The Effect of Long-Term Audit Support System Use on Declarative Knowledge Acquisition: A Test of the Theory of Technology Dominance[1]

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Abstract

The purpose of this study is to test proposition seven in the Theory of Technology Dominance (Arnold and Sutton, 1998), which predicts a negative association between the continued use of intelligent decision aids and the development of auditors' skills and abilities. An experiment was conducted which required auditors to list the key business risks common to clients in an industry familiar to them. The auditors, who normally have access to their firm's audit support system, completed the task unaided. The audit support systems used by these auditors differ significantly in the extent of decision support provided. The results suggest that this difference influences the task knowledge auditors store in memory, which in turn affects their task performance when the audit support system is not available. Auditors who normally have access to an audit support system that provides a low level of decision support were able to list more valid risks than auditors who normally use an audit support system that provides a high level of decision support. This finding has important implications for audit firms in their continued development and refinement of audit support systems, the extent of decision support embedded within these systems and the training of their staff.

Keywords: Theory of technology dominance, decision support, audit support systems, declarative knowledge development.

1. Introduction

Various types of decision aids are embedded within audit support systems (Dowling and Leech, 2006)[2]. Prior studies have focused on understanding the factors that influence auditor use of decision aids and the short-term implications of such use; including improved decision quality, improved decision consistency and the reduction of decision bias (e.g., Arkes et al., 1986; Ashton, 1990; Ye and Johnson, 1995; Murphy and Yetmar, 1996; Whitecotton, 1996; Boatsman et al., 1997; Eining et al., 1997; Whitecotton and Butler, 1998; Whitecotton et al., 1998; Kaplan et al., 2001; Bedard and Graham, 2002). Until now, the long-term implications of using decision aids have not been examined in the audit literature. Use of an audit support system with embedded decision support is an attribute of an auditor's experience that can influence their knowledge development (Libby, 1995; Rose, 2002; Rose, 2005) and has important epistemological implications for the audit profession (Arnold and Sutton, 1998).

The present study is the first to empirically test whether continued access to an audit support system that provides a high level of decision support is associated with a decline of auditors' skills and abilities as posited by proposition seven in the Theory of Technology Dominance (Arnold and Sutton, 1998). An experiment was conducted in which auditors, who normally have access to their firm's audit support system, completed a task unaided. The experiment tested an auditor's declarative knowledge

[2] Audit support systems are the specialized technology applications used by audit firms to facilitate and support audit work. Electronic work papers, banks of audit tests, sample selection software and several decision aids are embedded within these systems. The decision aids vary in the extent of decision support they provide; from simple checklists through to intelligent decision aids which provide recommendations based upon user inputs and information stored in the system's knowledge base (Dowling and Leech, 2006).

of strategic business risks by requiring auditors to list, from memory, five key business risks common to clients in an industry in which they frequently work.

The identification of strategic business risks (also referred to as business risks and inherent risks) is an important part of every audit and conducted during the planning phase. The correct identification and testing for business risks can minimize audit risk and maximise audit quality. This task is normally completed by auditors with the aid of their firm's audit support system (Dowling and Leech, 2006). The extent of decision support these systems provide differs across audit firms (Dowling and Leech, 2006). Although prior studies have documented a negative association between the short term use of aids that provide a high level of decision support and a user's declarative knowledge (Murphy, 1990; Brody et al., 2003), it is unclear whether this association continues in the presence of long-term use or if it is negated by other learning experiences. Understanding the effect of long-term audit support system use on declarative knowledge is important because it must be acquired for auditors to develop procedural knowledge and thus affects expertise development (Brody et al., 2003).

As hypothesized, auditors from a firm whose audit support system provides a low level of decision support were able to list more valid risks compared to auditors from firms whose systems provide a high level of decision support. Viewed through the Theory of Technology Dominance (Arnold and Sutton, 1998), the results suggest that the extent of decision support embedded within an audit support system influences the task knowledge acquired by auditors, which in turn influences their task performance when the audit support system is not available. Evidence of a negative association between the long-term availability of audit support systems with a high level of decision support and an auditor's declarative knowledge is found. This finding has important implications for audit firms, in terms of the design of audit support systems and the training of their auditors. The extensive use of audit support systems (Dowling and Leech, 2006) within and across audit firms means this finding has important implications for the long-term development of the audit profession (Arnold and Sutton, 1998).

