b** The use of an expert system results in the use of more inputs in the completion of the task than before expert system use.

**H1c** The use of an expert system results in a higher level of task performance than before expert system use.

These hypotheses were investigated through questioning the users and non-users of the expert system about the number and nature of the outputs, inputs, and task performance.

Sviokla [1986] found that for three expert systems studied, the hypotheses about information processing capacity and its parts were strongly supported. Increases of varying magnitude were observed for each of the components of information processing capacity.

**Organizational Programs.** A second measure that is useful in comparing changes in a task is the organizational (or performance) program, which will be referred to as a task program. These task programs provide a link between the individual's action and the organization [Sviokla, 1986]. Operationalizing these task programs through a flow
chart of the task process involves mapping the subtasks necessary to a particular task. These task process flow charts will be constructed for the task performed by each expert system and for the related pre-expert system task. These charts will be used to compare and rate the process of the tasks.

An expert system is the incarnation of a task program. Mapping of task programs at the case study site for the expert system task and the related pre-expert system task should reveal some of the effects of expert system use [Sviokla, 1986]. The following exploratory hypothesis concern the task process.

H2 The use of an expert system will change the task process.

The use of an expert system provides an opportunity to integrate parts of the business. For example, the use of ExpertTax allows a closer integration of the audit function and the tax planning function. Sviokla [1986] found that for the three expert systems studied, the task processes changed, although the magnitude of the changes varied. Scott Morton [1967, 1971] also found significantly different decision processes as a result of the use of a management support system. Use of an expert system will change the task because expert systems do much more than automate. Because expert systems mimic the behavior of experts the task process will change from the process used before the
task was performed by non-experts (e.g. inexperienced audit staff persons).

An increased integration of the task will result in a more global accessing of data. The expert system may allow more information to be available to the user than the previous non-expert system task process. Sviokla [1986] found that use of the expert systems resulted in consolidation of data and approaches, and more consistent information in the database. The groups using the XCON system became more interdependent and coordinated.

The Propositions in the Case Study. The propositions of the preliminary framework discussed in section 2.3 and included in the Delphi study are used in the case study to direct specific inquiry into interesting areas. While not operationally defining efficiency and effectiveness, the measures and hypotheses discussed in the previous section focus on efficiency and effectiveness. The number and nature of outputs and inputs can be said to be related to efficiency, while task performance is an element of effectiveness. Still, as the propositions indicate, there are many potential areas for expert systems to impact.

Accordingly, questions concerning the impacts proposed in section 2.3 provide direction for the case study interviews. These questions allow the case study endeavor to delve into areas beyond the more easily operationalized measures of the information processing framework.
Information obtained through the in-depth interviewing process provide a better understanding of the context of expert systems use and impact and allow an increased comprehension of impacts that are difficult to quantify.

Potential questions range from the very general concerning the major categories of impacts to very specific sub-impacts. These are open-ended questions.

Has the use of the expert system improved the overall efficiency of the performance of the task?

How has the expert system affected personnel productivity?

How has the expert system impacted the amount of staff time on the task?

How has the expert system changed the amount of time necessary for meetings concerning task decisions?

How has the use of the expert system affected the make-up of the audit decision unit?

Has the expert system impacted the effectiveness of the task?

How has professional judgement been changed?

Has audit task decision quality been altered?

Has quality control improved?

Are decisions more or less consistent?

Does the expert system assist in identifying exceptional circumstances related to the task that need additional investigation?

Has the expert system impacted the nature of the firm's expertise?

How has the expert system changed the distribution of expertise within the firm?
Does the expert system preserve the firm's expertise?

Does the expert systems allow the auditor to gain new insights into the decision process?

Does the expert system assist in providing documentation references for audit judgements and reasoning?

How has the ability to handle complex analyses and tasks been affected by the expert system's use?

Has the use of the expert system impacted in-house training and education?

Has in-house training been enhanced?

Has the learning curve for inexperienced auditors been affected?

Are new auditors able to improve decision-making ability for the task because of the expert system?

These questions are meant to directly address the propositions discussed in Chapter 3. However, they also provide some additional secondary evidence that may be useful in interpreting the hypotheses discussed in the previous section. For example, the relative number of outputs produced or inputs used is related to efficiency. These questions will provide a rich body of information concerning the impact of the expert system at the case study site.

**Case Study Summary**

This study is exploratory in nature. A preliminary framework of propositions is used to guide the expected findings. Exploratory hypotheses derived from the
information processing framework are also utilized. Strict causation between the use of expert systems and the identified effects cannot be drawn because of the large number of uncontrollable variables. The findings about the preliminary framework and propositions are used as a basis to develop theory and hypotheses for future investigation.
Chapter 5: DELPHI STUDY RESULTS

A Delphi study was conducted using a panel of auditing expert systems experts. The purpose of this study was to determine the likelihood of future technological events and trends and to gain a better understanding of why these events and trends may occur.

Three rounds were involved in the study. The questionnaire included thirty-one statements of events/trends derived from the propositions of chapter 3. The panelists were asked for the probability of occurrence of each in the next decade and rationales for those predictions. The propositions appeared in random order on the survey instrument and were consecutively numbered. The scale of probabilities was from .01 to .99 with .50 representing "either way."¹ The actual survey instrument is reproduced in Appendix A.

The first round included a cover letter explaining the study. Each second and third round questionnaire also included a reminder of the respondent's previous round predictions, the mean and inter-quartile ranges for the group on each prediction, and all rationales provided by the entire panel for each statement. Only general demographic

¹ For clarity and presentation purposes, subjects' responses were converted into whole numbers (.99 -> 99 and .50 -> 50), thus an average of .589 on the scale from .01 to .99 is listed in the Tables as 58.9.
information about the panel is presented. The panelists' names and specific affiliations remain confidential.

An initial and follow-up mailing of the first round Delphi survey yielded thirty-three usable responses, a response rate of approximately 33%. An initial and follow-up mailing of the second round Delphi survey resulted in twenty-eight usable responses (85% of the thirty-three subjects originally agreeing to participate completed the second round). The third round Delphi survey produced eighteen usable responses (55% of the original thirty-three completed the third round).²

Thirty of the thirty-one statements included in the survey directly correspond to the propositions discussed in chapter 3. In the interest of creating a useful, comprehensible and timely survey instrument, not all propositions were included as statements. Most noticeably, for the categories with three levels of statements, the middle level (e.g. P 1.2, P 1.1) was not included in the Delphi questionnaire.

The rest of this chapter is divided into three sections. First, the round one responses are presented in order to discuss significant differences between academicians and practitioners on initial probability

² The possibility of non-response bias was investigated by comparing round one data for those responding to later rounds with those who did not respond beyond the first round. Only one Delphi statement showed a significant difference (at alpha = .10) between responders and non-responders. The statement was proposition 5.3 and the P-value was .0891.
predictions. Second, tables of data for each round are exhibited and briefly discussed, including descriptive statistics for all respondents and for the academician and practitioner groups, and consensus measures across all three rounds. Third, the final round of the study is discussed, including group predictions and consensus.

**Round One**

The results of the final round are the major focus of any Delphi study. However, the first round yields an opportunity to analyze the initial reaction of each panelist to the statements without influence from the predictions and rationales of the other panelists. This discussion of the first round focuses on the differences that exist between the responses of the academicians and the practitioners on the Delphi panel.

An initial and follow-up mailing of the first round Delphi survey yielded thirty-three usable responses, a response rate of approximately 33%. Nineteen of the participants are academicians, and fourteen are employed by Big Six accounting firms. Collectively, the subjects include twenty-five Certified Public Accountants, four Certified Management Accountants, four Certified Internal Auditors, three Certified Information Systems Auditors, and one Certified Data Processor (one subject may hold more than
one professional certification). Nineteen of the respondents have received doctorates, several hold masters degrees, and the rest, bachelors degrees. The subjects hail from fifteen states, the District of Columbia, and one Canadian province.

Of the thirty-three Delphi panelists, twenty indicated that they have been or are involved in auditing, fourteen in teaching auditing, sixteen in auditing research, twenty-two in research in expert systems development, sixteen in research in expert systems impacts, twenty using expert systems, and fifteen involved in training staff auditors.

**Differences Between Academicians and Practitioners**

Analysis of variance (ANOVA) procedures were performed on responses to all thirty-one statements. The p values for all thirty-one statements are reported in Table 5-1. These p values represent differences in group responses on the initial round one Delphi survey. The number of responses on a particular statement may be less than thirty-three where one or more participants did not provide a probability prediction for the statement.

The ANOVA identified significant differences between the academic participants and the practitioner participants for seven of the thirty-one Delphi statements (propositions). These seven statements are listed in Table 5-2 below.
<table>
<thead>
<tr>
<th>Proposition</th>
<th>N</th>
<th>Pr &lt; F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>25</td>
<td>.7514</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>33</td>
<td>.6875</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>33</td>
<td>.8518</td>
<td></td>
</tr>
<tr>
<td>P1.1.1</td>
<td>33</td>
<td>.4618</td>
<td></td>
</tr>
<tr>
<td>P1.1.2</td>
<td>32</td>
<td>.4455</td>
<td></td>
</tr>
<tr>
<td>P1.1.3</td>
<td>32</td>
<td>.1869</td>
<td></td>
</tr>
<tr>
<td>P1.1.4</td>
<td>30</td>
<td>.2382</td>
<td></td>
</tr>
<tr>
<td>P1.2.1</td>
<td>33</td>
<td>.5094</td>
<td></td>
</tr>
<tr>
<td>P1.2.2</td>
<td>31</td>
<td>.1606</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>33</td>
<td>.2852</td>
<td></td>
</tr>
<tr>
<td>P2.1</td>
<td>32</td>
<td>.7406</td>
<td></td>
</tr>
<tr>
<td>P2.2</td>
<td>32</td>
<td>.0446</td>
<td>**</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>33</td>
<td>.4243</td>
<td></td>
</tr>
<tr>
<td>P2.3.2</td>
<td>33</td>
<td>.5965</td>
<td></td>
</tr>
<tr>
<td>P2.4</td>
<td>33</td>
<td>.0507</td>
<td>*</td>
</tr>
<tr>
<td>P3</td>
<td>33</td>
<td>.5616</td>
<td></td>
</tr>
<tr>
<td>P3.2</td>
<td>33</td>
<td>.1069</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td>31</td>
<td>.1502</td>
<td></td>
</tr>
<tr>
<td>P3.4</td>
<td>33</td>
<td>.2393</td>
<td></td>
</tr>
<tr>
<td>P3.5</td>
<td>33</td>
<td>.4022</td>
<td></td>
</tr>
<tr>
<td>P3.6</td>
<td>33</td>
<td>.0196</td>
<td>**</td>
</tr>
<tr>
<td>P4</td>
<td>32</td>
<td>.2739</td>
<td></td>
</tr>
<tr>
<td>P4.1</td>
<td>33</td>
<td>.7670</td>
<td></td>
</tr>
<tr>
<td>P4.2</td>
<td>33</td>
<td>.0090</td>
<td>***</td>
</tr>
<tr>
<td>P4.3</td>
<td>33</td>
<td>.9324</td>
<td></td>
</tr>
<tr>
<td>P5.2</td>
<td>29</td>
<td>.0373</td>
<td>**</td>
</tr>
<tr>
<td>P5.3</td>
<td>31</td>
<td>.4044</td>
<td></td>
</tr>
<tr>
<td>P5.4</td>
<td>32</td>
<td>.8621</td>
<td></td>
</tr>
<tr>
<td>P5.5</td>
<td>33</td>
<td>.2413</td>
<td></td>
</tr>
<tr>
<td>P5.6</td>
<td>33</td>
<td>.0575</td>
<td>*</td>
</tr>
<tr>
<td>P5.7</td>
<td>32</td>
<td>.0062</td>
<td>***</td>
</tr>
</tbody>
</table>

a Responses below thirty-three reflect omission(s) by respondent(s) for that statement.

b * significant at .1
   ** significant at .05
   *** significant at .01
<table>
<thead>
<tr>
<th>Proposition</th>
<th>Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2.2</td>
<td>The use of an expert systems for an audit task improves task decision quality.</td>
</tr>
<tr>
<td>P2.4</td>
<td>The development and use of expert systems for audit tasks leads to the standardization of audit tasks.</td>
</tr>
<tr>
<td>P3.6</td>
<td>The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.</td>
</tr>
<tr>
<td>P4.2</td>
<td>The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers completing the task.</td>
</tr>
<tr>
<td>P5.2</td>
<td>The development and use of expert systems result in increased non-accounting competition for auditing services.</td>
</tr>
<tr>
<td>P5.6</td>
<td>The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.</td>
</tr>
<tr>
<td>P5.7</td>
<td>The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.</td>
</tr>
</tbody>
</table>
### Table 5-3: Comparison of descriptive statistics for propositions showing significant differences by professions.

<table>
<thead>
<tr>
<th>Stmt</th>
<th>Number</th>
<th>---Academics---</th>
<th>---Practitioners---</th>
<th>All Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>Mean</strong></td>
<td><strong>StDev</strong></td>
<td><strong>Min</strong></td>
</tr>
<tr>
<td>P2.2</td>
<td>61.7</td>
<td>30.49</td>
<td>18.39</td>
<td>30</td>
</tr>
<tr>
<td>P2.4</td>
<td>76.0</td>
<td>30.49</td>
<td>14.97</td>
<td>45</td>
</tr>
<tr>
<td>P3.6</td>
<td>45.8</td>
<td>30.49</td>
<td>23.70</td>
<td>10</td>
</tr>
<tr>
<td>P4.2</td>
<td>58.9</td>
<td>30.49</td>
<td>24.38</td>
<td>10</td>
</tr>
<tr>
<td>P5.2</td>
<td>44.0</td>
<td>30.49</td>
<td>27.21</td>
<td>1</td>
</tr>
<tr>
<td>P5.6</td>
<td>30.8</td>
<td>30.49</td>
<td>17.02</td>
<td>10</td>
</tr>
<tr>
<td>P5.7</td>
<td>38.9</td>
<td>30.49</td>
<td>18.11</td>
<td>10</td>
</tr>
</tbody>
</table>
A comparison of descriptive statistics for the seven Delphi statements eliciting significantly different responses between academicians and practitioners are presented in Table 5-3. The mean and standard deviation for all subjects is also given for comparative purposes. Note the differences in means between the two groups ranges from 13.5 to 21.8.

**Proposition 2.4.** Proposition 2.4 states

The development and use of expert systems for audit tasks leads to the standardization of audit tasks. The practitioners, as a group, indicate that this future event is somewhat likely (mean = 62.5). However, the responses of the practitioners range as widely as possible from 1 to 99. The academicians, on the other hand, appear to agree that this event is likely. Not only is the mean academic response 13.5 greater than the mean practitioner response, the range of responses is narrower, and the standard deviation is lower (14.97 versus 23.19).

It is interesting to note that no academician response to this statement is lower than 45, and the responses range up to 99. The academicians as a group appear to believe that in a decade the development and use of expert systems for audit tasks will lead to the standardization of audit tasks, while the practitioner group is more uncertain of the possibility of this trend. The difference could stem from different interpretations of the term standardization and
its implications, whether positive or negative.

**Proposition 4.2.** Another interesting result is that no practitioner subject responded to proposition 4.2 with a probability below 50 (minimum response), whereas the responses of the academicians had a much wider range from 10 to 99. Most of the practitioner respondents believe that in the next decade it is likely or even very likely that use of an expert system for an audit task will accelerate the learning curve for inexperienced decision makers completing the task. The academicians, as a group, appear uncertain on this statement.

Note that no practitioner response to this statement is higher than 50. Either the practitioners believe that in a decade it is unlikely there will be a direct relationship between audit-related litigation and expert systems development, or the practitioners are naturally optimistic because most of them are using or developing systems at present.

**Proposition 5.6.** The likelihood that the development and use of expert systems for audit tasks will lead to a loss of prestige for firms relying heavily upon such systems is low according to the entire panel as a group, and according to the academician and practitioner sub-groups. There is little to note on this statement except that the range for both groups are relatively large and lie across the neutral (50%) probability mark. Despite the low means,
the responses range as high as 75 and 80. A low level of agreement exists within the panel for this statement during round one.

Proposition 5.7. Proposition 5.7 states

The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.

The academicians, as a group, indicate that this future event is unlikely. However, the responses of the academicians widely range from 10 to 75. The practitioners, on the other hand, appear to agree that this event is unlikely. Not only is the mean practitioner response 18 less than the mean academian response, the standard deviation is lower, and the range is smaller.

Propositions 2.2, 3.6, 5.2. These statements also yielded significant differences between the two groups. However, the standard deviations and the ranges of response of the two groups for each statement are similar. That, along with the fact that the mean responses for each statement fall on the same side of the neutral (50) response, means that the data for these statement does not lend itself to interesting interpretation of differences.

Table 5-4 contains descriptive statistics for all respondents on all statements for round one. The panel is divided in to academicians and practitioners and similar information by group is given in Table 5-5.
Table 5-4: Descriptive statistics for round one (all panelists).

<table>
<thead>
<tr>
<th>Proposition</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>25</td>
<td>71.24</td>
<td>24.02</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P0</td>
<td>33</td>
<td>79.00</td>
<td>17.12</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P1</td>
<td>33</td>
<td>61.70</td>
<td>21.64</td>
<td>20</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>33</td>
<td>56.12</td>
<td>24.27</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>32</td>
<td>62.31</td>
<td>16.68</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>32</td>
<td>59.34</td>
<td>23.08</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>30</td>
<td>40.57</td>
<td>23.24</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>33</td>
<td>46.18</td>
<td>23.30</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>31</td>
<td>49.68</td>
<td>24.39</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2</td>
<td>33</td>
<td>66.03</td>
<td>22.27</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.1</td>
<td>32</td>
<td>57.81</td>
<td>25.62</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.2</td>
<td>32</td>
<td>68.19</td>
<td>21.02</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>33</td>
<td>81.21</td>
<td>19.03</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>33</td>
<td>67.82</td>
<td>23.73</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.4</td>
<td>33</td>
<td>70.27</td>
<td>19.76</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P3</td>
<td>33</td>
<td>57.33</td>
<td>28.92</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P3.2</td>
<td>33</td>
<td>83.00</td>
<td>15.69</td>
<td>40</td>
<td>99</td>
</tr>
<tr>
<td>P3.3</td>
<td>31</td>
<td>77.45</td>
<td>16.85</td>
<td>40</td>
<td>99</td>
</tr>
<tr>
<td>P3.4</td>
<td>33</td>
<td>68.27</td>
<td>18.38</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P3.5</td>
<td>33</td>
<td>67.06</td>
<td>18.64</td>
<td>20</td>
<td>99</td>
</tr>
<tr>
<td>P3.6</td>
<td>33</td>
<td>37.36</td>
<td>24.64</td>
<td>1</td>
<td>95</td>
</tr>
<tr>
<td>P4</td>
<td>32</td>
<td>69.38</td>
<td>28.33</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P4.1</td>
<td>33</td>
<td>70.06</td>
<td>19.92</td>
<td>30</td>
<td>99</td>
</tr>
<tr>
<td>P4.2</td>
<td>33</td>
<td>68.00</td>
<td>24.05</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>P4.3</td>
<td>33</td>
<td>54.42</td>
<td>24.06</td>
<td>1</td>
<td>95</td>
</tr>
<tr>
<td>P5.2</td>
<td>30</td>
<td>33.48</td>
<td>23.52</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P5.3</td>
<td>31</td>
<td>31.00</td>
<td>25.26</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P5.4</td>
<td>32</td>
<td>52.38</td>
<td>26.55</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P5.5</td>
<td>33</td>
<td>34.88</td>
<td>23.24</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P5.6</td>
<td>33</td>
<td>24.64</td>
<td>21.80</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P5.7</td>
<td>32</td>
<td>31.03</td>
<td>19.13</td>
<td>1</td>
<td>75</td>
</tr>
</tbody>
</table>
Table 5-5: Descriptive statistics by profession for round one.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>StdDev</th>
<th>Min</th>
<th>Max</th>
<th>N</th>
<th>Mean</th>
<th>StdDev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>16</td>
<td>70.06</td>
<td>29.60</td>
<td>1</td>
<td>99</td>
<td>9</td>
<td>73.33</td>
<td>9.01</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td>P0</td>
<td>19</td>
<td>77.95</td>
<td>18.91</td>
<td>25</td>
<td>99</td>
<td>14</td>
<td>80.43</td>
<td>14.91</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P1</td>
<td>19</td>
<td>62.32</td>
<td>19.07</td>
<td>25</td>
<td>99</td>
<td>14</td>
<td>60.86</td>
<td>25.46</td>
<td>20</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>19</td>
<td>58.84</td>
<td>24.63</td>
<td>10</td>
<td>99</td>
<td>14</td>
<td>52.43</td>
<td>24.17</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>19</td>
<td>64.21</td>
<td>13.87</td>
<td>50</td>
<td>90</td>
<td>13</td>
<td>59.54</td>
<td>20.40</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>19</td>
<td>63.84</td>
<td>20.05</td>
<td>25</td>
<td>99</td>
<td>13</td>
<td>52.77</td>
<td>26.34</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>16</td>
<td>45.31</td>
<td>25.98</td>
<td>1</td>
<td>99</td>
<td>14</td>
<td>35.14</td>
<td>19.14</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>19</td>
<td>48.53</td>
<td>22.06</td>
<td>1</td>
<td>90</td>
<td>14</td>
<td>43.00</td>
<td>25.37</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>18</td>
<td>54.94</td>
<td>24.08</td>
<td>10</td>
<td>99</td>
<td>13</td>
<td>42.38</td>
<td>23.80</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P2</td>
<td>19</td>
<td>62.42</td>
<td>21.91</td>
<td>1</td>
<td>90</td>
<td>14</td>
<td>70.93</td>
<td>22.61</td>
<td>15</td>
<td>99</td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>59.17</td>
<td>25.51</td>
<td>1</td>
<td>99</td>
<td>14</td>
<td>56.07</td>
<td>26.62</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>61.67</td>
<td>13.39</td>
<td>30</td>
<td>95</td>
<td>14</td>
<td>76.57</td>
<td>21.83</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>19</td>
<td>83.53</td>
<td>14.14</td>
<td>50</td>
<td>99</td>
<td>14</td>
<td>78.07</td>
<td>24.41</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>19</td>
<td>69.74</td>
<td>16.29</td>
<td>50</td>
<td>90</td>
<td>14</td>
<td>65.21</td>
<td>31.73</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.4</td>
<td>19</td>
<td>76.00</td>
<td>14.97</td>
<td>45</td>
<td>99</td>
<td>14</td>
<td>62.50</td>
<td>23.19</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P3</td>
<td>19</td>
<td>59.89</td>
<td>27.48</td>
<td>10</td>
<td>99</td>
<td>14</td>
<td>53.86</td>
<td>31.46</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P3.2</td>
<td>19</td>
<td>79.21</td>
<td>17.71</td>
<td>40</td>
<td>99</td>
<td>14</td>
<td>88.14</td>
<td>11.05</td>
<td>75</td>
<td>99</td>
</tr>
<tr>
<td>P3.3</td>
<td>17</td>
<td>73.47</td>
<td>18.60</td>
<td>40</td>
<td>99</td>
<td>14</td>
<td>82.29</td>
<td>13.54</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P3.4</td>
<td>19</td>
<td>65.00</td>
<td>17.64</td>
<td>25</td>
<td>95</td>
<td>14</td>
<td>72.71</td>
<td>19.07</td>
<td>30</td>
<td>99</td>
</tr>
<tr>
<td>P3.5</td>
<td>19</td>
<td>64.68</td>
<td>19.58</td>
<td>20</td>
<td>99</td>
<td>14</td>
<td>70.29</td>
<td>17.46</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P3.6</td>
<td>19</td>
<td>45.79</td>
<td>23.70</td>
<td>10</td>
<td>95</td>
<td>14</td>
<td>25.93</td>
<td>21.73</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>74.28</td>
<td>20.43</td>
<td>25</td>
<td>99</td>
<td>14</td>
<td>63.07</td>
<td>35.94</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P4.1</td>
<td>19</td>
<td>69.16</td>
<td>19.86</td>
<td>30</td>
<td>99</td>
<td>14</td>
<td>71.29</td>
<td>20.68</td>
<td>35</td>
<td>99</td>
</tr>
<tr>
<td>P4.2</td>
<td>19</td>
<td>58.89</td>
<td>24.38</td>
<td>10</td>
<td>99</td>
<td>14</td>
<td>80.36</td>
<td>17.77</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P4.3</td>
<td>19</td>
<td>54.74</td>
<td>21.63</td>
<td>20</td>
<td>95</td>
<td>14</td>
<td>54.00</td>
<td>27.88</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P5.2</td>
<td>15</td>
<td>44.00</td>
<td>27.21</td>
<td>1</td>
<td>99</td>
<td>14</td>
<td>22.21</td>
<td>26.27</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>34.28</td>
<td>26.54</td>
<td>1</td>
<td>90</td>
<td>13</td>
<td>26.46</td>
<td>23.63</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P5.4</td>
<td>19</td>
<td>51.68</td>
<td>27.43</td>
<td>1</td>
<td>90</td>
<td>13</td>
<td>53.38</td>
<td>26.26</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>P5.5</td>
<td>19</td>
<td>39.00</td>
<td>20.62</td>
<td>1</td>
<td>75</td>
<td>14</td>
<td>29.29</td>
<td>26.13</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P5.6</td>
<td>19</td>
<td>30.79</td>
<td>17.02</td>
<td>10</td>
<td>75</td>
<td>14</td>
<td>16.29</td>
<td>25.26</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>38.89</td>
<td>18.11</td>
<td>10</td>
<td>75</td>
<td>14</td>
<td>20.93</td>
<td>15.74</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>
Descriptive Data Tables

For round one of the Delphi study, descriptive statistics of all statements were previously given for all respondents (Table 5-4), and for academicians only and practitioners only by group (Table 5-5). Similar tables are constructed below for rounds two and three. Table 5-6 provides descriptive statistics for all respondents on all statements for round two. Table 5-7 includes descriptive statistics for academician and practitioner respondents on all statements for round two. Round two data is not important, in itself, for the Delphi study discussion. It is given here for the benefit of the reader.

Round three information for all statements is given in Table 5-8 for the entire panel and Table 5-9 for academician and practitioner respondents. Table 5-10 contains a comparison of level of consensus (standard deviation) for all subjects. Note that table 5-10 identifies only four propositions whose round three standard deviations were higher than their round one standard deviations. Table 5-11 contains a comparison of range of responses for all subjects. No propositions resulted in wider ranges after three rounds than after one round.

Linstone [1975] states that, in most Delphis, consensus is assumed to have been achieved when a certain percentage of responses fall within a prescribed range such as when the
interquartile range is no larger than 20\% of the scale. This is interesting but ignores equally interesting information that might be derived from a bimodal or flat distribution. However, Linstone [1975] warns that there is no underlying statistical theory underlying such "measures" of consensus. Therefore, no true statistical level can be set. In the following section, consensus is discussed based on the standard deviations and range of responses of each proposition relative to the others.

Table 5-12 indicates that only ten of the thirty one propositions yielded interquartile ranges larger than twenty points. It is interesting to note that none of these eight larger interquartile ranges straddle the neutral 50, but rather all of them fall principally on one side of the scale. Therefore, the discussion of consensus or stability in the predictions found in the next section mentions consensus measures relative to the other propositions. However, most of the propositions appear to meet Linstone's [1975] rule-of-thumb for achieving consensus.
Table 5-6: Descriptive statistics for round two.

