FACTORS INFLUENCING THE ADOPTION OF CLOUD COMPUTING BY DECISION MAKING MANAGERS

by

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Abstract

Cloud computing is a growing field, addressing the market need for access to computing resources to meet organizational computing requirements. The purpose of this research is to evaluate the factors that influence an organization in their decision whether to adopt cloud computing as a part of their strategic information technology planning. Factors related to cloud computing being considered include its cost-effectiveness, the need for cloud computing, its reliability, and the perceived security effectiveness of cloud computing. This dissertation addresses these factors from the viewpoint of decision-making professionals that determine information technology policy for organizations. Each independent factor or variable was analyzed directly in comparison to the management interest in adopting cloud computing. A strong positive relationship was found between each of these four independent variables: cost-effectiveness, the need for cloud computing, its reliability, and the perceived security effectiveness of cloud computing; and the dependent variable: the management interest in adopting cloud computing technology.

Dedication

This dissertation is dedicated to my parents, Mrs. Juliette C. Watson and the late Dr. Harold J. Watson, who instilled in me a love of learning and to my husband, Mr. David O. Ross, who has been at my side encouraging me and making my accomplishments possible since our undergraduate days. Also, this dissertation is dedicated to our children, Chrys M., Steven, Helen, Mary, and David, who have added joy to our lives along the way.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

In the past few years there has been an explosive growth in computer usage for business, government and educational purposes. At the same time, the global nature of the Internet has opened up global markets and global competition. The combination of increased computer usage, global collaboration, and competition has brought with it the accompanying need to maximize the use of available resources while minimizing costs. One area of growing interest for meeting these needs is the use of cloud computing to centralize computing and information management functions for large, often geographically dispersed organizations and individual people.

Cloud computing is an approach where information technology services and capabilities are delivered to an organization or individual over the Internet by a centralized provider, often for a fee (Robinson, 2009). Cloud computing has a number of distinguishing characteristics. The computing resources are held by the provider. Computing resources are accessible over the Internet via personal computers, laptops, smart phones, and personal digital assistants. A cloud computer provides access to programs, storage, processing, applications, and software development. This access is granted after an agreement is negotiated between the cloud computing provider and the recipient of services. With a commercial cloud computing provider, resources are normally available, for a set fee, based on usage. For the majority of cloud vendors that charge for cycles or time used, an accounting and billing procedure is needed, with contractual terms agreed upon before service is granted. Cloud computing that is available within the public organization sector, such as from the National Science Foundation, is provided free of charge to approved users (National Science Foundation [NSF], 2008). For example, the University of Illinois was granted funding to establish a cloud computing center for data intensive computing applications for use by NSF-funded researchers. Examples of cloud computing given by Robinson include software as a service for providing computing applications, and data processing and storage services.

While seminal cloud computing research was published by Chellappa in 1997 (as cited in Mei, Zhang, & Chan, 2008), widespread awareness of cloud computing came later. In late 2006, Google CEO Eric Schmidt publicized the cloud computing concept (Aymerich, Fenu, & Surcis, 2008). As discovered during the literature search, an extensive increase in cloud computing research has occurred, especially starting around 2008. Research efforts emphasize a variety of topics related to cloud computing. Some of these topics include applications and their capabilities, costs, the need for cloud computing, security, reasons for adoption, and growth trends. The focus here is on factors influencing the adoption of cloud computing as a method for performing computing and information management functions for an organization.

One common theme in the literature is the advantages to organizations and individuals of having large scale computational resources available upon demand that are connected to the Internet (Armbrust et al., 2009; Buyya, Yeo, & Venugopal, 2008). Another theme that is addressed is the need to provide and maintain security for software, information and data, both against unauthorized outsiders and against other users of the cloud computing system that are not authorized access to specific files (Armbrust et al.;

Foster, Zhao, Raicu, & Lu, 2008; Weiss, 2007). With the large number of users on a system, maintaining separate access to different users is of paramount importance if the system is to be used for sensitive data (Hewitt, 2008). While the unauthorized release of files containing someone's wedding photographs may be considered less critical than releasing the sensitive design specifications for an electronic system or releasing private medical information, security must be properly addressed for all files. Reliability must be maintained, with a minimum of unplanned downtime, for a cloud computing system to be an attractive business option (Armbrust et al.).

This availability of computing capabilities for remote computing access to users around the globe is changing the world balance of power in computing (W. Jackson, 2009). As such, according to William Jackson, the United States' supremacy in computing simulations is threatened. To counter this trend, the United States needs to focus on training and maintaining a workforce able to capitalize on and leverage new trends and developments in computing technology, and to advance the current state-of-the-art in computational techniques. This is a significant challenge. Setting up and maintaining cloud computing systems within the United States will help with maintaining this competitive edge.