The remainder of this paper is divided into four sections. In section 2, the literature examining the effect of decision aid use on users' knowledge development and the audit support systems used at the participating audit firms are discussed. The hypothesis is developed based on the discussion presented in this section. The research method is described in section 3, and the results are presented in section 4. Section 5 discusses the implications of this study, the limitations and future research opportunities.

2. Background and Hypothesis Development

The Theory of Technology Dominance (Arnold and Sutton, 1998) consists of eight propositions which predict the conditions under which a user is likely to rely upon an intelligent decision aid (propositions one through four); the immediate decision-making implications of a mismatch between the expertise embedded in an intelligent decision aid and the user's expertise (propositions five and six); and the long-term effects of decision aid use on knowledge development (propositions seven and eight). Propositions one through six have been investigated in prior studies (Masselli et al., 2002; Noga and Arnold, 2002; Arnold et al., 2004; Hampton, 2005). Proposition seven is tested in the present study.

Proposition seven predicts that the continued use of an intelligent decision aid negatively affects the development of a user's skill and abilities, through affecting how user's acquire and store knowledge for tasks completed using the aid (Arnold and Sutton, 1998). Intelligent decision aids (or knowledge based expert systems) are differentiated from other forms of decision aids on the basis that they provide a recommendation based on user input and the system's decision rules (Abdolmohammadi, 1987; Abdolmohammadi, 1999). In the present study audit support systems are classified according to the level of decision support they provide. Systems which provide a recommendation are classified as providing a high level of decision support. Systems that prompt users' memory but do not provide a recommendation are classified as providing a low level of decision support.

Although no prior study has tested proposition seven, several studies have examined knowledge transfer from decision aids to users (e.g., Murphy, 1990; Hornik and Ruf, 1997; Rose and Wolfe, 2000; Brody et al., 2003; Smedley and Sutton, 2004; Rose, 2005). The predominant focus of these studies has been on investigating how learning is affected by the provision of explanations within expert systems. While early research indicated that explanations are inconsequential (Murphy, 1990), later studies suggest that the type and placement of explanations is important. Hornik and Ruf (1997) find evidence that knowledge transfer from an expert system to a user is enhanced when reflective/contrast explanations are included. Smedley and Sutton (2004) show that declarative explanations increase a user's declarative and procedural knowledge. The provision of procedural explanations was not found to significantly affect procedural knowledge. Rose and Wolfe (2000) suggest that explanations that are integrated into an expert system's problem solving steps reduce cognitive load and enhance user learning. In addition to factors related to the design of a decision aid, a user's interest in the domain and their perceived aptitude also influence the extent to which a user acquires domain knowledge when using a decision aid (Rose, 2005).

Two prior studies by Murphy (1990) and Brody et al., (2003) are particularly relevant. In both of these studies accounting students (novices) completed a series of learning exercises (either using a decision aid or no aid) before completing a task without the decision aid. Learning was measured as the difference in a subject's pre and post test scores. Murphy (1990) found that subjects using a non-automated practice aid developed higher levels of declarative knowledge than subjects using an expert system. Although Brody et al., (2003) found that subjects in all three treatment groups (expert system users, text reference aid users, and a control group with no decision support) significantly increased their declarative knowledge, subjects in the text reference group obtained significantly more declarative knowledge than subjects in the expert system group. Brody et al., (2003) also examined the extent of knowledge subjects retained over a two week period. They found that compared with subjects in the text reference group, expert system users retained less declarative knowledge.

The results reported by Murphy (1990) and Brody et al., (2003) are partially consistent with proposition seven of the Theory of Technology Dominance in that they demonstrate that the use of an intelligent decision aid negatively affects expertise development. Because the subjects had no prior experience they were required to draw on knowledge acquired during the experiment. This enabled a clear test of the effect of expert system use on a user's knowledge acquisition over a short-period of time. However, it is unclear as to whether the short-term negative association reported by Murphy (1990) and Brody et al., (2003) continues long-term as posited by proposition seven in the Theory of Technology Dominance (Arnold and Sutton, 1998), or if it is negated by other learning opportunities experienced by auditors.