(round two)

<table>
<thead>
<tr>
<th>Proposi-tion</th>
<th>N</th>
<th>Standard Mean Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>28</td>
<td>73.00</td>
<td>19.62</td>
<td>25</td>
</tr>
<tr>
<td>P0</td>
<td>28</td>
<td>83.82</td>
<td>12.25</td>
<td>50</td>
</tr>
<tr>
<td>P1</td>
<td>28</td>
<td>61.14</td>
<td>20.32</td>
<td>25</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>28</td>
<td>61.71</td>
<td>18.87</td>
<td>25</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>28</td>
<td>60.14</td>
<td>18.35</td>
<td>25</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>27</td>
<td>61.07</td>
<td>18.27</td>
<td>1</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>27</td>
<td>40.96</td>
<td>21.41</td>
<td>1</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>28</td>
<td>46.00</td>
<td>21.37</td>
<td>1</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>28</td>
<td>51.96</td>
<td>16.96</td>
<td>15</td>
</tr>
<tr>
<td>P2</td>
<td>28</td>
<td>69.25</td>
<td>19.22</td>
<td>10</td>
</tr>
<tr>
<td>P2.1</td>
<td>27</td>
<td>60.19</td>
<td>24.44</td>
<td>1</td>
</tr>
<tr>
<td>P2.2</td>
<td>28</td>
<td>73.32</td>
<td>12.84</td>
<td>50</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>28</td>
<td>84.25</td>
<td>12.52</td>
<td>50</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>28</td>
<td>70.14</td>
<td>22.87</td>
<td>1</td>
</tr>
<tr>
<td>P2.4</td>
<td>28</td>
<td>72.82</td>
<td>19.55</td>
<td>1</td>
</tr>
<tr>
<td>P3</td>
<td>28</td>
<td>59.61</td>
<td>24.92</td>
<td>1</td>
</tr>
<tr>
<td>P3.2</td>
<td>28</td>
<td>88.75</td>
<td>10.79</td>
<td>60</td>
</tr>
<tr>
<td>P3.3</td>
<td>28</td>
<td>81.11</td>
<td>12.37</td>
<td>50</td>
</tr>
<tr>
<td>P3.4</td>
<td>28</td>
<td>67.07</td>
<td>15.86</td>
<td>30</td>
</tr>
<tr>
<td>P3.5</td>
<td>28</td>
<td>71.43</td>
<td>12.39</td>
<td>50</td>
</tr>
<tr>
<td>P3.6</td>
<td>28</td>
<td>38.93</td>
<td>21.92</td>
<td>1</td>
</tr>
<tr>
<td>P4</td>
<td>28</td>
<td>75.86</td>
<td>18.06</td>
<td>35</td>
</tr>
<tr>
<td>P4.1</td>
<td>28</td>
<td>74.00</td>
<td>17.11</td>
<td>35</td>
</tr>
<tr>
<td>P4.2</td>
<td>28</td>
<td>67.00</td>
<td>21.70</td>
<td>10</td>
</tr>
<tr>
<td>P4.3</td>
<td>28</td>
<td>55.39</td>
<td>22.23</td>
<td>1</td>
</tr>
<tr>
<td>P5.2</td>
<td>27</td>
<td>30.41</td>
<td>22.46</td>
<td>1</td>
</tr>
<tr>
<td>P5.3</td>
<td>28</td>
<td>26.43</td>
<td>20.43</td>
<td>1</td>
</tr>
<tr>
<td>P5.4</td>
<td>28</td>
<td>55.50</td>
<td>25.55</td>
<td>1</td>
</tr>
<tr>
<td>P5.5</td>
<td>28</td>
<td>32.11</td>
<td>19.55</td>
<td>1</td>
</tr>
<tr>
<td>P5.6</td>
<td>28</td>
<td>17.89</td>
<td>13.90</td>
<td>1</td>
</tr>
<tr>
<td>P5.7</td>
<td>27</td>
<td>30.81</td>
<td>17.17</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 5-7: Descriptive statistics by profession for round two.

<table>
<thead>
<tr>
<th>Prop</th>
<th>N</th>
<th>Mean</th>
<th>StdDev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>16</td>
<td>76.63</td>
<td>22.17</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P0</td>
<td>16</td>
<td>83.50</td>
<td>13.29</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P1</td>
<td>16</td>
<td>61.19</td>
<td>19.75</td>
<td>25</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>16</td>
<td>69.00</td>
<td>12.38</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>16</td>
<td>63.13</td>
<td>14.24</td>
<td>35</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>16</td>
<td>63.94</td>
<td>14.51</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>16</td>
<td>43.93</td>
<td>23.68</td>
<td>10</td>
<td>99</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>16</td>
<td>50.69</td>
<td>19.82</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>16</td>
<td>57.50</td>
<td>13.54</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>P2</td>
<td>16</td>
<td>67.50</td>
<td>20.66</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>P2.1</td>
<td>15</td>
<td>65.00</td>
<td>23.15</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.2</td>
<td>16</td>
<td>68.75</td>
<td>10.72</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>16</td>
<td>85.44</td>
<td>11.43</td>
<td>60</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>16</td>
<td>72.81</td>
<td>14.49</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P2.4</td>
<td>16</td>
<td>77.13</td>
<td>12.79</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P3</td>
<td>16</td>
<td>61.25</td>
<td>23.06</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>P3.2</td>
<td>16</td>
<td>87.81</td>
<td>11.48</td>
<td>60</td>
<td>99</td>
</tr>
<tr>
<td>P3.3</td>
<td>16</td>
<td>78.69</td>
<td>12.61</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P3.4</td>
<td>16</td>
<td>64.69</td>
<td>12.58</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P3.5</td>
<td>16</td>
<td>71.56</td>
<td>11.65</td>
<td>55</td>
<td>95</td>
</tr>
<tr>
<td>P3.6</td>
<td>16</td>
<td>44.63</td>
<td>22.46</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>P4</td>
<td>16</td>
<td>76.81</td>
<td>14.37</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P4.1</td>
<td>16</td>
<td>74.00</td>
<td>15.08</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P4.2</td>
<td>16</td>
<td>58.75</td>
<td>21.25</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>P4.3</td>
<td>16</td>
<td>57.81</td>
<td>16.93</td>
<td>30</td>
<td>90</td>
</tr>
<tr>
<td>P5.2</td>
<td>15</td>
<td>36.00</td>
<td>17.85</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>P5.3</td>
<td>16</td>
<td>29.81</td>
<td>22.96</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P5.4</td>
<td>16</td>
<td>51.25</td>
<td>24.73</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>P5.5</td>
<td>16</td>
<td>35.06</td>
<td>19.38</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P5.6</td>
<td>16</td>
<td>24.06</td>
<td>13.32</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>P5.7</td>
<td>15</td>
<td>39.33</td>
<td>15.45</td>
<td>10</td>
<td>75</td>
</tr>
</tbody>
</table>
Table 5-8: Descriptive statistics for round three.

<table>
<thead>
<tr>
<th>Proposition</th>
<th>N</th>
<th>Standard Mean</th>
<th>Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>18</td>
<td>74.83</td>
<td>17.15</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P0</td>
<td>18</td>
<td>83.44</td>
<td>9.98</td>
<td>70</td>
<td>99</td>
</tr>
<tr>
<td>P1</td>
<td>18</td>
<td>58.56</td>
<td>14.47</td>
<td>45</td>
<td>99</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>18</td>
<td>57.50</td>
<td>17.93</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>18</td>
<td>59.44</td>
<td>17.05</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>18</td>
<td>59.78</td>
<td>20.37</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>18</td>
<td>42.50</td>
<td>19.65</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>18</td>
<td>47.06</td>
<td>20.68</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>18</td>
<td>47.00</td>
<td>17.17</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>69.72</td>
<td>15.38</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>60.89</td>
<td>19.99</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>75.28</td>
<td>10.50</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>18</td>
<td>86.22</td>
<td>12.03</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>18</td>
<td>67.50</td>
<td>25.97</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P2.4</td>
<td>18</td>
<td>71.94</td>
<td>22.24</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P3</td>
<td>18</td>
<td>60.28</td>
<td>16.22</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>P3.2</td>
<td>18</td>
<td>90.28</td>
<td>7.29</td>
<td>75</td>
<td>99</td>
</tr>
<tr>
<td>P3.3</td>
<td>18</td>
<td>81.28</td>
<td>12.41</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P3.4</td>
<td>18</td>
<td>67.78</td>
<td>12.97</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>P3.5</td>
<td>18</td>
<td>76.39</td>
<td>10.54</td>
<td>60</td>
<td>95</td>
</tr>
<tr>
<td>P3.6</td>
<td>18</td>
<td>35.50</td>
<td>16.39</td>
<td>5</td>
<td>65</td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>75.67</td>
<td>15.32</td>
<td>35</td>
<td>99</td>
</tr>
<tr>
<td>P4.1</td>
<td>18</td>
<td>71.67</td>
<td>16.27</td>
<td>35</td>
<td>90</td>
</tr>
<tr>
<td>P4.2</td>
<td>18</td>
<td>68.89</td>
<td>12.67</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P4.3</td>
<td>18</td>
<td>50.61</td>
<td>24.90</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P5.2</td>
<td>18</td>
<td>31.61</td>
<td>21.41</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>28.28</td>
<td>22.99</td>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>P5.4</td>
<td>18</td>
<td>59.44</td>
<td>21.55</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P5.5</td>
<td>18</td>
<td>32.06</td>
<td>17.63</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>P5.6</td>
<td>18</td>
<td>16.06</td>
<td>12.22</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>29.22</td>
<td>12.96</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>
Table 5-9: Descriptive statistics by profession for round three.

<table>
<thead>
<tr>
<th>Prop</th>
<th>N</th>
<th>Mean</th>
<th>StdDev</th>
<th>Min</th>
<th>Max</th>
<th>N</th>
<th>Mean</th>
<th>StdDev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>9</td>
<td>78.11</td>
<td>19.25</td>
<td>50</td>
<td>99</td>
<td>9</td>
<td>71.56</td>
<td>15.18</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P0</td>
<td>9</td>
<td>84.89</td>
<td>10.13</td>
<td>70</td>
<td>99</td>
<td>9</td>
<td>82.00</td>
<td>10.22</td>
<td>75</td>
<td>99</td>
</tr>
<tr>
<td>P1</td>
<td>9</td>
<td>57.78</td>
<td>12.28</td>
<td>45</td>
<td>80</td>
<td>9</td>
<td>59.33</td>
<td>17.11</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P1.1</td>
<td>9</td>
<td>64.44</td>
<td>9.50</td>
<td>50</td>
<td>75</td>
<td>9</td>
<td>50.56</td>
<td>22.00</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>9</td>
<td>63.33</td>
<td>15.00</td>
<td>45</td>
<td>90</td>
<td>9</td>
<td>55.56</td>
<td>18.95</td>
<td>25</td>
<td>90</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>9</td>
<td>66.67</td>
<td>15.00</td>
<td>50</td>
<td>90</td>
<td>9</td>
<td>52.89</td>
<td>23.45</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>9</td>
<td>46.56</td>
<td>22.76</td>
<td>20</td>
<td>99</td>
<td>9</td>
<td>38.44</td>
<td>16.30</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>P1.2</td>
<td>9</td>
<td>56.11</td>
<td>10.83</td>
<td>45</td>
<td>80</td>
<td>9</td>
<td>38.00</td>
<td>24.64</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>9</td>
<td>54.44</td>
<td>12.36</td>
<td>30</td>
<td>75</td>
<td>9</td>
<td>39.56</td>
<td>18.69</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>P2.1</td>
<td>9</td>
<td>70.00</td>
<td>13.69</td>
<td>50</td>
<td>90</td>
<td>9</td>
<td>69.44</td>
<td>17.76</td>
<td>25</td>
<td>80</td>
</tr>
<tr>
<td>P2.2</td>
<td>9</td>
<td>68.89</td>
<td>12.69</td>
<td>50</td>
<td>90</td>
<td>9</td>
<td>52.39</td>
<td>23.32</td>
<td>1</td>
<td>75</td>
</tr>
<tr>
<td>P2.3</td>
<td>9</td>
<td>73.33</td>
<td>8.66</td>
<td>60</td>
<td>90</td>
<td>9</td>
<td>77.22</td>
<td>12.28</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P2.4</td>
<td>9</td>
<td>89.89</td>
<td>6.90</td>
<td>75</td>
<td>99</td>
<td>9</td>
<td>82.56</td>
<td>15.16</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>P2.4.1</td>
<td>9</td>
<td>80.44</td>
<td>14.29</td>
<td>50</td>
<td>99</td>
<td>9</td>
<td>82.11</td>
<td>11.02</td>
<td>60</td>
<td>99</td>
</tr>
<tr>
<td>P3.4</td>
<td>9</td>
<td>69.44</td>
<td>10.14</td>
<td>50</td>
<td>80</td>
<td>9</td>
<td>66.11</td>
<td>15.77</td>
<td>30</td>
<td>75</td>
</tr>
<tr>
<td>P3.5</td>
<td>9</td>
<td>76.11</td>
<td>9.28</td>
<td>60</td>
<td>95</td>
<td>9</td>
<td>76.67</td>
<td>12.25</td>
<td>60</td>
<td>90</td>
</tr>
<tr>
<td>P3.6</td>
<td>9</td>
<td>62.67</td>
<td>14.76</td>
<td>20</td>
<td>65</td>
<td>9</td>
<td>28.33</td>
<td>15.41</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>P4</td>
<td>9</td>
<td>76.67</td>
<td>9.35</td>
<td>65</td>
<td>90</td>
<td>9</td>
<td>74.67</td>
<td>20.23</td>
<td>35</td>
<td>99</td>
</tr>
<tr>
<td>P4.1</td>
<td>9</td>
<td>75.00</td>
<td>12.99</td>
<td>50</td>
<td>90</td>
<td>9</td>
<td>68.33</td>
<td>19.20</td>
<td>35</td>
<td>90</td>
</tr>
<tr>
<td>P4.2</td>
<td>9</td>
<td>67.78</td>
<td>13.72</td>
<td>50</td>
<td>80</td>
<td>9</td>
<td>70.00</td>
<td>12.25</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P4.3</td>
<td>9</td>
<td>55.00</td>
<td>20.62</td>
<td>10</td>
<td>80</td>
<td>9</td>
<td>46.22</td>
<td>29.15</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>P5.2</td>
<td>9</td>
<td>36.67</td>
<td>16.39</td>
<td>10</td>
<td>50</td>
<td>9</td>
<td>26.56</td>
<td>25.45</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>P5.3</td>
<td>9</td>
<td>34.00</td>
<td>26.51</td>
<td>1</td>
<td>90</td>
<td>9</td>
<td>22.56</td>
<td>18.62</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>P5.4</td>
<td>9</td>
<td>62.22</td>
<td>15.43</td>
<td>50</td>
<td>90</td>
<td>9</td>
<td>56.67</td>
<td>27.05</td>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>P5.5</td>
<td>9</td>
<td>34.56</td>
<td>16.79</td>
<td>1</td>
<td>60</td>
<td>9</td>
<td>29.56</td>
<td>19.09</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>P5.6</td>
<td>9</td>
<td>22.22</td>
<td>11.76</td>
<td>10</td>
<td>50</td>
<td>9</td>
<td>9.89</td>
<td>9.68</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>P5.7</td>
<td>9</td>
<td>37.78</td>
<td>10.93</td>
<td>25</td>
<td>50</td>
<td>9</td>
<td>20.67</td>
<td>8.53</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>
### Table 5-10  
Comparison of consensus measures:  
standard deviation, all rounds

<table>
<thead>
<tr>
<th>Propos-</th>
<th>Standard Deviation</th>
<th>R2-R1</th>
<th>R3-R2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Round 1</td>
<td>Round 2</td>
<td>Round 3</td>
</tr>
<tr>
<td>P</td>
<td>24.02</td>
<td>19.62</td>
<td>17.15</td>
</tr>
<tr>
<td>P0</td>
<td>17.12</td>
<td>12.25</td>
<td>9.98</td>
</tr>
<tr>
<td>P1</td>
<td>21.64</td>
<td>20.32</td>
<td>14.47</td>
</tr>
<tr>
<td>P1.1</td>
<td>24.27</td>
<td>18.87</td>
<td>17.93</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>16.68</td>
<td>18.35</td>
<td>17.05</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>23.08</td>
<td>18.27</td>
<td>20.37</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>23.24</td>
<td>21.41</td>
<td>19.65</td>
</tr>
<tr>
<td>P1.2</td>
<td>23.30</td>
<td>21.37</td>
<td>20.68</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>24.39</td>
<td>16.96</td>
<td>17.17</td>
</tr>
<tr>
<td>P2</td>
<td>22.27</td>
<td>19.22</td>
<td>15.38</td>
</tr>
<tr>
<td>P2.1</td>
<td>25.62</td>
<td>24.44</td>
<td>19.99</td>
</tr>
<tr>
<td>P2.2</td>
<td>21.02</td>
<td>12.84</td>
<td>10.50</td>
</tr>
<tr>
<td>P2.3</td>
<td>19.03</td>
<td>12.52</td>
<td>12.03</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>23.73</td>
<td>22.87</td>
<td>25.97</td>
</tr>
<tr>
<td>P2.4</td>
<td>19.76</td>
<td>19.55</td>
<td>22.24</td>
</tr>
<tr>
<td>P3</td>
<td>28.92</td>
<td>24.92</td>
<td>16.22</td>
</tr>
<tr>
<td>P3.2</td>
<td>15.69</td>
<td>10.79</td>
<td>7.29</td>
</tr>
<tr>
<td>P3.3</td>
<td>16.85</td>
<td>12.37</td>
<td>12.41</td>
</tr>
<tr>
<td>P3.4</td>
<td>18.38</td>
<td>15.86</td>
<td>12.97</td>
</tr>
<tr>
<td>P3.5</td>
<td>18.64</td>
<td>12.39</td>
<td>10.54</td>
</tr>
<tr>
<td>P3.6</td>
<td>24.64</td>
<td>21.92</td>
<td>16.39</td>
</tr>
<tr>
<td>P4</td>
<td>28.33</td>
<td>18.06</td>
<td>15.32</td>
</tr>
<tr>
<td>P4.1</td>
<td>19.92</td>
<td>17.11</td>
<td>16.27</td>
</tr>
<tr>
<td>P4.2</td>
<td>24.05</td>
<td>21.70</td>
<td>12.67</td>
</tr>
<tr>
<td>P4.3</td>
<td>24.06</td>
<td>22.23</td>
<td>24.90</td>
</tr>
<tr>
<td>P5.2</td>
<td>28.52</td>
<td>22.46</td>
<td>21.41</td>
</tr>
<tr>
<td>P5.3</td>
<td>25.26</td>
<td>20.43</td>
<td>22.99</td>
</tr>
<tr>
<td>P5.4</td>
<td>26.55</td>
<td>25.55</td>
<td>21.55</td>
</tr>
<tr>
<td>P5.5</td>
<td>23.24</td>
<td>19.55</td>
<td>17.63</td>
</tr>
<tr>
<td>P5.6</td>
<td>21.80</td>
<td>13.90</td>
<td>12.22</td>
</tr>
<tr>
<td>P5.7</td>
<td>19.13</td>
<td>17.17</td>
<td>12.96</td>
</tr>
</tbody>
</table>

* The standard deviation for responses to these statements had a net increase from the first round to the third round.
Table 5-11  Comparison of consensus measures: range of responses, all rounds

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Range of Responses</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R1</td>
<td>R2</td>
</tr>
<tr>
<td>P</td>
<td>98</td>
<td>74</td>
</tr>
<tr>
<td>P0</td>
<td>74</td>
<td>49</td>
</tr>
<tr>
<td>P1</td>
<td>79</td>
<td>74</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>89</td>
<td>74</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>98</td>
<td>65</td>
</tr>
<tr>
<td>P2</td>
<td>98</td>
<td>89</td>
</tr>
<tr>
<td>P2.1</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P2.2</td>
<td>74</td>
<td>49</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>98</td>
<td>49</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P2.4</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P3</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P3.2</td>
<td>59</td>
<td>35</td>
</tr>
<tr>
<td>P3.3</td>
<td>59</td>
<td>49</td>
</tr>
<tr>
<td>P3.4</td>
<td>74</td>
<td>69</td>
</tr>
<tr>
<td>P3.5</td>
<td>79</td>
<td>45</td>
</tr>
<tr>
<td>P3.6</td>
<td>94</td>
<td>89</td>
</tr>
<tr>
<td>P4</td>
<td>98</td>
<td>64</td>
</tr>
<tr>
<td>P4.1</td>
<td>69</td>
<td>64</td>
</tr>
<tr>
<td>P4.2</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>P4.3</td>
<td>94</td>
<td>89</td>
</tr>
<tr>
<td>P5.2</td>
<td>98</td>
<td>74</td>
</tr>
<tr>
<td>P5.3</td>
<td>89</td>
<td>89</td>
</tr>
<tr>
<td>P5.4</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>P5.5</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>P5.6</td>
<td>79</td>
<td>59</td>
</tr>
<tr>
<td>P5.7</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>Proposition</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>-------------</td>
<td>-----</td>
<td>------</td>
</tr>
<tr>
<td>P</td>
<td>65</td>
<td>90</td>
</tr>
<tr>
<td>P0</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>P1</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>P1.1.1</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>P1.1.3</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>35</td>
<td>50</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>P2</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>P2.1</td>
<td>55</td>
<td>75</td>
</tr>
<tr>
<td>P2.2</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>80</td>
<td>95</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>P2.4</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>P3</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>P3.2</td>
<td>85</td>
<td>99</td>
</tr>
<tr>
<td>P3.3</td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td>P3.4</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>P3.5</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>P3.6</td>
<td>20</td>
<td>50</td>
</tr>
<tr>
<td>P4</td>
<td>70</td>
<td>85</td>
</tr>
<tr>
<td>P4.1</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>P4.2</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>P4.3</td>
<td>50</td>
<td>70</td>
</tr>
<tr>
<td>P5.2</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>P5.3</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>P5.4</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>P5.5</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>P5.6</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>P5.7</td>
<td>25</td>
<td>40</td>
</tr>
</tbody>
</table>

* indicates width of interquartile range is greater than twenty
Round Three

As stated in Chapter 4, the purpose of the Delphi study is to identify the most likely impacts of expert systems on auditing, and to gain a better understanding of why these effects may occur. Therefore, round three or final round responses are the focus of the Delphi study. These responses either show the group moving toward consensus or exhibit a relative lack of consensus concerning the probability of each event or statement. This identifies the events that are most or least likely according to the Delphi panel, and also discloses whether the panel was in general agreement concerning the probability of occurrence. The rationales give insight into the reasons for the predictions and the implications of them. In other words, the rationales answer the question "Why?"

First, the impacts identified as most or least likely are discussed. Second, the overall results of the Delphi study are discussed in the order of the categories of propositions as given in chapter 3 (elemental, efficiency, effectiveness, expertise, education) and as listed in Table 5-8. The rationales are given in this order in Appendix B.

The third round Delphi survey yielded eighteen usable responses; fifty-five percent of those originally agreeing to participate in the study completed all three rounds.
Only the response data for those who completed the third round are included in the following discussion.

Of the eighteen participants comprising the Delphi panel, nine are academicians, and nine are employed by Big Six accounting firms. Two of the panelists are female and sixteen are male.

The academicians represent eight universities. Five categorize themselves as accounting and auditing professors, and four as accounting/management information systems professors.

Of the panelists employed by Big Six firms (henceforth, the "practitioners"), three are partners and six are managers or senior managers. Of these nine practitioners, one characterized himself as a knowledge engineer, one is a computer scientist, one is an executive partner, and the rest describe themselves as practicing auditors. The nine practitioners represent three of the Big Six firms.

Collectively, the subjects include fourteen Certified Public Accountants, one Certified Management Accountant, and one Certified Information Systems Auditor. Nine of the respondents have received doctorates (note that one of the panelists possessing a doctorate is not an academician), two hold masters degrees, and the rest, bachelors degrees. The subjects hail from eight states, the District of Columbia, and one Canadian province.
Of the eighteen Delphi panelists, thirteen indicated that they have been or are directly involved in auditing, six in teaching auditing, nine in auditing research, twelve in research in expert systems development, six in research in expert systems impacts, eleven using expert systems, and eight involved in training staff auditors. Other special activities in which the panelists are or have been involved include EDP auditing, audit judgment research, development of knowledge acquisition tools, teaching expert systems, coordinating training and implementation of expert systems in a Big Six office, and developing a specific expert system for a Big Six firm.

As each set of propositions is discussed the expert panel's mean response, range of responses, and standard deviation is mentioned. To facilitate the discussion, the descriptive statistics have been resorted by mean, standard deviation, and range, in Tables 5-13, 5-14, and 5-15, respectively.

The Most Likely Impacts

The mean response of the Delphi panel was above 75 for seven of the thirty-one propositions. The most likely impact is that stated in Proposition 3.2.

The use of an expert system for an audit task provides documentation references for audit judgements and reasoning concerning the task.
<table>
<thead>
<tr>
<th>Proposition</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Scale Label³</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3.2</td>
<td>18</td>
<td>90.28</td>
<td>7.29</td>
<td>75</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.3.1</td>
<td>18</td>
<td>86.22</td>
<td>12.03</td>
<td>50</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>18</td>
<td>83.44</td>
<td>9.98</td>
<td>70</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td>18</td>
<td>81.28</td>
<td>12.41</td>
<td>50</td>
<td>99</td>
<td>very</td>
</tr>
<tr>
<td>P3.5</td>
<td>18</td>
<td>76.39</td>
<td>10.54</td>
<td>60</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>75.67</td>
<td>15.32</td>
<td>35</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>75.28</td>
<td>10.50</td>
<td>50</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>18</td>
<td>74.83</td>
<td>17.15</td>
<td>50</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.4</td>
<td>18</td>
<td>71.94</td>
<td>22.24</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P4.1</td>
<td>18</td>
<td>71.67</td>
<td>16.27</td>
<td>35</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>69.72</td>
<td>15.38</td>
<td>25</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P4.2</td>
<td>18</td>
<td>68.89</td>
<td>12.67</td>
<td>50</td>
<td>90</td>
<td>likely</td>
</tr>
<tr>
<td>P3.4</td>
<td>18</td>
<td>67.78</td>
<td>12.97</td>
<td>30</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>P2.3.2</td>
<td>18</td>
<td>67.50</td>
<td>25.97</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>60.89</td>
<td>19.99</td>
<td>1</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>18</td>
<td>60.28</td>
<td>16.22</td>
<td>25</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>P1.1.3</td>
<td>18</td>
<td>59.78</td>
<td>20.37</td>
<td>1</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P5.4</td>
<td>18</td>
<td>59.44</td>
<td>21.55</td>
<td>1</td>
<td>99</td>
<td>slightly</td>
</tr>
<tr>
<td>P1.1.2</td>
<td>18</td>
<td>59.44</td>
<td>17.05</td>
<td>25</td>
<td>90</td>
<td>likely</td>
</tr>
<tr>
<td>P1</td>
<td>18</td>
<td>58.56</td>
<td>14.47</td>
<td>45</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P1.1.1</td>
<td>18</td>
<td>57.50</td>
<td>17.93</td>
<td>25</td>
<td>90</td>
<td>neutral</td>
</tr>
<tr>
<td>P4.3</td>
<td>18</td>
<td>50.61</td>
<td>24.90</td>
<td>1</td>
<td>80</td>
<td>slightly</td>
</tr>
<tr>
<td>P1.2.1</td>
<td>18</td>
<td>47.06</td>
<td>20.68</td>
<td>1</td>
<td>80</td>
<td>slightly</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>18</td>
<td>47.00</td>
<td>17.17</td>
<td>1</td>
<td>75</td>
<td>unlikely</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>18</td>
<td>42.50</td>
<td>19.65</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P3.6</td>
<td>18</td>
<td>35.50</td>
<td>16.39</td>
<td>5</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>P5.5</td>
<td>18</td>
<td>32.06</td>
<td>17.63</td>
<td>1</td>
<td>60</td>
<td>unlikely</td>
</tr>
<tr>
<td>P5.2</td>
<td>18</td>
<td>31.61</td>
<td>21.41</td>
<td>1</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>29.22</td>
<td>12.96</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>28.28</td>
<td>22.99</td>
<td>1</td>
<td>90</td>
<td>very</td>
</tr>
<tr>
<td>P5.6</td>
<td>18</td>
<td>16.06</td>
<td>12.22</td>
<td>1</td>
<td>50</td>
<td>unlikely</td>
</tr>
</tbody>
</table>

³The scale labels come almost directly from the scale given on the survey instrument. However, in order for more accurate relative descriptions in the narrative the "likely" and "unlikely" labels from the scale have been subdivided with those mean responses between 1 and 10 points distant from neutral 50 relabeled as "slightly likely" and "slightly unlikely." Further, any mean response within one point of the neutral 50 response is considered as "either way" or neutral.
Table 5-14: Round three descriptive statistics sorted by standard deviation.