Researchers tend to agree on the advantages of the economy of scale brought by cloud computing, the potential global availability of cloud computing resources, and the need to maintain proper system, file, and information security (Armbrust et al., 2009; Foster et al., 2008; Hewitt, 2008). Cloud computing has the potential to expand the availability and usage of high performance and data intensive computing and information management applications to an expanded market segment. This expanded availability also comes with potential improved affordability and convenience compared to the costs for manpower, equipment, utilities, and maintenance of personally owning such systems (Armbrust et al.; Buyya et al., 2008).

To evaluate reasons affecting management decisions to employ cloud computing, adoption theory is being considered. The field of adoption theory applies to the reasons and methods that information technology decision making managers use to guide them in the adoption of cloud computing as a method for meeting some or all of their organizational computing needs. In the literature, adoption theory addresses reasons for choosing to adopt a new approach or method for doing something (Da Costa Hernandez & Mazzon, 2008; Glynn, Fitzgerald, & Exton, 2005; Hansen, 2004; Lease, 2005). The field of adoption theory, though fairly new, is gaining in research interest. More detailed seminal work on adoption theory is being used.

There are a variety of computer fields where adoption theory is being evaluated. For example, Lin and Yu (2006) employed adoption theory to evaluate increased consumer usage of the Internet for shopping, while Wang, Archer and Zheng (2006) applied adoption theory to research on business-to-business electronic marketplaces. Da Costa Hernandez and Mazzon (2008) found factors that influence people to adopt Internet banking. In another area, adoption theory was applied by Lease (2005) to evaluate factors influencing the adoption of biometric identification measures for computer security.

Overall, while there is extensive current research interest in cloud computing, one area that needs more investigation is to evaluate the factors influencing a management decision to adopt cloud computing. This applies to any cloud computing adoption decision, whether large or small. Studying the factors influencing an organization's decision to adopt cloud computing is the topic of this research effort.

Background of the Study

Before cloud computers became available, there were various precursor technologies, including thin clients, grid computing, and utility computing, used for remote access to computing resources (Leavitt, 2009). These technologies, as described by Leavitt, are as follows. A thin client is a keyboard and monitor connected to a centralized computer. Grid computing is an arrangement in which multiple similar systems, often geographically separated, can process computing jobs dispatched from a user to a centralized server. This centralized server dispatches the computing jobs to available computing resources. Utility computing is a method of providing computing to remote users, often on a fee basis, based on cycles used, much as providing an electrical utility. Both grid computing and utility computing have many features similar to those of cloud computing, with users sending jobs to a central server that arranges for these jobs to be run. A thin client can be a low-priced portal to a centralized or cloud computer, with all of the computing and storage functions provided by the centralized cloud computer.

Some of the primary types of cloud services include infrastructure as a service, platform as a service, and software as a service (Leavitt, 2009; National Institute of Standards and Technology [NIST], 2009). Leavitt also includes a general group called services, though NIST spreads these services applications over the other three groups. Descriptions of these cloud services, as explained by Leavitt, follow: Services consist of storage, middleware, collaboration, and databases provided via the Internet. Infrastructure as a service (IaaS) is a full computer infrastructure provided via the Internet. A platform as a service (PaaS) is a full or partial application development environment accessible online, with collaboration possible. Finally, software as a service (SaaS) consists of complete turnkey computing applications, such as for enterprise resource management, available online. These applications together comprise the majority of the types of computing services available from cloud computers, ranging from hardware and software services, to entire computing environments.

Statement of the Problem

The process of purchasing, maintaining, and administering computing assets requires a large investment of financial and manpower resources for a business, government, or university. One option that centralizes computing assets and can lower costs and manpower requirements for these organizations is the use of centralized computing assets provided as cloud computing. This research identified and evaluated factors that contribute to organizational decisions to adopt cloud computing.

A cloud computing system requires a large information technology investment, both financial and manpower. Although the investment is large, multiple benefits are offered. For example, cloud computing can provide a centralization of computing and information management functions, providing economy of scale, efficient resource usage, and the availability of the resources to a large user base (Armbrust et al., 2009; Buyya et al., 2008; Liu & Orban, 2008). All of these features are attractive to many organizations with limited resources and the need to use their resources wisely.

Cloud computing is an approach that provides computing resources to a large number of users or organizations while concentrating the overhead for providing, maintaining, and administering the computer systems on a central provider (Armbrust et al., 2009; Buyya et al., 2008). Additionally, it is being investigated as a way to minimize costs, maximize reliability, and meet organizations' needs for computing resources, while maintaining security for the systems and the data stored on them (Armbrust et al., Foster et al., 2008).

In performing this research effort, using a quantitative approach, factors that can lead to the adoption of cloud computing have been identified. Purposive sampling was used (Swanson & Holton, 2005). A validated survey instrument was employed. More details are included in Chapter 3. The population that was explored included chief information officers (CIOs), information technology (IT) and information systems (IS) managers, and other managers that are involved in policy-making decisions for computing systems. Conclusions were drawn from reviewing the factors that can lead to the adoption of cloud computing. Insights into the effects of these factors on decisions regarding the value of cloud computing to organizations have been drawn.