The present study significantly contributes to the literature discussed above by investigating the association between an auditor's expertise in listing strategic business risks and the extent of automated decision support embedded within their firm's audit support system. The expertise required by an auditor to assess a client's strategic business risks is not an inherent cognitive trait. Auditors develop this expertise through experience (Libby, 1995). Audit support systems are used extensively (Dowling and Leech, 2006) and are an important attribute of an auditor's learning experience (Libby, 1995). By influencing the nature of an auditor's learning experiences, audit support systems affect the task knowledge an auditor develops and stores in memory[3].

[3] Two types of knowledge are stored in memory: declarative and procedural knowledge (Bouwman, 1996; Brody et al., 2003). Declarative knowledge is an individual's memory of facts and events; it is their knowledge of "what is" (Bouwman, 1996, p.261). Declarative knowledge is stored in semantic or episodic memory (Murphy, 1990; Libby, 1995). Semantic memory contains an individual's knowledge of the meaning of the facts (for example, an auditor's understanding of GAAP is stored in their semantic memory). Episodic memory contains an individual's knowledge of past experiences and events (for example, an auditor's memory of where and when they learnt the meaning of GAAP is stored in their episodic memory). Procedural knowledge is knowledge of the skills and processes an individual uses when applying declarative knowledge; it is "how to" knowledge (Bouwman, 1996 ,p.261) (for example, procedural knowledge is an auditor's knowledge of how to evaluate the internal controls of a client).

Audit support systems differ in the extent to which the client risk assessment is automated; some systems require auditors to manually select the risks, while other systems recommend the risks based upon an auditor's responses to standard questions (Dowling and Leech, 2006)[4]. Differences in the extent of decision support mean that the learning experiences of auditors using these systems also differs (Libby, 1995). Expertise in risk identification is developed through an auditor's experiences of being required to identify risk factors. Audit support systems that recommend the generic factors reduce the extent of effort an auditor needs to expend to identify the risks. Effort reduction decreases an auditor's ability to acquire knowledge (Rose, 2005). Relative to auditors using less automated systems, the experiential opportunities for auditors who use more automated systems are lower because they can rely upon the system to do the work (Todd and Benbasat, 1992).

Experience is considered to be a crucial component in expertise development (Libby, 1995). Reducing an auditor's experiential opportunities negatively affects knowledge development, which in turn affects performance (Libby, 1995). When auditors have access to their firm's audit support system their task performance is not impaired because it is the joint product of the decision support embedded within the system, how the auditor uses the system, and the auditor's expertise. If, however, an auditor is required to perform the task without the assistance of their audit support system (as is the case in this study), the Theory of Technology Dominance predicts that the continued use of an audit support system that provides a high level of decision support will negatively affect an auditor's task performance (Arnold and Sutton, 1998). Based on the preceding discussion, the following hypothesis is proposed:

[4] The audit support systems used in the three participating audit firms are described in section 3.

H_1: *When performing a free listing task without access to their firm's audit support system, auditors who normally have access to an audit support system that provides a low level of decision support will list more valid strategic business risks than auditors who normally have access to an audit support system that provides a high level of decision support.*

3. Research Method

3.1 Audit support systems used at the participating audit firms

Auditors from three large international accounting firms performed an unstructured task[5]. The audit support systems used at these firms differ in the extent of decision support they provide. The three systems are briefly described below.

Risk identification and the incorporation of these risks into the audit program are completed manually in Firm A's audit support system. Auditors are required to select the client's industry, which triggers the system to produce a list of typical risks common to clients in that industry. The auditor manually selects the risks relevant to the client by dragging and dropping them in the client's file. The system contains a series of decisions the auditor needs to make. The questions are designed to prompt the auditor to make the correct decision, and help the auditor determine whether a risk is significant to the client. Because the system does not produce a recommendation, the audit support system used at Firm A is classified as providing a low level of decision support.

[5] Other audit firms were excluded from this study for various reasons. One firm was excluded because in the two year period prior to data collection this firm deployed a new audit support system. Another firm was excluded because it had recently merged with another audit firm. The auditors at these two firms therefore had recent experience using a different audit support system, which would confound the analysis. For the three firms participating in this study, their audit support system had been deployed for several years. To control for the time at which an auditor worked at their respective audit firm, a sensitivity analysis was conducted (see section 4).