<table>
<thead>
<tr>
<th>Proposition</th>
<th>N</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Level of Consensus</th>
</tr>
</thead>
<tbody>
<tr>
<td>P3.2</td>
<td>18</td>
<td>90.28</td>
<td>7.29</td>
<td></td>
<td>75</td>
<td>99</td>
</tr>
<tr>
<td>P0</td>
<td>18</td>
<td>83.44</td>
<td>9.98</td>
<td>70</td>
<td>99</td>
<td>very</td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>75.28</td>
<td>10.50</td>
<td>50</td>
<td>90</td>
<td>high</td>
</tr>
<tr>
<td>P1.3</td>
<td>18</td>
<td>76.39</td>
<td>10.54</td>
<td>60</td>
<td>95</td>
<td>high</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>18</td>
<td>86.22</td>
<td>12.03</td>
<td>50</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P5.6</td>
<td>18</td>
<td>16.06</td>
<td>12.22</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td>18</td>
<td>81.28</td>
<td>12.41</td>
<td>50</td>
<td>99</td>
<td>high</td>
</tr>
<tr>
<td>P4.2</td>
<td>18</td>
<td>68.89</td>
<td>12.67</td>
<td>50</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>29.22</td>
<td>12.96</td>
<td>1</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P3.4</td>
<td>18</td>
<td>67.78</td>
<td>12.97</td>
<td>30</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>18</td>
<td>58.56</td>
<td>14.47</td>
<td>45</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>75.67</td>
<td>15.32</td>
<td>35</td>
<td>99</td>
<td>moderate</td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>69.72</td>
<td>15.38</td>
<td>25</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>18</td>
<td>60.28</td>
<td>16.22</td>
<td>25</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>P4.1</td>
<td>18</td>
<td>71.67</td>
<td>16.27</td>
<td>35</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P3.6</td>
<td>18</td>
<td>35.50</td>
<td>16.39</td>
<td>5</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>P1.1.2</td>
<td>18</td>
<td>59.44</td>
<td>17.05</td>
<td>25</td>
<td>90</td>
<td>fair</td>
</tr>
<tr>
<td>P1.2.2</td>
<td>18</td>
<td>47.00</td>
<td>17.17</td>
<td>1</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>P5.5</td>
<td>18</td>
<td>32.06</td>
<td>17.63</td>
<td>1</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>P1.1.1</td>
<td>18</td>
<td>57.50</td>
<td>17.93</td>
<td>25</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P1.1.4</td>
<td>18</td>
<td>42.50</td>
<td>19.65</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>60.89</td>
<td>19.99</td>
<td>1</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P1.1.3</td>
<td>18</td>
<td>59.78</td>
<td>20.37</td>
<td>1</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P1.2.1</td>
<td>18</td>
<td>47.06</td>
<td>20.68</td>
<td>1</td>
<td>80</td>
<td>low</td>
</tr>
<tr>
<td>P5.2</td>
<td>18</td>
<td>31.61</td>
<td>21.41</td>
<td>1</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>P5.4</td>
<td>18</td>
<td>59.44</td>
<td>21.55</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P2.4</td>
<td>18</td>
<td>71.94</td>
<td>22.24</td>
<td>1</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>28.28</td>
<td>22.99</td>
<td>1</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>P4.3</td>
<td>18</td>
<td>50.61</td>
<td>24.90</td>
<td>1</td>
<td>80</td>
<td>very</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>18</td>
<td>67.50</td>
<td>25.97</td>
<td>1</td>
<td>99</td>
<td>low</td>
</tr>
</tbody>
</table>

4 The level of consensus labels are given as a means of identifying the level of consensus for a particular proposition relative to the rest of the propositions. These subdivisions are creations of the author.
Table 5-15: Round three descriptive statistics sorted by range.

ALL SUBJECTS (round three) sorted by range

| Proposition | N  | Mean Standard Deviation | Minimum | Maximum | Range | mi-ma | Described
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P3.2</td>
<td>18</td>
<td>90.28</td>
<td>7.29</td>
<td>75</td>
<td>99</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>18</td>
<td>83.44</td>
<td>9.98</td>
<td>70</td>
<td>99</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>P3.5</td>
<td>18</td>
<td>76.39</td>
<td>10.54</td>
<td>60</td>
<td>95</td>
<td>35</td>
<td>narrow</td>
</tr>
<tr>
<td>P4.2</td>
<td>18</td>
<td>68.89</td>
<td>12.67</td>
<td>50</td>
<td>90</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>75.28</td>
<td>10.50</td>
<td>50</td>
<td>90</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>29.22</td>
<td>12.96</td>
<td>1</td>
<td>50</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>18</td>
<td>74.83</td>
<td>17.15</td>
<td>50</td>
<td>99</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>P5.6</td>
<td>18</td>
<td>16.06</td>
<td>12.22</td>
<td>1</td>
<td>50</td>
<td>49</td>
<td>narrow</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>18</td>
<td>86.22</td>
<td>12.03</td>
<td>50</td>
<td>99</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td>18</td>
<td>81.23</td>
<td>12.41</td>
<td>50</td>
<td>99</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>P3.4</td>
<td>18</td>
<td>67.78</td>
<td>12.97</td>
<td>30</td>
<td>80</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>18</td>
<td>58.56</td>
<td>14.47</td>
<td>45</td>
<td>99</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>P4.1</td>
<td>18</td>
<td>71.67</td>
<td>16.27</td>
<td>35</td>
<td>90</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>18</td>
<td>60.28</td>
<td>16.22</td>
<td>25</td>
<td>80</td>
<td>55</td>
<td>medium</td>
</tr>
<tr>
<td>P5.2</td>
<td>18</td>
<td>31.61</td>
<td>21.41</td>
<td>1</td>
<td>60</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>P5.5</td>
<td>18</td>
<td>32.06</td>
<td>17.63</td>
<td>1</td>
<td>60</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>P3.6</td>
<td>18</td>
<td>35.50</td>
<td>16.39</td>
<td>5</td>
<td>65</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>75.67</td>
<td>15.32</td>
<td>35</td>
<td>99</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>P1.1.1</td>
<td>18</td>
<td>57.50</td>
<td>17.93</td>
<td>25</td>
<td>90</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>69.72</td>
<td>15.38</td>
<td>25</td>
<td>90</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>P1.1.2</td>
<td>18</td>
<td>59.44</td>
<td>17.05</td>
<td>25</td>
<td>90</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>P1.2.2</td>
<td>18</td>
<td>47.00</td>
<td>17.17</td>
<td>1</td>
<td>75</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>P1.2.1</td>
<td>18</td>
<td>47.06</td>
<td>20.68</td>
<td>1</td>
<td>80</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>P4.3</td>
<td>18</td>
<td>50.61</td>
<td>24.90</td>
<td>1</td>
<td>80</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>60.89</td>
<td>19.99</td>
<td>1</td>
<td>90</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>P1.1.3</td>
<td>18</td>
<td>59.78</td>
<td>20.37</td>
<td>1</td>
<td>90</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>28.28</td>
<td>22.99</td>
<td>1</td>
<td>90</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>P2.4</td>
<td>18</td>
<td>71.94</td>
<td>22.24</td>
<td>1</td>
<td>99</td>
<td>98</td>
<td>very</td>
</tr>
<tr>
<td>P5.4</td>
<td>18</td>
<td>59.44</td>
<td>21.55</td>
<td>1</td>
<td>99</td>
<td>98</td>
<td>wide</td>
</tr>
<tr>
<td>P1.1.4</td>
<td>18</td>
<td>42.50</td>
<td>19.65</td>
<td>1</td>
<td>99</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>P2.3.2</td>
<td>18</td>
<td>67.50</td>
<td>25.97</td>
<td>1</td>
<td>99</td>
<td>98</td>
<td></td>
</tr>
</tbody>
</table>

The range descriptions are given as a means of comparing the range of responses for a particular proposition relative to the ranges of the rest of the propositions. These subdivisions are creations of the author.
Not only did this proposition receive the highest mean response, but it also yielded the lowest standard deviation and the smallest range. So, the members of the panel strongly agree that this proposition is "very likely".

The fourth and fifth most likely propositions were also from the expertise category.

P 3.3 The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.

P 3.5 The use of an expert system for an audit task results in an increased ability to handle complex analyses.

The mean response for these propositions was 81.28 and 76.39, respectively. For proposition 3.5, the level of consensus was "very high" (SD = 10.54), and the range of responses was "very narrow." The level of consensus for proposition 3.3 was "high" (SD = 12.41), and the range of responses was "narrow".

The second most likely impact is from the effectiveness category (Proposition 2.3.1).

The use of an expert system for an audit task improves decision consistency for that particular task.

The mean Delphi panel response for this proposition was 86.22. A "high" level of consensus is indicated by a standard deviation of 12.03 and a "narrow" range of responses.

Another proposition from the effectiveness category was identified as very likely. The seventh most likely proposition was P2.2.
The use of an expert system for an audit task improves audit task decision quality.

The mean panel response was 75.28. The level of consensus was "very high" (SD = 10.50) and the range of responses was "very narrow".

The third most likely proposition was the elemental proposition (P0).

Expert systems will have an impact on auditing firms in the next two decades.

Obviously, the panel finds this event "very likely" with a mean response of 83.44, a "very high" level of consensus (SD = 9.98, the second highest of the study), and a "very narrow" range of responses.

The remaining proposition to receive a mean response above 75 was the main proposition concerning education.

P 4 The use of expert systems in auditing impacts the education of auditors.

The mean panel response for P4 was 75.67, "very likely."

However, the level of consensus was "moderate" (SD = 15.32), and the range of responses was "medium", ranging from 25 to 90.

The Least Likely Impact

Only one proposition received a mean panel response below 25. Proposition 5.6 states

The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.
With a mean panel response of 16.06, the panel indicated that this occurrence is "very unlikely." In fact, of all the events and trends described in the propositions, this one is the least likely. The level of consensus was "high" (SD = 12.22), and the range of responses was "narrow."

Note that the maximum response to this statement was 50. That is, no individual panelist believed that a loss of prestige was a likely result for firms relying heavily on expert systems. A review of the rationales given for this proposition reveals that most of the respondents believe the reverse of this proposition is more likely. In other words, a firm that uses expert systems heavily will be regarded as "on the cutting edge" of technology, which will enhance, not decrease, the firm's prestige.

In this section, the most and least likely propositions were briefly discussed. In the following sections all of the propositions are discussed in the order of the appearance of each category in Chapter 3.

**Expert Systems in the Year 2001**

Only one statement included in the survey was not derived from the propositions of chapter 3 (listed in the tables as "P"). This statement embodies the purpose the study, i.e. to identify the most likely impacts of expert systems on auditing firms in the next decade. According to this statement...
Expert systems for auditing tasks will be widely available and utilized by the year 2001.

The mean probability of this event occurring, according to the panel of experts, is 74.83%. On the survey scale, this is between "likely" and "very likely." Consensus indicators exhibit a "fair" level of consensus with a standard deviation of 17.15.6

The range of the responses is more interesting, indicating that all responses were between 50 and 99, inclusive. That is, none of the subjects believe that this statement represents an unlikely event. The most pessimistic response was 50% (i.e. either way). Therefore, the panel believes that it is likely that expert systems for auditing tasks will be widely available and utilized by the year 2001.

In their rationales, some of the panelists argued that it is likely that expert systems for auditing tasks will be utilized by the year 2001, but argued that "wide availability" will take more time, especially for the non-Big Six firms. However, most of the rationales given by the panelists supported the high probabilities given for this

---

6 For the purpose of discussion, standard deviations (SD) are described according to the relative consensus indicated. E.g. SD < 12 indicates very high consensus, SD between 12 and 14 indicates high consensus, SD between 14 and 16 represents a moderate level of consensus, SD between 16 and 18 indicates a fair level of consensus, SD between 18 and 24 indicates poor consensus, and SD > 24 indicates very low consensus.
proposition. Some of these rationales explaining why the panel believes this trend is likely are reproduced here.

- Limited resources and increasing degree of competition among accounting firms.
- Simple cases can be handled by ES faster, which allows auditors to focus on more complex cases.
- Auditing firms will be further driven to increase automation to reduce costs.
- Much of auditing involves applying logic to known data.
- Cost and quality pressures will demand it, but it will be difficult to model complex judgments.
- Capability exists today; it will replace human analysis and judgment in areas of routine and large masses of data.
- The growing body of technical literature and complexity, offset by limited resources.
- Expert systems development should mature by this time making them more available to auditors.
- Because of its use in unstructured decisions and because of cost/time savings. Quite a few systems are already becoming available.

According to the Delphi panel, this impact is likely because of increased competition for auditing services, increasing complexity of the audit tasks, firms' limited resources, and pressures to increase quality while minimizing costs.

The Elemental Proposition

The elemental proposition (P0) states that expert systems will have an impact on auditing firms in the next two decades.

This statement is elemental because if there is no impact of expert systems on auditing firms in the next two decades, then not only are the rest of the Delphi statements meaningless, but also the effort and capital poured into expert systems development and use would be better utilized elsewhere.
Fortunately for this study, the mean probability estimate of the Delphi panel for PO is 83.44. This is the third highest mean response for all thirty-one statements. The standard deviation of 9.98 indicates a very "high level" of consensus (the second highest in the study). This is confirmed by a "very narrow" range of responses, also the second narrowest. All probability predictions for the elemental proposition were between 70 and 99.

The vast majority of the rationales indicate a number of reasons why expert systems used for auditing task will have an impact on auditing firms in the next decade.

- A competitive tool and will evolve into a labor saving tool.
- ES will become the competitive edge. Also serve to deal more effectively with increasingly complex issues.
- Will help insure consistency of complex decision making.
- Increasing impact as time progresses and professionals become used to such systems.
- Most definitely - human resources are limited.
- More efficient use of resources.
- Can change the structure of the firms significantly, if used. Also some potential for new competition.
- In a competitive market place it will impact those who use an expert system and those who do not.
- Will affect competition - also task structure/audit planning.
- More efficient use of resources.
- ES are good decision aids. They can audit more data, more consistently, and do planning more efficiently.
- Saves time; cost; uniformity of decisions.
- Portable computing power is increasing and ES are better understood and more implementable by mainstream developers.
- Very cost beneficial, ensures consistency and quality.
- Should allow for lower staff levels to perform higher level tasks and learn from the process. ESs are/should be a way of preserving the expertise of highly experienced professionals.
- Improves audit planning and judgment, and therefore effectiveness; ultimately helping efficiency.
- Certain auditing tasks involve the analysis of conditions to arrive at conclusions (i.e. risk analysis (both audit and business), analytics, tax planning, disclosure selection, etc.). Utilizing expert systems correctly can enhance the quality and efficiency in these processes. I believe all international firms will eventually arrive at this conclusion.
- As a means to ensure uniform firm-wide standard of performance.
- Expert systems offer a meaningful way to standardize judgmental tasks. Increasing pressure will be experienced to force such standardization.
Continued concern on business failures, etc. require the auditor to reduce detection risk further. Expert systems will be used to "assist" the auditor.

In the minority, a few panelists argued that there will be an impact but the nature and amount of that impact is difficult to predict. One panelist argued that the impact will be detrimental.

Overall, the group of Delphi panelists indicates that expert systems will very likely have an impact on auditing firms in the next two decades. The panel is in relatively high agreement on this point. According to the rationales, this impact is very likely because the use of expert systems will reduce risk; ensure uniformity, quality, efficiency, and consistency; preserve expertise; save labor, time, and money; and provide a competitive advantage.

The Efficiency Propositions

The efficiency propositions concern personnel productivity and decision unit characteristics. To assist the discussion, the propositions in this group are reproduced in Table 5-16 and the Delphi results for the group are summarized in Table 5-17.

The mean responses for the efficiency propositions all fall in the gray area around the neutral response of 50. For all seven of these propositions, the mean response of the panel is within 10 points above or below 50. By ranking the mean responses on all statements, it is evident that the
Table 5-16: Efficiency propositions.

<table>
<thead>
<tr>
<th>Category</th>
<th>P.Number</th>
<th>Proposition (Statement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFFICIENCY</td>
<td>P 1</td>
<td>The use of an expert system for an audit task improves the overall efficiency of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>performance of the task.</td>
</tr>
<tr>
<td>Personnel</td>
<td>P 1.1.1</td>
<td>The use of an expert system for an audit task reduces the need for staff time on the task.</td>
</tr>
<tr>
<td>Productivity</td>
<td>P 1.1.2</td>
<td>The use of an expert system for an audit task reduces the time required to make</td>
</tr>
<tr>
<td></td>
<td></td>
<td>audit decisions related to the task.</td>
</tr>
<tr>
<td></td>
<td>P 1.1.3</td>
<td>The use of an expert system for an audit task reduces the time required to authorize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>proposed actions relevant to the task.</td>
</tr>
<tr>
<td></td>
<td>P 1.1.4</td>
<td>The use of an expert system for an audit task results in less of the auditing division's</td>
</tr>
<tr>
<td></td>
<td></td>
<td>time being absorbed in decision-related meetings.</td>
</tr>
<tr>
<td>Decision Unit</td>
<td>P 1.2.1</td>
<td>The use of an expert system for an audit task reduces the number of organizational</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td>levels involved in authorizing proposed task related actions.</td>
</tr>
<tr>
<td></td>
<td>P 1.2.2</td>
<td>The use of an expert system for an audit task reduces the number and variety of members</td>
</tr>
<tr>
<td></td>
<td></td>
<td>comprising the traditional face-to-face task decision unit.</td>
</tr>
<tr>
<td>Proposition</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>-------------</td>
<td>----</td>
<td>-------</td>
</tr>
<tr>
<td>1</td>
<td>18</td>
<td>58.56</td>
</tr>
<tr>
<td>1.1.1</td>
<td>18</td>
<td>57.50</td>
</tr>
<tr>
<td>1.1.2</td>
<td>18</td>
<td>59.44</td>
</tr>
<tr>
<td>1.1.3</td>
<td>18</td>
<td>59.78</td>
</tr>
<tr>
<td>1.1.4</td>
<td>18</td>
<td>42.50</td>
</tr>
<tr>
<td>1.2.1</td>
<td>18</td>
<td>47.06</td>
</tr>
<tr>
<td>1.2.2</td>
<td>18</td>
<td>47.00</td>
</tr>
</tbody>
</table>
efficiency statements are all in the lower half [See Table 5-13].

All but one (P1) of the standard deviations for the efficiency responses fall in the fair to poor consensus range [See Table 5-14]. Also, all but one (P1) of the ranges of responses for the efficiency propositions have a wide range between 65 and 98. Therefore, for the lower level efficiency propositions (i.e. excluding P1), the panel as a group either believes the chance of occurrence is around 50-50, and the level of consensus on all six of these propositions is relatively "fair" to "low". The results of an ANOVA performed on the round three data comparing academician and practitioner responses are listed in Table 5-18. Significant differences at the .1 level are shown for propositions 1.2.1 and 1.2.2. If the alpha is raised to .15, proposition 1.1.1 also shows significant differences.

The rationales for each of the lower level efficiency propositions appear to be split into three groups. Roughly a third of the rationales support the likelihood of these propositions. Another third assert that these propositions are unlikely. The rest believe these propositions could go either way, because of lack of information or because of too many other variable being involved. The rationales for propositions 1.1.1 through 1.1.2 underline the lack of consensus in the Delphi panel for these issues (Rationales are reproduced in Appendix B).
TABLE 5-18: ANOVA results by profession, round three (N = 18, 9 academicians + 9 practitioners)

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Pr &lt; F</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>.4342</td>
<td></td>
</tr>
<tr>
<td>P0</td>
<td>.5555</td>
<td></td>
</tr>
<tr>
<td>P1</td>
<td>.8274</td>
<td></td>
</tr>
<tr>
<td>P1.1.1</td>
<td>.1013</td>
<td></td>
</tr>
<tr>
<td>P1.1.2</td>
<td>.3487</td>
<td></td>
</tr>
<tr>
<td>P1.1.3</td>
<td>.1571</td>
<td></td>
</tr>
<tr>
<td>P1.1.4</td>
<td>.3975</td>
<td></td>
</tr>
<tr>
<td>P1.2.1</td>
<td>.0606*</td>
<td></td>
</tr>
<tr>
<td>P1.2.2</td>
<td>.0635*</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>.9417</td>
<td></td>
</tr>
<tr>
<td>P2.1</td>
<td>.0895*</td>
<td></td>
</tr>
<tr>
<td>P2.2</td>
<td>.4487</td>
<td></td>
</tr>
<tr>
<td>P2.3.1</td>
<td>.2051</td>
<td></td>
</tr>
<tr>
<td>P2.3.2</td>
<td>.1967</td>
<td></td>
</tr>
<tr>
<td>P2.4</td>
<td>.0488**</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>.1307</td>
<td></td>
</tr>
<tr>
<td>P3.2</td>
<td>.9754</td>
<td></td>
</tr>
<tr>
<td>P3.3</td>
<td>.7853</td>
<td></td>
</tr>
<tr>
<td>P3.4</td>
<td>.6010</td>
<td></td>
</tr>
<tr>
<td>P3.5</td>
<td>.9150</td>
<td></td>
</tr>
<tr>
<td>P3.6</td>
<td>.0610*</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>.7912</td>
<td></td>
</tr>
<tr>
<td>P4.1</td>
<td>.4011</td>
<td></td>
</tr>
<tr>
<td>P4.2</td>
<td>.7217</td>
<td></td>
</tr>
<tr>
<td>P4.3</td>
<td>.4715</td>
<td></td>
</tr>
<tr>
<td>P5.2</td>
<td>.3313</td>
<td></td>
</tr>
<tr>
<td>P5.3</td>
<td>.1050</td>
<td></td>
</tr>
<tr>
<td>P5.4</td>
<td>.5999</td>
<td></td>
</tr>
<tr>
<td>P5.5</td>
<td>.5633</td>
<td></td>
</tr>
<tr>
<td>P5.6</td>
<td>.0272**</td>
<td></td>
</tr>
<tr>
<td>P5.7</td>
<td>.0019***</td>
<td></td>
</tr>
</tbody>
</table>

* * significant at .1
** significant at .05
*** significant at .01
Two items of interest should be considered here. First, the panel does not find the lower level efficiency propositions highly likely. This is contrary to much of the literature discussed in Chapter 3 that speculates and makes claims about the impact of expert systems on auditing firms and in general. A number of authors have supported the primacy of the impact of expert systems on personnel productivity and decision unit characteristics. Second, not only are the mean responses near neutral, relatively wide ranging responses and the widely divergent rationales indicate that the panelists do not agree on the actual probability.

Of the efficiency propositions, only P1 indicates a consensus level in the "moderate" range (standard deviation = 14.47). The panel does reach a reasonable level of consensus on this proposition relative to the other efficiency propositions. All of the probability predictions for P1 fall between 45 and 99 and the mean response is a "slightly likely" 58.56.

The rationales for proposition 1 fell more often on the likely side of the scale. However, a number of rationales mention the fact the ES could improve efficiency, but there

---

7 See, for example, Englard et al., 1989; Huber; 1990 Juras, 1989; Srim & Srinivasan, 1989; Sviokla, 1989; Shafer et al., 1988; AICPA, 1987; Bortchick, 1987; Borthick & West, 1987; Connell, 1987; Sviokla, 1986; and Elliott & Kielich, 1985.
are many moderating variables. Another group of rationales insists that the focus is on effectiveness and quality, not efficiency. A sample of the rationales from these three groups are given below.

ES improves overall efficiency because...

- Works through problem logically - not distracted by gray areas so much.
- Computer is programmed to assimilate input and go to the next step - computers are faster.
- Expert systems help the staff focus on key audit areas.
- ES should assist in the judgment process, but not make judgments. The task process may be better structured - procedurally - through ES. In this sense one might say overall efficiency is improved.
- Individuals utilize a standard approach which tends to increase efficiency.

ES might improve overall efficiency, but...

- For routine tasks - yes. For non-routine - no.
- They could - but could also slow down if you decide to override its suggestions.
- Unlikely in and of itself. Any increase in speed of completing tasks (made possible by the use of ES) will be offset by increased complexity of the task.
- It could, but it may actually slow down an expert who's able to jump to the key point without going through every step in the process.
- The inherent efficiency of using such a system may be offset by an increase on the comprehensiveness of the work being done.
- If efficiency means time reduction, probably not. Time would be used for other tasks.

ES more likely to improve effectiveness than efficiency because

- I distinguish efficiency and effectiveness from one another. I do not believe ES are efficient. A good ES may make up for being inefficient, however, by being consistently effective.
- Use of ES affects effectiveness and quality, more than a direct reduction of hours.
- Depends on the purpose of the system. May be used to improve quality.
- Efficiency may not necessarily be enhanced, but proper procedures are more likely to be performed.

While the majority of the panel believes that efficiency is likely to be improved by expert systems in the next decade, clearly the nature of this improvement is open to speculation. As one panelist said, "Efficiency is hard to measure when so many other variables are involved."
The Effectiveness Propositions

In contrast to the efficiency propositions, all of the effectiveness propositions fall in the upper half of the panel means for all propositions. In addition, all of these propositions are on the "likely" side of the probability scale; the lowest mean response for the effectiveness group is 60.89 (P 2.1). In light of the rationales given for propositions 1, it is not surprising that effectiveness impacts appear to be more likely than efficiency impacts of expert systems. The effectiveness propositions are reproduced in Table 5-19 and the Delphi results are summarized in Table 5-20.

Overall the consensus measures are trichotomous for the effectiveness propositions. Propositions 2.2 and 2.3.1 show a high level of agreement, the general effectiveness proposition (P2) appears in the middle of Table 5-13, and propositions 2.1, 2.4, and 2.3.2 show much lower standard deviations. The effectiveness propositions will be discussed in this general order.

Propositions 2.2 and 2.3.1 were discussed briefly in an earlier section because they were ranked seventh and second, respectively, in the overall ranking of propositions by the mean response of the panel. These propositions concern aspects of quality related to the audit task.
Table 5-19: Effectiveness propositions.

<table>
<thead>
<tr>
<th>Category</th>
<th>P. Number</th>
<th>Proposition (Statement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFFECTIVENESS</td>
<td>P 2</td>
<td>The use of expert systems improves the effectiveness of auditing.</td>
</tr>
<tr>
<td>Professional Judgment</td>
<td>P 2.1</td>
<td>The use of expert systems in auditing results in augmented professional judgement.</td>
</tr>
<tr>
<td>Decision Quality</td>
<td>P 2.2</td>
<td>The use of an expert system for an audit task improves audit task decision quality.</td>
</tr>
<tr>
<td>Quality Control</td>
<td>P 2.3.1</td>
<td>The use of an expert system for an audit task improves decision consistency for that particular task.</td>
</tr>
<tr>
<td></td>
<td>P 2.3.2</td>
<td>The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.</td>
</tr>
<tr>
<td>Standardization</td>
<td>P 2.4</td>
<td>The development and use of expert systems for audit tasks leads to the standardization of audit tasks.</td>
</tr>
<tr>
<td>Proposition</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>-------------</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>P2</td>
<td>18</td>
<td>69.72</td>
</tr>
<tr>
<td>P2.1</td>
<td>18</td>
<td>60.89</td>
</tr>
<tr>
<td>P2.2</td>
<td>18</td>
<td>75.28</td>
</tr>
<tr>
<td>P2.3.1</td>
<td>18</td>
<td>86.22</td>
</tr>
<tr>
<td>P2.3.2</td>
<td>18</td>
<td>67.50</td>
</tr>
<tr>
<td>P2.4</td>
<td>18</td>
<td>71.94</td>
</tr>
</tbody>
</table>
P 2.2  The use of an expert system for an audit task improves audit task decision quality.