These results can lay a foundation for further research in cloud computing and other methods of providing centralized computational resources to meet the needs of large groups of people. The contribution to knowledge is an increased understanding of the factors of most concern for making decisions to adopt a centralized computing provider, such as cloud computing. This knowledge can provide organizations with the tools needed to find optimum ways to address organizational computing needs.

The advantages of cloud computing include cost savings, meeting growing computational needs for organizations and individuals, enhanced computational and information handling reliability, and the convenience of a centralized security function. Overall, this equates to lower costs, improved computational and information handling capabilities, and greater convenience to the users. All of these advantages make cloud computing an attractive option to consider.

Purpose of the Study

The purpose of this study is to evaluate reasons for adopting cloud computing to satisfy some or all of the computing needs of an organization. The research goal was to supply decision makers, both potential or current cloud computing customers and providers, with information to enable them to make informed decisions about providing and employing cloud computing to meet current and future organizational computational resource needs.

Conceptual Framework

This study is based on a conceptual framework encompassing the problem, the important areas of interest, and potential solutions. This framework covers exploring the problem concept, the computer user or account holder, the computing needs of the organization, evaluating potential cloud computing options, and potential solutions to this problem. This was the basis for the research. The solutions will lead to future research possibilities. This study employed data collection and analysis by using a validated survey. The survey instrument was derived from one developed by Lease (2005) to evaluate factors influencing the adoption of biometric security technologies. Data analysis employed ANOVA. More details are included in Chapter 3.

Rationale

As organizations are being tasked with finding ways to minimize costs, while their computing and data management needs grow, cloud computing can be a viable option to consider. With its economy of scale and high performance assets, it has the potential for meeting increased organizational computing and data management needs, and surges in demand, while minimizing costs. The challenge is to determine what factors drive decision makers to choose or not choose to employ cloud computing to meet organizational needs.

Research Questions

Since the decision on whether or not to adopt cloud computing can be a difficult decision for managers to make, considerable thought goes into making such a decision. The goal of this research was to give organizational managers further insight into how such complicated decisions are made, to help them in making appropriate decisions for their own organizations. Since managers overseeing the information technology planning area of an organization provide guidance and input on these decisions, these are the people being surveyed. These decisions are dependent on different variables, especially the cost-effectiveness, the need, the reliability, and the security effectiveness of cloud computing. As a result, this survey covers all of these areas. The specific research questions follow.

Question 1

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its cost-effectiveness?

Question 2

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of the need for cloud computing?

Question 3

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its reliability?

Question 4

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its security effectiveness?

Research Hypotheses

Based on these research questions, the study tested the following hypotheses:

Hypothesis 1

Ho1: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness.

Ha1: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its cost-effectiveness.

Hypothesis 2

Ho2: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of the need for cloud computing.

Ha2: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of the need for cloud computing.

Hypothesis 3

Ho3: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its reliability.

Ha3: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its reliability.

Hypothesis 4

Ho4: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its security effectiveness.

Ha4: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its security effectiveness.

Significance of the Study

The significance of this study is that it shows reasons influencing an organization to adopt cloud computing. These reasons for adopting cloud computing should aid in strategic planning, by both cloud providers and by organizations that could consider using cloud computing assets to meet current or future computing and data and information management needs.

Definition of Terms

Cloud computing. Cloud computing is a term used as early as 2006 by Google CEO, Eric Schmidt, to refer to computing over the Internet (Aymerich et al., 2008). This term is commonly used to refer to using centralized computing resources available over the Internet to a large group of users, often which are paying customers.

Data storage as a service. Data storage as a service (DaaS) is an infrastructure resource that allows users to store data remotely and retrieve it at any time over the Internet from any location (Youseff, Butrico, & Da Silva, 2008).

Grid computing. Grid computing refers to a network of computers set up so that a job submitted to the network can be completed on any available network computer (Leavitt, 2009).

High performance computing. High performance computing (HPC) refers to the use of massive multiprocessor computers to handle multiple large parallel computing jobs.

Infrastructure as a service. Infrastructure as a service (IaaS) is an arrangement that provides a full computer infrastructure via the Internet (Leavitt, 2009).

Platform as a service. A Platform as a service (PaaS) is a full or partial application development environment accessible online, with collaboration possible (Leavitt, 2009).

Provider. A provider is an organization supplying cloud computing resources to outside users.

Quality of service. Quality of service is the level of service provided, including transmission rate and error rate. This quality of service can be negotiated between the provider and the user.

Quantitative research. Quantitative research is research that analyzes numerical data.

Service level agreement. A service level agreement is a contractual agreement between the cloud provider and the customer regarding the level of service provided.

Service–Oriented Architecture. A Service–Oriented Architecture (SOA) is the underlying structure supporting communications between services.

Services. Services are cloud computing support applications that can include storage, middleware, collaboration, and databases provided via the Internet.

Software as a service. Software as a service (SaaS) is a complete turnkey computing application available online (Leavitt, 2009).

