The Expert Systems Life Cycle in AIS Research: What Does it Mean for Future AIS Research?

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Working Paper

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August 30, 2013

ABSTRACT

Accounting information systems (AIS) is the intersection of the accounting domains and the computer science and information systems domains. Periodically, new technology emerges that generates a new AIS research to explore the application of that technology to the accounting domains. AIS researchers compete with researchers in information systems, computer science, electrical engineering, plus other technology-related disciplines. AIS researchers are also frequently competing with the organizations (e.g., accounting firms) that have resources that far exceed academic resources. This paper explores the life cycle of expert systems research by accounting researchers to provide general insights into the roles of accounting researchers in technology domains.

From 1980 through 2011, 233 accounting-related expert systems papers were published. Those publications generally transitioned through the industry life cycle stages. The peak years were the early 1990s. Although most of the expert system publications appeared in AIS-oriented publications, by the 2005-2011 timeframe, a little more than 50% appeared in non-system journals. There were 352 unique authors involved in writing the 233 articles. Interestingly, 14 (4%) authors wrote 30% of the papers and 303 (86%) authors wrote just one paper. In the practice community, Brown (1991) listed 43 expert systems in use or under development at the Big 6, all of which have disappeared.

1. Introduction

This paper explores the life cycle of expert systems research by accounting researchers, primarily accounting information systems (AIS) researchers. We analyzed the accounting-related expert systems publications since the early 1980 and we interviewed some of the academic pioneers from that time period and representatives from the Big 4 accounting firms. From this expert systems life cycle research we provide general insights into the roles of accounting researchers in technology domains. AIS research has some unique characteristics compared non-AIS (NAIS) accounting research (e.g., financial accounting, management accounting, tax, etc.). As Sutton (2005) opines, AIS research is more applied research vs. basic research. This puts AIS researchers at a disadvantage since, generally, applied research is more difficult to get published in A-level journals. Adding to this challenge, as Alles et al. (2008) point out, AIS researcher have more academic competitors (compared to NAIS researchers) outside of the accounting domain, including researchers in information systems, information technologies, computer science, electrical engineering, plus other technology-related disciplines. Alles et al. (2008) also points that AIS researchers are frequently competing with the organizations (directly with accounting firms and indirectly with technology-related organizations) they are studying—and these organizations have labor and financial resources that far exceed academic resources, and as such, academic researchers must find their comparative advantages to successfully compete in this highly-competitive AIS domain.

To explore the challenges presented above, we choose expert systems research because it has apparently transitioned through all the typical life cycle stages (embryonic, growth, stakeout, maturity, and decline).[1] In addition, research regarding the application of expert systems (and other artificial intelligence areas) to accounting was one of the unique technologies where academic research initially led the practice community. Early expert system research by pioneering accounting professors in the early and mid-1980s (e.g., Michaelsen (1982) and Dungan (1983)) was essentially design science and proof-of-concept research that demonstrated the feasibility of the rather pragmatic application to the auditing and tax domains to what was up

[1] We say "apparently" because a life cycle never really ends and, more importantly, a disruptive technology or event can completely change a life cycle. Traditional CRT-type televisions were considered to be in the mature stage of their life cycle for many years; but then the introduction of flat-panel TVs suddenly shifted the life cycle back into the growth stage.

until then esoteric research being conducted by researchers in computer science, cognitive science, and cognitive psychology. In some instances, accounting researchers introduced that pragmatic application of experts system to the esoteric researcher. For example, Ray Meservy was teaching accounting at Carnegie Mellon and discussed the application of expert system to accounting with Herbert Simon (also at Carnegie Mellon), who is considered one of the founding fathers of artificial intelligence research.[2] Robert Michaelsen, who wrote one of the first accounting-related expert systems dissertation (1982), lived across the street from David Waltz, who was an award-winning computer science professor in the AI research field. After Michaelsen discussed his initial tax research interest for his dissertation, it was Professor Waltz who suggested that Michaelsen include expert systems as part of dissertation research. In that same early period, at the University of Southern California (USC), a great deal of cross-disciple activities were occurring between the School of Accounting, computer science, and psychology departments, and the Information Sciences Institute (ISI). Starting in the mid-1980s, the accounting firms began making significant investments in developing their own expert systems. Brown (1991) listed 43 expert systems in use or under development by the then Big 6. Those were very optimistic times. Gray et al. (1991) pointed out that the expert systems of that time were separate stand-alone systems that typically addressed one issue. Gray et al. went on to envision a day when stand-alone audit-related systems would be pulled together to create meta-level expert systems that gave that the auditors a complete toolbox of expert systems. During those early years, there are a relatively strong synergy between academics and the practice community regarding expert systems, but as the firms increased their investments in expert systems, that synergy decreased.

This paper analyzes the number of accounting-related expert systems publications along several dimensions in each year from 1980 to the present to illustrate the life cycle in accounting-related expert systems research. We also discuss this life cycle in the light of the rise and fall of expert system activities of accounting firms, and expert systems research outside of the accounting domain. We first frame the discussion within the industry life cycle, technology adoption life cycle, and the Gartner hype cycle, which have been used in earlier papers to discuss the life cycle of various types of AIS research (e.g., see O'Leary 2008b, 2009). In addition, we introduce—and

[2] The personal anecdotes included in this paper are from telephone interviews conducted in May and June of 2013.

expand on—another framework to the discussion, namely, the concept of "chasms" that occur in the adoption cycle (Moore 2002). Although Moore's focus is on the adoption of new products, these chasms can also represent barriers or inhibitors to the adoption of a body of research that can help explain why a body of research can suddenly stop growing. That is, adoption does not grow in a smooth, linear fashion; instead, there are chasms that must be crossed for a body of research to continue to grow and to ultimately be considered a success.

In our research, we found that the first accounting-related expert system, called TAXMAN, was actually created by a law professor (McCarty, 1977). For the period from 1980 through 2011, we located 233 accounting-related expert systems papers[3]. Those publications generally transitioned through the industry life cycle stages. The peak years were 1991 and 1995 when 21 and 22 articles were published, respectively. In 1999 the number of publications dropped to 7 publications from 13 in 1998. From 1999 to 2011, the average stayed around 5 publications per year. Although most of the expert system publications appeared in AIS-oriented publications, by the 2005-2011 timeframe, a little more than 50% appeared in non-system journals, reflecting the evolution of research from pure technology to the application of technology. There were 352 unique authors involved in writing the 233 expert system articles. Interestingly, 14 (4%) authors wrote 30% of the papers and 303 (86%) authors wrote just one paper. The practice community went through its own life cycle. Brown (1991) listed 43 expert systems in use or under development at the Big 6. Based on recent interviews with representatives of the Big 4, all of those expert systems essentially disappeared by completely falling out of use or some parts embedded in current audit tools. One Big 4 representative called this a "reality mugging," meaning what worked in the research lab did not successfully work in the field.

The remainder of this paper is organized as follows. Section II provides a brief overview of expert systems and discusses technology and expert systems research in the light of four technology adoption life cycle frameworks, including the industry life cycle, the technology adoption life cycle, the Gartner hype cycle, and we introduce Moore's (2002) concept of the

[3] During the early years of expert systems publications several new journals were launched and anthologies were published. Some of these were probably never included in the traditional online academic database, as such; the 233 articles probably understand the total number of accounting-related expert systems articles published in the early years. With that said, we are generally confident that the various relative (e.g., year-to-year) comparisons are representative.

crossing the chasms that exist between the different key adoption groups in the adoption life cycle. Section III introduces our research methodology. Section IV presents our findings. Section V includes our conclusions and implications for future technology-related accounting research.

2. Background

AIS teaching and research includes the intersection of the accounting domains (audit, tax, financial accounting, etc.) and the computer science and information systems domains. Periodically, new technology-related research topics emerge from outside of accounting that generates a new corresponding body of AIS research to primarily explore the application of that technology to the accounting domains. The first part of this section provides a brief overview of expert systems. The second part discusses technology and expert systems research in the light of four technology adoption life cycle frameworks. The second part starts with an overview of industry life cycle, the technology adoption life cycle, and the Gartner hype cycle that have that have been used in the past to characterize the general evolution of AIS research (e.g., O'Leary 2008b, 2009). To this discussion we introduce and expand on Moore's (2002) concept of the crossing the chasms that exist between the different key adoption groups in the adoption life cycle. As Moore points out, the transition from one adoption group to another adoption group is not as smooth and continuous as illustrated in the traditional adoption life cycle diagram or, for that matter, the Gartner hype curve. Instead, technology can be successful with one adoption group and be a failure in transitioning to the next group.

2.1 A Brief History Expert Systems from Bacteria to Accounting

The first expert systems were created by computer scientist in the 1970s as part of broader studies of artificial intelligence (AI). The number of expert systems in a wide variety of domains grew rapidly in the 1970s and 1980s. Expert systems generally include a set of rules, frequently requiring binary, yes or no answers, and an inference engine that directs the search through the rules. Sometimes expert systems also included some form of confidence factors or certainty factors such that the expert system could provide a probabilistic-like number with the results. Early expert systems work was conducted at the Stanford Heuristics Programming Project, which included the "father of expert systems" Edward Feigenbaum. One of the expert systems from Stanford, frequently cited by early AIS researchers, was called Mycin that was developed

over five years by Edward Shortliffe as a doctoral dissertation. This expert system had over 600 rules to diagnose infectious (bacterial) diseases and to recommend a course of drug treatment. The Stanford Medical School found the proposed therapy from Mycin was acceptable in 69% of the cases—which was a higher level of accuracy than the therapy proposed by a panel of infectious disease experts using the same criteria.

The first reported "accounting" expert system was a tax-related expert system called TAXMAN developed by a law professor (McCarty 1977). Michaelsen (1982) and Dungan (1983) were the first accounting professors to publish something (their dissertations) on developing accounting-related expert systems. Other AIS researchers followed developing prototype or demonstration (relatively small) expert systems, mostly in the audit domain plus some in the tax domain. These early AIS researchers were building what could be considered proof-of-concept systems. This early academic research drew the interest of the practice community. Practitioners saw the potential benefits of expert systems in the judgment-rich audit and tax domains. The early interest of AIS researchers and practitioners was reflected in the attendance at initial expert systems conferences. For example, in 1984 and then again in 1986, the Audit Judgment Symposium at USC dedicated a large part of their program to expert systems papers. In 1988 through 1990, USC also held separate annual expert systems conferences. The number of attendees at these conferences grew to a few hundred and included both AIS researchers and a large representation from the then Big 8 accounting firms. Coopers & Lybrand was a major sponsor of the USC expert systems conferences. In addition to these specialized expert systems conferences, a growing number of expert systems papers were presented at AAA conferences. In these early years, a number of PhD students produced expert systems dissertations.