P 2.3.1 The use of an expert system for an audit task improves decision consistency for that particular task.

The Delphi panel indicated by mean responses of 75.28 and 86.22, that both proposition 2.2 and 2.3.1 are very likely to occur in the next decade. The level of consensus was very high for proposition 2.2 (SD = 10.50), and high for proposition 2.3.1 (SD = 12.03). A high level of agreement is confirmed by a very narrow range of responses for P 2.2 and a narrow range of responses for P 2.3.1. In both cases, no panelist gave a prediction below 50 for either proposition 2.2 or 2.3.1.

The majority of the rationales for proposition 2.2 support the contention that quality will be improved by the use of an expert system. Here are some of the most descriptive rationales.

- It should improve staff level decisions - by keeping them better focused, eliminating extraneous information, and explaining the decision process.
- More thorough and consistent fact gathering and comprehensive review of literature.
- It should by making expertise more widely distributed.
- If by "improve" you mean "makes more consistent and complete" then yes.
- I think it gets staff level to focus better - not necessarily improve the end product - but instead eliminate extraneous information.
- Look at the task in a more systematic form.

A few of the rationales did express differing opinions. These are printed below.
- What we have now and what I expect that we will have for years to come would improve decision quality only for the novice and not overall for the firm.
- Depends on design and validation and type of decision. Research, e.g. Pincus, has shown the DSS applications in auditing may lower the effectiveness of the decision maker.
- Maybe, but if auditor just learns how to use the systems and relies on it too much, it may cause problems just as too much structure could be detrimental.
- Not necessarily - In the long run, increased use of ES will lead to decrease in decision quality as machines do more of our thinking.

The high level of consensus for proposition 2.3.1 is supported by the rationales. In fact, only one did not support the proposition.
- Decisions and judgments are made by humans. Use of ES does not necessarily improve decision consistency.

The other rationales supported the proposition of improved decision consistency. A few of these are reproduced here.
- A higher level of discipline is motive - both the ES and human aspect.
- Consistency will improve if a common tool is used.
- Due to structuredness of ES.
- If the same set of support information is used to arrive at a conclusion, the higher likelihood that the conclusions will be the same.
- Because documentation and information gathering consistency will be improved.

Overall the data and the rationales indicate that the Delphi panelists agree that expert systems are very likely to have a positive impact on quality in the next decade. Specifically, audit task decision quality and decision consistency will be improved through the use of an expert system.

Proposition 2 gives a positive, but not quite as strong, picture of the impact of expert systems on effectiveness. The mean panel response for proposition 2
was 69.72, making this the eleventh most probable trend to occur in the next ten years as a result of the use of expert systems. The level of consensus for this proposition was "moderate" (SD = 15.38), whereas the range of responses was relatively "wide", with a minimum response of 25 and a maximum response of 90. In responding to proposition 2, it appears that the panel's optimistic view of propositions 2.2 and 2.3.1 was somewhat offset by a slightly less confident view of propositions 2.4, 2.3.1, and 2.1.

One-third of the rationales for proposition 2 support the improvement of effectiveness.

- It provides a structured and well-thought approach.
- Reduces performance variance and bias.
- ES will tend to upgrade the performance of the less knowledgeable users.
- It can reduce the risk of "audit failures" or improper advice given by bringing a lot of information "to the table." However, most auditors (including myself) will tell you that audits as currently performed are satisfactorily effective.
- ES can keep staff level more focused on appropriate audit activities.

A slightly larger group of rationales also supports the proposition, but states that the system must be well-developed, designed, properly used with sound professional judgment. Only a few rationales support the view that ES use does not significantly impact effectiveness.

- It is the conduct of the audit process that determines the effectiveness of auditing, not computer software alone.
- Use alone will not improve effectiveness. Improvement in effectiveness will be dependent on the incorporation of the ES into the audit process.
- Efficiency, perhaps, effectiveness much more doubtful.

While the panel as a whole suggests that it is likely that efficiency will be impacted, the level of agreement
throughout the panel on this proposition is somewhat less than that for propositions 2.2 and 2.3.1.

Propositions 2.1, 2.3.2, and 2.4 all received a rating of "likely" on the probability scale according to the mean Delphi panel response. However, the level of consensus and range of responses for all three of these propositions are in the lower third of Tables 5-14 and 5-15. These propositions concern various aspects of effectiveness.

P2.1 The use of expert systems in auditing results in augmented professional judgement.

P2.3.2 The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.

P2.4 The development and use of expert systems for audit tasks leads to the standardization of audit tasks.

The level of consensus for propositions 2.1 and 2.4 was relatively "low" with standard deviations of 19.99 and 22.24. This is in not surprising considering the mean responses of the academician and practitioner groups differ significantly on both these propositions (See Table 5-18). The responses to proposition 2.3.2 yielded the lowest standard deviation of the entire study (2.3.2), which translates to a "very low" level of consensus. The ranges of responses for these three propositions were also ranked at the bottom. All three ranges were "very wide" and the responses for propositions 2.4 and 2.3.2 were the maximum possible on the probability scale (minimum response is 1, maximum response is 99).
The rationales for propositions 2.1, 2.3.2, and 2.4 are enlightening in that they illustrate the lack of consensus within the panel. The rationales run the gamut from strong support to strong opposition. A sample of rationales for proposition 2.1 illustrates this lack of unanimity.

- Allowing a firm to focus on a given task or a judgment area.
- A lot of real issues here. Generally yes if the systems are well developed with an eye toward comprehensive explanation facilities, users are well trained, and the system properly supported and maintained. A big IF.
- Professional judgment is a human function. ES can support; doubtful it can augment.
- Professional judgment is difficult to quantify.
- I don't think ES will improve professional judgments given that necessary information is available through other means.

While the trends of propositions 2.1, 2.3.2, and 2.4 are likely to occur in the next decade according to the Delphi panel mean response, the confidence in these predictions is much lower than the confidence in two-thirds of the other propositions, and certainly in the other three effectiveness propositions.

The Expertise Propositions

The expertise propositions concern the effect of expert systems use on the nature of the firm's expertise. These are listed in Table 5-21 and the Delphi results for the expertise propositions are summarized in Table 5-22. Overall, three of the six expertise propositions in the Delphi study determined "very likely" to occur, two were "likely" to occur, and one was ascertained "unlikely" to
Table 5-21: Expertise propositions.

<table>
<thead>
<tr>
<th>Category</th>
<th>Proposition (Statement)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EXPERTISE</strong></td>
<td></td>
</tr>
<tr>
<td>P 3</td>
<td>The use of expert systems in auditing impacts the nature of</td>
</tr>
<tr>
<td></td>
<td>the expertise of the firm.</td>
</tr>
<tr>
<td>Documentation</td>
<td></td>
</tr>
<tr>
<td>P 3.2</td>
<td>The use of an expert system for an audit task provides</td>
</tr>
<tr>
<td></td>
<td>documentation references for audit judgements and reasoning</td>
</tr>
<tr>
<td></td>
<td>concerning the task.</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
</tr>
<tr>
<td>P 3.3</td>
<td>The use of an expert system for an audit task results in the</td>
</tr>
<tr>
<td></td>
<td>distribution of expertise pertaining to the task within the</td>
</tr>
<tr>
<td></td>
<td>auditing firm.</td>
</tr>
<tr>
<td>New insights</td>
<td></td>
</tr>
<tr>
<td>P 3.4</td>
<td>The use of an expert system for an audit task allows</td>
</tr>
<tr>
<td></td>
<td>auditors to gain new insights into the decision process.</td>
</tr>
<tr>
<td>Complex analyses</td>
<td></td>
</tr>
<tr>
<td>P 3.5</td>
<td>The use of an expert system for an audit task results in an</td>
</tr>
<tr>
<td></td>
<td>increased ability to handle complex analyses.</td>
</tr>
<tr>
<td>Inhibition</td>
<td></td>
</tr>
<tr>
<td>P 3.6</td>
<td>The use of an expert system for an audit task inhibits the</td>
</tr>
<tr>
<td></td>
<td>development of task-related expertise by the users of the</td>
</tr>
<tr>
<td></td>
<td>system.</td>
</tr>
<tr>
<td>Proposition</td>
<td>N</td>
</tr>
<tr>
<td>-------------</td>
<td>---</td>
</tr>
<tr>
<td>P3</td>
<td>18</td>
</tr>
<tr>
<td>P3.2</td>
<td>18</td>
</tr>
<tr>
<td>P3.3</td>
<td>18</td>
</tr>
<tr>
<td>P3.4</td>
<td>18</td>
</tr>
<tr>
<td>P3.5</td>
<td>18</td>
</tr>
<tr>
<td>P3.6</td>
<td>18</td>
</tr>
</tbody>
</table>
occur. These propositions will be discussed in order of their mean panel response (overall likelihood of occurrence).

According to the Delphi panel, proposition 3.2 is the most likely impact of expert systems on auditing firms in the next decade.

P 3.2 The use of an expert system for an audit task provides documentation references for audit judgements and reasoning concerning the task. This proposition received the highest mean Delphi panel response (90.28), the highest level of consensus (SD = 7.29), and the narrowest range of responses (24). The minimum prediction for proposition 3.2 was 75, and the maximum was 99.

In addition to the high mean response, each of the panelists individually indicated that this trend is very likely to occur. The rationales bear this out. Of all the rationales provided in three rounds of the study only two strongly oppose this proposition.

- Only certain kind of knowledge can be documented. Also, the documented judgment and reasoning may be completely different from the actual human reasoning process.
- Often, recurring simple issues or issues specific to an industry are not documented in the work papers as they are not felt to be significant or unusual. Reports from expert systems typically also do not make such distinctions.

Some of the many rationales supporting proposition 3.2 indicated that this is a main function of expert systems.

- Since audit judgment and decision rules are pre-determined, they could easily be documented.
- This, to me, is the basic way that ES can improve and become more useful in an audit.
Facts and rationale are automatically documented.

Overall, there is widespread agreement among the panelists that the provision of documentation references by audit expert systems is practically assured in the next decade.

Proposition 3.5 addresses the expert system user's ability to execute complex analyses.

P 3.5 The use of an expert system for an audit task results in an increased ability to handle complex analyses.

The mean panel response for P 3.5 was 76.39, the fifth highest mean for the study, indicating the panel believes this trend is "very likely" to occur in the next decade. The members of the Delphi panel appear in agreement on this prediction. The level of consensus is also "very high" (SD = 10.54). This is the fourth highest level of consensus for all propositions. The range was very narrow, with a minimum response of 69 and a maximum response of 95. This was the third narrowest range of responses reported.

The majority of the rationales for proposition 3.5 support an increased ability to handle complex analyses. A sample of these is given below.

- If ES can aim ABM and if that is an example of complex analysis we handle only with ES, then who could disagree with the statement?
- It allows to break down the complex task.
- Easier for the ES to handle a multivariate environment.
- The complexity once captured becomes routine.
- To the extent a firm can leverage its knowledge, they may be able to undertake additional work. Individual ability may not improve with ES technology if not designed properly.
The responses of every member of the panel indicated that an increased ability to handle complex analyses was likely or very likely to result from the use of expert systems in the next decade. Consequently, there is agreement among the Delphi subjects that this trend will occur. Proposition 3.5 represents one of the five most likely impacts of expert systems on auditing firms.

The implication of proposition 3.3 is that the firm's best expertise is accessible to more of its auditors because of the use of expert systems.

P 3.3 The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.

The Delphi panel's mean response to this proposition was 81.28, signifying that they believe this trend is "very likely" to occur.

The agreement of the members of the Delphi panel on this prediction is also as strong as that for proposition 3.5. The standard deviation of 12.41 is the seventh lowest, a "high" level of consensus. The range is "narrow", with a minimum response of 50 and a maximum response of 99. Thus, no panelist believes the distribution of expertise to be an unlikely result of the use of an expert system.

Based on these results, it is not surprising that the rationales strongly support proposition 3.3. Here is a sample.
- The expert systems will capture expertise from some experts and make it available to all users of the system.
- Gives staff quicker access to more advanced knowledge and decision making.

The distribution of expertise, often referred to as knowledge sharing, is one of the most discussed benefits of expert systems in the accounting and auditing literature.\(^8\) On this point, the Delphi panel appears to whole-heartedly agree with those in the literature who speculate and make assertions about the impact of expert systems on auditing firms.

As a result of the distribution of expertise, auditors will gain new insights into the audit decision process and will exhibit an increased ability to handle complex analyses and tasks, according to some portions of the accounting and auditing literature.\(^9\) This possible event is included in proposition 3.4

\[ P \text{ 3.4 } \text{ The use of an expert system for an audit task allows auditors to gain new insights into the decision process.} \]

The Delphi panelists tended to agree with the speculation in the literature. The mean panel response to \( P \) 3.4 was 67.78, which corresponds to a "likely" occurrence of the event. The level of consensus of the panel was "high"

---

\(^8\) See, for example, Englard et al., 1989; AICPA, 1987; Borthick, 1987; Borthick & West, 1987; Coopers & Lybrand, 1987; Elliott & Kielich, 1987.

(SD = 12.97), and the range of responses was "narrow." The minimum response was 30 and the maximum response was 80, which implies that all the members of the panel were not convinced of the likelihood of this event.

While the panel, as a whole, tends to agree that gaining new insights into the audit process is a likely result of expert systems use, their agreement is less unanimous than that of propositions 3.2, 3.5, and 3.3. In contrast, those three propositions received no predictions below 50.

Overall, the rationales for proposition 3.4 are supportive, but indicate that there may be moderating variables at work. Many assert that the ability to gain new insights will depend on the quality of the system and the experience of the user. A number of rationales highlight that this proposition may be true only for novice users.

Proposition 3 is interesting. This proposition is the general proposition concerning whether expert system use will impact the nature of the firm's expertise.

P 3 The use of expert systems in auditing impacts the nature of the expertise of the firm.

The four previously discussed propositions (3.2 through 3.5) are specific instances of impacts on expertise. One might expect that the predictions for the general category would fall somewhere in the middle of the predictions for the specific types of impact in that category as in the two
categories previously discussed, efficiency and effectiveness. Nevertheless, this is not the case with the expertise category.

While the mean of 60.28 is still in the "likely" range, Proposition 3 received a lower mean response than any of the propositions 3.2 through 3.5. The level of consensus was "fair" (SD = 16.22) and the range of responses was "medium." The maximum response was 80 and the minimum response was 25. This data may be characterized as somewhat compelling, but not nearly as compelling as that for the specific instances of expertise impacts discussed above.

The rationales tend to support an impact on the nature of the firm, but a few disagree. While the majority agree that there will be an impact on expertise, the nature of that impact is open to speculation. Here are some interesting rationales.

- The ES can only reflect the nature of the firm's expertise, not change it. However, the distribution of the expertise may change.
- It may spread expertise to lower levels. In some ways, however, the expertise of the firm would always be around.
- Highly leverages expertise, makes the most advantage of a firm's expertise.
- Clearly if expertise can be encoded, it can be studied and enhanced.
- It won't change the types of expertise but the number of experts and how expertise is disseminated would change.

The only expertise impact to receive a low mean response was proposition 3.6 which may be characterized as a "bad" impact.

P 3.6 The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.
The mean response for this proposition was 35.50 or "unlikely" to occur. The level of consensus was "fair" (SD = 16.39). The range of responses was "medium," with a maximum response of 65 and a minimum response of 5. Note that two-thirds of the respondents scored this proposition as "unlikely" or "most unlikely," with scores below 50. Only one respondent believes that this event is likely (65). However, it is interesting to note that Table 5-18 reveals significant differences between academician and practitioner panelists. The practitioners, as a sub-group, believe this proposition is even more unlikely than the academician sub-group.

More rationales opposed proposition 3.6 than supported it. However, several suggested that this proposition is dependent on the design of the system and the nature of the task. Others expressed concern that expertise development might be hindered.

- Some problem of learning software program, not task, is possible. This is one of my worries but I don't have data to back it up. Presumably, by becoming dependent on an ES, the lower level staff may lose the chance of developing expertise by trial and error experience.
- No - it augments ROTE learning while the review process enhances the creative/intuitive aspects of expertise.
- No, enhances such development - if rolled out and supported properly.
- The use of an expert system should enhance the development of expertise, since the user can learn from the system's results and reasoning.
- Generally I would expect auditing professional to attempt to gain an understanding of the rationale used by the system in arriving at its conclusion.

According to the Delphi panel results, it is unlikely that the use of an expert system for an audit task will inhibit
the development of task-related expertise by users of the system. However, steps should be taken to insure proper design and use.

The Education Propositions

The education propositions address the impact of expert systems on the training of auditors. The propositions are listed in Table 5-23 and the Delphi results for these propositions are summarized in Table 5-24. Proposition 4 states:

The use of expert systems in auditing impacts the education of auditors.

This proposition was identified as "very likely" by the mean panel response of 75.67. This was the sixth highest mean probability prediction in the study.

The overall agreement among the panelists on this proposition can be characterized as mid-range relative to the rest of the propositions. The standard deviation of 15.32 falls roughly in the middle of Table 5-14, indicating a "moderate" level of consensus. The range of responses is also found in the middle of Table 5-15 reflecting a "medium" range of 64. Consequently, the panel has reached a reasonable, but not high, level of agreement that the use of expert systems in auditing is very likely to impact the education of auditors.
Table 5-23: Education propositions.

<table>
<thead>
<tr>
<th>Category</th>
<th>P. Number</th>
<th>Proposition (Statement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P 4</td>
<td>The use of expert systems in auditing impacts the education of auditors.</td>
</tr>
<tr>
<td>In-house training</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P 4.1</td>
<td>The use of an expert system for an audit task enhances the in-house training program related to that task.</td>
</tr>
<tr>
<td>Learning curve</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P 4.2</td>
<td>The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers.</td>
</tr>
<tr>
<td>Training time</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P 4.3</td>
<td>The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.</td>
</tr>
<tr>
<td>Proposition</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>-------------</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>P4</td>
<td>18</td>
<td>75.67</td>
</tr>
<tr>
<td>P4.1</td>
<td>18</td>
<td>71.67</td>
</tr>
<tr>
<td>P4.2</td>
<td>18</td>
<td>68.89</td>
</tr>
<tr>
<td>P4.3</td>
<td>18</td>
<td>50.61</td>
</tr>
</tbody>
</table>
The vast majority of the rationales for proposition 4 support the contention that the use of expert systems is very likely to impact the education of auditors in the next decade.

- Firms must integrate these tools into their training - thus a truism. College level impacts are far less likely in near future.
- Perhaps as auditors find out that certain things cannot be automated.
- As long as ES are used in auditing they have to effect the education of auditors both in-house and in school (the former will occur first).
- I have already added ES coverage in my graduate auditing courses.
- Must learn to use them. Also, the knowledge gained in building systems will be used to improve education.
- The use of an expert system may accelerate an auditor's education. The auditor must learn about the application and limitations of expert system technology.
- By 2001, the classroom will lag.
- We'll have to include ES in the educational environment.
- Appropriate education will include the use, pros and cons of the technologies being utilized in practice.
- ES should be used for training extensively by the year 2001. I envision the program users on the audit will be the same as that used in the training course.

There is some discussion, however, on exactly what the nature of this impact will be. Several of the respondents believe the impacts on education will be mostly on-the-job, and much less at the university level.

Proposition 4.1 deals with the impact of expert systems on firms' in-house training.

P 4.1 The use of an expert system for an audit task enhances the in-house training program related to that task.

The mean panel response indicates that this is a "likely" occurrence (mean = 71.67). The standard deviation of 16.27 reveals a "fair" level of consensus, along with a "medium" range of responses. The responses ranged from a low of 35 to a high of 90.
A review of the actual response distribution somewhat moderates the impact of width of the range because only one person (a practitioner) actually responded to this statement with a probability below 50. Except for that one practitioner response, all of the panelists agree that this proposition is not unlikely.

Most of the rationales for proposition 4.1 support the likelihood that in-house training will be enhanced. Several panelists feel this is the most important function of expert systems. Some believe that the enhancement is dependent upon the quality of the design of the system. One rationale suggests that expert systems will not enhance in-house training, but rather be detrimental.

- I feel expert systems may reduce the actual learning involved with each particular professional (i.e. relying on the system for the thought process).

Generally, the data and the rationales indicate that in the next decade the use of an expert system for an audit task is likely to enhance in-house training programs related to that task.

Proposition 4.2 pertains to the learning curve for an audit task.

P 4.2 The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers.

The mean response to this proposition was 68.89, a "likely" probability of occurrence. The level of consensus was
"high" (SD = 12.67) and the range of responses was "very narrow" with no responses below 50.

The rationales reiterate the position that most of the panelists maintain that the use of an expert systems for an audit task is likely to accelerate the learning curve for inexperienced decision makers.

- More sophisticated systems create their own learning curve.
- The creation of more real life cases in a very short period of time.
- Most current ES do not have appropriate explanation facilities. Learning will improve in the future as better logic explanations are included.
- An expert "at your side" to explain why info is needed and how it is combined to reach a decision.
- Generally this is true, however there is a possibility that decision maker will not understand basis for decisions. Systems must be designed to facilitate such an understanding.
- Automatic reasoning explanation features help staff conceptualize problems and solutions more effectively than traditional training.
- Expert systems, if appropriately designed, can leverage the knowledge and experience of "experts" and communicate that knowledge to more junior members of the firm.
- It provides a more structured exposure to an efficient approach to task encapsulation.
- Viewing the completed task and the rationale for decision making contributes to the learning process.
- It can if used as training tool and if decision rules and logic are appropriately explained. Most systems are not currently being deployed in this fashion.

While, most of the rationales agree with this proposition, many of them point out that the impact will be dependent on the design and proper use of the system.

The panelists generally agree that the use of an expert system for an audit task is likely to accelerate the learning curve for inexperienced decision makers in the next
decade. This stance concurs with much of the literature mentioned in chapter 3.\textsuperscript{10}

The last education proposition concerns improving decision making ability for new auditors.

P 4.3 The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.

The mean response for this proposition, at 50.61, is not particularly enlightening. It appears that the panel has concluded that this proposition can go "either way." That is, it is neither particularly likely or particularly unlikely to occur. Responses to this proposition achieved the second highest standard deviation (24.90) and, therefore, the second lowest level of consensus. The range was "wide," with a minimum of 1 and a maximum of 80. Hence, the panelists did not even strongly agree that this proposition could go "either way."

The range of rationales for proposition 4.2 was similar to the range of probabilities. Various reasons suggested high likelihood, low likelihood, neutral probability because of moderating variables, and no relationship between expert system use and decision making ability. The panelists do not agree on the likelihood or the rationale for this proposition.

\textsuperscript{10} See, for example, Englard et al., 1989; Juras, 1989; McCarthy & Outslay, 1989; Jancura & Overbey, 1988; AICPA, 1987; Borthick, 1987; Borthick & West, 1987; Elliott & Kielich, 1985; Jancura, 1987.
In general, the Delphi panel suggests that expert systems will impact the education of accountants. Most likely, that impact will be on in-house training. Depending on the design of an explanation facility, expert systems may be capable of accelerating the learning curve for inexperienced decision makers by the year 2001.

**The External Propositions**

The external propositions concern broader impacts of the use of expert systems on the auditing firm's environment. They are the possible result of the general use of expert systems; they do not address specific task effects. Most people would consider these "bad" impacts. These propositions are listed in Table 5-25 and the Delphi results are summarized in Table 5-26.

When scanning Table 5-13, it becomes evident that five of these six propositions are the five propositions least likely to occur according to the mean panel response. Only proposition 5.4 is deemed "slightly likely" to occur. This proposition is discussed first.

Proposition 5.4 addresses an important area of consideration for all auditing firms: risk.

**P 5.4** The development and use of expert systems for audit tasks cause auditing firms to identify and/or eliminate the highest-risk areas in their practice.
Table 5-25: External propositions.

<table>
<thead>
<tr>
<th>Category</th>
<th>P.Number</th>
<th>Proposition (Statement)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTERNAL</td>
<td>P 5.2</td>
<td>The development and use of expert systems for audit tasks results in increased non-accounting competition for auditing services.</td>
</tr>
<tr>
<td></td>
<td>P 5.3</td>
<td>The development and use of expert systems in auditing results in an increasing difficulty in hiring and retaining top auditing experts.</td>
</tr>
<tr>
<td></td>
<td>P 5.4</td>
<td>The development and use of expert systems for audit tasks causes auditing firms to identify and/or eliminate the highest-risk areas in their practice.</td>
</tr>
<tr>
<td></td>
<td>P 5.5</td>
<td>The development and use of expert systems for audit tasks leads to the dehumanization of auditing.</td>
</tr>
<tr>
<td></td>
<td>P 5.6</td>
<td>The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.</td>
</tr>
<tr>
<td></td>
<td>P 5.7</td>
<td>The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.</td>
</tr>
<tr>
<td>Proposition</td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>-------------</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>P5.2</td>
<td>18</td>
<td>31.61</td>
</tr>
<tr>
<td>P5.3</td>
<td>18</td>
<td>28.28</td>
</tr>
<tr>
<td>P5.4</td>
<td>18</td>
<td>59.44</td>
</tr>
<tr>
<td>P5.5</td>
<td>18</td>
<td>32.06</td>
</tr>
<tr>
<td>P5.6</td>
<td>18</td>
<td>16.06</td>
</tr>
<tr>
<td>P5.7</td>
<td>18</td>
<td>29.22</td>
</tr>
</tbody>
</table>
The mean panel response for proposition 5.4 was 59.44 or "slightly likely." The standard deviation of 21.55 indicates a "low" level of consensus and the range of 98 is "very wide", in fact, the widest possible. However, removing the two most outlying responses (01 and 99) would change the range to a "narrow" range of 40 to 90. Regardless, these results are not convincing that this proposition is either particularly likely or particularly unlikely to occur.

The rest of the external propositions received very low mean responses ranging from 16.06 to 32.06. All of these means indicate that the occurrence of any of these propositions is "unlikely". Only two of these propositions, 5.6 and 5.7, reveal an impressive amount of agreement among the panelists.

P 5.6 The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.

P 5.7 The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.

Both of these propositions produced a "high" level of consensus and a "narrow" range. No panelist gave a probability above 50 for either of these two propositions. These two are the first (5.6) and third (5.7) least likely propositions to occur according to the mean response of the panel.
Table 5-17 indicates that for both of these propositions the practitioner responses were significantly below the academician responses. The highest practitioner responses were 25 and 30 for propositions 5.6 and 5.7, respectively. That is, the academicians are not quite as strongly convinced that loss of prestige and increased litigation are unlikely to occur as a result of the development and use of expert systems.

The other three external propositions also received very low mean responses. However, they are less compelling than propositions 5.6 and 5.7 based on mediocre to poor levels of consensus and the widely divergent rationales given.

Conclusion

The Delphi panel suggests that expert systems are very likely to have an impact on auditing firms in the next decade. The most likely impact identified was that use of an expert system for an audit task provides documentation references for audit judgements and reasoning. Other specific impacts that were identified as very likely include distribution of expertise, increased ability to handle complex analyses, and improved decision consistency and quality. The panel also indicated that use of expert
systems in auditing is very likely to impact the education of auditors.