Firm B's audit support system requires auditors to answer a series of standard questions. This triggers the system to create an audit file by loading the applicable industry/client package from a standard set of packs. The auditor is then required to answer more questions. These questions can either be answered at a high level or the auditor can choose to drill down and answer a sub-set of lower level questions. The audit support system uses the answers provided by the auditor to further refine the engagement file by recommending the appropriate generic audit risks[6]. The auditor also has the option of including additional specific risks relevant to the client that are not recommended by the system. The auditor then answers more questions. The system uses the auditor's responses to input the control objectives and recommended tests into the work file. The system's recommendations are relatively generic, and auditors at Firm B are required to tailor and modify these generic recommendations to the specific circumstances of each client.

The system used at Firm C requires auditors to answer a set of inherent risk questions. The system uses the auditor's responses and information in its knowledge base to generate a list of risk factors relevant to the client. The system uses these risk factors to automatically tailor the client's file to ensure the risk factors are addressed. The system also creates a list of critical assertions relevant to a standard client in the same industry. The recommended critical assertions can be overridden by the auditor. The risk factors and critical assertions are used by the audit support system to set the assertion level, which is then used by the system to generate the appropriate audit tests.

[6] The recommended generic audit risks are the pervasive risks recorded in the system for similar clients in the same industry.

In contrast to the audit support system used at Firm A, the audit support systems used at Firms B and C provide recommendations based upon user input and information stored in their knowledge base. As such, these two systems are classified as providing a high level of decision support[7].

3.2 Sample

The sample comprised 31 auditors from Firm A and 27 auditors from Firms B and C. The descriptive statistics of the 58 participating auditors are provided in Table 1. While the participants from Firm A have on average more experience (5.94 years) than the participants from Firms B and C (6.39 years), the difference is not significant (t=0.347, p=0.730, not reported).

[Insert Table 1 here]

3.3 Experiment

Participants completed an unstructured listing task for clients in two different industries, the manufacturing and superannuation industries.[8] For the purposes of testing the hypothesis, only the data for the industry in which the participant most frequently audits clients is included (i.e., only one task for each participant is included). Restricting the test to the industry in which the auditor most frequently works maximises the extent to which auditors will have had an opportunity to develop the requisite task experience.

[7] The auditors from Firms B and C are grouped together based upon the similarity in their audit support systems. Use of the audit support system is mandatory at both of these firms.

[8] This data was collected as the second part of a larger experiment, in which participants from 12 accounting firms completed two tasks. The first task, which comprises two industry-based cases, is explained in Moroney and Dowling (2006), and is not used in this study.

An experienced researcher was present when the experiment was conducted in each of the offices of the participating firms. A standard introduction and consent form was provided to each participant outlining in broad terms the purpose of the experiment. Using a unique username and password, participants were then invited to log on to the internet based program designed by a specialist programmer. After logging on, each participant read an introduction which explained the project and how the software was to be used. After completing a practice case and the manufacturing and superannuation case studies used in Moroney and Dowling (2006), participants completed the unstructured listing task used in the present study. After completing this task they answered some demographic questions.

The unstructured listing task was developed in close co-operation with an expert panel to assess a participant's knowledge of strategic business risks for each industry. The expert panel comprised industry specialist partners. Participants were asked to list the five most important business risks faced by clients in the manufacturing and superannuation industries[9]. Participants did not have access to their firm's audit support system when completing the task; rather they demonstrated their knowledge of this task by providing information from memory. Respondents completed the task using an internet program where the questions were at the top of the screen and they typed in their answer. No other information was available, all aspects of the task relied on their memory, and as such the task is a test of an auditor's declarative knowledge of the generic inherent risks of the industry in which the auditor has recent audit experience.

[9] The auditors listed the risks for each industry separately; the order of the industries was randomized. There is no significant difference in the number of risks listed by participants if the data included in this study is from the first or second listing task the participant completed (t=0.492, p=0.625, not reported).