Technology Acceptance Model. The Technology Acceptance Model (TAM) is a model of the acceptance behavior for a type of technology (Straub & Burton-Jones, 2007).

User. A user is an organization or individual that uses cloud computing resources as a customer of a cloud computing provider.

Virtual machine. A virtual machine is a software implementation of a system that operates like an actual machine.

Assumptions and Limitations

The main assumptions of this study are that the decision to adopt cloud computing services by an organization is made by managers or decision makers and that such services are available to organizations over the Internet. The lack of high speed Internet availability could be a limitation at some rural or underdeveloped locations. It is assumed that decisions on cloud computing adoption by organizations are made willingly without coercion or undue outside influence.

This study focuses on the viewpoint of current or potential users of cloud computing services, rather than from the point of view of a provider. In addition, even though both organizations and individuals can be users of cloud computing, for this study, only the viewpoints of organizations are being considered. Future research could address factors influencing the adoption of cloud computing by individuals. This study is leaving detailed consideration of legal issues influencing cloud computing adoption, especially the international transport of data and information, to other researchers.

Scope of the Study

The scope of this study includes decision making managers in organizations that have information technology needs. Respondents were limited to those in a decision making role for planning information technology strategy within an organization. The survey instrument is designed to handle respondents within a broad range of organizational environments.

Organization of the Remainder of the Study

Chapter 2 covers the literature review for cloud computing. A background of cloud computing, its methods, cost-effectiveness, the need for cloud computing, and the reliability and security issues related to cloud computing are discussed. Next, adoption theories and their application to cloud computing are covered. Chapter 3 covers research methodology. The research results are shown in Chapter 4, with a discussion of the results, implications, and recommendations for future research covered in Chapter 5.

CHAPTER 2. LITERATURE REVIEW

Cloud Computing Background and History

While seminal cloud computing research was published by Chellappa in 1997 (as cited in Mei et al., 2008), adoption of cloud computing has been a fairly recent phenomenon. This term began surfacing commonly in the literature around 2006 and refers to computing over the Internet (Aymerich et al., 2008). By 2008, cloud computing was receiving extensive research interest and had surpassed grid computing in the amount of media interest received (Wang, Tao, et al., 2008; Youseff et al., 2008). Many of the initial cloud providers were Web-based companies and start-up companies (Leavitt, 2009). As cloud computing demand expanded, the types of cloud providers extended to include public and community clouds (NIST, 2009). Although the term cloud computing is relatively new, this technology had its basis in many other earlier computing methods.

A cloud computing entity contains parallel and distributed resources from a group of connected and virtual computers that are exhibited as one combined system (Buyya et al., 2008; Foster et al., 2008). These systems are made available based on service-level agreements between the provider and the user (Buyya et al.). The key features of a cloud computing entity are massive scalability to meet user needs, the existence as an abstract entity to deliver multiple service levels to outside users, economy of scale, and dynamic configuration of services on demand, often by virtualization (Foster et al.). Delic and Walker (2008) portrays cloud computing to be the third wave of Internet advancement, following the Internet as the first wave and the Web as the second wave. From a different perspective, Hayes (2008) compares cloud computing to computing fifty years ago when service bureaus and time sharing systems gave users access to mainframe computers. These computing advances were fostered by earlier precursor technologies.

Some of the precursor technologies to cloud computing include Service-Oriented Architecture (SOA), distributed computing, virtualization, and grid computing (Androutsellis-Theotokis & Spinellis, 2004; Aymerich et al., 2008; Youseff et al., 2008). Cloud computing has strong ties to ubiquitous computing, where multiple computing resources are available for use via the Internet (Park, Park, & Kim, 2008; Su, Kuo, & Huang, 2008). It also had its roots in the search and retrieval systems that emerged in the 1990s (Aymerich et al.). These search and retrieval systems originally were based on cluster computing but eventually migrated to the geographically dispersed grid computing (Aymerich et al.). Cloud computing can be considered a natural evolution from grid computing in its approach to providing computing resources to remote users.

Cloud Computing Methods

Cloud computing technology runs applications as a service over the Internet on a computer architecture that is scalable to meet user needs (Curry, Kiddle, Markatchev, Simmonds, & Tan, 2008). The methods employed by cloud computing depend on the services being offered. The general types of cloud computing applications offered, in the areas of services, infrastructure as a service, platform as a service, and/or software as a service, must accommodate these applications (Leavitt, 2009). These applications capitalize on technology innovations such as Web-based operating systems (Lawton, 2008). There are various cloud computing applications available. An example of the types of cloud-based applications available from a vendor can include some of those available from Google. Google cloud-based applications include Google Enterprise for websites and e-mail, Google Applications productivity tools, Google search engines, and Google Earth for map-based applications (Marshall, 2008). One specific application example is MapReduce, which is a Google programming model using large server clusters to process massive data sets (Computer Language Company, 2008; Mika & Tummarello, 2008). Other companies provide cloud-based applications for similar purposes.