In contrast, the development and use of expert systems for audit tasks is very unlikely to lead to a loss of prestige for firms relying heavily upon such systems during the next decade. In fact, it is more likely that firms that use expert systems will have their prestige enhanced because they will be considered "on the cutting edge" of the technology. Overall, the propositions that contained "bad news" predictions were considered unlikely by the Delphi panel.

The greatest difference between the Delphi panel and the literature discussed in Chapter 3 concerns efficiency. In the literature, the possible efficiency gains from the use of expert systems are highly touted. The panel does not agree, and indicated that most of the efficiency propositions are only slightly likely at best. Many panelists pointed out that effectiveness gains are much more likely than efficiency gains. As the future approaches, it will be interesting to note the developments and advances in efficiency caused by expert systems to determine if the panel accurately predicted the future.
Chapter 6:  CASE STUDY RESULTS

The case study involved one office of a Big Six firm\(^{11}\) located in the Carolinas. The office includes about twelve audit staff (in addition to tax and other staff) and handles about twenty audits annually. The firm uses exclusively (for the past five years) Apple Macintosh technology on the audit side. Other advanced uses of technology include network for e-mail, and access to shared databases and dialing purposes.

This firm utilizes an expert system to assist with the audit planning task. Nine audit staff members\(^{12}\) (seniors and managers) were interviewed concerning the audit planning task. Five of the nine had used the system\(^{13}\) during the course of one or more audits.

**The System**

The expert system is one part of a set of audit program tools, a sort of multi-module decision support system. Before the firm merger, the audit program tool system was

\(^{11}\) As a condition for publishing this research, the identity of the firm remains confidential.

\(^{12}\) Names of all personnel have been changed to preserve confidentiality.

\(^{13}\) The firm's expert system will be referred to for the balance of this document as "the system."
marketed to clients and potential clients, usually through a narrative included in the audit proposal.

The primary audit program tools include several different audit support systems. One module is a filing cabinet package that allows the creation and storage of documents and forms. The second module allows the recording of adjustments, preparation of financial statements and consolidated statements.

A third module facilitates the budgeting and recording of time utilization on audits, not only by audit area but also by audit level. Time may be budgeted by the week, for example. This module is used on and off depending on the difficulty of the audit job. It is used on 20-25% of the audit clients, mostly the larger, more complex and difficult jobs.

Another module allows the firm to manipulate data from many sources including IBM pcs and all sizes of computers. This is especially important for auditing clients who are not running a Mac-based system. For example, the firm can extract information from the audit client's mainframe computer system and manipulate that information on the firm's Mac system.

The fifth module is the expert system. The goal of the [expert] system is to facilitate the thought process used in planning an audit. The system follows a logical flowchart and provides guidance when needed in determining the nature
and extent of testing for a particular audit. The system is
text sensitive. The user can enquire about a specific
procedure simply by double clicking on that portion of text.

The system prompts the user to make assessments
necessary according to the firm's audit methodology. In
this office, the system has been used on 40-50% of audit
engagements, primarily the larger clients.

Special versions of the system for audit clients in
specialized industries have been developed. Versions for
the insurance and banking industries exist. This particular
office has used the banking version of the system. The
system is used by seniors (4 years experience) and managers
(up to 10 years audit experience).

The system was developed by harnessing audit partners'
thought processes and end documents used in audit planning,
including interviews with various firm members. This system
is a computer program that, with input from an inexperienced
auditor, emulates the thinking process of human audit
planning experts to attain a level of performance comparable
to those experts at the audit planning task. This is in
line with the AICPA definition of an expert system discussed
in Chapter 1.

According to system documentation, the system is
designed to help the auditor plan the audit approach in an
organized manner and within the boundaries of the firm's
audit methodology. After specifying the significant
accounts or groups of accounts, the auditor uses the system to plan the audit approach for each significant account or group of accounts. The system is designed to assist the auditor in selecting audit procedures so that the auditor can estimate the appropriate extent of the procedures selected. The system also assists in evaluating whether the audit approach is "likely to be effective, efficient, and complete."

The output of the system is a plan for approaching the audit and detailed audit programs for each account, the Plan of Audit Approach (PAA). The programs can be customized according to the client situation. The system also provides guidance material found in the firm's audit manual (a rather lengthy document). The user may request the display of this material based on where the cursor is located. The ability to show the guidance material is "text-sensitive", that is, it will display the specific material from the audit manual that is relevant to the portion of text found under the user's cursor and to the part of the planning process currently being undertaken.

**Complaints About The System**

Without exception, every person who has used the system cited problems with formatting of output. The system allows no flexibility in the appearance of the PAA and programs. The user often desires to adjust the output to appear in a
certain format, either that he prefers or that his reviewer, manager, or partner prefers. As one staff member stated, "sometimes, presentation is half the battle and [the system] does not allow for altering the presentation from its format."

The other complaint heard from almost all users was the temptation when using the system to choose too many procedures. While the system does check to see that enough audit procedures have been selected, i.e. all of the audit objectives have been addressed for each account, the system does not check to see if too many procedures have been chosen. It is possible to choose procedures such that one audit objective is covered by several procedures when only one or two would have been sufficient.

**Exploratory Hypotheses**

In chapter four, five exploratory hypotheses are identified addressing the impact of expert systems on the firm's information processing capacity and organizational programs. The following section discusses the results relating to these hypotheses.

**Information Processing Capacity**

Sviokla [1986, 1989, 1990] used the information processing framework originally introduced by Galbraith
[1977, 1973] as a starting point for investigating the impact of expert systems on the firms that used them. This framework provides a measure useful in identifying impacts: information processing capacity.

**Information processing capacity** is the diversity of the outputs, the number of inputs, and the level of task performance for a given task [Galbraith 1977, 1973]. Inputs are the number of data sources and people used in the process of the task. Outputs are the number of different versions of the service the task provides. The level of task performance is management's assessment of performance and any available objective measures [Sviokla, 1986].

Exploratory hypothesis H1 was identified in chapter 4:

\[ H1 \text{ } \text{Use of an expert system increases the information processing capacity of the firm.} \]

Sviokla [1986] studied the impact of three expert systems on their respective firms: PlanPower on The Financial Collaborative (TFC), XCON on Digital Equipment Corporation (DEC), and MUDMAN on NL Baroid. His results stated the following ratings of the information processing capacity: PlanPower and MUDMAN increased the information processing capacity of their firms and XCON significantly increased the information processing capacity of its firm. Based on this multi-case example, the expectation for the present case study of an expert system was that information processing capacity would be increased.
Use of an expert system should provide more information processing capacity to the organization because it enumerates and automates an important task. These changes may be evident in any of Galbraith's three measures: diversity of outputs, number of inputs, and level of task performance. Because the expert system task may provide more outputs, use more inputs and elicit a higher level of task performance than the pre-expert system task, these sub-hypotheses were identified in chapter 4:

**H1a** The use of an expert system results in more outputs from the task than before expert system use.

**H1b** The use of an expert system results in the use of more inputs in the completion of the task than before expert system use.

**H1c** The use of an expert system results in a higher level of task performance than before expert system use.

Sviokla [1986] found that for three expert systems studied, the hypotheses about information processing capacity and its parts were strongly supported. Increases of varying magnitude were observed for each of the components of information processing capacity for the expert systems in use by TFC, DEC and Bariod.

In the present case study, hypotheses H1, H1a, H1b, and H1c were investigated through questioning the users and non-users of the expert system about the number and nature of the outputs, inputs, and task performance. Based on the information obtained from the interviewees each hypothesis
has been given an overall subjective rating on a four point scale: not supported, weakly supported, supported, and strongly supported. Table 6-1 lists the exploratory hypotheses and their ratings on this scale. The hypotheses
Table 6-1 Case study hypotheses and results.

<table>
<thead>
<tr>
<th>#</th>
<th>Hypothesis Statement</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Use of an expert system increases the information processing capacity of the firm.</td>
<td>Weakly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported</td>
</tr>
<tr>
<td>H1a</td>
<td>The use of an expert system results in more outputs from the task than before expert system use.</td>
<td>Not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported</td>
</tr>
<tr>
<td>H1b</td>
<td>The use of an expert system results in the use of more inputs in the completion of the task than before expert system use.</td>
<td>Not</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported</td>
</tr>
<tr>
<td>H1c</td>
<td>The use of an expert system results in a higher level of task performance than before expert system use.</td>
<td>Weakly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported</td>
</tr>
<tr>
<td>H2</td>
<td>The use of an expert system will change the task process.</td>
<td>Weakly</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Supported</td>
</tr>
</tbody>
</table>
are discussed in the following order: inputs (H1b), task performance (H1c), outputs (H1a), and overall information processing capacity (H1).

Inputs. The basic inputs to the task of planning the audit approach include knowledge about the firm and its business environment, the firm's audit methodology, the client's significant accounts, and assessments of internal controls. This information is necessary in order to properly select audit procedures and estimate the extent of those procedures.

In order to obtain this information the audit staff person may contact a number of persons including higher level audit staff, and the client's controller and managers. The interviewees identified the same group of persons contacted regardless of the method of completing the audit approach planning task.

Staff members (some of whom completed the audit approach planning task without the systems, some who had completed the task using the expert system, and some who had done both) were asked to identify the inputs necessary to complete the task. All staff members interviewed identified essentially the same list of inputs, some in greater detail than others. In fact, those who had completed the task both manually and with the system, asserted that the inputs were basically no different when using the system from those needed when creating an audit approach plan manually.
The only identifiable difference in inputs between the manual and system versions of the task is the amount of time spent referring to and using the inputs. Specifically, the interviewees stated that the biggest benefit of using the system was to the novice users who spend less time manually looking for information in the firm's lengthy audit methodology manual. Those not using the system spend a significant amount of time checking procedures and requirements in the audit manual. Those using the system may more efficiently utilize the audit manual (a principle input) because they need only click on the specific procedure or portion of text shown on the screen and the related portion of the audit manual is presented for review. Those experienced at the task spend relatively little time reviewing the audit manual (whether using the system or not) because they have obtained audit methodology expertise over time.

Based on the results of interviews with staff members, exploratory hypothesis H1b is not supported. The number of inputs does not appear to increase as a result of using the expert system to plan the audit approach, although the efficiency of the use of inputs is increased for the less experienced users (see discussion of efficiency below).

Level of task performance. Using the system appears to impact the level of task performance when one or both of two variables are present. The first variable, user experience,
was touched on in the previous section. When the user is relatively inexperienced at the task of planning an audit approach, the use of the system results in less time spent referring to the firm's lengthy audit manual. Therefore, level of the performance of the task by a novice is higher, given that efficiency is an indicator of performance.

The second variable, client status, is more quality oriented. Client status refers to whether the client is a first-time or continuing audit client. When auditing a first-time client, the system is useful as a quality control mechanism that insures that a comprehensive audit approach plan is developed. Because the system is comprehensive concerning the audit approach planning task, 75% of those interviewed prefer to use the system when auditing a first-time client. Conversely, when auditing a continuing client, the system may become cumbersome, since, on continuing engagements, using the previous year's working papers is the preferred starting point.

Based on the information provided by the interviewees, hypothesis H1c is weakly supported. The use of the system results in a higher level of task performance than performing the task without the expert system only when the staff person performing the task is inexperienced and/or the audit approach plan is being prepared for a first-time client.
Outputs. The output of the audit approach planning task is a plan of audit approach for the specific client. The opinion of the audit staff was unanimous that the output of the task did not differ according to use of the system or manual preparation. In fact, if the output were different, that would be a signal that something is amiss. Regardless of the method (manual or system) of preparing the plan of audit approach, the result should be in accordance with the firm's audit methodology as describe in the audit manual and within the system.

The only possibility of differences in output would be, presumably, as the result of human error, i.e. the audit methodology of the firm was not appropriately followed. Using the system provides some limited insurance that the firm's methodology is followed. However, no staff person would claim that the firm's methodology was disregarded at any time. Therefore, hypothesis H1a is not supported. The use of an expert system does not result in more and diverse outputs from the task than without the expert system use. The output of the task is a plan of audit approach prepared according to the firm's audit methodology regardless of the manner in which it is created.

Overall information processing capacity. The concept of information processing capacity is composed of the three parts just discussed: inputs (H1b), level of task performance (H1c) and outputs (H1a). Because H1a and H1b
were not supported and H1c was only weakly supported, the overall hypothesis for information processing capacity (H1) also weakly supported. The use of the expert system appears to cause a small increase in the overall information processing capacity of the firm.

Organizational Programs

According to Sviokla [1986] and Scott-Morton [1967] process flow diagrams, or organizational programs can be used to determine whether the technology changes the task process. In his study of three expert systems, Sviokla discovered that use of an expert system appeared to make the task more complex, to decrease the amount of time necessary to complete the task, and to shift the nature of the responsibilities of the persons involved in the task.

Task process. An examination of the audit approach planning task reveals that two documents are developed during the task. The Memorandum of Audit Plan (MAP) is generated in basically the same fashion whether the system is used or not. The Plan of Audit Approach (PAA) may be generated manually or by using the system.

MAP contains lots of client information such as background information, sensitive items to note, control assessments, materiality levels, etc. After the MAP has been generated, internal controls are reviewed.
once controls have been reviewed, the PAA is developed. This includes documentation of risk assessments and procedures by account group. For each significant account group, a narrative of the audit gameplan is included. A risk assessment is given and audit procedures for this significant account group are identified including the extent, timing, and objectives of the procedures. Discussion of the relevance of SAS 39 is also included.

These tasks and subtasks are included in the organizational task programs, figures 6-1 and 6-2. Figure 6-1 shows the inputs necessary to the task, the basic task, and its output. Figure 6-2 details the subtasks involved in the audit approach planning task. Because the task program was the same regardless of whether the system was used or the task was completed manually, separate task programs for manual and expert system completion are not identified in the diagrams.

While the diagrams did not identify any differences in task process between expert systems and manual preparation of the PAA, more subtle issues do address differences in the time required for the task and the nature of the responsibilities of the audit staff.

Time. An auditor who is not utilizing the system, will refer to the Audit Methodology Book for reference concerning what is included in the PAA and what procedures are appropriate under certain circumstances. An auditor may
Figure 6-1
Task program for audit approach planning (first level)
Figure 6-2

Task program for audit approach planning (second level)
refer to the Audit Manual for 10% or more of needed
information depending on his experience at the planning
task. More experienced managers may need to refer to the
Audit Manual only for a few items of information. The use
of the system reduces the time spent searching through the
audit manual, particularly for inexperienced users.

Responsibilities. The system puts the information
found in the lengthy Audit Manual at the audit planners'
fingertips. The system provides guidance on Audit Planning
and preparation of the PAA. The system insures quality of
audit planning and consistency of planning across audits.
When audit planning is performed without the system, quality
control and consistency must be insured solely through
review. The interviewees agreed that the use of the system
by the audit staff person tended to decrease review
responsibilities of the manager and/or partner responsible
for the audit.

Summary and rating. The evidence appears to be
somewhat mixed on hypothesis H2. The more obvious data
contained in the diagrams of the task process show that the
subtasks of the process are not changed by using the system.
However, the timing of the task and the nature of the
responsibilities of those supervising the task are affected.
Based on this assessment, hypothesis H2 is weakly supported.
Conclusions: Exploratory Hypotheses

Use of the system elicits a number of impacts on the firm. First, while the overall information processing capacity of the firm is not largely increased (H1, H1a, and H1b not supported), the system does increase the level of performance on first-time audits and for users inexperienced at the task (H1c weakly supported). Second, the process of completing the plan of audit approach did not change in its basic task and sub-tasks. However, part of the responsibility for reviewing the task is moved to lower levels and to the system; and the amount of time needed to complete the task for inexperienced staff persons is decreased when using the system (H2 weakly supported).

Impacts of the Preliminary Framework

At the case study site, information about the impacts of the preliminary framework were gathered using two methods. First, in semi-structured interviews, staff persons were asked if the system affected the firm's efficiency, effectiveness, expertise, and education. Following any affirmative responses, the interviewee was asked to describe the impacts.

Second, these same persons were asked to fill out a questionnaire return it to the researcher. The case study
questionnaire\textsuperscript{14} consists of twenty-seven statements adapted from the Delphi survey instrument specifically for the case study firm. For each statement, the respondents (n=4) were asked to circle a response alternative indicating their level of agreement with that statement. The alternatives were 1. strongly disagree, 2. disagree, 3. slightly disagree, 4. no opinion, 5. slightly agree, 6. agree, and 7. strongly agree.

Each of the following sections discusses a category of propositions, addressing information obtained through interviewing and through the case study questionnaire. Information about the case study questionnaire responses is found in table 6-2.

\textbf{Efficiency}

According to system users, the system does appear to impact the overall efficiency of the audit. However, the efficiency impact is moderated by two factors: 1) How many times the firm has previously audited the client, and 2) How much experience the person using the system has at the audit planning task.

\textit{First}, the efficiency impact is greatest when the audit being conducted is for a first-time client. Three-fourths of the users interviewed stated that they especially

\textsuperscript{14} The entire case study questionnaire is reproduced in Appendix C.
Table 6-2

Case Study Questionnaire\textsuperscript{15}: Description of Responses\textsuperscript{16}

<table>
<thead>
<tr>
<th>Statement</th>
<th>Average</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Max-Min</th>
<th>Related Proposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.75</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>5.25</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>4.2</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>2.75</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>1.1.4</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5.7</td>
</tr>
<tr>
<td>7</td>
<td>1.5</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1.2.1</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>3.2</td>
</tr>
<tr>
<td>9</td>
<td>5.25</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>4.1</td>
</tr>
<tr>
<td>10</td>
<td>3.5</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>5.6</td>
</tr>
<tr>
<td>11</td>
<td>2.75</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>5.4</td>
</tr>
<tr>
<td>12</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>2.1</td>
</tr>
<tr>
<td>13</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2.3.2</td>
</tr>
<tr>
<td>14</td>
<td>3.25</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>1.1.2</td>
</tr>
<tr>
<td>15</td>
<td>3.75</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>2.4</td>
</tr>
<tr>
<td>16</td>
<td>2.5</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>3.5</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>3.4</td>
</tr>
<tr>
<td>18</td>
<td>2.75</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>5.5</td>
</tr>
<tr>
<td>19</td>
<td>3.75</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>2.2</td>
</tr>
<tr>
<td>20</td>
<td>1.5</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>21</td>
<td>3.25</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>3.6</td>
</tr>
<tr>
<td>22</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>1.1.3</td>
</tr>
<tr>
<td>23</td>
<td>4.5</td>
<td>2</td>
<td>7</td>
<td>5</td>
<td>4.3</td>
</tr>
<tr>
<td>24</td>
<td>5.25</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>2.3.1</td>
</tr>
<tr>
<td>25</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>5.2</td>
</tr>
<tr>
<td>26</td>
<td>3.25</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>1.1.1</td>
</tr>
<tr>
<td>27</td>
<td>3.75</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>3.3</td>
</tr>
</tbody>
</table>

\textsuperscript{15} Note: n=4.  

\textsuperscript{16} Response alternatives were: 1. strongly disagree, 2. disagree, 3. slightly disagree, 4. no opinion, 5. slightly agree, 6. agree, and 7. strongly agree.
preferred to use the system when auditing a client for the first time. According to one user, when auditing a new client, "You don't have to worry about missing things when you use [the system], because it is comprehensive" in planning the audit approach and programs. When auditing a continuing client, using the system for planning the audit approach was considered too time consuming, because the work papers (including the plan of approach) from last year may be used as a much more efficient starting point.

According to another user, the purpose of the system is "to plan for the most efficient audit, i.e. the work that should be done, given the evaluations and assessment of internal controls." However, one complaint that several users had with the system was the temptation to choose too many audit procedures. One the one hand, the system will not let the user choose too few procedures. The chosen audit procedures for a significant set of accounts must satisfy all of the objectives of the audit (completeness, existence, etc.), or the system will prompt the user to choose more procedures. Therefore, the system may be said to identify omissions.

On the other hand, the system does not tell the user when too many procedures have been chosen, such as when a chosen audit procedure is applicable to assertions that are already adequately covered by other planned procedures.
Second, the efficiency impact is greatest when the user is inexperienced at the audit planning task. Because the inexperienced staff member not using the system would spend much time referring to the firm's lengthy audit manual, using the system is more efficient. The material in the manual is also available to the user of the system, and it is available in a timely fashion.

For a novice audit planner, the system assists them in understanding how to develop a plan of approach for an audit and the audit programs, and in learning the required steps to accomplish this. When using the system, the inexperienced planner may save time that otherwise would be spent looking up details in the firm's audit manual. For the most experienced audit manager, the system may actually slow his work because he does not need the guidance that the system gives. The experienced audit manager understands the audit planning process and the firm's methodology, i.e. he has become an expert and no longer needs the system expert system. An experienced manager may manually generate a plan of audit approach and audit programs that is within 15% of the system generated ones.

Concerning efficiency, respondents to the case study questionnaire slightly agreed (average response 5.25) that the system improves the overall efficiency of the planning task. However, for all of the lower level statements concerning aspects of efficiency (1.1.1, 1.1.2, 1.1.3,
1.1.4, 1.2.1), the average answers were all 3.25 or below (see Table 6-2), indicating that most people using the system did not note the existence of specific efficiency impacts identified in the lower level propositions (1.1.1 through 1.2.1).

**Effectiveness**

Most users assert that use of the system does not really impact the effectiveness of the audit, or the judgment of the auditor. Generally, the information needed to plan the audit (from the client, the audit manual, and pronouncements, etc.) is already available to the user in some other format. Presumably, auditors performing the audit planning task without the system are doing an adequate job at planning; therefore, the use of the system will not necessarily impact audit planning quality significantly.

Using the system does impact consistency because users are forced to follow the prescribed audit planning policy of the firm. In addition, the system checks to insure that the audit planners do not omit any significant accounts or overlook any audit objectives, i.e. the user is warned of omissions that must be corrected before continuing with planning the audit.

Several of those persons who have used the system often use it as a sort of quality controller. After preparing a plan of audit approach and audit programs, the use the
system to see if system-generated PAA and programs are significantly different from the documents they prepared manually. This is particularly useful in identifying any routine portions of the audit that have been overlooked.

The responses to the case study questionnaire for the statements addressing components of effectiveness indicated that respondents identified no effectiveness effects of using the system. One exception was statement 24 (proposition 2.3.1) concerning decision consistency. The average response to this statement was 5.25, with relative agreement between respondents (all respondents either "agreed" or "slightly agreed" with statement 24. These results reinforce the idea that the system serves as a sort of quality controller, but not a quality enhancer.

**Expertise**

Most of the users agree that the firm's expertise is impacted by the use of the system only in so far as the inexperienced audit planners are affected. One of the senior audit managers states that managers who have relatively little experience at audit planning gain useful knowledge of audit planning and the firm's methodology when using the system. The expertise of the inexperienced users is increased as they use the system and gain more knowledge (and develop expertise) concerning audit planning and the firm's audit methodology. For the most experienced audit
manager, however, the system does not appear to change his level of audit planning expertise. Presumably, at some point, the experienced audit planner becomes "expert" at the task.

Only one of the expertise statements included in the case study questionnaire yielded an average response greater than 4.0. Three out of four respondents agreed to statement 8 (proposition 3.2), which concerns documentation references for audit judgments and reasoning (average response 5.0).

**Education**

Audit staff who have relatively little experience at audit planning gain useful knowledge of audit planning and the firm's methodology when using the system. Therefore, the system not only serves to increase the expertise of the less experienced staff, but also acts as a training tool. Occasionally, an audit manager will have an inexperienced senior walk through the system as a method of training. All of the staff who have used the system agreed that for the first few times a person is involved in planning an audit, the system is particularly useful in training them in planning the audit approach and audit programs and in teaching the firm's audit methodology pertaining to planning.

According to the case study questionnaire responses, the proposed educational impacts may have had the most
perceivable effect on the firm. Responses to statements 9, 3, 23 (corresponding to propositions 4.1, 4.2, and 4.3, respectively), generated averages of 5.25, 6.0, and 4.5, indicating that the average user of the system perceived a slight to moderate impact of using the system on the education and training of the auditors.

**External**

The staff auditors using the system are not expected to possess expertise concerning the impact of expert systems on auditing firms in general, as the experts included in the Delphi study. However, in the interest of completeness and curiosity, five statements addressing external impacts were included in the case study questionnaire. Statements 25, 11 18, 10, and 6 (propositions 5.2, 5.4, 5.5, 5.6, and 5.7) address the concerns of non-accounting competition, risk, dehumanization, loss of prestige, and litigation. The average responses indicate that the respondents tended to have no opinion or to disagree with the proposed external impacts.

**Conclusions: Impacts of the Preliminary Framework**

Relating to the impacts identified in the propositions of the preliminary framework, any significant effect on efficiency and expertise is moderated by the level of experience of the person completing the task and the status
of the audit client. The greatest impact on efficiency is that of assuring consistency. From the education viewpoint, the use of the system assists the novice user in learning the task, improving task performance, and gaining knowledge about the task.

Conclusion

As expected, the use of the expert system does have an impact on the firm. However, the impact is not as great or as comprehensive as once thought. The effect of using the system is moderated by two variables, the level of experience of the person completing the task, and the status of the client. The impacts are most evident when the user of the system is a novice at the task, and/or the client is a first-time client. The moderating variables appear to exist whether the impacts are addressed through the concepts of information processing capacity and organizational programs, or by addressing the efficiency, effectiveness, expertise, and education impacts identified in the propositions in chapter three.

The fact that these results do not show the wide-ranging impacts and result in the strongly supported hypotheses reported by Sviokla [1986] is not surprising given the nature of auditing firms and the nature of the task studied. Auditing, in and of itself, is not a task that technology appears to transform. In contrast to the
situations at DEC and NL Baroid the task of performing an audit is much less a physical task (not involving, for example, configuring and delivering large computer systems or diagnosing and correcting oil well drilling problems), and more an intellectual task, or art, as some assert.

Notwithstanding the difficulty of placing the expertise of such a task in an expert system, the purpose of the expert system at the firm studied is primarily intended to address problems of consistency and education. The primary purpose of the system is not, like XCON and MUDMAN [see Sviokla, 1986], to change and improve the completion of the task that was not being satisfactorily managed prior to the introduction of the system. The auditors assert that they were doing an adequate job at the task before the expert system was invented. The expert system only enhances the completion of the task process.

Update

Due to a recent change in the structure of the firm at the national level and due to modifications in audit methodology, the system is no longer in regular use by this office of the firm. However, the firm is in the process of developing a replacement audit planning expert system that not only embraces the new audit methodology but also includes changes in presentation and other improvements over the system discussed herein.
Chapter 7: SUMMARY AND CONCLUSIONS

This research has identified a number of interesting areas of interest regarding expert systems development and use in auditing firms. Table 7-1 summarizes the expectations and results of this research. The Delphi panel suggests that expert systems are very likely to have an impact on auditing firms in the next decade. The nature of these probable impacts is even more interesting.

Efficiency

In the last few years, articles touting the efficiency effects of expert systems have appeared in the CPA Journal, Accounting and Business Research, Accounting Horizons, Advances in Accounting, the Journal of Accountancy, the Journal of Accounting and EDP, accounting firm publications, AICPA special reports, and in other publications, such as the Academy of Management Review, and MIS Quarterly, not specifically addressing auditing expert systems. Both studies undertaken by this researcher appear to refute the claim that use of an expert system results in shorter decision time and other efficiency gains. The Delphi panel determined that the proposed efficiency impacts had between only a 40% and 60% likelihood of occurring in the next ten years. The case study revealed that, for this particular firm and expert system, efficiency impacts are only evident.