Because AIS researchers felt that their research, in general, was not receiving adequate consideration for publications in traditional accounting research journals such as *The Accounting Review*, in 1976, they established their own Information Systems (IS) Section under the name Management Advisory Services (MAS) Section within the AAA. Then in 1983 the section changed their name to Information Services/ Management Advisory Services Section. In 1986, this group started publishing their own journal, *Journal of Information Systems* (JIS). As expert systems research grew in popularity, the expert systems researchers within the IS group felt they were not receiving adequate coverage in JIS and, as such, in 1991 they created a separate group

which was then called the Artificial Intelligence/Expert Systems (AI/ES) Section, which was changed to Artificial Intelligence/Emerging Technologies (AI/ET) Section in 1998. In 2004, they published their own journal called the *Journal of Emerging Technologies in Accounting* (JETA). Reflecting the subsequent decline in AI publications in the intervening years, the AI/ET section eventually changed its name to Strategic and Emerging Technologies (SET). Also in the early days of expert systems research, Dan O'Leary, at USC, launched a new journal called *Intelligent Systems in Accounting, Finance and Management*. In addition, several books and collections of articles on accounting-related expert systems research were published.

Paralleling this growth in AIS expert systems research, expert systems was also moving into the classroom. AIS textbooks in the 1980/1990 timeframe started including a chapter (or sections of chapters) and tutorials on expert systems. A popular software package at the time, called the VP Expert, was frequently included with textbooks. VP Expert was also frequently used by AIS researchers to develop expert systems used for their research.

While all this activity was going on with AIS researchers in the 1980s, practitioners were making major investments in expert systems. Big 4 representatives we interviewed said they were interested in what academics were doing with expert systems and academic research had an "indirect" influence on what the accounting firms subsequently did with expert systems. That is, none of the accounting firms took one of these academic systems as the core of the systems they built. Once they saw the potential benefits in expert systems, they quickly started developing expert systems. As mentioned earlier, Brown (1991) provided a brief description of 43 expert systems either in use or under development at the Big 6.[4] These expert systems were being used for accounting, auditing, and tax related tasks. Brown characterized many of these systems as automating "time-consuming manual processes that do not require a high level of expertise—tasks typically performed by staff or senior level auditors" (p6). Price Waterhouse had a group at their research center in San Jose developing expert systems for auditors and tax specialists. Unfortunately for academics, these large investments by the accounting firms leapfrogged them past the small demonstration systems built by AIS researchers. This was clearly demonstrated at the last (1990) expert systems conference at USC where professors were still talking about their

[4] Some other survey articles include Abdolmohammadi 1987; Connell 1987; Liao 2005; O'Leary 1991; O'Leary 2008a; Rada 2008; Sahin et al. 2012; Wong and Monaco 1995.

small (e.g., 25 rules) prototype expert systems versus ExperTAX that was demonstrated by Coopers & Lybrand. ExperTAX had over 1,000 frames, rules, and facts and it was based on knowledge derived from over 20 senior tax and audit experts (Shpilberg 1986). This was probably one of the tipping points where academic and practitioner research separated and practitioners interested in attending academic expert systems research conferences declined. This is one of the general challenges AIS researchers face (Alles et al. 2008).

AIS researchers continued to conduct expert systems research. In the latter years of expert systems research more neural networks research papers appeared. Frequently these research papers would compare the results of neural network's ability to predict bankruptcy of companies compared to other traditional statistical bankruptcy prediction techniques. These papers were heavy on statistical analysis and were more in line with traditional statistical, quantitative accounting and auditing research.

2.2 Technology Adoption Frameworks

The following section starts with an overview of industry life cycle, the technology adoption life cycle, and the Gartner hype cycle that have been used in the past to characterize the evolution AIS research as well as other technology-related research. Then we introduce Moore's (2002) concept of the crossing the chasms that exist between the different key adoption groups in the adoption life cycle. Although Moore's framework is based on the adoption of products, as we demonstrate, it also seem particularly applicable to discussing the accounting-related expert systems life cycle.

2.2.1 Industry Life Cycle

Research topics—AIS and other research—generally follow the life cycle stages similar to the generic industry life cycle shown in Figure 1. In the embryonic stage, a few AIS researchers, typically with a deeper interest in information systems or computer science, start writing papers on this new technology topic (at least new to AIS and accounting literature). Hevner et al (2004) states that, in general, design science dominates in this stage. As O'Leary (2008b) observers, these early papers are frequently broad and conceptual in nature; not empirical. Researchers in the embryonic stage will typically have to build their own prototype or demonstration systems.

Research in this stage could also include summaries of activities or opinions from other fields outside of accounting. For example, Baldwin-Morgan (1993) used the Delphi method to have a panel of experts (Big 6 and vendor representatives and other stakeholders) predict how expert systems would be used as audit tool one decade in the future (the year 2001).

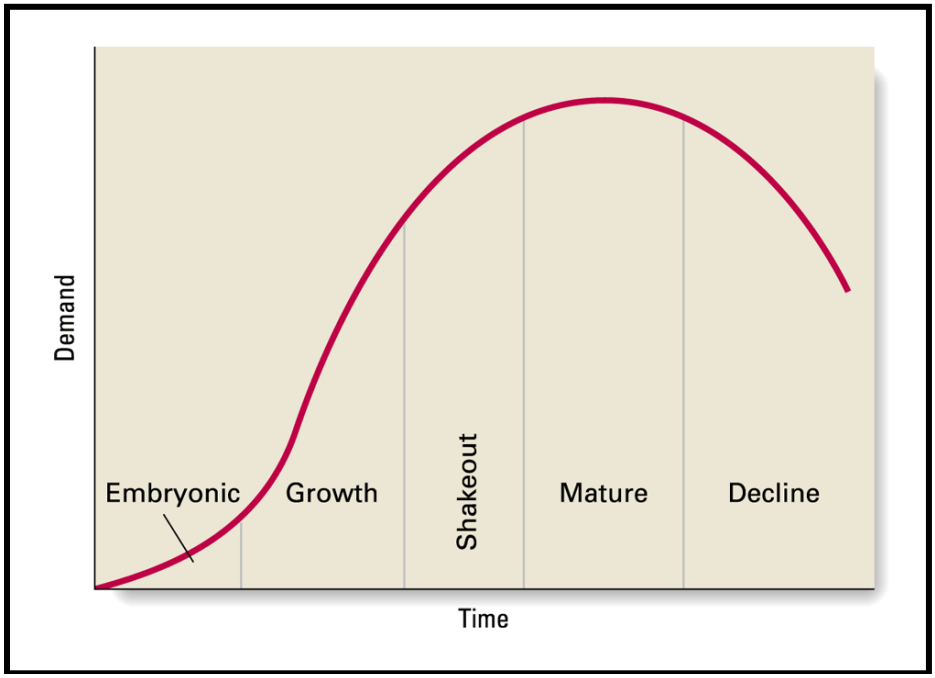

Figure 1. Industry Life Cycle.

In the early part of the growth stage (also called emerging stage), interest grows in the topic and additional researchers start writing papers on the topic. The research is still mostly design science and any expert systems are still first-generation systems. Much of the work here could still be considered proof-of-concept activities. As accounting firms and/or other organizations start incorporating the new technology, the next round of AIS papers will typically include some case studies, summaries of real-world activities, and interviews with members of the practice community as to how they are implementing expert systems (e.g., Brown 1991). The focus of the research can move away from building prototype systems to more sophisticated production systems. Research can focus on different aspects of expert systems such as knowledge acquisition (different approaches to capture the heuristics from the human experts), human interface issues, and implementation issues. Because of the growing real-world use of the technology, behavioral research can start focusing on the strengths and limitations in using the

technology (O'Leary 2009). Over time, the papers become more empirical and the topics become more disaggregated as the research moves through the growth stage. Second generation systems are being implemented that reflect findings and experiences with first-generation systems.

If the initial research proves popular, more researchers may join the research domain and start producing papers, but some of the earlier researchers will lose interest as the research moves through the shakeout stage. The departure of those early researchers can potentially have a negative impact on the continuation and growth of research because these researchers may have been particular enthusiastic advocates ("true believers") for the technology. That enthusiasm may have attracted the attention of the practice community. Rogers (1962) says these early adopters have the highest degree of opinion leadership. For example, Robert Michaelsen, whose dissertation (Michaelsen 1982) was about a tax-based expert system, was approached by the IRS about his work. He subsequently spent six-months at the IRS helping them develop an expert system.

If the technology becomes more mainstream and reaches a steady-state situation where researchers initially interested in the topic will continue to produce papers in that particular area and some other researchers will join the bandwagon because of the topic's popularity, which mean the research is in the mature stage. Prototype and demonstration systems (unless introducing some true innovation), design science, case studies, and similar types of research popular (and appropriate) in the earlier stages are of little interest in the mature stage. In the mature stage, the field is crowded and different researchers try to find niches to distinguish their research. For example, there was a shift to neural network research, which had a traditional appeal because the research focused heavily on inferential statistics that appeared less frequently in the early life cycle stages. Paralleling the academic life cycle, on the practice side, accounting firms and other organizations were developing a wide variety of expert systems. This broader use of expert systems in practice should reduce the empirical bias that O'Leary (2009) indicated could happen in the earlier life cycle stages. This broader real-world use can mean that behavioral research can be more robust (e.g., Arnold et al 2006). Finally, over time, interest in this new topic may fade naturally and newer (hotter) topics will attract AIS researchers' interest and the existing research enters the decline stage.

2.2.2 Adoption Life Cycle

One way to examine technology diffusion is the adoption life cycle generalized by Rogers (1962) that groups different technology adopters in terms of demographics and psychological (psychographic) characteristics. To illustrate the wide applicability of the adoption life cycle, although the current discussions of the adoption life cycle is usually applied to high-tech products, Rogers' work came from the research regarding how farmers adopted new stains of seed potatoes. AIS researchers can be categorized by the groups in Figure 2. Innovators are the AIS researchers who "discover" some new technology (new to the accounting domain) and provide the early visibility of this new topic to other AIS researchers, other accounting researchers, and the practice community, in general. Innovators are intrigued by new technology. Innovators are small in number, but these pioneers are critical in kicking off interest in new technology. Innovators are the gatekeepers for new technologies (Moore 2002). If some of the innovators are a well-respected AIS researchers that will even provide more credibility to the new technology. Innovators are willing to deal with the implementation problems that someone working with new technologies may face. For example, Paul Steinbart, who was a PhD student at Michigan State University (MSU) in the early 1980s, wanted to build an expert system with EMYCIN.[5] To do so, he needed a DEC VAX computer, but MSU did not have the required computer. Paul found a community college in a nearby city that had the appropriate DEC computer. The community college representative told Paul he could use the computer, but only at night. So, while Paul was working on his dissertation, he would work at the community college at night until 6:30am the next morning. Another issue innovators face is lack of peers to confer with because of the newness of the technology. Early adopters are very different than innovators. According to Moore (2002), early adopters are not technologists, but they are visionaries who more clearly see the benefits of the new technology and are looking for a fundamental breakthrough. Early adopters build on the work of the innovators and, as said before, Rogers (1962) considers this group to have the highest degree of opinion leadership. Peer groups have grown where researchers now have colleagues they can confer with. While the early majority is more attracted to the technology than late majority, both the early majority and late majority are far more interested in the practical aspects of the technology and the application of the technology to various accounting activities. In fact, they may have zero interest in (or even the

[5] EMYCIN is an expert system shell based on Mycin.

skills to) actually building expert systems. When Elaine Mauldin was a PhD student at Nebraska in the mid-1997, she wanted to include some aspect of expert systems in her dissertation, but she was not interested in design science research. So, she found a commercial expert system that determined loan loss reserves and she used it for what was, in essence, a behavioral study.[6] The early and late majorities may wait to see if the new technology is not just a passing fad before committing to do research in the area (Moore 2002). The early majority and late majority are also in that part of the research life cycle where their research must be more quantitative and empirical to be publishable. Laggards would be those researchers who have no interest in the technology per se, but they feel somewhat compelled to do some research in this area or to at least acknowledge this research in their own research portfolio.