The validity of each participant's answer was measured as the extent of consensus between their answer and the model list of 5 key risks for their industry. The model lists developed by the expert panel are contained in Table 2. Because declarative knowledge is factual knowledge it can be measured reasonably accurately by comparing a subject's response to a model answer. The extent of consensus was measured by awarding one point for each risk which matched a risk included in the model list. Two experienced researchers independently coded each participant's answer. Cohen's Kappa (1960) is 0.895 for the manufacturing task and 0.915 for the superannuation task, which indicates that the coders achieved a very high degree of consensus in the initial coding. Coding differences were resolved before analysing the data.

[Insert Table 2 here]

4. Results

The results (reported in Table 3 (Panel A)) support hypothesis 1. Participants from Firm A, whose audit support system provides a low level of decision support, listed significantly more valid strategic business risks than participants from Firms B and C, whose audit support systems provide a high level of automated decision support. Auditors from Firm A listed on average 2.90 valid risks compared to an average of 2.15 valid risks listed by auditors from Firms B and C[10]. This difference is significant (F=12.757, t=3.572, p=0.001).

[10] Although the theoretical range is 0 to 5, actual responses range from 1 to 4. The average extent of consensus with the expert panel is 58% for auditors from Firm A, and 43% for auditors from Firms B and C.

[Insert Table 3 here]

Three sensitivity tests were conducted to assess the robustness of this result. First, the model was re-run with number of years experience and industry included as covariates. Number of years experience was included because there is a slight difference in average years experience across the treatment groups (Table 1). It is well accepted that there is a positive relationship between number of years audit experience and opportunity for learning (Libby, 1995; Bouwman, 1996). Therefore, it is possible that the difference in years experience across the treatment groups may influence the results. Industry is included because the sample includes auditors who frequently work in either the manufacturing or superannuation industry. Recent research indicates that there are differences in the extent of sub-speciality knowledge acquired across regulated (superannuation) and unregulated industries (manufacturing) (Moroney and Dowling, 2006). The results reported in Panel B of Table 3, indicate that neither number of years experience (F=0.259, p=0.613) or industry (F=2.182, p=0.145) are significant. Importantly, the association between task performance and extent of decision support embedded within a firm's system remains significant (F=10.629, p=0.002).

Second, auditors who had recent experience at another audit firm were excluded from the analysis. Including auditors who have used other firms' audit support systems may confound the results. The participating audit firms provided the commencement dates for all auditors. These dates were compared to the number of years audit experience provided by the participating auditors. Auditors who had worked a significant amount of time at another audit firm (more than 50%) or those with less than 5 years experience at their current firm (for auditors with a significant number of years of audit experience at another firm) were excluded and the tests described above redone. One auditor from Firm A and four from Firms B and C were excluded. The mean for Firm A remained at 2.90 and the mean for Firms B and C decreased slightly to 2.13. The results reported above remain substantially unchanged. The difference between the two groups remained significant (F=10.974, p= 0.002) (not reported)[11].

Third, the effect of grouping auditors from Firms B and C was assessed. Although, the extent of decision support provided by these firms' audit support systems is similar, there are slight differences which could lead to differences in their task performance. To assess this, the task performance for the 12 participants from Firm B (mean 2.3) was compared to those for the 15 participants for Firm C (mean 2.0). The difference is not significant (F=0.992, t=0.945; p=0.329) (not reported), which provides further validation for combining these auditors into one group on the basis of the similarity between these firm's audit support systems.

5. Discussion and Limitations

The present study provides the first empirical test of proposition seven in The Theory of Technology Dominance (Arnold and Sutton, 1998). Proposition seven posits that the long-term use of an intelligent decision aid is associated with a decline in auditors' skills and abilities. To test this proposition, an experiment was conducted in which practicing auditors were required to list five valid risks relevant to the industry in which they have audit experience. Although the participating auditors normally have access to their firm's audit support system when completing this task, no decision

[11] The analysis was re-run with audit experience and industry included as covariates. They are not significant (F=0.265, p=0.609 [audit experience]; F=1.581, p=0.215 [industry]). The difference between the treatment groups remains significant (F=9.330, p=0.004).

support was provided during the experiment. Therefore, the participating auditors were required to generate their list of risks by drawing on the declarative knowledge stored in their memory. The auditors' responses were compared to a list prepared by an expert panel. The results support proposition seven. Auditors who developed their task expertise using an audit support system that provides a low level of decision support were able to list significantly more valid risks than auditors who developed their task expertise using an audit support system that provides a high level of decision support. The key distinguishing difference in the extent of decision support provided by these systems is that the system providing a low level of support does not provide recommendations, whereas the systems providing a high level of support provide recommendations based upon user input and information in the system's knowledge base.