Although cloud-based applications provide users with many capabilities, cloud computing also involves some trade-offs. For example, reliable distributed systems, such as Amazon's cloud computing, require a trade-off between their consistency and availability (Vogels, 2009). Similar trade-offs would be expected with other vendors.

Since cloud computing employs remote access, a secure online login and authentication method is needed. Also, for the majority of cloud vendors that charge for cycles or time used, an accounting and billing procedure is needed, with contractual terms agreed upon in advance of granting service. A workflow method, linked to billing, is used for scheduling jobs (Yang et al., 2008). In addition, with the large number of users, file and directory allocation and permissions must be set up to enable individual and organizational users and their authorized group members access to their files and prevent unauthorized others from obtaining access to these specific files.

Cost Effectiveness

Cloud computing addresses computing as a utility, providing computing as a service (Armbrust et al., 2009). One attractive cost issue is the ability to pay for services as they are needed, avoiding large up-front expenses for computer system purchases (Armbrust et al.). Another attractive aspect of cloud computing is the savings on space, utilities, and maintenance staff which can be realized by outsourcing computing applications to a cloud computer provider. This practice can also be attractive to organizations interested in green issues, enabling efficient use of power and other utilities by shared use of computing resources. According to Healey (2009), about ten percent of recent IT purchased to support green initiatives went to support services contracts, such as cloud computing.

According to Armbrust et al. (2009), providing very large scale commodity computing resources at low cost locations has been the key enabler for cloud computing. Armbrust claims that this can produce cost reductions of a factor of five to seven times in areas such as electricity, network expenses, operations, and software and hardware expenses due to the economy of scale. Since the cloud computing providers combine both cost savings and higher system utilization compared to individual organizations, this allows individual customers to save money while the cloud computing provider realizes a reasonable return on investment (Armbrust et al.).

In addition, the convenience of performing large computations rapidly upon demand can save an organization both time and money because of the more rapid response time possible with the large number of processors on a cloud computer. For example, a cloud computer can have thousands of nodes, while most private computer systems are smaller. Because of the discrepancy, many large parallel calculations can be performed much faster on a cloud computer than on most private computing systems. These can mean a difference between minutes or hours running a job on a cloud computing system compared to days or even many years on a desktop system. As a result, calculations that were previously impractical to solve can now be solved in a reasonable time and applications with time urgency can often be completed more rapidly, assuming that transferring data to and from the cloud is performed with limited latency.

A method for performing calculations on the cost effectiveness of moving computing applications to a cloud provider is shown by Armbrust et al. (2009). The factors to consider are the costs and time for computing at the user's site compared to the costs and time needed for transferring data to and from the cloud provider and having the cloud provider perform the computation. Applications with large data transfers needed are often unprofitable to transfer to a cloud. To counter this problem, minimizing data transfer delays and costs can make cloud computing more competitive (Armbrust et al.).

According to McDougall (2008), energy costs are predicted to be about sixty percent lower when performing computations on a cloud system. This is a smaller savings than predicted by Armbrust et al. (2009). It is possible that the higher utilization on cloud computers compared to individual systems could lead to the anticipated five to seven times reduction in electrical costs predicted by Armbrust et al. Another possibility could be that one author may have calculated the overall change in energy usage, for both the provider and the customer combined, while the other may have only considered energy cost savings at the user site. Either way, significant utility savings are expected with cloud computing. The expected footprint of systems for cloud computing is also predicted to be about sixty percent less than comparable private systems, saving space (McDougall). These energy and space savings can be attractive both from cost and environmental standpoints.

Many of the reservations that organizations have about adopting cloud computing are typical outsourcing concerns. These can include a culture shift and loss of technical talent from the cloud computing user or outsourcing organization. Also, the ownership of the application processing shifts to the cloud provider. Cash flow issues may be a concern with the cloud provider. In addition, with reduced control over the application, security concerns can be an issue. All of these issues can be addressed as part of the overall business strategy. If the United States wishes to maintain its leadership role in computing technology, it is imperative that the country embrace important new computing trends (Jackson, W., 2009). Advancing the cloud computing field is one way to improve the national standing in technology leadership.

Need for Cloud Computing

Cloud computing addresses a variety of needs for providing computing resources to organizations. This includes making large amounts of computing resources available upon demand to meet user needs, minimizing up-front resource commitments for users, and enabling users to pay for services upon demand (Armbrust et al., 2009). The cloud computing provider also manages system security for customer data. One attractive area for cloud computing is for affordable, available high performance computing for demanding applications. While the emphasis of this study is on cloud computing provided by commercial vendors, an individual organization can provide cloud computing services to its organizational members, sometimes referred to as enterprise computing. Such an arrangement could be appropriate for a large organization, such as in the government, financial services, or health care industries. According to Biddick (2008), the most likely applications to migrate to cloud computing are storage and business applications, while specialized information technology applications, such as security, management, or compliance, are far less likely to migrate to cloud computing. This shows a tendency to use cloud computing for data intensive applications but less so for sensitive, proprietary applications.