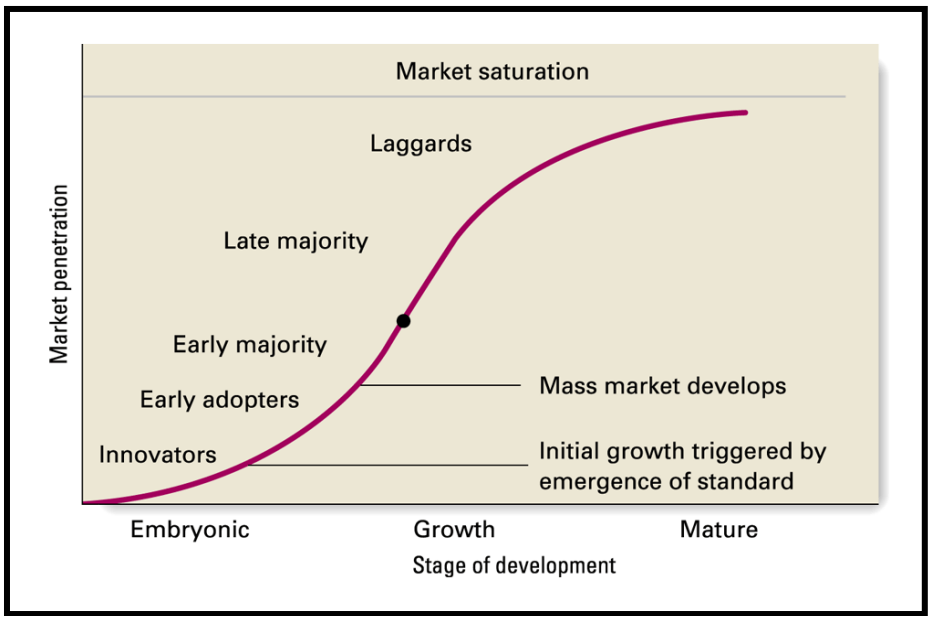

Figure 2. Researcher Groups.

2.2.3 Gartner Hype Cycle

A frequently cited framework to illustrate technology adoption is the Gartner hype cycle shown in Figure 3 published by the Gartner Group.[7] O'Leary (2008b and 2009) provides a wide-ranging discussion of a variety of information system research topics and the Gartner hype cycle. As the diagram illustrates, in the beginning, new technologies generate lots of hype (with high

[6] In addition to her dissertation, her results are also reported in Mauldin (2003).
[7] www.gartner.com

expectations) and people over-attribute potential benefits to the new technologies. As fast as the expectations move up the left face of curve, expectations fall down the right face of the curve into the "Trough of Disillusionment." Then the technology enters the more steady-state plateau where the technology finds it niche in the marketplace and the expectations more closely match the actual benefits that can be derived from the technology. A key point to understand about the hype cycle is that the first rise to the peak on the left and the fall through the trough of disillusionment occurs in just the first 5% of the market adoption stage. That is, mapping the Gartner's hype cycle to the industry life cycle in Figure 1, that whole movement from highest to lowest expectations happens in the before the life cycle has barely entered the growth stage.

A problem with the highly generalized Gartner hype cycle is there is no scale after the 5% point and the right side the hype cycle after the trough of disillusionment slopes upward. When a product is inside the trough of disillusionment it is hard to predict how long the technology will stay in the trough, particularly since expectations are at their lowest point and pessimism will be at the highest level. Plus there is no certainty that the expectation will always slope upward. Aranda (2006) calls this upward sloping line "irrational optimism."[8] An example of not sloping upward would be WebTrust, the e-commerce-related assurance service developed by the AICPA in the late 1990s (Boulianne 2009). In the real world, when researchers are in the trough, they do not know the duration of the trough or the eventual slope of enlightenment and of the plateau of productivity. This uncertainty and pessimism when in the trough can discourage AIS researchers and drive them to other research areas.

An example of the front side of hype cycle (technology trigger and peak of inflated expectations) is Brown (1991) that reported 43 expert systems were being used or developed at the Big 6 accounting firms. Looking to the future from 1991, Balwin-Morgan (1993) used the Delphi method to survey stakeholders in the accounting-related expert systems domain. The participants were presented several propositions regarding their opinions about expert systems as an audit tool one decade in the future (year 2001). The respondents mostly indicated that it was very likely that expert systems would have an impact on auditing firms in the next decade. Specific very-likely impacts included,

[8] http://catenary.wordpress.com/2006/10/22/cheap-shots-at-the-gartner-hype-curve/

> …better documentation references, enhanced 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 result in changes in the education of auditors, particularly in-house training. (p16)

Loss of prestige for firms using expert systems was identified as the least likely impact identified. Interesting, the panel concluded that expert systems were only somewhat likely to improve audit efficiency.

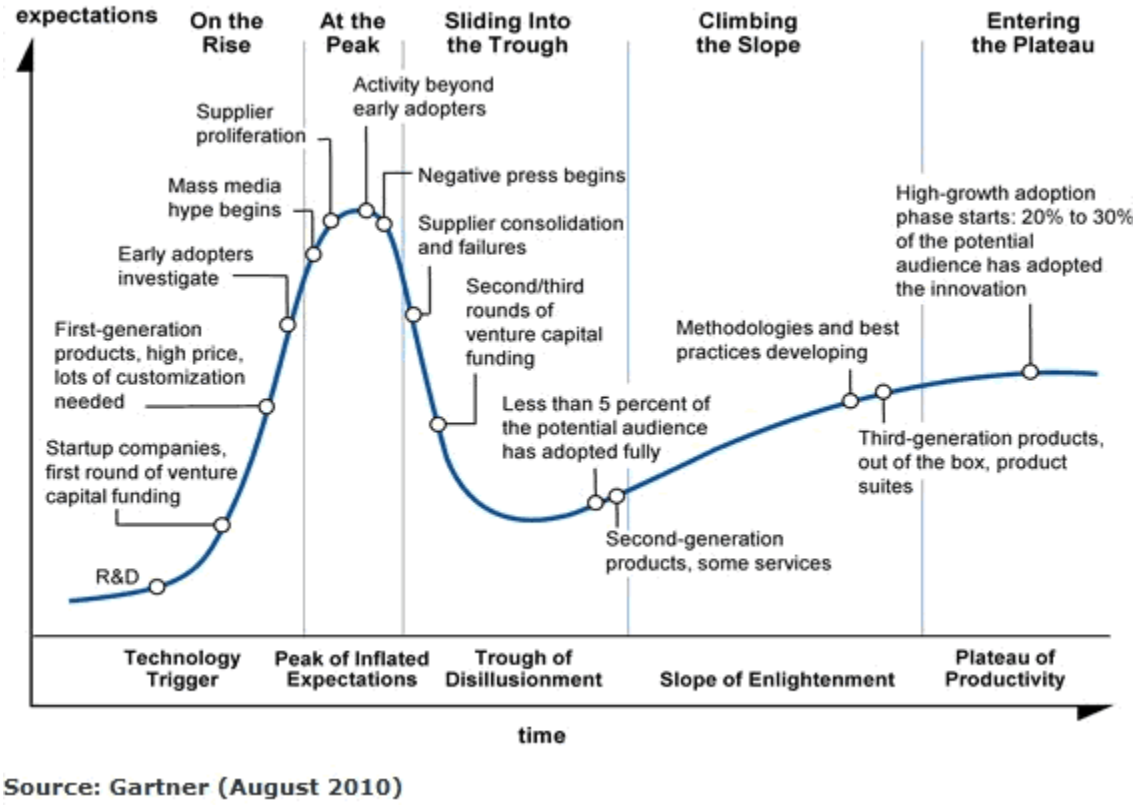

Figure 3. Gartner Hype Cycle

2.2.4 Crossing the Chasms

Some new technologies (as well as streams of technology research) lose momentum and never break out of a small group of innovators and early adopters. Reflecting this reality, building on Figure 2, Geoffrey Moore in his book first published in 1991 (revised in 2002), "Crossing the Chasm" introduces the idea that there is a chasm between each of the adoption groups shown in Figure 2 leading to Figure 4. We described the diverse characteristics of different adoption groups in the prior paragraphs. Those differences create chasms trying to move from one group

to the next. In other words, the motivations and interests of these different groups are quite diverse and momentum can be lost trying to move from one group to the next group. Moore (2002) states that the first critical chasm is between innovators ("technology enthusiasts") and early adopters ("visionaries"). If early adopters do not see clear benefits from the technology, they will not pick up the momentum and the technology adoption will probably end quickly. Moore states that the other critical chasm is between early majority ("pragmatists") and late majority ("conservatives"). The early majority is willing to learn about the technology itself, but the late majority is far less willing to do so. As critical as those two chasms are, Moore goes on to state that "by far the most formidable and unforgiving" chasm is between early adopters and early majority. These two groups are the two most different and incompatible groups. He said this chasm is particularly dangerous because it typically goes unrecognized (Moore 2000, p19). Whereas the innovators are a very small group, early adopters are the change agents. This view supports what Rogers (1962) indicated earlier that early adopters are opinion leaders. Early adopters are far more flexible in terms of switching from one technology to another and putting up with the bugs and other inconveniencies they encounter with the new technology. On the other hand, early majority are far less willing to debug the technology. As Moore says, "They want evolution, not revolution." (p20) Early majority do not get excited about new technology compared to the excitement expressed by early adopters. Early majority mostly trust the opinions of other early majority. In a sense, early majority have to create their own synergy or critical mass; building on each other's successes.

In summary, if all the chasms cannot be crossed and the technology domain does not attract early majority and late majority, then the body of research will not reach a critical mass and will probably disappear.

We see these potential chasms in AIS research in that when a new technology enters the AIS domain, the early papers by innovators are reporting on prototype and proof of concepts systems. Papers from early adopters are less empirical, less quantitative, and more conceptual. Paper reviewers and editors typically do not apply as rigorous standards to these papers because they recognize that these conceptual papers will stimulate more-empirical future research. On the other hand, over time, if this body of research does not become more empirical and quantitative, it will be difficult if not impossible to get the subsequent papers published in the higher-ranked

journals. Steinbart, who had an expert systems paper published in Accounting Review (Steinbart 1987), opined that it would have been difficult for other researchers following him to get similar papers subsequently published in Accounting Review because the novelty factor associated with expert systems had dissipated with the publishing of his paper. If the innovators and early adopters do continue to produce papers they may form special-interest groups, hold their own conferences, and may even launch their own journals. This is exactly what happened in the expert systems domain.