173
Table 7-1: Summary of Results

<table>
<thead>
<tr>
<th>Proposition</th>
<th>Expected Result from Literature</th>
<th>Delphi Study</th>
<th>Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Expert systems will have an impact on auditing firms in the next two decades.</td>
<td>likely</td>
<td>very likely</td>
</tr>
<tr>
<td>1</td>
<td>The use of an expert system for an audit task improves the overall efficiency of the performance of the task.</td>
<td>likely</td>
<td>slightly likely</td>
</tr>
<tr>
<td>1.1</td>
<td>The use of expert systems in auditing improves personnel productivity.</td>
<td>likely</td>
<td>not tested</td>
</tr>
<tr>
<td>1.1.1</td>
<td>The use of an expert system for an audit task reduces the need for staff time on the task.</td>
<td>likely</td>
<td>slightly likely</td>
</tr>
<tr>
<td>1.1.2</td>
<td>The use of an expert system for an audit task reduces the time required to make audit decisions related to the task.</td>
<td>likely</td>
<td>slightly likely</td>
</tr>
<tr>
<td>1.1.3</td>
<td>The use of an expert system for an audit task reduces the time required to authorize proposed actions relevant to the task.</td>
<td>likely</td>
<td>slightly likely</td>
</tr>
<tr>
<td>1.1.4</td>
<td>The use of an expert system for an audit task results in less of the auditing division's time being absorbed in decision-related meetings.</td>
<td>likely</td>
<td>slightly unlikely</td>
</tr>
<tr>
<td>1.2</td>
<td>The use of expert systems in auditing affects the characteristics of the audit decision unit.</td>
<td>somewhat likely</td>
<td>not tested</td>
</tr>
<tr>
<td>1.2.1</td>
<td>The use of an expert system for an audit task reduces the number of organizational levels involved in authorizing proposed task related actions.</td>
<td>somewhat likely</td>
<td>slightly unlikely</td>
</tr>
<tr>
<td>1.2.2</td>
<td>The use of an expert system for an audit task reduces the number and variety of members comprising the traditional face-to-face task decision unit.</td>
<td>somewhat likely</td>
<td>slightly likely</td>
</tr>
<tr>
<td>2</td>
<td>The use of expert systems improves the effectiveness of auditing.</td>
<td>likely</td>
<td>likely</td>
</tr>
<tr>
<td>2.1</td>
<td>The use of expert systems in auditing results in augmented professional judgement.</td>
<td>likely</td>
<td>likely</td>
</tr>
<tr>
<td>2.2</td>
<td>The use of an expert system for an audit task improves audit task decision quality.</td>
<td>likely</td>
<td>very likely</td>
</tr>
<tr>
<td>Proposition</td>
<td>Expected Result from Literature</td>
<td>Delphi Study</td>
<td>Case Study</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>---------------------------------</td>
<td>--------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>2.3 The use of expert systems in auditing improves quality control.</td>
<td>likely</td>
<td>very likely</td>
<td>slightly agree</td>
</tr>
<tr>
<td>2.3.1 The use of an expert system for an audit task improves decision consistency for that particular task.</td>
<td>likely</td>
<td>likely</td>
<td>disagree</td>
</tr>
<tr>
<td>2.3.2 The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.</td>
<td>somewhat likely</td>
<td>likely</td>
<td>either way / no opinion</td>
</tr>
<tr>
<td>2.4 The development and use of expert systems for audit tasks leads to the standardization of audit tasks.</td>
<td>likely</td>
<td>likely</td>
<td>slightly disagree</td>
</tr>
<tr>
<td>3 The use of expert systems in auditing impacts the nature of the expertise of the firm.</td>
<td>likely</td>
<td>likely</td>
<td></td>
</tr>
<tr>
<td>3.1 The use of an expert system for an audit task results in the preservation of expertise.</td>
<td>likely</td>
<td>very likely</td>
<td>slightly agree</td>
</tr>
<tr>
<td>3.2 The use of an expert system for an audit task provides documentation references for audit judgement and reasoning concerning the task.</td>
<td>likely</td>
<td>very likely</td>
<td>either way / no opinion</td>
</tr>
<tr>
<td>3.3 The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.</td>
<td>likely</td>
<td>very likely</td>
<td>either way / no opinion</td>
</tr>
<tr>
<td>3.4 The use of an expert system for an audit task allows auditors to gain new insights into the decision process.</td>
<td>likely</td>
<td>likely</td>
<td></td>
</tr>
<tr>
<td>3.5 The use of an expert system for an audit task results in an increased ability to handle complex analyses.</td>
<td>likely</td>
<td>very likely</td>
<td>disagree</td>
</tr>
<tr>
<td>3.6 The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.</td>
<td>somewhat likely</td>
<td>unlikely</td>
<td>slightly disagree</td>
</tr>
<tr>
<td>4 The use of expert systems in auditing impacts the education of auditors.</td>
<td>likely</td>
<td>very likely</td>
<td></td>
</tr>
<tr>
<td>4.1 The use of an expert system for an audit task enhances the in-house training program related to that task.</td>
<td>likely</td>
<td>likely</td>
<td>slightly agree</td>
</tr>
<tr>
<td>4.2 The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers.</td>
<td>likely</td>
<td>likely</td>
<td>agree</td>
</tr>
</tbody>
</table>

175
<table>
<thead>
<tr>
<th>Proposition</th>
<th>Expected Result from Literature</th>
<th>Delphi Study</th>
<th>Case Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.</td>
<td>likely</td>
<td>neutral / either way</td>
<td>either way / no opinion</td>
</tr>
<tr>
<td>5.1 The use of expert systems will result in greater capital investment by auditing firms.</td>
<td>likely</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2 The development and use of expert systems for audit tasks results in increased non-accounting competition for auditing services.</td>
<td>somewhat likely / unlikely</td>
<td></td>
<td>either way / no opinion</td>
</tr>
<tr>
<td>5.3 The development and use of expert systems in auditing results in an increasing difficulty in hiring and retaining top auditing experts.</td>
<td>somewhat likely / unlikely</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4 The development and use of expert systems for audit tasks causes auditing firms to identify and/or eliminate the highest-risk areas in their practice.</td>
<td>somewhat likely / slightly likely</td>
<td></td>
<td>slightly disagree</td>
</tr>
<tr>
<td>5.5 The development and use of expert systems for audit tasks leads to the dehumanization of auditing.</td>
<td>somewhat likely / unlikely</td>
<td></td>
<td>slightly disagree</td>
</tr>
<tr>
<td>5.6 The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.</td>
<td>somewhat likely / very unlikely</td>
<td></td>
<td>slightly disagree</td>
</tr>
<tr>
<td>5.7 The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.</td>
<td>somewhat likely / unlikely</td>
<td></td>
<td>disagree</td>
</tr>
</tbody>
</table>
when the expert systems user is inexperienced or when auditing a first-time client.

**Effectiveness**

Overall, the effectiveness impacts are quite likely in the future. Not one of the proposed effectiveness impacts was considered unlikely by the Delphi panel. In particular, decision quality and consistency are very likely to be improved by the use of expert systems. While quality impacts were not yet obvious in the firm studied, decision consistency and quality control were important results of using the system. As better expert systems are developed and used to their potential, these impacts will become more noticeable.

**Expertise**

The category of impacts showing the most potential is the expertise category. The case study found the expertise of the firm impacted in that inexperienced users gained useful knowledge and expertise via the expert system. Evidence of stronger effects in the future was obtained in the Delphi study. The provision of documentation references, an increased ability to handle complex analyses, and the distribution of expertise throughout the firm, are the impacts to look for in the coming decade according to the Delphi panel.
Education

In the next decade the education of auditors may change as a result of the development and use of expert systems. This is a very likely event according to the Delphi panel. However, most of the participants noted that the impacts on education in the next decade are likely to be most noticeable on the job. In-house training is likely to be enhanced by the use of expert systems. In observing the use of an expert system today, the case study determined that the expert system was particularly useful in training inexperienced auditors in the audit planning task.

External

Various impacts of expert systems development and use have been proposed which affect the firm's environment. Most of these impacts could be characterized as "bad" effects. As a group, these were the least likely impacts of experts systems on auditing firms, according to the Delphi study.

Additional Implications of the Case Study

Contrary to previous studies of expert systems in non-auditing environments [i.e. Sviokla, 1986, 1989, 1990], the use of the expert system in the case study did not result in significant impacts on information processing capacity and organizational programs. This indicates that the most
useful effects of the system, other than the basic completion of the task, were not broad changes in the structure or content of the task, but rather improvements in consistency and quality control, and training of inexpert auditors.

**Moderator Variables**

Previous studies investigating the impacts of information technology have highlighted several important moderator variables such as task, size, environment. In the auditing environment, another possible moderator variable must be addressed: the level of experience of the users of the system. The rationales of the Delphi study contain many suggestions that the level of experience of the user can affect the strength of a specific impact, particularly in the effectiveness, expertise, and education categories. These results are in line with the conclusions of the case study. In the future, auditing expert systems developers and users should consider the influence of user experience on (1) the effectiveness of the system, and (2) the impact on the firm of using the system.

**Future Implications of Expert Systems for Auditing Firms**

Sviokla [1986] stated that "The strength of expert systems, in contrast to other types of information systems, is in their ability to help practitioners make progress on
structuring ill-structured problems." The fact that the Delphi panel identified several effectiveness and expertise impacts as likely implies that expert systems will have different impacts on auditing firms than other types of information systems and computer automation. Additionally, the contention in chapter 2 that environment and industry are moderator variables is supported by the results of this research which contrasts with the large efficiency effects identified in studies of expert systems in other industries. The results of this study indicate that the greatest potential for task improvement through expert systems is not in efficiency gains, but rather in increased effectiveness, the enhancement and distribution of expertise, and the education of inexperienced auditors.

The Framework of Propositions and Future Research

Based on the result of these two studies, the preliminary framework can be refined to include the more likely impacts, and to exclude the least likely impacts and effects that appear to be unrelated. Figures 7-1 through 7-6 display the refined framework.

The refined framework highlights the very likely and likely impacts discussed earlier in this chapter in thick and thin-sided boxes. The impacts that were determined to be unlikely in the next decade appear in dashed-boxes.
Figure 7-1: The refined framework of propositions: major categories
Legend:

☐ Propositions that are very likely in the next decade.

☐ Propositions that are likely in the next decade.

☐ Propositions that are unlikely in the next decade.

☐ Propositions that were not included in the Delphi.

Figure 7-2: The refined framework of propositions: efficiency
Figure 7-3: The refined framework of propositions: effectiveness
Legend:

☐        Propositions that are very likely in the next decade.

☐        Propositions that are likely in the next decade.

◼        Propositions that are unlikely in the next decade.

〇        Propositions that were not included in the Delphi.

**Figure 7-4:** The refined framework of propositions: expertise
Legend:

☐ Propositions that are very likely in the next decade.

☐ Propositions that are likely in the next decade.

擐 Propositions that are unlikely in the next decade.

☐ Propositions that were not included in the Delphi.

Figure 7-5: The refined framework of propositions: education
Legend:

☐ Propositions that are very likely in the next decade.

☐ Propositions that are likely in the next decade.

☐ Propositions that are unlikely in the next decade.

☐ Propositions that were not included in the Delphi.

Figure 7-6: The refined framework of propositions: external
Future research should first focus on the impacts identified as likely or very likely.

By filtering out the unlikely impacts, specific areas are identified for future research. For example, as expert systems continue to be developed and implemented, studies should be undertaken that address impacts, not in a broad sense as in this research, but in more specific areas such as expertise, education, or effectiveness, or even more precise domains such as quality and consistency.

Actual measurement of quality and consistency, for example, will provide more compelling evidence concerning expert systems impacts. The opportunities to begin such investigations should expand in direct relation to the number of expert systems development and implementation projects that occur in the next decade.

Future research should include additional case studies of expert systems in use to provide more information about impacts of systems used for different tasks, and field experiments and studies that address specific impacts.

Contributions and Limitations

Expert systems for auditing task are being more frequently developed and implemented than ever before. As auditing firms increase their use of such systems, an understanding of how that use impacts the firm and its auditing performance increases in importance. The primary
contribution of this research was to address questions and concerns about the impact of expert systems on auditing firms.

In this research, the probable impacts of expert systems on auditing firms in the next decade were identified. Reasons for these effects were also recognized. This investigation provided for a refined framework of expert systems impacts that are most important in an auditing context. This refined framework can be utilized as a starting point for future investigation of expert systems impacts.

The case study provided evidence about how an expert system is impacting a firm, not in the future, but right now. This study suggests that some of the impacts that are likely in the future are occurring now in a more limited sense.

Because this research addressed an area not previously studied, it suffers from a number of limitations common to exploratory and survey research, and case studies. Limitations of these studies include

1. Differences in impact due to firm characteristics are not identified. Multiple, comparative studies are necessary to address this issue.
2. Few firms have widely implemented expert systems at this time. Therefore, an in-depth empirical examination of a specific effect of an expert system is not feasible. Such a study may be possible as more systems are developed and implemented.
3. This research, like much exploratory and theory-building research, involves a large amount of soft data. Future research can now begin to focus on
measuring specific impacts with hard data, as it becomes available.

These limitations may be mitigated somewhat when one recalls that the inconsistencies in past empirical studies of the impact of information technology have resulted from a lack of theory [Markus and Robey, 1988]. These two studies attempted to answer the call for more theory development in technological impact research by narrowing the scope of possible impacts into a framework that can lead to the development of a better model of expert systems impacts [Huber, 1990; Kauffman and Weill, 1989; Markus and Robey, 1988; Bakos, 1987].
BIBLIOGRAPHY


AICPA [1987]. An Introduction to Artificial Intelligence and Expert Systems. A management advisory services special report prepared by the EDP Technology Research Committee, American Institute of Certified Public Accountants.

AICPA [1985]. The Future Issues Committee, First Annual Report to the Board of Directors, June.


Cundiff, W. E. [1985]. Interactive Software for the Capture, Management, and Analysis of Data in Delphi


Symposium viii, proceedings of the 1986 Touche Ross University of Kansas Symposium on Auditing Problems, Lawrence, KS: University of Kansas, 182-188.


Faculty working paper, University of Kansas, School of Business.


APPENDIX A

This appendix contains a sample Delphi questionnaire. The instrument was identical for each round.
From this scale, assign a two digit decimal value to each development indicating your best estimate of:

--The probability of occurrence before the year 2001.

0. Expert systems for auditing tasks will be widely available and utilized by the year 2001.
   
   **Rationale**
   
   ___________________________  
   ___________________________

1. Expert systems used for auditing tasks will have an impact on auditing firms in the next decade.
   
   **Rationale**
   
   ___________________________  
   ___________________________

2. The use of an expert system for an auditing task improves the overall efficiency of the performance of the task.
   
   **Rationale**
   
   ___________________________  
   ___________________________

3. The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers completing the task.
   
   **Rationale**
   
   ___________________________  
   ___________________________

4. The use of expert systems improves the effectiveness of auditing.
   
   **Rationale**
   
   ___________________________  
   ___________________________

5. The use of an expert system for an audit task results in less of the auditing division’s time being absorbed in decision related meetings.
   
   **Rationale**
   
   ___________________________  
   ___________________________
6. The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.

Rationale ____________________________________________

----------------------------------

7. The use of an expert system for an audit task reduces the number of organizational levels involved in authorizing proposed task-related actions.

Rationale ____________________________________________

----------------------------------

8. The use of an expert system for an audit task provides documentation references for audit judgments and reasoning concerning the task.

Rationale ____________________________________________

----------------------------------

9. The use of an expert system for an audit task enhances the in-house training program related to that task.

Rationale ____________________________________________

----------------------------------

10. The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.

Rationale ____________________________________________

----------------------------------

11. The use of expert systems in auditing impacts the education of auditors.

Rationale ____________________________________________

----------------------------------

12. The development and use of expert systems for audit tasks causes auditing firms to identify or eliminate the highest-risk areas in their practice.

Rationale ____________________________________________

----------------------------------

13. The use of expert systems in auditing results in augmented professional judgement.

Rationale ____________________________________________

----------------------------------
14. The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.

   Rationale

15. The use of an expert system for an audit task reduces the time required to make audit decisions related to the task.

   Rationale

16. The development and use of expert systems for audit tasks leads to the standardization of audit tasks.

   Rationale

17. The use of expert systems in auditing impacts the nature of the expertise of the firm.

   Rationale

18. The use of an expert system for an audit task allows auditors to gain new insights into the task decision process.

   Rationale

19. The development and use of expert systems for audit tasks leads to the dehumanization of auditing.

   Rationale

20. The use of an expert system for an audit task improves task decision quality.

   Rationale

21. The use of an expert system for an audit task results in an increased ability to handle complex analyses.

   Rationale

22. The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.

   Rationale
23. The use of an expert system for an audit task reduces the time required to authorize proposed actions relevant to the task.

Rationale

24. The use of an expert system for an audit task shortens the time new auditors need to improve decision making ability.

Rationale

25. The use of an expert system for an audit task improves decision consistency for that particular task.

Rationale

26. The development and use of expert systems result in increased non-accounting competition for auditing services.

Rationale

27. The use of an expert system for an audit task reduces the need for staff time on the task.

Rationale

28. The development and use of expert systems result in an increasing difficulty in employing the top auditing experts.

Rationale

29. The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.

Rationale

30. The use of an expert system for an audit task reduces the number and variety of members comprising the face-to-face task decision unit.

Rationale

31. What other impacts should be included in this survey?


Note:
The scale was the same for all rounds.
APPENDIX B

This appendix contains the rationales given by the Delphi panel for all propositions. The rationales were recorded in random order during a given round. However, the round three rationales are first, followed by the round two rationales. The round one rationales appear last. The rationales were recorded exactly as the panelists wrote them.
Comments received on proposition (P) which was:

Expert systems for auditing tasks will be widely available and utilized by the year 2001.

- Currently in evidence, likely to be widely available soon.
- Auditing has many unstructured tasks which are ill-suited to ES. I see it as a 50/50 chance that such systems will be widely available.
- There are still immense difficulties in developing these systems. Such development is likely to require significant investment in research. How likely this is, I don't know.
- Expert system usage will continue during the next decade. However, whether such systems will be widely available and utilized will be dependent upon the ability of the profession to dedicate adequate resources to the development of such systems.
- I really don't believe many small firms will be using by 2001.
- Limited resources.
- I may be more optimistic than most, but my 99% answer may just differ because of interpretations of "widely."
- I believe without a doubt that this will happen - since it is happening today.
- It still seems a certainty. ES will be used - they are now - that won't stop. They will never replace humans but they are and will be "widely available and utilized."
- Limited resources and increasing degree of competition among accounting firms.
- I maintain - they are being used now, and will continue to be more widely used. You could possibly quibble with the meaning of "widely."
- Much research needs to be done. Current expert systems are not much more than the traditional methods - computerized.
- Some efforts in this direction already but economics may slow development significantly.
- Expert systems is used synonymously with computer systems.
- Will continue to grow, but I'm not as optimistic about the rate as some.
- Simple cases can be handled by ES faster, which allows auditors to focus on more complex cases.
- Only half, not widely.
- I don't think they will become any more available than they are now. As use has increased problems have been noted and I believe some cutback has arrived.
- Auditing firms will be further-driven to increase automation to reduce costs.
- Already are used by many.
- I really don't think smaller firms will be using by then.
- Much of auditing involves applying logic to known data.
- Used now for many tasks in large firms.
- Cost and quality pressures will demand it, but it will be difficult model complex judgments.
- Beginning to see expert systems deployed in auditing now, and value seems apparent.
- I believe the Big 6 are currently using some sort of expert system(s) - should soon filter down to other firms.
- Many are already being used but I don't believe the use will increase as rapidly as they have been in the past.
- Capability exists today; it will replace human analysis and judgment in areas of routine and large masses of data.
- Available yes; used as a decision support aid.
- Perhaps in large firms only by then.
- The growing body of technical literature and complexity, offset by limited resources.
- Expert systems development should mature by this time making them more available to auditors.
- Because of its use in unstructured decisions and because of cost/time savings. Quite a few systems are already becoming available.
- There is a problem - some structured tasks may be impacted - many unstructured tasks will not.
- Some use now. More coming.
- Under development, in limited field use now.
- Auditing firms have not historically been at the leading edge in the use of technology. The extent of use by auditing firms will be dependent upon the degree of success other industries have in utilizing such systems.
- Based on the present trend in ES development.
Comments received on proposition 0 which was:

Expert systems used for auditing tasks will have an impact on auditing firms in the next decade.

- Limited effect - few significant systems up and running.
- A competitive tool and will evolve in to a labor saving tool.
- Just a matter of degree.
- Definitely - just a question of what type.
- ES will become the competitive edge. Also serve to deal more effectively with increasingly complex issues.
- Have an impact? Yes. ...positive impact? I am not sure.
- Will help insure consistency of complex decision making.
- The use of any tool has an impact on the user - and ES are now and will be used to a significant extent.
- It's not the ES but the explanation function that helps the users learn. Therefore, it depends upon system design.
- I agree - the big Q is the nature of their impact.
- Increasing impact as time progresses and professionals become used to such systems.
- Just a matter of degree.
- Most definitely - human resources are limited.
- More efficient use of resources.
- Can change the structure of the firms significantly, if used. Also some potential for new competition.
- Continuing and growing impact, but not as much as some hope.
- In a competitive market place it will impact those who use an expert system and those who do not.
- Will affect competition - also task structure/audit planning.
- Already have.
- Organizations are slow to change.
- Sure they'll have an impact, the question is the nature of that impact.
- More efficient use of resources.
- ES are good decision aids. They can audit more data, more consistently, and do planning more efficiently.
- Growing "impact" over time. Question of how much.
- Use will almost certainly result in impact.
- Saves time; costs; uniformity of decisions.
- Portable computing power is increasing and ES are better understood and more implementable by mainstream developers.
- Very cost beneficial, ensures consistency and quality.
- Should allow for lower staff levels to perform higher level tasks and learn from the process.
- ESs are/should be a way of preserving the expertise of highly experienced professionals.
- Improves audit planning and judgment, and therefore effectiveness; ultimately helping efficiency.
- Changes are going to occur.
- Certain auditing tasks involve the analysis of conditions to arrive at conclusions (i.e. risk analysis, both audit and business, analytics, tax planning, disclosure selection, etc.).
- Utilizing expert systems correctly can enhance the quality and efficiency in these processes. I believe all international firms will eventually arrive at this conclusion.
- As a means to ensure uniform firm-wide standard of performance.
- If using them [ES] is itself an impact then - yes.
- I believe we will find more and more that they will have a detrimental effect.
- Expert systems offer a meaningful way to standardize judgmental tasks. Increasing pressure will be experienced to force such standardization.
- Concerned over business failures, etc. require the auditor to reduce detection risk further. Expert systems will be used to "assist" the auditor.
- Already in use.
- Several expert systems are already being used. Many more are under development.
Comments received on proposition 1 which was:

The use of an expert system for an auditing task improves the overall efficiency of the performance of the task.

- Efficiency is a broad term - seems very likely.
- Task dependent.
- Works through problem logically - not distracted by gray areas so much.
- An ES will save time by performing some task faster than a human could - note that this says nothing about effectiveness.
- Assumes that majority of users will be non-experts.
- Unlikely in and of itself. Any increase in speed of completing tasks (made possible by the use of ES) will be offset by increased complexity of the task.
- I distinguish efficiency and effectiveness from one another. I do not believe ES are efficient. A good ES may make up for being inefficient, however, by being consistently effective.
- Probably improves effectiveness, not efficiency.
- Utilization of computer model in standard task will increase efficiency.
- ES should assist in the judgment process, but not make judgments. The task process may be better structured procedurally through ES. In this sense one might say overall efficiency is improved.
- Computers are faster and don't make errors.
- For routine tasks - yes. For non-routine - no.
- They could - but could also slow down if you decide to override its suggestions.
- Expert systems help the staff focus on key audit areas.
- Task dependent.
- Use of ES affects effectiveness and quality, more than a direct reduction of hours.
- Depends on the purpose of the system. May be used to improve quality.
- Computer is programmed to assimilate input and go to the next step - computers are faster.
- Efficiency is hard to measure when so many other variables are involved.
- It could, but it may actually slow down an expert who's able to jump to the key point without going through every step in the process.
- It provides the opportunity for improvement, but not a guarantee.
- Assuming quality is equal. Reason: avoidance of blind alleys.
- Does make it faster in most cases.
- Individuals utilize a standard approach which tends to increase efficiency.
- Depends on system purpose - not really an ES issue.
- Automation of even mundane tasks improves efficiency.
- I believe it improves the "effectiveness" more than the efficiency.
- The inherent efficiency of using such a system may be offset by an increase on the comprehensiveness of the work being done.
- It is very clear to me that they improve efficiency.
- Yes, in human terms, "no" in terms of risk reduction.
- Assuming relevant variables are included in the model.
- Depends on the task. If the task needs a certain amount of expertise and time to arrive at the appropriate conclusions, then an expert system can add efficiency. Additionally, if the tasks can be linked and the same data be used to arrive at more than one conclusion, then greater efficiencies can be achieved.
- Typically not. ES are not known to be efficient processors. Besides, ES should enhance quality, not efficiency.
- Computers work faster than humans.
- By focusing audit staff on key issues and improving initial work, it may shorten supervision and review time.
- Depends on the use. Perhaps for less judgmental tasks.
- It very much depends on the task.
- If efficiency means time reduction, probably not. Time would be used for other tasks.
- Efficiency may not necessarily be enhanced, but proper procedures are more likely to be performed.
Comments received on proposition 1.1.1 which was:

The use of an expert system for an audit task reduces the need for staff time on the task.

- Probably should after initial learning.
- I still believe that expert system usage will improve decision making quality but not necessarily efficiency. Auditor will still be required to attain required inputs and because decisions are pushed to a lower level the auditor may need to ask questions of clients over a period of time thereby creating inefficiencies. I have already seen this in practice.
- Perhaps just a shift to lower level staff.
- Yes, else why have an ES?
- It should - but requirements to collect data many increase time.
- This is the main reason behind efficiency of ES.
- Because of reduced data gathering and compilation time.
- Efficiency will be improved and this will lower staff time.
- May just refocus the task, or may require the staff to progress faster.
- If well-designed.
- Yes, for routine tasks.
- Questionable, could go either way.
- ...due to higher efficiency.
- Doesn't perform detail work, only enhances risk based decisions.
- I already see positive returns. Informed users of ESs can save great deals of time. Poorly informed professionals "spin wheels" with ES.
- Again, if you accept its efficiency.
- Yes - if it didn't improve efficiency, why build it.
- Assuming quality is equal. Reason: avoidance of blind alleys.
- Would seem so - again efficiency.
- Yet to be proven.
- Requires less preparation and paperwork.
- They still need to collect evidence, etc.
- No more so than the mechanical process of gathering data.
- Refocuses the tasks, and requires staff to progress quicker.
- ES should increase efficiency.
- Maybe depends on offsets.
- In absolute terms yes - in relative terms no.
- Time spent researching and evaluating should be decreased.
- Somewhat - at the staff level.
- Very unlikely - time consuming tasks related to decision processes, administrative tasks, etc. not readily replaced by ES.
- Depends on purpose and users.
- Possibly.
Comments received on proposition 1.1.2 which was:

The use of an expert system for an audit task reduces the time required to make audit decisions related to that task.