The results indicate that the level of decision support embedded within an audit support system influences the declarative knowledge auditors develop and store in memory. This has implications for an auditor's task performance when the audit support system is not available. It should be of concern to the auditing profession that auditors who normally use an audit support system that recommends the relevant risks were unable to perform the listing task at a level comparable with auditors who use a system that requires the auditors to manually select the relevant risks.

This finding has important implications for the design of audit support systems. Providing an opportunity and means to acquire knowledge is a necessary condition for developing expertise (Bouwman, 1996). The negative association between some audit support systems and auditors' declarative knowledge reported in the present study suggests that the design of these systems plays an important role in providing sufficient opportunities and means for auditors to develop this knowledge. This finding should be of importance to audit firms as they continue to develop and refine their audit support systems.

The experiment reported here has limitations which need to be considered when interpreting the results. Testing proposition seven required comparing the task performance of auditors who had developed their expertise over a period of time using an intelligent decision aid. Because these decision aids are embedded within firms' audit support systems (Dowling and Leech, 2006), testing proposition seven required recruiting subjects from audit firms whose audit support systems differed in the extent of decision support provided and that had been deployed for an extensive period of time. Three audit firms satisfied these requirements. A limitation of the research design is that it prohibited manipulation of the treatment conditions and random assignment of auditors to treatment groups. Sensitivity analyses were conducted to control for potential omitted factors by including audit experience and industry case as covariates. The significance of hypothesis 1 was robust to these inclusions. Even so, there may be other omitted factors, such as auditor ability, the complexity of the clients they have worked on, firm specific training, whether auditors use their firm's system and how they use it, which limit our results.

We were also unable to have auditors perform the same task using their firms' audit support system. From our understanding of these audit support systems, auditors performance on the task used in this study should not differ across firms. Not having a control group of auditors perform the same task with the aid of their firm's audit support system limits our ability to rule out that the reported differences only occur when these auditors do not have access to their firm's audit support system.

The present study is the first to test the long-term effects of the continued availability of audit support systems that provide different levels of decision support on the development of an auditor's task knowledge, and their subsequent ability to perform the task unaided. The task tested an auditor's declarative knowledge of industry specific inherent risks. Future research could extend this investigation to examine different tasks and/or the effect of audit support systems on auditor's procedural knowledge. Audit support systems also differ in the extent to which an output in one audit phase is automatically integrated to become an input into a subsequent audit phase (Dowling and Leech, 2006). This difference suggests that auditors who develop their expertise using automatically integrated audit support systems have less opportunity to develop knowledge about the links which are automated within the system compared with auditors who use manually integrated systems that require auditors to input the links.

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Table 1: Descriptive Statistics

	Firm A	Firms B and C
Number of Participants	31	27
Average number of years audit experience	5.94	6.39
Minimum years audit experience	2 yrs	2 yrs
Maximum years audit experience	27 yrs	18 yrs
Industry in which auditor frequently works		
Manufacturing	18 (58%)	20 (74%)
Superannuation	13 (42%)	7 (26%)

Table 2: Strategic Business Risks provided by the Expert Panel

Manufacturing Industry	Superannuation Industry
Product obsolescence/competitive forces	Investment management/performance (including Funding Position)
Loss of market share/going concern	Coping with changes in legislation
Technological change	Compliance
Economic factors – interest rates, external financing, demand, exchange rates	Administrative issues
Level of demand – customers/risk of losing business	Fraud

Table 3: Data Analysis

Panel A: *Strategic Business Risks* [Mean (Standard Deviation)]			
Firm A (n=31)	**Firms B and C (n=27)**	***F* (*t*-value)**	***p*-value**
2.90	2.15	12.757	.001
(0.75)	(0.86)	(3.572)	.001

Panel B: *Analysis of Covariance*

Variable	***F***	***p*-value**
Extent of decision support in audit support system (Firm A vs Firms B & C)	10.629	0.002
Audit Experience	0.259	0.613
Industry	2.182	0.145