Moore's chasms are based on demographics and psychological (psychographic) characteristics of the different adoption groups. In addition to these differences discussed by Moore, we suggest there are other causes of chasms that inhibit AIS research. Another cause is types of research. Innovators will be mostly limited to building and testing demonstration expert systems, but there is limit to how many papers of this type of research that can get published. If early adopters want to get their research papers published, they will have to move into other research types such as real-world case studies and, eventually, empirical research. However, accounting firms are very reluctant to share their internal activities with academics and may not allow researchers to study their expert system implementations. Another type of early research would be behavioral, laboratory studies. But if that research is based on demonstration systems and the subjects are students or even practitioners with little expert system experience, both internal and external validity will be questioned by reviewers. In terms of moving to empirical studies, as O'Leary (2009, 2) observed, early empirical research can be "vulnerable to sample bias" because the early implementers in practice are also innovators in their domains and will be biased toward expressing positive views about the implementations.

Another cause of chasms that can impede progress of research regarding a particular technology is that the characteristics of the technology itself can change over time. The technology can change in terms of complexity or sophistication and the number of AIS professors who have the requisite skills to conduct research in this domain will decrease. A specific technology can also merge or be embedded in other technologies and it will become difficult to conduct research in the "pure" form of the technology of interest.

A significant chasm that AIS researchers face is the decline and eventual disappearance of the

technology of interest from the external organizations of interest. After making significant investments in expert systems technology, the use of expert systems (at least as a stand-alone system) by accounting firms has basically disappeared. As such, AIS researchers who were planning on studying production (real world) systems for case studies or use subjects from accounting firms to research various aspects of the expert systems for behavioral studies would be stifled.

Finally, as research in a particular technology is expected to evolve into empirical research; to conduct empirical research has certain prerequisites that must be met to conduct the research. First, researchers will need a large enough sample that is appropriate for the statistical technique that will be used. Second, and probably the most critical, the owners of the systems or the data related to the systems must be willing to allow access to that data. As researchers have encountered in the past, accounting firms are very reluctant to share internal data.

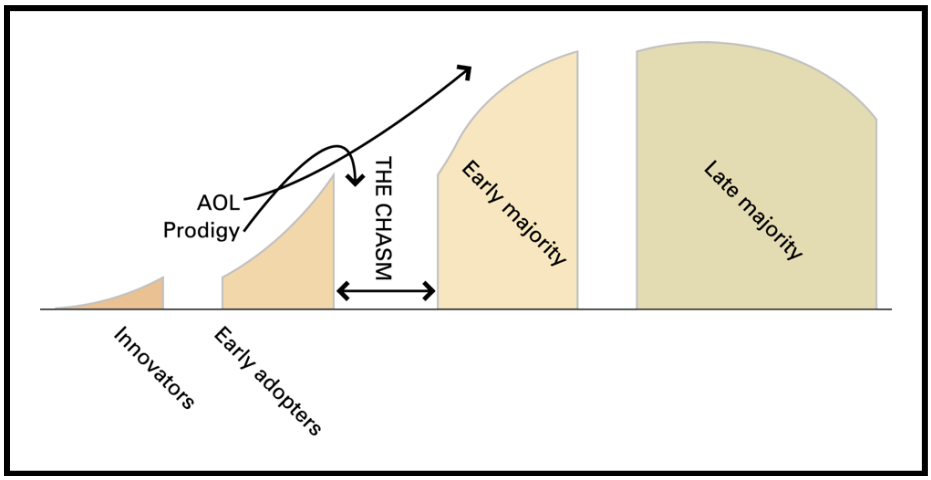

Figure 4. The Chasms.

2.3 Research Questions

In the remainder of this paper, we explore the life cycle of expert systems research by AIS researchers in light of the four frameworks presented the prior paragraphs. These four frameworks lead us to the following research questions:

RQ1: Did expert systems research in accounting and AIS domain go through a similar industry life cycle over time?

RQ2: Did the *type of research* evolve over time as would be predicted by the industry life cycle and the Gartner hype curve?

RQ3: Did the *type of researcher* evolve over time as would be predicted by the adoption life cycle?

RQ4: Did the evolution of the type researcher encounter a chasm that slowed or stopped expert system research as would be predicted by Moore?

RQ1 and RQ2 mostly reflect the industry life cycle and to some extent the Gartner hype cycle. RQ3 reflects the adoption life cycle. RQ4 directly reflects the Moore's (2002) chasms. However, in many ways, RQ4 is an overarching RQ in that it can help explain the results of the other RQs. For example, if RQ3 proves not to be true, it may be that the chasm between the different adoption groups could not be crossed.

3. Research Methodology

3.1 Data collection & preprocessing- expert systems publications

Searches of expert systems relevant articles in the accounting and AIS domain were carried out through multiple online databases including *EbscoHost, Science Direct, Wiley* and *Scopus* using keywords "expert systems & accounting," "expert systems & auditing," "expert systems and tax", "artificial intelligence & accounting," and "artificial intelligence & auditing." After the search was completed, a review was subsequently performed to exclude any duplicate article listings across databases and to screen out false positive findings, i.e., studies that fall under other disciplines that are outside the scope of this research[9]. With no limitation on time frame and publication source during the searches, we located 233 unique expert systems relevant articles. Yearly distribution, article source and article type as well as most-frequent authors of these 233 expert systems articles are examined. The following results analysis section illustrates

[9] Articles that belong to other domains (e.g. computer science) and do not cover accounting or accounting information systems relevant topical areas were excluded.

descriptive statistics, data distribution percentages and rankings of the expert systems articles in understanding its research life cycle.

3.2 Data collection & preprocessing - expert system dissertations

Besides the search of journal articles, we also searched the accounting Ph.D. dissertations on expert systems in the *ProQuest dissertation and thesis database*. We queried all the accounting Ph.D. dissertations including "expert systems" in their title or abstract. In total, there are 44 English-language dissertations found in the database. We examined the institutional and yearly distribution of these dissertations, and the publications' authors. The results are discussed in next section.

3.3 Data collection & preprocessing – AAA annual meeting presentations

In addition, we searched the expert systems related presentations in the AAA annual meetings from 1998 to 2011 (we limited our search in these years because the online programs of AAA annual meetings are only available from 1998). After searching all the AAA annual meeting online programs, we identified 11 expert systems related presentations. Yearly distribution of these presentations are examined and discussed in the following section.

3.4 Interviews with Innovators and other Participants

In addition to collecting publication data, we interviewed a small sample of academics and practitioner who could provide some insights on the motivation and concerns that were being expressed by people as expert systems were going through a life cycle. The interviews were conducted over the telephone. The interviews lasted from 30 to 60 minutes. The pool of academics was those academics whose names appeared on the early expert systems publications, including dissertations. On the practice side, finding knowledgeable representatives was more difficult. Because the accounting firms have a mandatory retirement age of 60, the number of people in the firms that would be knowledgeable about what their firm's history with expert systems in the 1980's and early 1990 is a shrinking population. To develop a pool of practice contacts, we started by contacting anyone we knew at the firms, gleaned names from accounting-related expert system conferences and publications, and, in one case, contacted the chairman of the firm.

4. Preliminary Results Analysis

4.1 Yearly distribution of expert systems research

Examining the yearly distribution of expert systems research between 1984-2011 (Figure 5), the emergence of this area of research in the accounting domain occurred in 1984 where an article "*An expert system for federal tax planning*" by Michaelsen (1984) was published in *Expert Systems.* With this one publication in 1984, expect for 1989, the number of expert systems publications grew through 1991. There was a second wave, peaking in 1996. There was a general decline through 2004, with a lesser third wave from 2005 to 2010. On average, we found 13.17 articles published yearly between 1987 and 1998.

As shown in figure 5, there is a decrease in the quantity of expert systems publications after 1998. In the most recent 1999-2011 period, the quantity of publications decreased to a yearly average of 5 articles, which is less than half of the average in the 12-year period prior to 1998. Regarding Research Question 1 (RQ1), regarding the industry life cycle, it appears that the life cycle of accounting-related expert systems research had gone through the embryonic stage at early 1980s, the growth stage through 1998, and now resides in the mature stage as opposed to moving into the decline stage with a downward slope toward zero. Interestingly, expert systems research seems to staying in the mature stage. AI and expert systems research continues outside the accounting domain. We speculate this outside activity may continue to motivate some AIS researcher to find applications in their domain.

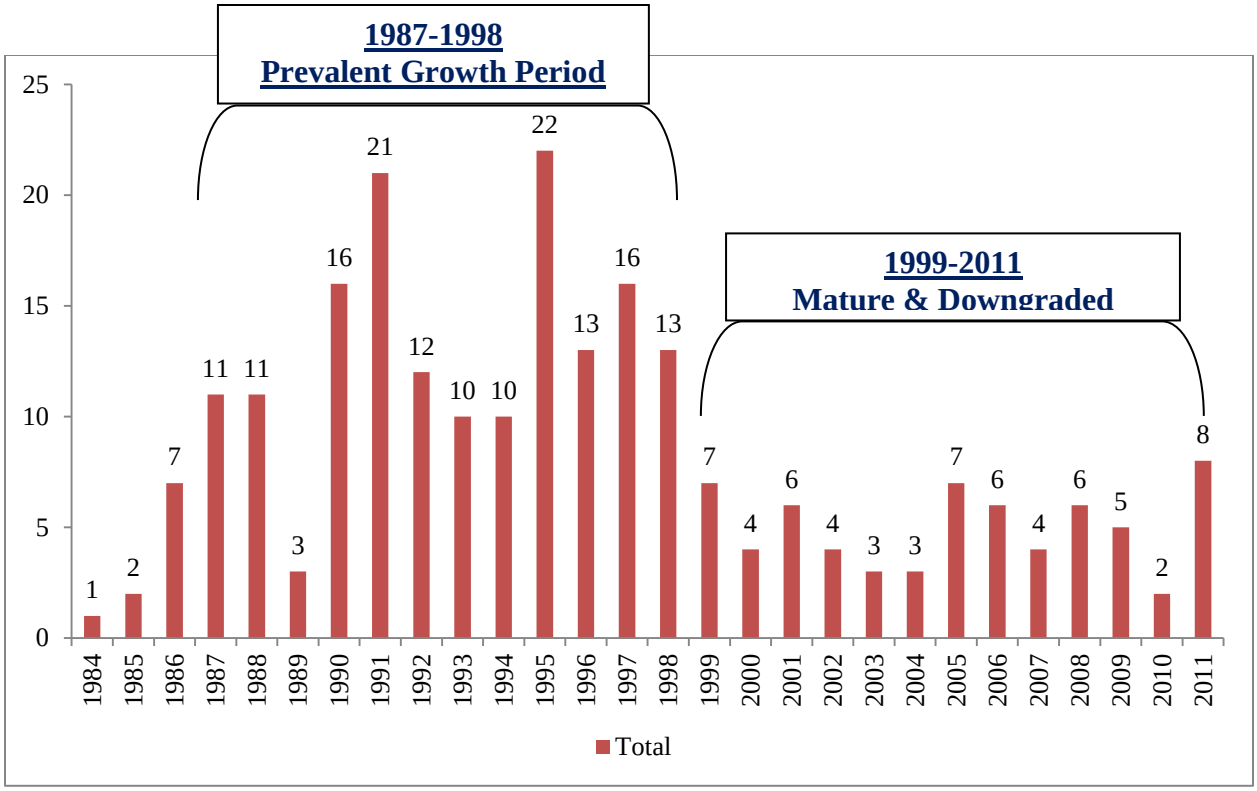

Figure 5. Expert Systems Publications Count by Year.