- Decisions can be made much quicker because the ES facilitates the process.
- I still believe that expert system usage will improve decision making quality but not necessarily efficiency. Auditor will still be required to attain required inputs and because decisions are pushed to a lower level the auditor may need to ask questions of clients over a period of time thereby creating inefficiencies. I have already seen this in practice.
- Machine speed - efficiency issue again.
- The decision-making process is more efficient.
- Have high expectations that ES will. It will depend on the breadth of the knowledgebase, the scope of any information base used and the documentation of the decision supplied by the ES.
- Time to make decisions will remain unchanged. Time to gather and analyze all relevant information may well decrease.
- Absolutely - ES in use bear this out, I believe.
- On balance, probably - but for some tasks or some firms, probably may increase time.
- Can lead to bad answers also.
- Most routine cases will be solved by ES.
- Empirical evidence says it depends on system.
- Doesn't really reduce the time to make audit decisions just the time required to complete a task.
- Efficiency is one major rational for development of ES.
- No. Maybe to perform task; but not to make the decision.
- Depends on system purpose.
- It should save time.
- Little correlation - decision making similar after fact gathering is done.
- Perhaps, but very limited.
- In one sense, yes - cause have pushed down level of decision making. But, by forcing auditor to be more thorough in data collection, may actually increase time, too.
- It depends ... again - efficient.
- But, may increase the time spent gathering data because the ES will have a more complete decision model than most users.
- More likely the time is increased as it forces the auditor to consider all relevant factors.
- It very much depends on the task.
- Not necessarily related - depends on the nature; actually, it helps identify, not resolve.
- The time required may be reduced because the expert system may produce documentation which would otherwise required additional research.
- It should improve the quality of the decisions.
- Certainly, many systems do.
- Could go either way.
- Reduces (perhaps) time required to gather info needed as input to decision-making process. May reduce or lengthen time needed to actually make decisions.
- At the staff level - somewhat.
- It can.
- By bringing tailored, reference and specifically crafted information to light, it can enhance the judgement process.
- For untrained and inexperienced auditors.
- Probably "yes" - some of the time gain may be offset by pushing data through the interface with the ES.
- To me this is the basic reason for expert systems.
- Efficiency gains may be offset by what-if.
- It provides a standardized approach which should increase efficiency.
Comments received on proposition 1.1.3 which was:

- The use of an expert system for an audit task reduces the time required to authorize proposed actions relevant to the task.
- Because collection of facts is improved, then should be reduced.
- Allows for quicker decision making.
- I'm even more confident after reading the comments.
- Presumably authorization is a priori - while ES was developed.
- Efficiency is a major rationale for use of such systems. If efficient, should reduce time if ES widely accepted.
- Maybe - maybe not.
- Provided the use of the ES results in a superior explanation of the proposed decision.
- Maybe - but will still need to get approval.
- It would not necessarily reduce the time - variance in authorization would be related to the humans, not the ES.
- If you accept the premise that it's efficient...
- Authorization will still be needed, but time may be reduced.
- The actions are part of the ES.
- ES should enhance the decision making process.
- No relationship.
- Authorization can't/shouldn't be made by ES, but by reviewers.
- In some cases.
- Depends entirely on system purpose and how well it is built.
- As long as it's agreed to accept the ES opinion without question.
- Yes, there's the idea of pushing down expertise and responsibility.
- Not supervision?
- Time stays about the same, the results of the system should make the process more complete.
- In long run, yes. Depends on user and system purpose (novice vs. expert user).
- If this happens it is the fault of the ES.
- If system used properly.
- Don't think so.
- Only if the rationale for the proposed task is better documented.
- Assuming ES reduces total time to perform task.
- Again, what if could offset.
- Overall audit process should be speeded up if ES are used.
- Info available search.
- Should enhance the decision making process.
Comments received on proposition 1.1.4 which was:

The use of an expert system for an audit task results in less of the auditing division's time being absorbed in decision related meetings.

- The ES will gather facts and focus attention, but meetings to discuss/resolve will be unchanged.
- To the contrary...
- There will always be meetings.
- The acceptable decision rules are already programmed in ES model.
- Yes for the limited tasks available.
- Depends - could meet to discuss all ES recommendations.
- Decisions/evaluation must still be made. ES help focus attention earlier and gather facts, but decision process (vs. fact finding) will not change appreciably.
- If expert systems take over individual decision making, more time will be spent on making sense of it all.
- Better focuses the decisions.
- The acceptable decision rules are already provided.
- I will stick with "very unlikely". Technology has not had this type of impact over the past twenty years. Won't happen this decade either.
- Better communication if properly used.
- I think auditors will still make decisions in groups - this is human nature - but with ES the character of these decisions may change.
- It could to some extent, but not very much. There's too much nonverbal communication that is important and can't be replaced by ES.
- Depends on system - entirely.
- I believe the opposite will happen when people rush to automate processes that we don't yet have the technology for.
- There will always be meetings.
- Most current ES tasks are individual decisions such as sampling, etc. There will be less need for defending these decisions to higher levels since they will tend to rely on systems once the systems are proven.
- Could be but could go the other way and more issues are explored.
- In limited areas, yes.
- Once the decisions have been made and incorporated in the system, they are programmed - however, exceptions will require meetings.
- System makes the decisions.
- Depends on whether expert systems are used as individual judgment aids or group judgement aids.
- ES cannot be sued. Auditors have to meet, decide and understand responsibility.
- Expert system can't be used as a surrogate for auditor's judgments. Accordingly, auditors should review judgments made by expert systems and ensure that such judgments are appropriate.
- All auditors are included in the package, thus there is no need to list all the options again.
- ES will never replace effectiveness of face to face meetings.
- Probably not - firms must still keep supervision and review practices in place. May improve initial analysis work - perhaps reducing some aspects of supervision and review.
- Such meetings should accomplish more.
- It merely helps focus the efforts so meetings are timely and comprehensive.
- I hope judgement is not foregone.
- On the contrary, I believe it brings to light a larger number of issues to the forefront which thus increase the length of the meetings. I view this as a positive attribute of expert systems. Note that I do feel the time spent on individual issues will be less (there will just be more issues).
- will still rely on auditors judgement. Auditors liable regardless of decision support aids.
- I do not think a case can be made.
- I don't think firms will ever give over the judgment aspect of auditing to expert systems.
- Efficiencies may be offset by a greater tendency to explore options.
- Better focuses the decisions.
- Maybe just make meetings more productive.
- Assuming appropriate validation and user acceptance of system.
Comments received on proposition 1.2.1 which was:

The use of an expert system for an audit task reduces the number of organizational levels involved in authorizing proposed task-related actions.

- Authorization unchanged - ES assures better input coordination, but doesn't eliminate the authorization.
- Authorizing tasks is a management decision not a software function.
- Minor reduction.
- May reduce organizational levels, more likely will reduce extent of involvement at various organizational levels.
- Task dependent. CPA firm chain of command likely to remain the same.
- Should do so if the auditors "trust" the ES.
- I really don't see any link between the use of an ES for an audit task and organizational levels involved in task-related actions - no effect!
- Task dependent.
- Impact not likely to be dramatic. Will probably happen to group task organization rather than organizational hierarchy.
- Double edged sword.
- "Authorizing proposed task-related actions" is an audit management function not a computer software function.
- Depends on task complexity.
- Probably not.
- Depends on any change in organizational structure.
- Probably not a lot - there are limited number of levels now.
- It shouldn't! The same levels of review must remain intact. However, the actual tasks should be reduced.
- The system in many cases enhances the product but does not allow for a reduction in oversight.
- I still don't see a relationship.
- Not clear. May have small effect.
- Simply blanket approval for specific types of decisions using ES rather than individual approvals.
- Yes, because machine replaces some levels.
- Probably - the idea is to push down experience.
- Yes - because pre-programmed.
- Depends on whether expert systems are used as individual judgment aids or group judgement aids.

- Checks and balances are still important.
- Don't see a relationship.
- It depends on whether or not the ES has been vested with decision authority.
- Depends on organization.
- Not clear on any effect here.
- I don't see the use of the ES having any effect on the authorization of task related actions -- it's putting too much power into a system.
- Time will tell.
- If the firm trusts the expert system, there could be a reduction of higher level reviews performed.
- It certainly could.
- Again, it may reduce the total number reviewers, but the levels and nature of reviews should not change.
- Again, this depends on task and degree of learning.
- Only 2 levels to authorize now - partner and manager.
- Transfer of expertise to lower level professionals.
Comments received on proposition 1.2.2 which was:

The use of an expert system for an audit task reduces the number and variety of members comprising the face-to-face task decision unit.

- Could.
- Efficiency gains will probably be offset by increases in task complexity in other areas.
- I doubt it.
- Although extent of involvement at various levels may be decreased somewhat, extent of involvement is most likely to experience largest reduction.
- Number should be smaller. Composition will probably be similar.
- Since all experts are reduced to a software.
- Perhaps not number, but I would think variety.
- Audit teams will be smaller due to efficiency gains.
- Possibly.
- Only marginally - will still need supervisory control.
- Human element will still be needed to validate the ES findings.
- No.
- To some degree - if the ES didn't reduce staff why would be use them?
- Possibly, but minor effect.
- Fewer people to be consulted - system assimilates thinking of many.
- Yes - if ES increases efficiency, need less people to do task.
- Yes - because need lower level staff only usually.
- Depends.
- Does not necessarily follow. Not a design consideration of ES. Results of an ES could point out more work that needs to be done.
- Possibly.
- Probably not, due to increasing complexity of decisions that need to be made.
- No - supervision and review policies remain intact.
- It can reduce the time spent by the more senior members of the firm.
- No, as I understand the question. The ES result will be a tentative finding, to be validated by human examination.
- No reason to expect this.
- Audit teams will be smaller due to efficiency gains from ES technology.
- I don't think expert systems are that far along or the profession that confident on the systems.
- All the alternatives have already been defined thus there is no need for any face-to-face meeting.
- Not sure whether this is a good idea or not.
Comments received on proposition 2 which was:

The use of expert systems improves the effectiveness of auditing.

- It is the conduct of the audit process that determines the effectiveness of auditing, not computer software alone.
- Yes for the limited tasks available.
- If well designed. Bad systems always produce bad results.
- If properly developed and used.
- If properly used.
- Only when used with sound professional judgement.
- If properly used.
- If properly developed, can improve consistency and understanding.
- It provides a structured and well-thought approach.
- I am not so optimistic.
- If properly used.
- Given the rate of ES development and problems encountered with use I don't think this will occur before 2000.
- Use alone will not improve effectiveness. Improvement in effectiveness will be dependent on the incorporation of the ES into the audit process.
- Efficiency, perhaps, effectiveness much more doubtful.
- It should, but may not.
- I really don't have any evidence one way or another.
- If properly used for proper task.
- Maybe - but if the auditor just learns how to use the system and relies on it too much, it may cause problems just as too much structure could be detrimental.
- Reduces performance variance and bias.
- Lower level staff work with program - may lose something not captured in program.
- ES will tend to upgrade the performance of the less knowledgeable users.
- Depends on purpose (efficiency vs. effectiveness).
- Used in conjunction with sound professional judgment.
- It would provide a structured systematic approach.
- This is the aspect now being questioned - ideally it should but that depends on the quality of the system and user interaction.
- More auditing for same input of effort.
- Used as one source of information in audit decisions.
- It can reduce the risk of "audit failures" or improper advice given by bringing a lot of information "to the table." However, most auditors (including myself) will tell you that audits as currently performed are satisfactorily effective.
- May not understand task.
- More consistency.
- ES can keep staff level more focused on appropriate audit activities.
- It very much depends on the task.
- By identifying high risk areas - and again, if such systems can really be built and maintained.

- Provides more consistency in judgment of audit professionals.
- If properly used and users are adequately trained.
- Time/cost savings. Mundane tasks can be done by ES.
Comments received on proposition 2.1 which was:

The use of expert systems in auditing results in augmented professional judgement.

- I certainly hope that use of these systems does not decrement or degrade professional judgment. Gentlemen: If we implement and use these systems and they do not result in "augmented professional judgement" then one must ask: What is our basis for avoiding commitment to institutions for the feebleminded.
- It is the intent - but judgment is difficult to quantify.
- To me ESs are a way of gathering evidence. They have not been developed to the point where they will supplant judgment - and will not be by 2000.
- Yes, if such professional judgement is used when necessary.
- Allowing a firm to focus on a given task or a judgment area.
- This is a key current use of ES - "augmented" may not be quite the right word. Also depends on the quality and currency of the ES.
- For some people yes, but for others no. Depends on quality of system, firm policy/attitudes on its use and prior expertise of user.
- This one seems self-proving unless I'm really missing the point.
- I don't strongly agree. Professional judgement must not be increased or decreased.
- Professional judgment is difficult to quantify.
- A lot of real issues here. Generally yes if the systems are well developed with an eye toward comprehensive explanation facilities, users are well trained, and the system properly supported and maintained. A big IF.
- Professional judgment is a human function. ES can support; doubtful it can augment.
- Augmented, yes; replaced, no.
- OK - since it represents the thinking of many "experts".
- Professional judgment will have to incorporate the ES reasoning even if only to reject it.
- Hard to measure professional judgement.
- Maybe - but if the auditor just learns how to use the systems and relies on it too much, it may cause problems just as too much structure could be detrimental.
- Not sure - if low level staff with program that is not well-developed, will not.
- It depends . . .
- Maybe - if used properly. But subject to supplanting use of individual judgment (if the user surrenders judgment to the machine).
- Questionable.
- By focusing in an organized manner and providing access to appropriate data and knowledge.
- This is possible, but not a guaranteed result.
- Professional judgement is always required - hard to measure.
- Augmented?
- Augmented - yes. Replaced - no.
- For staff level users.
- Not yet.
- By bringing tailored, referenced and specifically crafted information to light, it can enhance the judgement process.
- One source of information for decision making.
- Seems consistent with nature of ES.
- I don't think ES will improve professional judgments given that necessary information is available through other means.
- More expertise would be widely available.
- The firm's judgment, as represented by the ES, influences or replaces individual judgment.
- ES should be used for decision support and not be looked to to replace judgement.
Comments received on proposition 2.2 which was:

The use of an expert system for an audit task improves task decision quality.

- If properly designed.
- If done properly it should. If not we should not call it an "expert" system.
- It shouldn't make decision for you; it should offer you the criteria to make the decision.
- Overall - yes.
- If it's well designed - certainly will improve consistency/consensus.
- Effectiveness is a major rationale for development of ES. Question should state "average task decision quality" since some individual decisions may be better than ES recommendations.
- With a good ES used correctly.
- Consistency of decisions.
- If expert systems are used wisely.
- Provided questions are properly answered.
- It should improve staff level decisions - by keeping them better focused, eliminating extraneous information, and explaining the decision process.
- Not necessarily - In the long run, increased use of ES will lead to decrease in decision quality as machines do more of our thinking.
- More thorough and consistent fact gathering and comprehensive review of literature.
- Generally, yes, at least that is one of the goals.
- Should happen if used properly.
- If ES is really well-developed (there may be bad ones).
- Maybe, but if auditor just learns how to use the systems and relies on it too much, it may cause problems just as too much structure could be detrimental.
- - on average (won't outperform the best individuals).
- Should be the goal of an ES.
- ES needs to be in good and proper hands.
- Depends on design and validation and type of decision. Research, e.g. Pincus, has shown the DSS applications in auditing may lower the effectiveness of the decision maker.
- It should be made expertise more widely distributed.
- What we have now and what I expect that we will have for years to come would improve decision quality only for the novice and not overall for the firm.
- If by "improve" you mean "makes more consistent and complete" then yes.
- I think it gets staff level to focus better - not necessarily improve the end product - but instead eliminate extraneous information.
- Depends on how system is used. ES support but does not replace the decisions that constitute audit quality.
- Look at the task in a more systematic form.
- We have to wait and see.
- Consistency, really.
- No arguments here, when used in conjunction with auditor judgment and experience.
- There are some indications that this is possible but it is contentious.
- It will present additional information to the auditor, and makes the decision process more formal rather than intuitive.
- In the aggregate.
Comments received on proposition 2.3.1 which was:

The use of an expert system for an audit task improves decision consistency for that particular task.

- It should.
- At least, this is what is expected of ESs.
- If it doesn't, why use it?
- A higher level of discipline is motive - both the ES and human aspect.
- Not necessarily although it is somewhat likely since decision inputs will be consistent.
- Will depend on the use of the tool in the audit process and review process.
- Yes - just as required documentation does.
- Consistency will improve if a common tool is used.
- Due to structuredness of ES.
- A key objective and benefit of ESs.
- Agree most of the time.
- It has to, based on the software design for typical ES.
- One of its main functions.
- Agreed.
- If applied appropriately.
- Certainly, a program follows its logic consistently.
- It should as it enforces same steps for everyone.
- Programmed decisions.
- The same facts should produce the same answer.
- One of their purposes.
- Inherent in ES nature.
- If the same set of support information is used to arrive at a conclusion, the higher likelihood that the conclusions will be the same.
- Probably.
- Probably - if ES applied consistently.
- Agreed.
- Consistent - yes.
- Because documentation and information gathering consistency will be improved.
- Though it is necessary that data input is consistent.
- Assures comprehensive review of data.
- All the alternatives already know to the auditor.
- Decisions and judgments are made by humans. Use of ES does not necessarily improve decision consistency.
Comments received on proposition 2.3.2 which was:

The use of an expert system for an audit task assists in identifying exceptional circumstances warranting further investigation.

- Available today; do not have to wait until 2008.
- Ours do.
- It should be so designed.
- It should be so designed.
- Yes - if the ES is complete and up to date.
- Because the routine cases are already part of the expert system.
- If that's its function.
- By bringing together the broadest knowledge base possible, I believe it assists.
- Yes, because those not included in program (if well developed) are exceptional.
- Yes - when expert systems fail.
- As viewed by an expert - very likely.
- This statement is absolutely true, today! Underline "assists in identifying."
- Depends on the sophistication involved. But most "exceptional circumstances" are identified without ES.
- Limited. ES today handle the 95% most common situations. Most lack ability to appropriately handle remaining 5%.
- Entirely dependent on quality of system. This is tough stuff to implement.
- "Exceptional" circumstances are typically not well identified by ES but this could improve if systems designers improve process.
- If properly designed it will - hopefully "exceptional circumstances" can be identified without the system as well.
- "Yes," if "exceptional" means to the user, but "no" if it refers to the knowledge engineer.
- It depends...
- If written so that it fixes issues.
- ES should help pull together data to identify trouble spots.
- This is big!
- It depends on the design of the ES. Ideally, it should identify when further detail is needed. However, in practice we tend to see a "closed world" assumption.
- This would depend on how well the system is developed.
- Given increased sophistication of expert systems.
- It will if you mean "circumstances previously anticipated" as these are the only ones for which the ES can test.
- For untrained and inexperienced auditors.
- A risk based expert systems, if appropriately designed, would do this.
- It can.
- I think ES is only good at identifying known problem types. This is why the review process remains critical.
- Depends on quality of ES.
- Ours do.
- Hopefully it is highlighting. You have a problem in prior years if "exceptional circumstance" are caught.
Comments received on proposition 2.4 which was:

The use of an expert system for an audit task leads to the standardization of audit tasks.

- By focusing on "best procedures".
- This is a key benefit.
- Yes - that's result of any automation doesn't mean standardized results, but will standardize the process.
- To some degree; however, ESs are not and probably still won't be applicable to each specific client's data/needs by 2001.
- To me this is one of the purposes of ESs - standardization.
- The tasks will have to be standardized - I agree.
- I agree.
- Different firms may still have different approaches and procedures.
- ESs provide more structure to the nature of audit tasks.
- Carrying out audit tasks is a human function not an ES function.
- I would think no more than what is currently being done.
- Certainly - the same programmed expert approaches to task.
- By the use of a common system there would be.
- Becomes codification of company policy to some extent.
- Yes, that's been the history of most automation.
- Imposes structure on the audit.
- ES implementation often standardizes a subset of the task supported.
- Same program or expert makes all decisions.
- Somewhat.
- The use of expert systems may lead to standardization of work papers and documentation.
- Expert systems should supplement the determination process of audit tasks.
- "Can" lead... may reflect best practice.
- May be at lower levels but not at judgmental levels.
- Current audit methodologies of the audit firms.
- No more or less than existing practice guidance disseminated by firms.
- It certainly encourages it.
- It can.
- As judgment is involved, the way professionals deal with and document tasks will always vary.
- Only of those for which the ES is designed and only until a new version of that ES is created.
- If ES are in fact heavily used then audit tasks will become standardized probably to the detriment of effectiveness.
- Yes.
- Most systems do not include many alternative approaches.
- By definition, there is standardization anyway.
- ES have nothing to do with standardizing audit tasks.
Comments received on proposition 3 which was:

The use of expert systems in auditing impacts the nature of the firm's expertise. It will become more and more like the ES.
- As ESs become used more and more the nature of the firm's expertise will become more and more like the ES.
- Yes - but question is: will it leverage it, or will it hinder future development?
- The ES can only reflect the nature of the firm's expertise, not change it. However, the distribution of the expertise may change.
- Not really.
- Spreads it, if anything.
- It may spread expertise to lower levels. In some ways, however, the expertise of the firm would always be around.
- It may open new areas to a firm that have not been exposed.
- I rate very unlikely in the sense that experts will still be required (and this need will probably expand).
- Does impact nature, but I was reacting to concerns about loss of expertise.
- It makes the expertise of an expert available to large numbers of auditors.
- Spreads the expertise through training.
- Highly leverages expertise, makes the most advantage of a firm's expertise.
- Possibly - if judgments become automated, what is expertise? How is it developed? Maintained?
- After knowledge captured, experts will do other things? High level of expertise trickles down.
- By definition.
- The firm's expertise, formerly in the heads of its people, will be stored extra-somatically.
- Clearly if expertise can be encoded, it can be studied and enhanced.
- Usually a reflection of the expertise as well.
- The experts need to develop the system.
- Certainly it "leverages" it.
- The expertise may shift in the area of ES in less to routine audit tasks.
- No - only disseminates such expertise further.
- It won't change the types of expertise but the number of experts and how expertise is disseminated would change.
- Makes people aware of the technology, and as previously discussed, can improve the education (OJT) that the firm provides.
- No - it better defines that expertise but the "nature" of the expertise remains as before - logical, scientific, professional, analytic.
- Again, if ES are heavily used it is a given that it will affect the expertise of the firm.
- Depends mostly on training issues. Potentially going both ways.
- Expertise can be partially stored in hardware as opposed to humans. This has always existed to a certain extent in other types of DSS.
- Spreads expertise.
- Should become a vehicle for recording and preserving expertise.


224
Comments received on proposition 3.2 which was:

The use of an expert system for an audit task provides documentation references for audit judgments and reasoning concerning the task.

- Ours do.
- It will unless the developer really messes up.
- As long as system well-documented.
- Since audit judgment and decision rules are pre-determined, they could easily be documented.
- By definition, that's the rule trace.
- Agreed.
- This, to me, is the basic way that ES can improve and become more useful in an audit.
- Facts and rationale are automatically documented.
- It does provide rationale and references.
- This is already happening - will be a major benefit by 2000.
- Yes - rule trace.
- ES will capture all judgmental inputs and humans will have to write memo if rejecting ES advice.
- That is its purpose, if it is well done.
- A well designed ES will document all decision made.
- As long as system well-documented.
- Yes. An important contribution.
- Only certain kind of knowledge can be documented. Also, the documented judgment and reasoning may be completely different from the actual human reasoning process.
- It certainly depends on the system.
- True, but clients may want something beyond this.
- I agree.
- Yes - expert systems can now document rationale.
- Depends on the individual ES but most would.
- More so [in a decade] than now, but, I expect people to still be held accountable.
- Facts and relationships automatically documented.
- It is part of the software documentation.
- A main reason for such systems.
- I think this is a key reason for pursuing ES.
- If good system.
- Often, recurring simple issues or issues specific to an industry are not documented in the work papers as they are not felt to be significant or unusual. Reports from expert systems typically also do not make such distinctions.
- Yes.
- Self-evident - use of ES will itself be an audit trail of the part of the audit where the ES was used.
- This is a great way of documenting all aspects of the audit process.
- That is one of their functions.
- In our systems, yes.
- Data should be well preserved in ES applications.
- To the extent based on literature; also, add personal experience and judgment.
- Agree, documentation can be improved.
- A well designed expert system will supply documentation references and supporting material for decisions it has made.
- Very key for auditors.
- Assuming the system is developed properly.
- One of the major strengths of ES.
Comments received on proposition 3.3 which was:

The use of an expert system for an audit task results in the distribution of expertise pertaining to the task within the auditing firm.

- Ours do.
- This is the main reason that ESs are developed.
- It should.
- By definition deployment of an ES firm-wide will distribute expertise.
- To some degree.
- Physical distribution, yes - but if you mean more auditors understand the expertise - NO. More auditors use the expertise via an expert system - YES.
- By definition.
- That's the reason they are built.
- If the firm allows easy access to the system.
- Yes, since everyone is exposed to the ES.
- The nature and purpose of ES.
- That is the purpose.
- Gives staff quicker access to more advanced knowledge and decision making.
- Agreed.
- Only if the theory behind ES is learned by the professional using it.
- As long as accessible.
- Yes - this is rationale - to capture and distribute limited expertise to many users.
- Agreed - better communicates the task more uniformly.
- Non-experts will be able to examine expert knowledge.
- To some degree.
- Certainly - that's the whole point!
- That is the purpose.
- Again, if expertise can be encoded.
- Yes - "leverages."
- The expert systems will capture expertise from some experts and make it available to all users of the system.
Comments received on proposition 3.4 which was:

The use of an expert system for an audit task allows auditors to gain new insights into the task decision process.

- If proper feedback mechanisms.
- True for less experienced auditors.
- Only if a good ES is used correctly.
- To the extent the user does not just blindly respond to system's questions.
- Maybe in performing the task; but the decision must still require professional judgment.
- By definition.
- Yes, the new insights will be to realize some things cannot be automated.
- The user may go the other way - follows the answer and does no thinking.
- Mostly easy stuff is programmed.
- By forcing a higher quality (completeness) of logical documentation.
- If proper feedback mechanisms.
- The decision making process in ES environment is more rational than intuitive.
- Not necessarily so if applied on a routine basis without much thought. It all depends on software design.
- If used right - some users may not bother and go after the answer only.
- Maybe - but just as likely to get fixated on the questions asked by the system.
- Obvious.
- I'd say the creation does more to allow new insights than the use.
- Should.
- If appropriate explanation facilities, e.g. hypertext, are included in the ES.
- This is true for inexperienced auditors.
- This is probably true for a novice but if an only if a true ES exists.
- Not new insights - but the role of intuition will be diminished; the role of logic enhanced.
- The expert system should provide a trail as to how the conclusion was reached. This should give people insight into the task decision process.
- Perhaps.
- Depends on quality of the ES.
- Look at the task in a more systematic form.
- Reflecting "best practice,"
- Agree - may bring a "fresh" look at an issue.
- Access to broad base of knowledge is easily gained.
- This seems very clear even if the insights show that decisions or judgments cannot be automated.
- This is true if the expert system allows the reasoning to be visible. This spreads the expertise embodied by the system to its users.
- Not likely yet.
- For untrained and inexperienced auditors.
Comments received on proposition 3.5 which was:

The use of an expert system for an audit task results in an increased ability to handle complex analyses.

- Available today!
- If properly designed to do so.
- If ES can aim ABMs and if that is an example of complex analysis we handle only with ES, then who could disagree with the statement? Why DO people disagree? Are they THINKING? Or what?
- Yes, because collects from several experts.
- It should.
- It allows to break down the complex task.
- Depends on training of users.
- By providing easier access to decision making at a lower level.
- Handling complex analyses is typically the justification for developing an ES.
- If routine tasks are automated.
- Easier for the ES to handle a multivariate environment.
- I strongly believe that as presently handled complexity is captured by ES, we can incorporate additional complexity for which previously we did not have time.
- The intent is to provide a tool to simplify complex tasks.
- Increased ability and efficiency.
- It is what an ES should do, but whoever said complexity is also increasing is right, tool for staff level personnel.
- Usually part of a large system, so would probably be better able to manage a large number of data items.
- Complexity in the business world is increasing at the same rate as power of ES.
- It's possible if properly designed - but research shows it may hinder learning, too. If the auditor just learns how to use the system and relies on it too much, it may cause problems...
- It all depends...
- A complex task usually involves a multitude of variable. It is difficult, if not impossible, to develop a system which contemplates all possible combinations of variables.
- It can.
- By helping to sort through massive data.
- More effective and efficient activity.
- Depends on system purpose.
- We have to wait and see.
- Breaking the task into smaller parts.
- Only in hands of skilled, experienced user.
- At the staff level.
- Brings pertinent information to the forefront.
- The complexity once captured becomes routine.
- Certainly not over and above general experience and native talent.
- Can push this to lower levels.
- To the extent a firm can leverage its knowledge, they may be able to undertake additional work.
- Individual ability may not improve with ES technology if not designed properly.
- The nature of ES.
Comments received on proposition 3.6 which was:

- The use of an expert system for an audit task inhibits the development of task-related expertise by the users of the system.