Cloud computing also brings additional opportunities to users. For example, the large computing power of these cloud systems can enable organizations to solve computational problems that were previously unsolvable with their in-house organizational computing resources (Delic & Walker, 2008). Some of the other opportunities that cloud computing provides, as mentioned by Armbrust et al. (2009), include mobile interactive applications, parallel processing of batch jobs, business analytics, and parallel use of MATLAB and other desktop applications. Liu and Orban (2008) state that while parallel computing can meet the need for increased computational power, parallel programming is difficult and error prone. A user-friendly cloud-based system can overcome these hurdles (Liu & Orban). Even though many applications lend themselves well to cloud computing, some applications that involve rapid data transfer and low latency, such as some stock trades, are still not ready for cloud computing.

Some examples of these opportunities follow: For organizations with geographically dispersed staff or staff that work at multiple locations, having a centrally located, remotely accessible computer provider for all of these people to use can provide added business value. This central computing provider can enable these staff members to use the computing resources from multiple geographically separate locations. For compute jobs that can be processed in parallel, such as updating thousands of financial accounts, each performed separately from the others, computations can be sped up almost linearly by parallelization to multiple processors. For example, performing updates on 1000 financial accounts using 1000 processors can reduce overall processing time by close to 1000 times while using a 1000 processor system as compared to using a single processor. Similar gains are possible with parallelizing MATLAB and other applications. With more capable computing systems, businesses can increase the complexity of their business analytics research. This increased complexity is possible because the availability of faster, more powerful computing resources enables more detailed computations to be performed, often in a shorter time than is possible on many organizations' existing computer systems.

An example of an organization that has moved business applications to cloud computing is the largest casino operator in the world, Harrah's Entertainment, which has moved applications such as reservations and their extensive customer loyalty database to a cloud provider (McDougall & Weier, 2008). According to McDougall and Weier, these cloud applications are used by Harrah's casinos, 50 branch offices, and around 250 other representatives. This cloud computing transition has both advantages and disadvantages. A benefit that is mentioned for Harrah's cloud computing applications is localized innovation, while one disadvantage is that these applications are provider-specific and would be difficult to migrate to another provider's platform.

Another cloud computing implementation, the Qatar Cloud Computing Initiative, was spearheaded by three universities, namely Carnegie Mellon University in Qatar, Qatar University, and Texas A & M University at Qatar (IBM, 2009). These universities are joining forces to address local business and industrial computing needs. Some areas of special interest include seismic modeling, gas exploration, and production operations support for the petroleum industry. This initiative also addresses compute intensive and parallel computing applications such as an Arabic language search engine, testing and migrating applications to enable parallel computing using MapReduce programming, and support of secure computing research. The "Secure and Reliable Server-Aided Computation" project at Qatar University enables secure outsourcing of government and business data (IBM).

There also is a demand for cloud computing to support medical research. The Computational Intelligence Research Group located at the University of Pretoria, South Africa, is using cloud computing for medical research (IBM, 2009). Some applications include DNA modeling and studying drug absorption rates. Cloud computing technology enables the students to have powerful computing resources readily available for their use without having a dedicated machine for each student. Cloud computing also can reduce the compute time from that needed to perform a computation on a desktop computer, because of the size and throughput capability of the cloud computing resources. Because of cost, such resources are easier to provide to a large group than to a user of a small group, especially in a country with limited financial resources.

Other groups can benefit from the economy of scale and centralized resources provided by cloud computing. A software as a service approach could bring needed computing capabilities to impoverished rural and Third-World areas (Parikh, 2009). Also, the Higher Education Alliance enables students at seven universities in East Africa to have access to advanced software, computing resources and educational materials, without the cost of acquiring and maintaining these resources at each site (IBM, 2009).

Another growing market sector for cloud computing is for individual or small groups of users, such as for online gaming (Ross, 2009). Cloud computing technology enables the game actions to be processed rapidly on a supercomputer with the user interface being either a portable device, such as a cell phone, or a stationary system, such as a desktop computer (Ross). The cloud computer allows the individual gamer to benefit from the higher fidelity and more rapid computation obtainable from a supercomputer, while the user has a much smaller and less expensive hardware investment. Individual and small group cloud computing applications can support other purposes, such as where a file, such as a photo album, can be centrally stored and accessed by approved group members.

Reliability

With the massive scale of cloud computing and the availability of well-trained administrative and maintenance staff, high reliability is anticipated, with minimal downtime. This can be attractive to organizations that depend on rapid responses and secure, reliable computing and data and information storage for computer-based applications. Even with these precautions, software malware and bugs can affect cloud reliability (Sedayao, 2008). For this reason, software reliability is critical to cloud computing success. A quality of service approach benefits Internet-based computing applications (Su et al., 2008). While there are some risks associated with sending jobs across the Internet to a centralized computer, with appropriate safeguards, cloud computing can be very reliable.