4.2 Source and type distribution of expert systems research

The 233 expert systems articles we identified were publications of 101 different journals. Among which, the top 5 journals in terms of the most expert systems publications are *Expert Systems with Applications (11.16%), Auditing: A Journal of Practice and Theory (6.44%), Journal of Information Systems (6.01%), New Review of Applied Expert Systems and Emerging Technologies (3.86%), and Accounting Education (3.43%).* These journals altogether accounts for 30.9% of the 233 articles. Although most of the expert system publications appeared in AIS-oriented publications, a significant number of expert system publications appeared in NAIS publications, reflecting the evolution of research from pure technology to the application of the technology.

	Top Journals with the Most Expert Systems Publications	Count	%
1	Expert Systems with Applications	26	11.16%
2	Auditing: A Journal of Practice & Theory	15	6.44%
3	Journal of Information Systems	14	6.01%
4	New Review of Applied Expert Systems and Emerging Technologies	9	3.86%

5	Accounting Education	8	3.43%
6	Accounting, Organizations and Society	6	2.58%
7	International Journal of Accounting Information Systems	6	2.58%
8	Intelligent Systems in Accounting, Finance & Management	6	2.58%
9	Journal of Accountancy	5	2.15%
10	Expert Systems	5	2.15%
11	European Journal of Operational Research	4	1.72%
12	The British Accounting Review	4	1.72%
13	Accounting Horizons	4	1.72%
14	Management Accounting Research	4	1.72%
15	International Journal of Production Economics	4	1.72%
16	International Journal of Intelligent Systems in Accounting Finance & Management	4	1.72%

Table 1. Top Journals with Expert Systems Publications.

In sum, we observed that the 233 expert systems articles are published in quite a diverse set of journals, with the top 16 journals (Table 1) accounted for 53.22% of the total publications. Additionally, considering all 101 journal, 2.31 articles are published in each on average. In terms of publication source type, citations collected from online databases are mainly academic. We provided publication type classifications and distributions in Table 2.

	Publication Type	**Count**	**%**
1	Academic Journals Articles	182	78.11%
2	Academic Journals - Educational Oriented Articles	15	6.44%
3	Conference Proceedings	14	6.01%
4	Professional Journals Articles	11	4.72%
5	Discussions	7	3.00%
6	Academic/Professional Journals Articles	3	1.29%
7	Reply	1	0.43%

Table 2. Publication Source Type.

As surrogate to address Research Question 2 (RQ2), changes in type of research, we compared the relative number of papers published in systems-related journals vs. non-system journals (e.g., Auditing: A Journal of Practice & Theory). Presumably, articles published in non-system journal are focused on the application of expert systems vs. the more design science type articles that are more likely appear in system-related journals. We compare the mix of publications over four 7-

year periods. If the frameworks hold true, we would expect the mix to shift away from system journals. Except for the 1998-2004 period, there was a downward trend in the percent of expert systems articles published in system-related journals, which generally supports the RQ2.

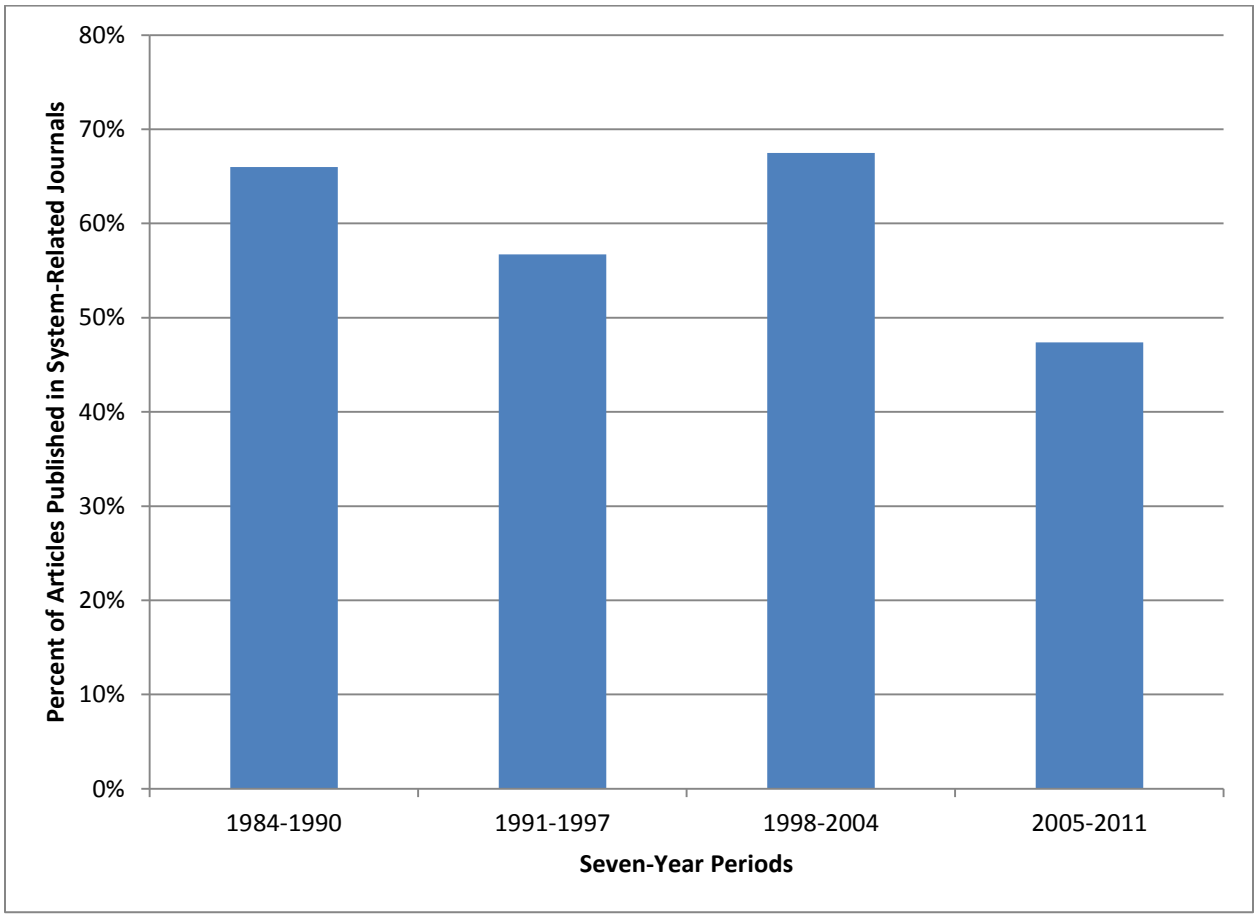

Figure 6. Percent of Articles in Systems-Related Journals.

4.3 Accounting areas distribution of expert systems research

It is interesting to examine whether and how these expert systems articles concentrate/distribute in specific areas in the accounting domain. The 233 expert systems articles were manually classified into six areas, including accounting (generic, not financial or managerial specific), financial accounting, managerial accounting, auditing, tax, and education. Since a number of research articles fall under multiple areas, such as auditing and accounting, we apply the multiple disciplines label to represent them. The statistics is shown in Table 3 and Figure 7. Among these articles, the area with the most expert systems publications is auditing (32.62%). In the

accounting area, there are 58 out of 233 articles (24.89%). We have 19 out of 233 articles related to financial accounting and 20 out of 233 articles related to managerial accounting. We have 20 articles about the application of expert systems in accounting educations (8.58%). There are eight articles related to multiple disciplines (3.43%). In summary, expert systems are mostly applied to auditing and accounting areas.

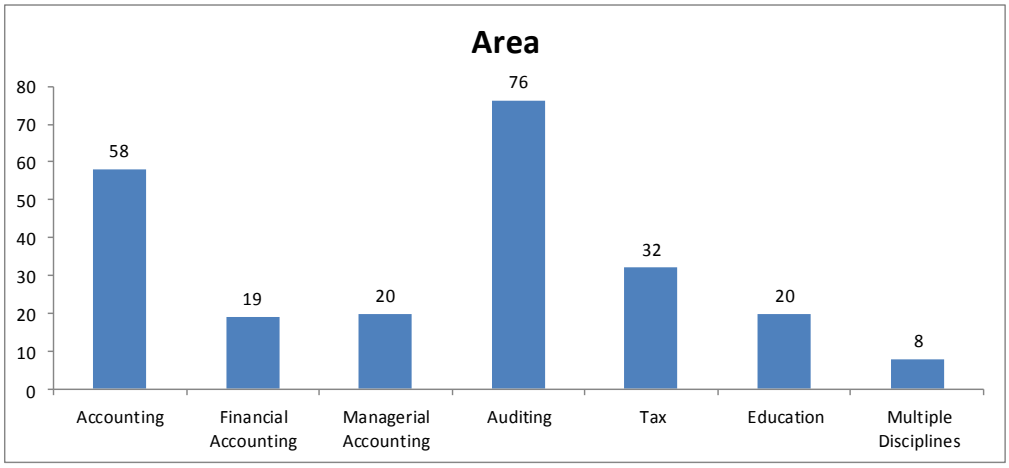

Figure 7. Expert Systems Research Distribution by Accounting Area

Area	Publication Count	%
Accounting	58	24.89%
Financial Accounting	19	8.15%
Managerial Accounting	20	8.58%
Auditing	76	32.62%
Tax	32	13.73%
Education	20	8.58%
Multiple Disciplines	8	3.43%

Table 3. Expert Systems Research Accounting Area Count and Percentage

Although we did not have an ex ante prediction, we wanted to explore how the mix of application areas would change over time. Again using four 7-year periods, we compared the mix of application areas as illustrated in Figure 8. The three "accounting" areas had a significant jump in the last time period. This partly reflects the increased in expert systems and neural networks bankruptcy prediction papers. These papers were statistical, empirical papers that support RQ2 that the type of research evolves as the research domain matures. There was an

interesting jump in the education area in the second (1991-1997) period. This was not a surprise. As we discussed in the Background section, many AIS books in that time period included expert system discussions and some books included a copy of VP-Expert software. The general decrease in the audit domain may reflect the general decrease in the use of audit-related expert systems by the practice community.