- Makes users more productive.
- Not if implemented properly.
- Depends on system.
- Depends on how the system is developed.
- Depends on the design of the systems and nature of the task.
- Users often over rely on the ES to make the decision.
- Not with proper use.
- Some problem of learning software program, not task, is possible.
- It, in part, improves the situation.
- ES, properly developed, enhances the development of task-related expertise.
- The system will improve expertise by reducing time needed for data gathering.
- Need to allow for mis-use.
- If the ES is used for the task then users of the ES will be inhibited in the development of expertise.
- It all depends on the type of system.
- This is one of my worries but I don't have data to back it up. Presumably, by becoming dependent on an ES, the lower level staff may lose the chance of developing expertise by trial and error experience.
- Depends on design of ES.
- May accelerate the development?
- Should help in training.
- I don't believe it does.
- No - it actually helps through their learning.
- It's possible if properly designed - but research shows it may hinder learning, too.
- If properly managed, should do the opposite, but risk of mismanagement.
- Quite the contrary.
- Depends on design of ES.
- Depends on training.
- This, in my opinion, is the big problem with ES and decision aids.
- This may be true. On the other hand, the time released by the ES need not necessarily be diverted from such development.
- The task itself is the same, the only thing that has changed is the delivery tool.
- No - it augments ROTE learning while the review process enhances the creative/intuitive aspects of expertise.
- No, enhances such development - if rolled out and supported properly.
- Actually, it enhances the training effect.
- Expertise is still developed, but time is focused on critical areas.
- The use of an expert system should enhance the development of expertise, since the user can learn from the system's results and reasoning.
- Users may not learn task.
- Generally I would expect auditing professional to attempt to gain an understanding of the rationale used by the system in arriving at its conclusion.
Comments received on proposition 4 which was:

The use of expert systems in auditing impacts the education of auditors.

- Yes, but minimal.
- Firms must integrate these tools into their training - thus a truism. College level impacts are far less likely in near future.
- Yes - on the job.
- True, since it is such a valuable training tool.
- Probably right, when using an expert system the accountant does increase his or her knowledge base.
- ES are great training devices.
- Sometimes for better, sometimes for worse.
- This is already happening - will be a major benefit by 2000.
- They must learn new technology.
- Perhaps as auditors find out that certain things cannot be automated.
- Yes, a new tool, must be covered; may be a vehicle, too.
- As long as ES are used in auditing they have to effect the education of auditors both in-house and in school (the former will occur first).
- Must learn to use them, but that is minor (assuming ES not used as intelligent tutors).
- It will naturally impact the education process, I am unsure to what extent.
- It may impact the way we educate but not the actual education or learning.
- On the job "education" - yes college classroom will lag behind.
- Ability to effectively use the tool without over-reliance is important.
- I have already added ES coverage in my graduate auditing courses.
- Must learn to use them. Also, the knowledge gained in building systems will be used to improve education.
- Tautologically true. If they use a system, they will need to learn it.
- Only in so far as they must learn the technology.
- It's a tool to be used after the basic training.
- The use of an expert system may accelerate an auditor's education. The auditor must learn about the application and limitations of expert system technology.
- Professional judgement, regulations, etc. are still required.
- Within the firm.
- On the other hand the impact may be positive (my response is based on positive impact).
- Simulating a real life situation.
- A main reason for such systems.
- I think it would improve it somewhat.
- By 2001 - the classroom will lag.
- It can greatly impact the education of lower level professionals.
- We'll have to include ES in the educational environment.
- I believe expert systems are great devices for training programs.
- Greater emphasis would need to be placed on critical analysis of rationales.
- Appropriate education will include the use, pros and cons of the technologies being utilized in practice.
- Still need to offer input in judgement areas.
- ES should be used for training extensively by the year 2001. I envision the program used on the audit will be the same as that used in the training course.
Comments received on proposition 4.1 which was:

- The use of an expert system for an audit task enhances the in-house training program related to that task.
- There tends to be a natural link here that causes this to happen.
- If properly used.
- "Pushes-down" the knowledge to lower level staff.
- A prime advantage of an ES.
- It could but education research shows no guarantee.
- I'm unsure if it enhances - if teaching is sound, one wouldn't need an expert system.
- An important contribution of such systems.
- It's possible but I still believe the balance of a course - history, etc. is necessary.
- Simulating a real-life situation.
- This is already happening - will be a major benefit by 2000.
- As the ESs become better designed especially with respect to documentation references for audit judgments and reasoning in-house training will clearly be enhanced.
- ES are great for training/learning!
- The ability to incorporate the knowledge of in-house experts into training programs should not be passed up.
- An iffy proposition.
- Maybe.
- Use of ES for audit tasks is not the same thing as, and need not lead to, use of ES for training lessons.
- I feel expert systems may reduce the actual learning involved with each particular professional (i.e. relying on the system for the thought process).
- If properly used.
- Training should be increased due to ability to perform sensitivity analysis.
- Depends somewhat on how well built the system is but the explication of knowledge necessary to develop such a system should by itself lead to better training.
- Same knowledge required to build (good) course or expert system.
- It provides the opportunity for improvement, but not a guarantee. Can de-skill, or create learning depending on management, training, an quality of interface design.
- How and what-if capabilities allow training.
- It's possible if properly designed - but research shows it may hinder learning, too.
- Simulating a real-life situation.
- A main reason for such systems.
- Depends on quality and nature of ES.
- Somewhat.
- Depends on whether learn task or software.
- It can increase the focus of the person doing the task. The reports can give clear guidance of what the objectives of the task are.
- Reinforces concepts.
- I believe expert systems are great devices for training programs.
- It makes the rationale explicit and would allow greater use of simulations.
- It depends on the design of the in-house training program.
- Not necessarily related.
- Spread knowledge of expert.
- ES should be used for training extensively by the year 2001. I envision the program used on the audit will be the same as that used in the training course.
Comments received on proposition 4.2 which was:

The use of an expert system for an audit task accelerates the learning curve for inexperienced decision makers completing the task.

- Generally true of most users.
- More sophisticated systems create their own learning curve.
- Dependent on interface.
- Only if the system is well designed for professional use. Cost concerns may result in the necessary features to do this being dropped.
- Dependent on interface.
- I continue to believe this is highly likely and will prove in fact to be one of the chief benefits of ES.
- The creation of more real life cases in a very short period of time.
- I'll not argue with the majority - they might even be right.
- Maybe it will - but maybe it won't. It can de-skill as easy as up-skill - viz effects of calculators on ability of check-out clerks to correct mistakes.
- Wishful thinking.
- In reality, if an expert system is used for an audit task then the inexperienced decision maker learns nothing. If it is used as a training tool and is properly designed then my answer would remain at 99.
- Less start up time.
- Most current ES do not have appropriate explanation facilities. Learning will improve in the future as better logic explanations are included.
- Does allow for access to information, yet does this accelerate the learning curve to where one "understands" the task?
- A primary effect of ES.
- The system doesn't accelerate or hinder the curve; it's based on the individual. However, inexperienced decision makers often inadvertently rely on the system to make the decision, and they are not aware how the system makes a decision.
- Trace logic.
- An expert "at your side" to explain why info is needed and how it is combined to reach a decision.
- It provides the opportunity for improvement, but not a guarantee. Can de-skill, or create learning depending on management, training, and quality of interface design.
- Again, it's possible if properly designed, but my research and others shows it may hinder learning, too.
- Generally this is true, however there is a possibility that decision maker will not understand basis for decisions. Systems must be designed to facilitate such an understanding.
- If ES can be architected to achieve their advertised potential.
- It very much depends on the task.
- A good training tool. But have to wait and see.
- Automatic reasoning explanation features help staff conceptualize problems and solutions more effectively than traditional training.
- Spread knowledge, great training.
- one of the major benefits of ES.
- Immediate access to info.
- May learn program but not task.
- Expert systems, if appropriately designed, can leverage the knowledge and experience of "experts" and communicate that knowledge to more junior members of the firm.
- Provided there is an explanation facility. CPAs should have the competence equivalent to those in ES.
- It increases decision throughput but the users don't necessarily learn how to do the task being performed in the ES.
- This would be true for a well developed expert system.
- It provides a more structured exposure to an efficient approach to task encapsulation.
- One can place more reliance on the system vs. professional judgement.
- Viewing the completed task and the rationale for decision making contributes to the learning process.
- Yes, yes, yes.
- It can if used as training tool and if decision rules and logic are appropriately explained. Most systems are not currently being deployed in this fashion.
comments received on proposition 4.3 which was:

The use of an expert system for an audit task shortens the time new auditors need to improve
decision making ability.

- Unrelated.
- Should provide "training effect."
- Accepting an ES result is not the same as making a decision. If ES result must be understood
  in context, auditors will take almost as long to make a decision without ES - anyway is
  "auditor decision making" an oxymoron?!
- Due to training and learning curve.
- Due to training.
- Has an impact on quality of staff time, but not necessarily quantity.
- Again - it depends on the system's design and nature of the task.
- They may become more involved in the decision making process earlier in their career.
- It should - leverage expertise.
- Sometime yes, sometimes no.
- I believe new auditors will have less practice making decisions and so their "auditor autonomy"
  will require longer to develop.
- Improving decision making ability comes from experience not computer software.
- It depends on the design and explanation capabilities of the ES.
- As ESs are used to complete the task, new auditors can be involved more quickly in analyzing
  the output of the ES.
- Decisions will improve, but whether "ability" improves is different issue.
- Yes, although more experimental data is necessary.
- I feel they over rely on the ES and don't actually learn.
- If properly built. I'm no longer as optimistic about that.
- Probably - because of its training potential.
- Probably, due to training.
- It is possible if properly designed, but research shows it may hinder learning, too.
- May not learn task.
- Time stays about the same, the results of the system should make the process more complete.
- Yes, due to training effect.
- Probably not - decision making process very complex - requires experience. ES may help in
  relatively limited ways.
- At the staff level.
- This is true to a certain extent as they can become involved in the decisions at an earlier
  point in their career.
- No - it creates improved decisions in the same time or the same quality decisions in less time.
- With appropriate training, exposes to a consistent and explicit approach.
- Depends on documentation in ES and training used only by them.
Comments received on proposition 5.2 which was:  

The development and use of expert systems result in increased non-accounting competition for auditing services.

- Don't see how this could occur.
- Probably will be regulated by state, AICPA.
- I believe the ability to distribute expertise will result in competition from non-traditional sources.
- Yes, we're already seeing it today.
- Maybe - but I guess not in near future.
- When all the alternatives are reduced to a set of decision rules, any type of computer software firm may jump into this market.
- I don't see a relationship.
- Could significantly reduce barriers to entry. It's most likely that someone outside of accounting will make the necessary investment.
- Not for auditing services (could for taxes).
- Maybe internal auditors will do more of the audit.
- I'll stick with "very unlikely". The increased complexity in the accounting profession will be a growing barrier to entry.
- Not by the year 2000.
- Auditing services are performed by an auditor. By "non-accounting competition" do you mean non-auditors could perform audit services because they used an ES - not likely.
- ES transportable knowledge raises the possibility (at least) of lowering the cost of entry into auditing.
- Possibly.
- Unlikely the statutory monopoly of the CPA will be broken in 10 years, but it's possible.
- Possibly, but not too likely.
- Yes, ES not limited to auditing only. CPAs can build/use them for much consulting advice.
- Auditing is a relatively static market; at least in the US. Price competition will make it difficult for others to make inroads.
- Ability to "clone" expertise may reduce barriers to entry.
- Expertise available to persons who didn't have it before - at one extreme to everyone and therefore an end to the CPA monopoly.
- Expert systems will never replace judgement - they can only enhance the judgement process.
- I think that solid quality control and impeccable reputation are too important.
- Auditing and accounting are too complex, getting so at accelerating rate.
- Could, if knowledge base were salable by developer - e.g. estate planning software.
- Possibly.
Comments received on proposition 5.3 which was:

The development and use of expert systems results in an increasing difficulty in employing the top auditing experts.

- The reverse of this statement would be true. Audit experts contribute to the development of better ES.
- Always need the experts.
- Maybe due to their displacement.
- You'll always need human experts.
- No, will still need auditing experts to make the decisions.
- Why?
- We always need experts to develop new systems.
- Someone has to employ the "top auditing experts," if for nothing else, to develop the ES.
- Quite the opposite.
- More likely to have the opposite effect.
- Possibly.
- I interpret "difficulty in employing" as meaning that the audit experts capable of training ESs will be so much in demand that other auditors will find it difficult to have professional access to them.
- I don't believe the use of new "tools" will change the employment market that much.
- Unlikely.
- Little effect - need experts to keep ES functioning and current.
- Expert will always be in demand for the development of software, intuitive/creative skills, and ability to deal with new situations.
- Not likely at all since experts usually have career commitments to the firms.
- I don't see why.
- They're usually developed, not employed after becoming experts.
- NO - you won't replace the experts, because even by 2001, will only be able to capture a small part of what makes one an expert.
- The ES might be current regarding decision rules (due to new standards, etc.).
- This seems to assume expert replacement or job degradation.
- Always needed. ES may keep them more productive and doing fewer "routine" things.
- We may still need experts. I don't believe ES can handle every task.
- On the contrary, we need their knowledge.
- Dollars will prevail.
- Quite the opposite - will attract better talent.
- I don't see how.
- Not related.
- It will make "superstars" of those capable of creating improved ES.
- Shouldn't have much effect.
- After 20-30 years in a specialty it is difficult to switch to another area. I don't foresee any employment problems. The technology has to be constantly monitored and updated when deployed for field use.
- Expert systems are not flawless, also "substance over form".
- It's actually a way to "clone" them efficiently.
- They still need to collect evidence, etc.
- Not applicable. Top auditing experts will always be in demand and needed for judgement, vision and continued development of better audit software.

235
Comments received on proposition 5.4 which was:

The development and use of expert systems for audit tasks causes auditing firms to identify or eliminate the highest-risk areas in their practice.

- Identify yes - 95%. Eliminate, not necessarily - 50%.
- The use of ES for risk analysis is a common use today.
- Could also be looking for savings and automation.
- How could they help but do so?
- Technically feasible.
- Yes, because problems/decisions are examined in detail.
- Possibly - but no guarantee.
- It will allow auditing firms to better identify the risky areas.
- Certainly identify, but eliminate may be too strong a word.
- Yes, where applicable.
- I continue to think this is highly likely - particularly as firms become more adept at capturing and analyzing data about their client base.
- Disagree.
- I don't see how ESs will help in this way.
- I don't think it has "practice wide" implications that a firm isn't already aware of.
- Don't we try to do this anyway?
- ES will not eliminate risks. They help control risks.
- Audit expert systems can be used to assist in identifying audit risk areas. This is available today.
- They could - but the desire for more fees may prevail.
- Identification could be aided but this would typically be done by traditional type of research. Elimination involves cost/benefit decisions on an overall basis not on a software basis.
- Identify but not eliminate.
- Yes - to look for applications.
- It depends on management.
- This would require a much higher level of judgment impounded in the ES than we have ever seen to date.
- Well, obviously if they can identify those areas, they'd probably reduce their exposure, but I'm not sure ES will always do that.
- Sound practice management, not software eliminates the highest risk areas in a practice.
- Firms will take high risk assignments if appropriately compensated. ES technology is not more expertise than various traditional risk identification techniques.
- This would tend to be an early part of the development process.
- I just don't see how ES will be used in this way.
- A good application for them!
- An expert systems itself will not eliminate a high-risk area, it will just allow a firm to better confront and deal with the higher risk area.
- It could - but $ will still control.
- As ESs are developed, it triggers closer analysis of the decision process and may identify high risk areas. I don't see it as the impetus for eliminating high risk areas.
- Identify - yes. Eliminate - only if not profitable.
- Too speculative.
- I don't believe the ES will be the main contributor.
- Certainly should be or the systems are not being used to their effective "max."
- This is required without expert systems.
Comments received on proposition 5.5 which was:

The development and use of expert systems for audit tasks leads to the dehumanization of auditing.

- Not necessarily a relationship.
- Still need to gather data and interpret and act on output.
- Inevitable situation.
- No - still need input and analyze output.
- This situation is inevitable anytime that individuals are replaced by computer programs.
- It may.
- A common theme on the use of technology is that this type of effect is always predicted - and quite the opposite is usually the case.
- Quite the opposite.
- I just don't agree that computers and software can dehumanize if dehumanize means humans get treated like machines.
- So what.
- Unfortunately (or fortunately) it does and will.
- Auditing is an art. ES is a science. Auditing is done by humans using tools such as ES, calculators, pencils, etc.
- The use of software is not inherently dehumanizing.
- It is a tool just like LOTUS, FASBs, etc.
- Increased machine use by definition means less human involvement. If large numbers of ES used, this will tend to dehumanize a large segment of auditing.
- Depends on its use.
- To some extent, yes.
- Depends on education and supervision of users.
- If you mean restriction of scope of judgment, possibly yes.
- Could depersonalize interaction with clients - standardization.
- Possibly.
- It all depends on what expert systems - how they are developed and implemented.
- Professional judgment is still required.
- Depends on how used, though.
- No. No more than ATMs in banks or computers in everyday life.
- No. Makes info gathering and reduction quicker - frees time for qualitative processes.
- Are you saying auditing is humanistic?
- No way.
- Use of tools is not inherently dehumanizing. Does use of a net dehumanize a fisherman?
- I think people in all types of professions are becoming more attuned to the human aspects.
- Not necessarily, depends on training.
- Machines take over more of an audit so this tends to reduce human judgment options.
- Absolutely not!
Comments received on proposition 5.6 which was:

The development and use of expert systems for audit tasks leads to a loss of prestige for firms relying heavily upon such systems.

- Firms involved in proper application will be cutting edge - more prestige.
- The reverse is true.
- Much to the contrary.
- Opposite likely.
- Appears the prestige firms are at the forefront of development.
- Why should it?
- Quite the contrary.
- Yes - as it will backfire.
- In my opinion, it's expertise not ES that leads to image.
- On the contrary, better use of human resources.
- Firms not using ES by the year 2000 will be viewed as "behind the times."
- The opposite will be the case.
- Unless ES are clearly demonstrated to be useful in audit judgments I believe firms relying more and more on them will tend to be thought of as less prestigious.
- I believe use of ES only enhances.
- The firm would be perceived as technologically advanced - clients love ES.
- Purchased systems are a risk that must be considered.
- No - the reverse is likely.
- Should actually help; it just a matter of keeping up with what clients are already doing.
- Opposite, if anything.
- Using leading type technology usually enhances prestige.
- NO - if anything, it could be the reverse as they're perceived to be more technologically sophisticated.
- Quite the contrary - those first with ES will gain prestige.
- Loss of prestige will result for firms that are behind the technology curve.
- Quite the opposite - they are seen as state of the art.
- The opposite is true - firms which exploit available technology are more highly regarded than those which ignore it.
- The word "heavily" is the concern here. I believe the prestige is enhanced if used efficiency and effectively.
- Only if "purchased" systems including knowledge base data and maintenance.
- So far as ES does not replace auditor, I don't believe this would be a problem.
- The clients are not aware of what goes on inside a firm.
- Hard to tell - by 2000 there may well be areas that require ES (again if such systems really can be built). Or, ES may be like UNIX, always ready to take off "next year."
- I don't see how.
- High tech would be good.
- Most clients are not so backwards in their thinking. Most clients would view it as a natural outgrowth of the technology.
- Firms might be perceived as being technologically advanced.
- Seems unlikely. Of course, some persons believe low-tech is more prestigious - like handmade clothing.
- The more we find that ES have a detrimental effect (and I believe we will) the more this will be true.
- No reason to expect this.
- That depends on marketing, appropriate validation, and appropriate user training.
- ES are a step forward.
- Firms will need to ensure that their systems are not replacing an auditors professional judgement.
- Quite the contrary!
Comments received on proposition 5.7 which was:

The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.

- Assuring proper design, implementation, no.
- Not likely to increase because of computer tools.
- The incidences are already high and I do not believe it will get any better.
- No basis for agreeing with this assertion.
- Don't think it has an effect either way.
- Unsure if there is any evidence.
- No evidence, but access to decision rational is more attainable.
- Not likely to increase because of computer tools.
- There is not such a thing as perfect software. Thus, auditor could blame ES package for their failure.
- This will likely happen as firms put more emphasis on technology that is not ready.
- Use of ES or any other audit software should have no bearing on audit failures - they are only tools.
- No evidence to date to support this statement.
- Need to allow for misuse in practice by inexperienced personnel.
- So long as the lawyers are free on the streets, use of new professional methodologies (like ES in auditing) will lead to litigation.
- It could, but I guess firms will build in procedures to process versus misuse.
- No evidence available on this issue.
- Maybe - if design/use leads to ineffective over-reliance on system. But, if design/use improves effectiveness, no.
- Misused, they could increase risk. Used properly, they should reduce successful litigation against auditors.
- Not sure - standardized approach, but human attention decreased.
- Some individuals may "think" less because they are relying on system. These cases may be offset by increased effectiveness when used by other individuals.
- No evidence to date.
- Probably less because the approach would be systematic and documented.
- Expert systems can lead the decision maker to believe they have considered all relevant information when in reality they have not.
- I just don't know.
- Should have little impact - I have served as expert witness and have assisted in litigation support.
- If an expert system have been properly designed, and is being used properly in the field, the incidence of audit failures will decline.
- Not likely to increase because of computer tools.
- Use and reliance on audit software, ES or not, is not and element in incidences of litigation or damages. Software is simply a tool.
- I see ES focussed at the staff level without modifying current supervision and review policies. I don't see any risks in this area.
- No evidence for opinion.
- Only if they are poorly designed systems, or not maintained.
- Depends on extent of reliance on ES decisions.
APPENDIX C

This appendix contains a copy of the case study questionnaire.
For each of the following statements circle one of the seven alternatives. Only the average results of all respondents will be reported. Your answers are confidential. Only the researcher will see them. Please return this survey to the researcher.

1. Expert systems used for auditing tasks, such as , have an impact on my firm.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

2. The use of for auditing planning improves the overall efficiency of the performance of the planning task.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

3. The use of for the audit planning task accelerates the learning curve for inexperienced decision makers completing the task.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

4. The use of improves the effectiveness of the audit.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

5. The use of for the audit planning task results in less of the auditing unit's time being absorbed in decision related meetings.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

6. The development and use of expert systems for audit tasks leads to an increased incidence of litigation and damages surrounding audit failures.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

7. The use of for audit planning reduces the number of organizational levels involved in authorizing proposed planning-related actions.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

8. The use of for audit planning provides documentation references for audit judgements and reasoning concerning the planning task.
   - strongly disagree
   - disagree
   - slightly disagree
   - no opinion
   - slightly agree
   - agree
   - strongly agree

9. The use of for audit planning enhances the in-house training program related to audit planning.

241
10. The development and use of for audit planning leads to an increase in prestige for my firm.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

11. The development and use of for audit planning causes my firm to identify or eliminate the highest-risk areas of our practice.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

12. The use of in auditing results in augmented professional judgement.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

13. The use of for audit planning assists in identifying exceptional circumstances warranting further investigation.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

14. The use of for audit planning reduces the time required to make audit decisions related to the planning task.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

15. The development and use of for audit planning leads to the standardization of audit planning tasks.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

16. The use of in auditing impacts the nature of the expertise of my firm.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

17. The use of for the audit planning task allows auditors to gain new insights into the planning decision process.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

18. The development and use of for audit planning tasks leads to the dehumanization of auditing.

strongly disagree

disagree
	slightly disagree

slightly disagree

opinion

agree

agree

5
disagree disagree opinion agree agree

19. The use of for the audit planning task improves audit planning decision quality.
   strongly disagree disagree slightly no slightly agree strongly agree

20. The use of for audit planning task results in an increased ability to handle complex analyses.
   strongly disagree disagree slightly no slightly agree strongly agree

21. The use of for the audit planning task inhibits the development of task-related expertise by the users of the system.
   strongly disagree disagree slightly no slightly agree strongly agree

22. The use of for audit planning reduces the time required to authorize proposed actions relevant to audit planning.
   strongly disagree disagree slightly no slightly agree strongly agree

23. The use of for audit planning shortens the time inexperienced auditors need to improve decision making ability in the planning task.
   strongly disagree disagree slightly no slightly agree strongly agree

24. The use of for the audit planning task improves decision consistency for that particular task.
   strongly disagree disagree slightly no slightly agree strongly agree

25. The development and use of expert systems could result in increased non-accounting competition for auditing services.
   strongly disagree disagree slightly no slightly agree strongly agree

26. The use of for the audit planning task reduces the need for staff time on the planning task.
   strongly disagree disagree slightly no slightly agree strongly agree

27. The use of for audit planning results in the distribution of expertise pertaining to the planning task within the auditing firm.
   strongly disagree disagree slightly no slightly agree strongly agree

243
AMELIA ANNETTE BALDWIN-MORGAN
2785 Windwood Drive #173
Ann Arbor Michigan 48105-3401
(313) 741-1712

Department of Accounting
406 Owen Building
Eastern Michigan University
Ypsilanti, Michigan 48197
(313) 487-1230

e-mail: ACC_ABALDWIN@emunix.emich.edu

EDUCATION

Doctor of Philosophy in Business Administration, 1991
Virginia Polytechnic Institute & State University,
Blacksburg, Virginia
Primary Field: Accounting
Concentration: Information Systems
Supporting Field: Organizational Psychology/Behavior

Master of Accountancy, December 1987
Auburn University, Auburn, Alabama

Bachelor of Science in Business Administration, Dec. 1986
Auburn University, Auburn, Alabama (accounting major)

REFEREED PUBLICATIONS


DISSERTATION RESEARCH

The Impact of Expert Systems on Auditing Firms: An Investigation Using the Delphi Technique and a Case Study Approach
PAPERS PRESENTED AT PROFESSIONAL MEETINGS


EMPLOYMENT

Assistant Professor, Eastern Michigan University
1991-present Teaching EDP Auditing and Accounting
Graduate Teaching Assistant, VPI&SU
1990-91 Taught Personal Computers
1990 Taught intro information systems
1988-89 Taught principles of accounting
Graduate Research Assistant, VPI&SU
1989-1990 Participated in model management research with professors
Graduate Teaching Assistant, Auburn University
1987 Taught principles of accounting

RESEARCH INTERESTS

Impact of Information Technology on Organizations
Expert Systems in Accounting and Auditing
Behavioral Issues in Accounting and Information Systems
Information Systems in Accounting Education
Intelligent Information Systems
TEACHING INTERESTS

Accounting Information Systems Related Courses
Management Information Systems Related Courses
Management/Cost Accounting Courses

HONORS AND AWARDS

Women's Research Institute Travel Award (twice), VPI&SU
Beta Alpha Psi, Auburn University
Auburn Alumni Association Scholarship, Auburn University
Graduated in top 25% of College of Business, Auburn Univ.
National Merit Scholarship finalist

MEMBERSHIPS AND ACTIVITIES

American Accounting Association
Graduate Accounting Society, VPI&SU
College of Business Library Committee, VPI&SU
Graduate Women in Business, VPI&SU
Graduate Student Senate, Auburn University
Auburn Student Accounting Association, Auburn University

PERSONAL INFORMATION

Born 13 November 1964
Married
United States citizen