Security

Thurman (2008) expressed various security concerns about cloud computing, namely: control and associated data integrity, commingling of data, and virtualization; with data integrity concerns at remote locations. Computer-related risks are still considered by Thurman to be high with the gap between R&D and actual practice needing to be bridged more effectively. Trustworthy systems that are designed for human usability, encouraging well-trained people to take responsibility, rather than to blindly trust technology, are needed (Neumann, 2008).

To be successful as a cloud computing provider, it is imperative that the provider furnish effective security protection for users' data and files. Using multicore computing systems with multiple processing cores facilitates data separation and privacy (Hewitt, 2008). These security measures must protect this information from unauthorized release to other users or to outside parties, while the information is at the cloud provider and while the information is in transit over the Internet between the user and the cloud provider. Providing security can be complicated. Not only must a cloud provider set up a secure system, but the provider must also include safeguards against user and employee carelessness. With the use of remote logins, a secure login method is needed.

In the security area, preventative innovations or security practices need to be adopted to ensure enhanced system and information security. Adopting preventative innovations to avoid unwanted consequences involves convincing people that adopting a certain behavior or innovation is advantageous to them (Rogers, 2002). In terms of system security, this involves having strong security measures and also convincing users to adopt and maintain appropriate security safeguards, often with strict consequences for carelessness. These precautions should include prohibitions against sharing or releasing information needed for system or account access.

There are limits on which applications can be safely transferred to a cloud provider. For example, very sensitive data, such as the secret recipe for Coca-Cola or classified government data would need a higher level of data protection than less sensitive data, such as photographs from a company picnic. As a result, an organization must carefully weigh the pros and cons of transferring various applications and data to a cloud provider. Encrypting data is another method of adding extra protection.

Cloud Computing Adoption

Youseff et al., (2008) explored methods to foster rapid adoption of cloud computing by the scientific community. This trend toward adopting cloud computing has been perceived differently by various prominent members of the computing community. For example, Microsoft did not foresee the trend toward cloud computing, which is being led by Amazon and Google (Cusumano, 2009). Even though many firms showed little early interest in cloud computing, with the maturation of virtualization technology and the current, almost explosive increase in interest in cloud computing, many firms are joining the cloud computing wave.

Recently, the Open Cloud Manifesto was signed by a group of 38 companies and academic organizations, calling for open standards in cloud computing (Merritt, 2009). This manifesto is an effort to promote common standards for cloud computing in areas such as security, portability, interoperability, management, and monitoring. The National Institute of Standards and Technology is also working on cloud computing standards (NIST, 2009). If such standards are adopted by the majority of cloud vendors, this would make it easier to move applications from one cloud provider to another, which is currently not possible with some vendors, because of proprietary cloud applications. Although many major corporations, such as Advanced Micro Devices, Juniper, and IBM, along with the Open Cloud Consortium, are backing this manifesto, some major cloud participants, namely Amazon, Microsoft, and Google are conspicuously absent (Merritt). The Open Cloud Consortium, which includes Cisco Systems, Yahoo, and several academic partners, runs a cloud computing test bed and has developed a cloud services benchmark (Merritt). This movement toward cloud computing standards and the conspicuous absence of some major cloud computing providers appears to be a battle between some early major cloud computing participants to attempt to protect their turf and others that want to make cloud computing a more open, standardized technology. This turf includes proprietary, non-portable applications and is being met with an effort by other current and future cloud computing participants to create an even playing field where it is easy for the players to have common standards for engaging in cloud computing, including the ability to move data and applications from one cloud provider to another. Such common standards could also make it easier and more affordable for potential cloud computing customers to participate in cloud computing. Cloud providers, both existing and planned, have a vested interest in the future of cloud computing (Weiss, 2007).

There is currently a widespread interest in cloud computing and growth in available options for using cloud computing. There are many advantages, such as economy of scale and the availability of large computing resources to many users (Greenberg, 2008). In addition, cloud providers can keep a very high level of availability, often with considerably less downtime than individual organizations (Greenberg).

Parthasarathy and Bhattacherjee (1998) and also Rogers (1962) found that when clients were displeased with a technology that they adopted, they tended to discontinue its use. Because of this issue, it is important for a cloud computing provider to maintain customer satisfaction to retain its client base. Maintaining customer satisfaction involves continuing to satisfy client needs, staying cost-competitive, maintaining system reliability and availability and ensuring information security and confidentiality. One illustration of a process for running a successful cloud computing organization is given by Kaliski (2008). In describing how to promote a well run cloud computing entity, Kaliski says that the cloud computing entity should run like a container ship or cruise line, with standardized products, set costs, and non-interference with other customers' products. This model could appeal to cost-conscious, organized people. Various organizations are beginning to adopt cloud computing, ranging from individuals and smaller organizations that often do not have comparable dedicated resources available, to larger organizations that have chosen the cloud model for business reasons.