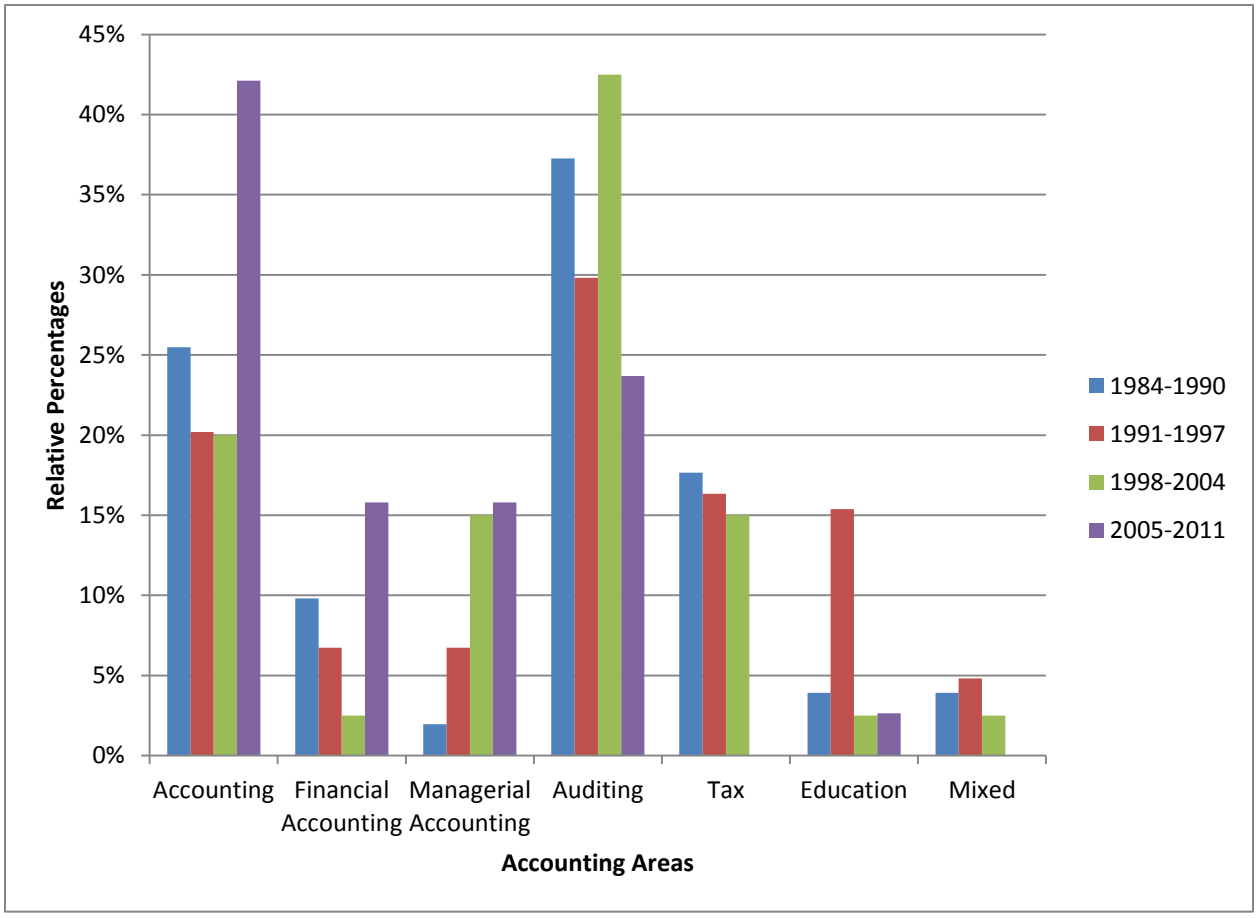

Figure 8. Changing Mix of Application Areas.

4.4 Top accounting researchers in expert systems research domain

In our analysis we found that 352 unique authors were involved in writing the 233 expert system articles. The number of authors exceeded the number of articles because we included all co-authors of the articles. On one hand, 352 authors is a significant number demonstrating a wide range interest in expert systems. On the other hand, as shown in Table 4, 303 (86%) of these authors were associated with only one article in the 28 years of our analysis, which could be to

disconcerting. An interesting question for future research would be to determine why so many authors published just one article. Were they discouraged? Did they move on to other topics? If they were discourages, was it by their administration (e.g., deans, chairs, promotion and tenure committees, etc.) and/or by difficulty in getting their research published in high-level journals? Either discouragement may be a portent for future technology-related research by AIS professors.

Number of Articles Published	Number of Authors	Percent of Authors
7	2	0.57%
6	2	0.57%
5	1	0.28%
4	9	2.56%
3	10	2.84%
2	25	7.10%
1	303	86.08%

Table 4. Distribution of Authors in Terms of Articles Published.

The most productive researchers in the field of expert systems in accounting are identified in Table 5. The researchers with the most publications are Carol E. Brown and Daniel E. O'Leary, *each of* whom published 7 articles (3.00%) in the expert systems area in accounting. Robert H. Michaelsen and Alan Sangster are second, each with 6 publications (2.58%), and Mary Ellen Phillips, is third with 5 publications (2.15%). Taking Tables 4 and 5 results together, 14 (4%) authors published 30% of all accounting-related expert system articles.

	Top Expert Systems Arthors	Publications	%
1	Carol E. Brown	7	3.00%
2	Daniel E. O'Leary	7	3.00%
3	Robert H. Michaelsen	6	2.58%
4	Alan Sangster	6	2.58%
5	Mary Ellen Phillips	5	2.15%
6	Mohammad J. Abdolmohammadi	4	1.72%
7	Andrew D. Bailey, Jr.	4	1.72%
8	Amelia Annette Baldwin-Morgan	4	1.72%
9	Martha M. Eining	4	1.72%
10	James V. Hansen	4	1.72%
11	Clyde W. Holsapple	4	1.72%

12	R. Steve McDuffie	4	1.72%
13	David S. Murphy	4	1.72%
14	Paul J. Steinbart	4	1.72%

Table 5. Top Researchers with Expert Systems Publications in Accounting Field.

In terms of Research Question 3 (RQ3), it is not clear that the type of researchers evolved over time. All of the researchers listed in Table 5 are essentially "pure" AIS professors or, at least, have a strong interest in technology. Maybe it is just too optimistic to assume that an esoteric technology such as expert systems will become so mainstream that NAIS professors will become regularly involved in doing research related to that technology. And maybe there are some NAIS professors in the 303 professors who published just one expert systems paper. However, the Moore (2002) chasm captured in Research Question 4 (RQ4) does exist (and appears deep and wide) in the expert systems research. Moore stated the most significant chasm is between early adopters and early majority and we argue that chasm was not successfully crossed in expert systems research. The first pioneers in researching and publishing accounting-related expert systems, such as Michaelsen, Dungan, Meservy, Steinbart, and others who did initial expert systems research, could be classified as innovators (from the adoption life cycle framework). Those AIS professors who published research starting in the later 1980s could probably be classified as early adopters. The early adopters had a long run, but during that long run, a critical mass of early majority did not form to make expert systems research more mainstream.

4.5 Top institutions with expert systems dissertation

The 44 expert systems related Ph.D. dissertations are from 34 different institutions. Among which, nine institutions have more than one expert systems dissertations (shown in table 6). Texas A&M University, having three expert systems dissertations (6.82%), is ranked in the first place. The institutions with two expert systems dissertations (4.55%) are Georgia State University, Kent State University, Louisiana Tech University, Michigan State University, Oklahoma State University, The University of Nebraska-Lincoln, The University of Texas at Arlington, and University of South Carolina. Each of the other 25 institutions has one expert systems related Ph.D. dissertation.

Top #9 Expert Systems Dissertation (Institutions)	Dissertation #	%
Texas A&M University	3	6.82%
Georgia State University	2	4.55%
Kent State University	2	4.55%
Louisiana Tech University	2	4.55%
Michigan State University	2	4.55%
Oklahoma State University	2	4.55%
The University of Nebraska - Lincoln	2	4.55%
The University of Texas at Arlington	2	4.55%
University of South Carolina	2	4.55%

Table 6. Top 9 Expert Systems Dissertation Institutions.

4.6 Yearly distribution of expert systems dissertations

The yearly distribution of these 44 expert systems dissertations is shown in figure 9. The figure demonstrates a similar trend as yearly distribution of expert systems publications shown in Figure 5. First expert systems related accounting dissertation appeared in 1983. However, in each year prior to 1987, the number of expert systems dissertations is very small, and there are no expert system related dissertation in 1984, and 1999 through 2002. From 1987 to 1995, the number of expert systems dissertations is relatively stable, with two peak years, which are 1991, with 6 expert systems dissertations and 1995, with 5 expert systems dissertations. From 1995 to 1998, the number decreased slightly. There is only one expert systems related dissertation after 1998 in 2003.

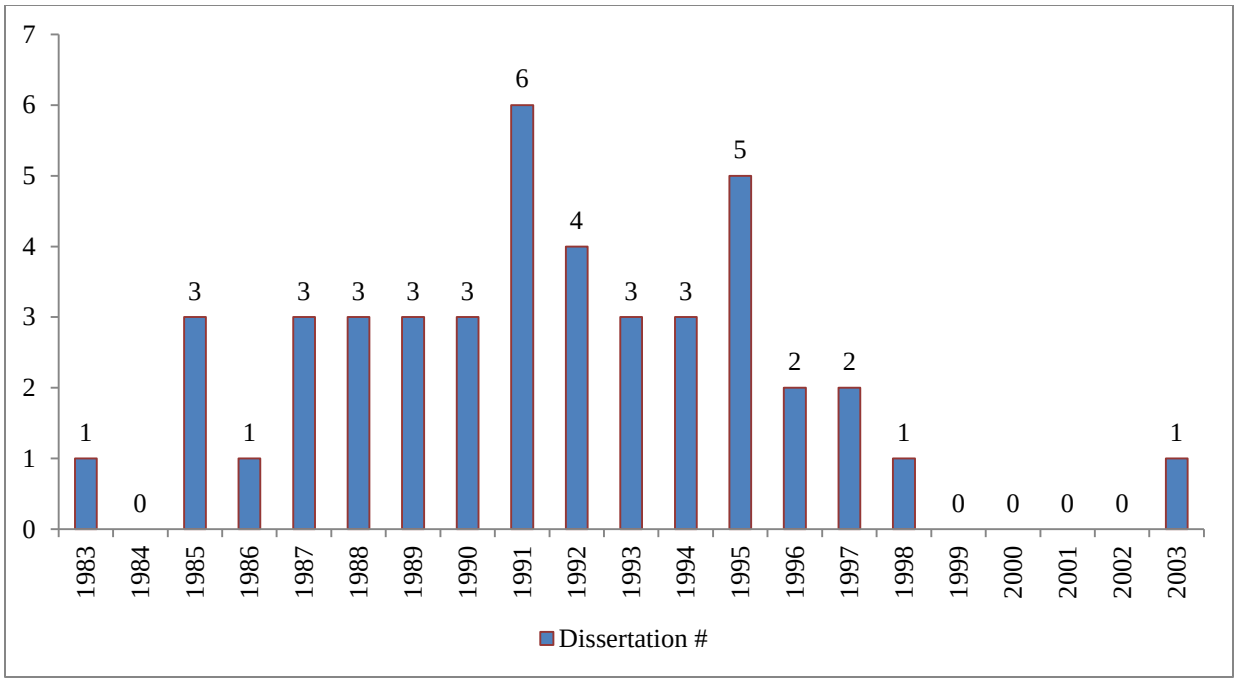

Figure 9. Expert Systems Dissertations Count by Year.

4.7 Top dissertation authors with expert systems related publications

To analyze the expert systems publications of the authors of these dissertations; we count each author's publications collected in our expert systems publication database of 233 publications. The results (shown in table 7) reveal that 21 dissertation authors (less than 50%) have published expert systems related articles. Among which, 5 authors have 4 publications, 1 author has 3 publications, 5 authors have 2 publications and the other 10 authors have 1 publication. We can also infer that 23 dissertation authors (52%) do not have any expert systems related publication. When we compare the researchers in table 7 and table 5 we find that the 5 top dissertation authors are also highly active researchers in expert systems publications. On the other hand, why less than 50% did not publish articles after their dissertations, is a good question for future research.

4.8 Yearly distribution of expert systems related AAA annual meeting presentations

As another measure of the rise and fall of expert systems activities, we also investigate the yearly distribution of expert systems related presentations in AAA annual meetings from 1998 to 2011. Even though according to our previous analysis, expert systems related research entered the mature stage since 1999, we can still identify a trend based on the summary shown in table 8.

From 1998 to 2006, expert systems related presentations exist nearly every year in AAA annual meetings except 2000 and 2005. Since 2007 this topic almost disappeared from the annual meeting; only one expert system related article was presented in 2010's AAA annual meeting.

Author	Publication #
Baldwin-Morgan, Amelia Annette	4
McDuffie, Robert Stephen	4
Murphy, David Smith	4
Eining, Martha McDonald	4
Steinbart, Paul John	4
Changchit, Chuleeporn	3
Mauldin, Elaine Gay	2
Lenard, Mary Jane	2
Back, Barbro Christina	2
Wensley, Anthony Kevin	2
Meservy, Rayman David	2
Kowalczyk, Tamara K.	1
Williams, Paul Richard	1
Ingraham, Laura R.	1
Odom, Marcus Dean	1
Swinney, Laurie S.	1
Hsu, Ko-Cheng	1
Trewin, Janet	1
Fedhila, Hassouna	1
Viator, Ralph Edward	1
Dungan, Christopher Wright	1

Table 7. Expert System Publications of Dissertation Authors.

Year	Presentation #
1998	2
1999	2
2001	3
2002	1
2003	1
2004	1
2006	1
2007-2009	0
2010	1

Table 8. Distribution of AAA Meeting Presentations by Year.

4.9 Expert Systems Activities in the Practice Community

Somewhat paralleling AIS researchers' expert systems activities, the major accounting firms were developing expert systems to help with audit and tax work as well as developing expert systems for clients. As Brown (1991) briefly described, the then Big 6 had 43 expert systems either in use or under development. In the intervening years, those expert systems, even any mention of expert systems, seems to have disappeared from the practice community. Unfortunately, the members of the practice community do not regularly write articles about their internal activities. As such, we could not do the same statistical analysis that we did for academic publications. Instead, we discussed expert systems history and current activities with representatives of the Big 4 accounting firms. The following paragraphs are an amalgamation of those discussions. The representatives wanted to maintain their anonymity, so specific firms are not attributed to specific comments. With that said, the "story" the representatives of each firm told we very similar. That is, although the timing and durations were a little different, there were not significant differences in terms of the life cycle of expert systems at the firms.

Typically, the first question the representatives asked us was: How are you defining expert systems? Specifically, one representative asked if "expert systems" mean the same as the definition on Wikipedia at http://en.wikipedia.org/wiki/Expert_system. The site started with the following sentences:

> In artificial intelligence, an expert system is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, like an expert, and not by following the procedure of a developer as is the case in conventional programming. The first expert systems were created in the 1970s and then proliferated in the 1980s. Expert systems were among the first truly successful forms of AI software.

Using the above or similar definition, all the representatives indicated that those traditionally-defined expert systems fell out of use. On the other hand, representatives from the audit side said that rule-based decision aids are built into current audit tools. For example, one representative mentioned that an audit questionnaire that has a total population of approximately100 questions, but after answering several preliminary questions, the internal rules in the tool select the specific

additional questions that will apply to the specific client. In other words, not all 100 questions will be asked because they will not all be applicable to a specific client. Another example given by a representative could be to have internal rules review data collected by the auditor as part of analytic procedures and suggest specific data or financial numbers (e.g., accounts receivable reserve) where the auditor may want to conduct additional investigations.

The point these representatives were making is that traditional expert systems that were designed to make decisions are gone, however the modern implementation of internal rules is to increase efficiency (e.g., decrease the number of questions used from a questionnaire) or increase effectiveness (e.g., highlight anomalies in data that an auditor may miss when looking at massive data).

Why did the traditional, decision-making expert systems disappear after significant investments by the firms in the 1980s and early 1990s? Expert systems did not *suddenly* stop being used. Their use gradually decreased to the point that doing maintenance work (to reflect, as applicable, changes in firm procedures, changes in audit standards, changes in tax regulations, etc.) did not seem appropriate. Because they gradually fell out of use, none of the Big 4 representatives could provide an exact year when stand-alone expert systems stopped being used. The primary reasons for their disuse seem to be a combination of being too structured and their use being voluntary. In general, the power of expert systems and the general reason they could outperform the experts on which they were built, was their consistency of asking *all* relative questions every time they were used. But for partners, in particular, being required to answer the comprehensive set of questions for every client seemed inefficient. Based on their vast experiences, the partners could quickly identify a risk or a particular procedure and they did not the expert systems to arrive at the same decision.

One of the representatives said the use of their expert system (which was part of a broader audit tool) was mandatory at one point, but eventually the expert system part of the tool became voluntary. After that point, its use decreased to the point where it stopped being used or maintained.

As a concluding remark, one representative wondered if the highly-structured aspect of the expert systems may be a particularly important benefit (and may motivate the return of expert

systems) in the currently environment because the PCAOB stresses consistency in their annual inspections. An expert system may help ensure the every audit is conducted in exactly the same manner. This would be an interesting topic for future research.

4.10 Comparison analysis on expert systems research across disciplines

We attempt to see whether there is a matching research life cycle for expert systems between the accounting domain and other disciplines. Therefore, we collect the total count of research papers related to expert systems from 1984 to 2011 from four databases, Science Direct, Scopus, WILEY, and EBSCO. Figure 10 shows that the count of collected articles from these databases. Since the number of collected articles from databases is different, we rely on Scopus database for our analysis since Scopus may contain the most expert systems articles. Generally, there is an increase from 1984 to 1991, which is matching with the research status of expert systems in the accounting domain. Then, the total count of expert systems articles decreased from about 2,700 to about 1,000 during 1991 to 2001. At the same time, the number of research articles related to expert systems in the accounting domain declined. Figure 11 shows the year count of expert systems research in accounting and its moving average trend line. Then, it fluctuated during the next ten year based on the data from Scopus, and there is a similar trend in the accounting domain. Therefore, the research life cycle of expert systems in the accounting domain follows the research life cycle in all the disciplines.

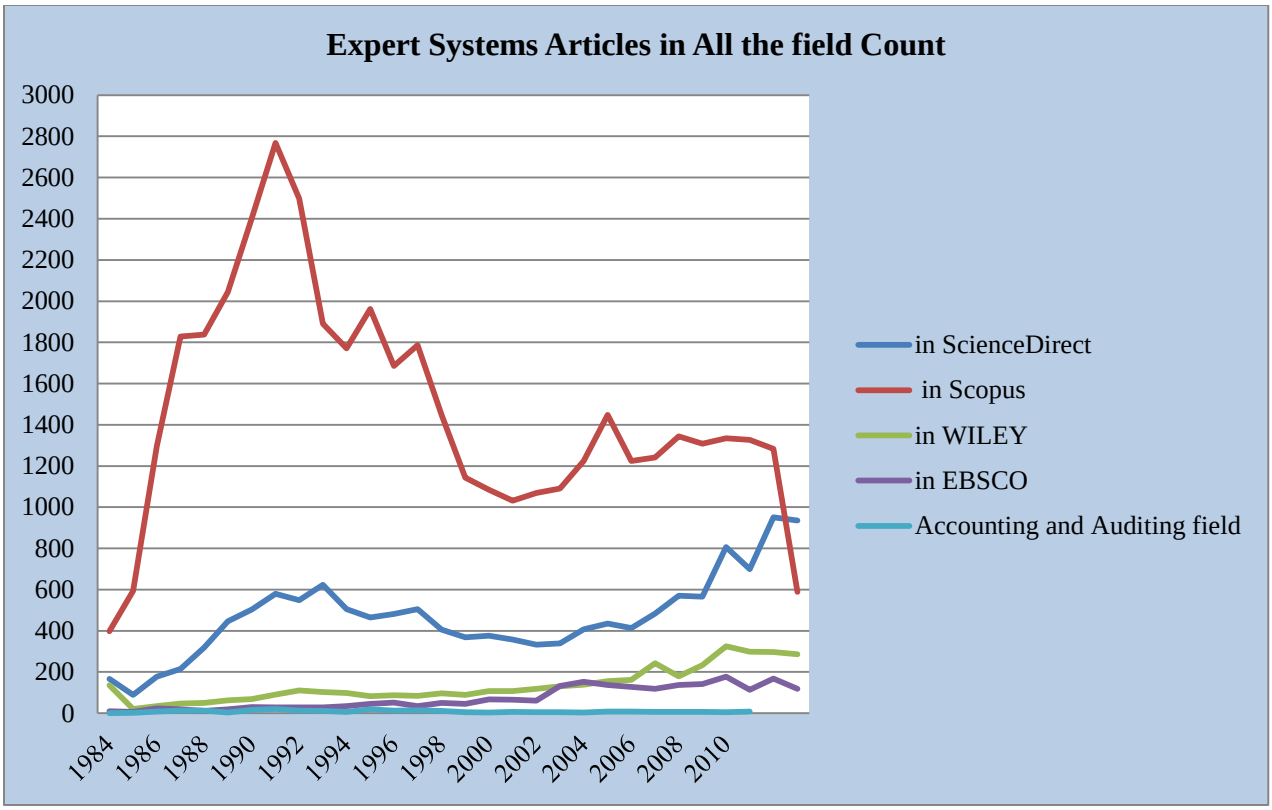

Figure 10. Expert Systems Publications Cross Discipline Count by Year.

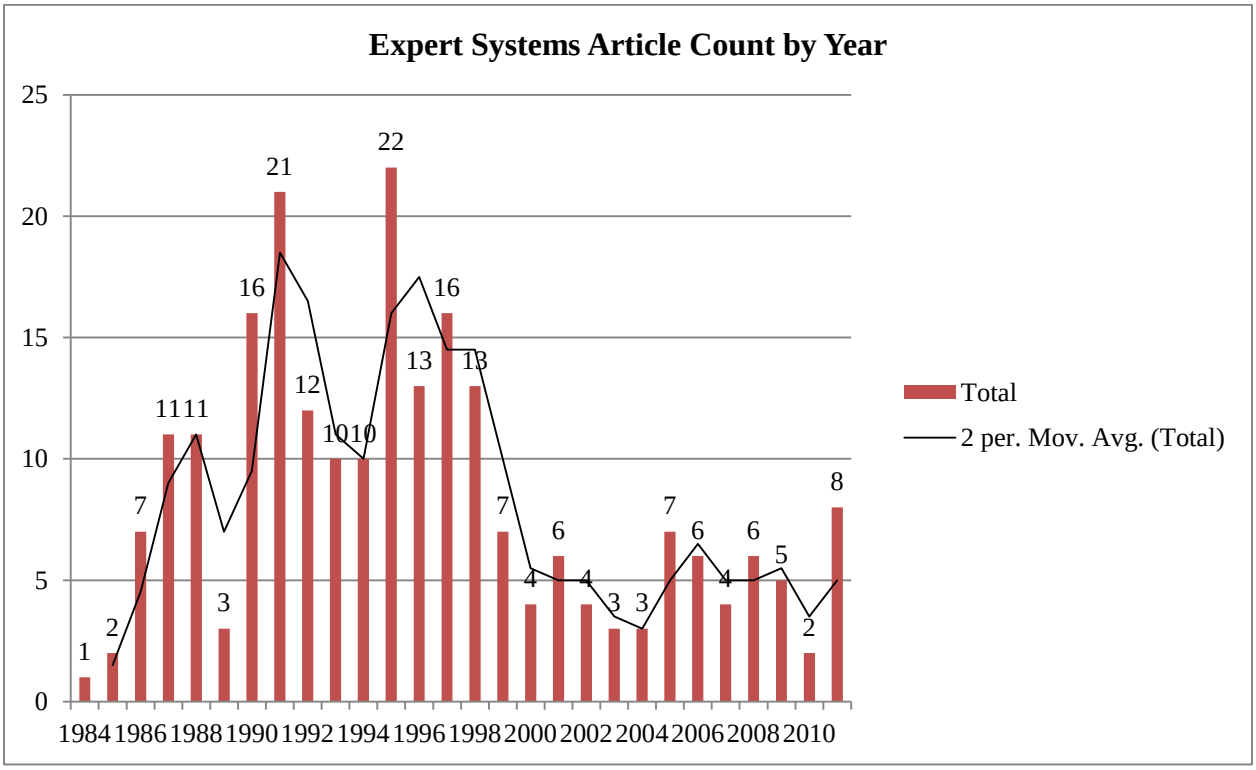

Figure 11. Expert Systems Research in Accounting - Year Count and Trend.

5. Conclusions and Implications

The purpose of this study is to examine the life cycle of expert systems research in the accounting domain. The life cycle of expert systems research is examined by searching multiple online literature databases and collecting a set of 233 expert systems relevant publications, interviewing with academic accounting-related expert systems pioneers, and interviewing with Big 4 representatives. In general, the adoption of expert systems research was not wide spread. On one hand, 352 authors were involved in publishing 233 expert system articles. On the other hand, 14 (4%) authors published 30% of all accounting-related expert system articles and 303 (86%) authors were associated with only one article in the 28 years of our analysis. In terms of our four research questions that were based on four related technology-adoption frameworks, our findings did generally support RQ1 (expert systems research did have a life cycle similar to the traditional industry life cycle) and RQ2 (the type of research did change *somewhat* over time). We say somewhat because the research did move into the empirical space but it was far short of what would be predicted based on O'Leary (2009). Our results for RQ3 directly support RQ4 too. The researchers who wrote accounting-related expert systems papers were almost exclusively AIS professors. In the adoption life cycle, those researchers were in effect innovators and early adopters. It is not clear if any researchers could be classified as early majority, but we are very confident that none of the researchers could be classified as late majority. This finding essentially supports RQ4 that when technology is involved there is wide chasm between early adopters and early majority and not crossing that chasm stifles research.

5.1 Lessons Learned

The following paragraphs provide some general insights that we derive from our study. Not all observations will apply to all encounters between technology and AIS researchers, but it we expect that most would apply in most situations.

1. Being first to embrace a new technology limits the types of research, but it also provides some freedom.

Early research is going to be limited to developing prototype and demonstration systems, some one-shot case studies, interviews, and focus groups and other forms of qualitative (vs. quantitative) research. However, conferences and editors may be more open to accepting this

research because of its originality. However, that originality wears off quickly (e.g., editor's interests will fall off quickly for the second and third demonstration systems.) This was demonstrated by Steinbart (1987). After his paper was published in *Accounting Review*, no other expert systems papers were subsequently published.

2. Being in the lead (ahead of practice) is a prized position.

AIS research in expert systems generally led the practice community. Apparently the accounting firms saw value in what the academics were doing and, for example, Coopers & Lybrand sponsored expert system symposiums at USC. More recently, we saw a similar phenomenon in the XBRL domain when XBRL International purposely scheduled their semi-annual meeting to be in the same city and the two days after the AAA Annual Meeting in 2000 (Philadelphia) and 2002 (San Antonio) so XBRL professionals could participate in the Annual Meeting and academics could participate in XBRL meetings.

3. It is hard to lead if no one is following.

If the practice community (or the real world in general) never adopts the technology or subsequently loses interest in a technology, it is hard to keep the momentum going on the research side. In fact, one may even question why conduct the research if the real world has lost interested in a technology.

4. If academics do a good job of leading practice, practice eventually will take the lead.

This is a good-news, bad-news lesson. Because of limited financial resources and other demands on an academic's time (e.g., teaching), once the practice community starts heavily investing in a technology, practice will pass up academics and take the lead—and the influence of academics on practice can fall off quickly. We saw that with expert systems and we see that today with XBRL. After 2002, XBRL International stopped trying to coordinate their meetings with the AAA Annual Meetings. To be clear, XBRL US and XBRL International communities are cooperative with the academic community, members speak at academic conferences, and XBRL International does include an academic track at their international conferences; but it is not clear how much academic research influences XBRL professional activities.

5. The Gartner hype cycle will usually catch up with researchers (what goes up, must come down).

If a researcher is an innovator or early adopter, he or she may get less encouragement as that technology moves toward the trough of disillusionment.

Corollary: When researchers are in the trough of disillusionment it hard to tell how long the trough is and what the resulting slope of the plateau will be—and some researchers will leave at this point instead of risking a long trough or a downward sloping plateau.

6. The types of research within a domain must evolve over time.

Corollary: Chasms will be encountered trying to evolve from one type of research to another—some may be impossible to cross.

As O'Leary (2009) states, the appropriate types of research change over time. In the early days of expert systems research, it was enough to build a demonstration system or develop a case study. But there was no data to conduct archival research across rule-based expert systems. As expert systems research matured, the research evolved to neural-networks where the research focused on comparing the ability of neural networks to predict bankruptcy compared to regression models.

7. The types of researchers will change as the types research progresses.

Corollary: After crossing each chasm, some current researchers will leave and new researcher will join the domain.

Different types of research attracts researchers with different skill sets and interest. Losing early adopters can mean losing the opinion leaders that was driving the research forward.

5.2 Did academics and the practice community abandon expert systems too soon?

Although a few expert systems papers in the accounting and auditing domain continued to be published, based on our analysis it appears that the peak years of activities, which we might characterize as the mature phase of the life cycle, occurred in the 1990 to 1998 timeframe and then made a rather rapid decline to a lower steady-state level. An interesting question for future

research would be: Was this life cycle a natural life cycle or could it be argued that AIS researchers should have or could have increased the number of publications and extended the life cycle? If one takes the view that the role of AIS researchers in the expert systems domain was essentially proof of concept activities then one could argue that it was a fairly natural life cycle. Once the innovators and early adopters and even early majority AIS researchers demonstrated that acquiring knowledge from audit or tax experts and implementing that knowledge into expert system shells could produce a useful, valuable expert systems motivated large accounting firms to develop their own expert systems. The large accounting firms have immense resources (people, talent, and money) that go beyond the resources that AIS researchers could apply to expert systems development. It could also be argued that AIS researchers eventually hit the limit of their information systems and/or computer science skills and knowledge. In other words, it is probably a very rare AIS researcher that could develop a 600-rule expert system in LISP that would be the equivalent of MYCIN developed by Shortliffe at Stanford.

We could also argue the other side and say that AIS researchers missed a unique opportunity. Instead of AIS researchers and practitioners diverging in the 1980s to go down their separate paths, AIS researchers should have been more proactive to work more closely with the practitioners to extend the expert systems life cycle for AIS researchers. As stressed by Alles et al. (2008), AIS researchers could have found their competitive advantage.

Interestingly, it should be noted that the use of expert systems by practitioners has also essentially completed its life cycle. After the Big 6 invested millions of dollars in expert systems research, we could not find an accounting firm that was actually using stand-alone expert systems as part of the audit. As well as asking, did academics get out of expert systems research too soon, one could also ask, did accounting firms abandon expert systems too soon? This is probably a missed opportunity. With hindsight, it would have been interesting research to gain a deeper understanding of how accounting firms were using (or not using) expert systems when expert systems were still part of their practice.

5.3 What does this mean for other technologies?

In the intervening years since AIS researchers “discovered” expert systems, various other new technologies have been adopted by AIS researchers, including continuous auditing, WebTrust,

SysTrust, electronic commerce, and, most recently, XBRL. WebTrust and SysTrust had very short life cycles in the practice community and, as such, had very short life cycles in AIS research[10]. Electronic commerce (e-commerce) which has exploded in the real world has generated only a limited amount of research by AIS researchers. It is not clear why this is. It may be that the real-world implementation was so far ahead of AIS researchers that it was not possible for AIS researchers to identify their competitive advantage and to have any influence on e-commerce. Continuous auditing, which had a very long embryonic phase in the real world, has a parallel long embryonic phase in AIS research.

XBRL is the newest technology to be adopted by AIS researchers—at least by innovators and early adopters. We can see significant parallels between expert systems and XBRL. In 1997, Debreceny and Gray presented a paper at the AAA Annual Meeting that discussed the need for electronic financial reporting and the potential use of XML as a way to tag accounting information. This paper was eventually posted on the SEC website as comments associated with the SEC's movement towards electronic financial reporting and eventually a copy was sent to Charlie Hoffman who at the time was developing a financial reporting system based on XML for the AICPA. As a result of this paper, Professor Gray was invited to be the first academic member of the then XBRL Steering Committee in January of 2000. In the first two or three years after that, there was a relatively frequent collaboration between the academic community and the practitioners involved with XBRL. As mentioned before, in 2000 and 2002, the XBRL steering committee scheduled their meetings to take place in the same city as the AAA Annual Meeting on the two days following that meeting to make it easy for practitioners to participate in the AAA Annual Meeting and for academics to participate the XBRL meetings. But that practice ended after two years. The XBRL steering committee said it was too difficult to make arrangements that matched the AAA annual meeting in terms of time and place. Since AAA Annual Meetings are held in the largest cities, one cannot but speculate that if XBRL US truly found value in this meeting, they could have continued to schedule their meetings to coincide with AAA meetings.

Although some academics are members of XBRL International, and there are personal working

[10] WebTrust and SysTrust still exist and lead to other trust services. For more information, use “trust services” to search the AICPA web site at aicpa.org.

relationships between some academics and some of the members of the XBRL community, XBRL research by AIS researchers still appears to be in the embryonic phase being done by a few innovators and early adopters. Although one needs to be careful in reading too much into the statistics, there were fewer XBRL related papers presented at the 2011 annual meeting compared to the 2010 annual meeting. This may be an indicator that academic XBRL research is already moving into the mature stage or even the declining stage of this life cycle.

Another factor in the collaboration between academics and practitioners may be that, unlike the expert systems domain, in the XBRL domain some academics have been very vocal in their negative comments regarding XBRL development and implementation activities, which may discourage cooperation between the academic and XBRL communities.

If XBRL research is actually already moving into a declining stage does that mean AIS research in this area has run its course or should AIS researchers (and practitioners for that matter) be doing something to reverse that decline. Whereas expert systems, WebTrust, and SysTrust seem to have gone through a complete life cycle in the practitioner world, it could be argued that XBRL has just barely moved into the growth phase of its life cycle in the real world. As such, there should be the potential for AIS researchers to continue to contribute to this body of research. The question is: How to best do this? One could argue that like expert systems, practitioners have already leapfrogged AIS researchers in basic XBRL research. So it is going to be important for AIS researchers to find their specific competitive advantages where they can be the most valuable.

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