Although there is extensive current interest in cloud computing, there can be a gap between the promise of cloud computing and market adoption. Greenberg (2008) anticipates that, while individuals are already adopting cloud computing for applications readily available, and small organizations will adopt cloud computing in the near term, it may take from fifteen to twenty years for larger corporations to convert to cloud computing. Aligning a company's technology and corporate strategy by addressing the needs of management, resource issues, and external factors improves organizational functioning (Chen, He, & Jin, 2008). Adopting cloud computing can meet the technology and corporate needs of smaller, resource-poor organizations and individuals while large organizations can afford to purchase and maintain their own large computing resources. As a result, larger organizations have less of an incentive to go to outside providers than do smaller organizations or individuals. An example of the gap between the potential and the actual is the recent survey results presented by Delahunty (2009), where the participant responses showed that eleven percent of their firms currently use cloud computing for data and information storage, with another nineteen percent considering using cloud computing. This leaves seventy percent of the respondents showing little interest in cloud computing. As the technology matures, and if more market incentives appear, additional firms are expected to embrace cloud computing or similar technologies.

Cloud computing also shows promise for online gaming, a growing market with a large user base (Green, 2009; Ross, 2009). Since cloud computing technology enables the game actions to be processed rapidly on a supercomputer with the user needing only a relatively inexpensive user interface device, such as a cell phone or a laptop or personal computer, cloud computing brings affordable gaming to the masses. The cloud computer allows the individual gamer to benefit from the higher fidelity and more rapid computation obtainable from a supercomputer, while the user has a much smaller and less expensive hardware investment.

Even with the movement toward transitioning computing and storage applications to cloud computing, there are some applications that organizations are choosing not to transition. These applications are especially in the area of mission critical applications, which are expected to be retained by their owners rather than being transitioned to the cloud (Greenberg, 2008). These applications are retained in-house for reasons such as the criticality of response times or concerns about the inadvertent release of very sensitive information.

Another barrier to converting to cloud computing involves legal restraints. For example, there are legal restrictions prohibiting moving some information, such as German health care information, out of the European Union (Greenberg, 2008). Since cloud computing providers can be multinational, it is imperative that such providers are aware of and abide by national regulations where they do business.

Cloud computing also has the potential to enable people in third world nations to capitalize on the economic advances of high technology. Cloud computing can contribute to the economy of scale of computing resources to promote rural development (Parikh, 2009). These advantages can benefit both rural and other technically limited areas in the United States and elsewhere, giving people in such areas a virtual presence in high performance computing and other advanced technology applications, as long as they have adequate Internet access to use these resources.

Cloud computing is also being considered for hosting publicly available government websites hosting non-sensitive data (J. Jackson, 2009). For example, a

Google cloud site was used for hosting a virtual town hall discussing the economy by the Obama administration (J. Jackson). Various advantages of this practice mentioned by Joab Jackson include that the government did not need to write code or determine the amount of computer hardware to allocate. In this instance, in a 48-hour period, about 92,000 questions were submitted with over 3 million votes on the questions with as many as 700 hits per second (J. Jackson). This sort of application required high performance, multi-processor computing resources for a short period of time, which are easier to get from a cloud provider than from within most organizations. Cloud computing has the advantage for such applications of low cost and rapid availability, with little or no need for the customer to purchase computing hardware or pay for programming and maintaining the computing infrastructure.

User training can further an organization's adoption of cloud computing by making users more comfortable with using the technology (Marshall, 2008). The younger and more technology-savvy workers may more easily adopt cloud computing than those that are technology-adverse. Even though some potential users more rapidly adopt new technologies than others, any user; when faced with the ability to perform a job more easily, more completely, at lower cost, and faster, can find cloud computing attractive.

Adoption Theories

Rogers's (1962) diffusion of innovation theory, which has undergone multiple updates over the years, forms the basis for much of the current adoption theory research (Lundblad, 2003). In 1962, Rogers mentioned three major factors for innovation adoption by an individual: the actor's identity and perception of the innovation, the process, and the result: either adoption or rejection. In subsequent refinement of Roger's theory of innovation, in the fourth edition (1995) as cited in Lundblad, four primary elements were considered by Rogers for technology adoption. These elements include an innovation, a time frame for adoption, and a social structure that fosters technology innovation adoption. Brown (1981) further explained that a communication or learning process can foster innovation adoption. For an innovation, such as cloud computing, to be considered for adoption, it must offer potential benefits to the users and be compatible with the users' current technology (Lundblad). Adequate communication is needed to educate and persuade potential users of the technology's value. Champions within an organization and change agents from outside an organization can promote adoption of a new technology (Lundblad).

Adoption of a new technology occurs in stages. As is the case with cloud computing, there is a staggered time frame for adoption, with some early adopters embracing the technology before the mainstream users begin using it. Adoption decisions are also vulnerable to many social influences, both inside and outside an organization. Negative social influences can have a more profound effect on a technology adoption decision than can positive social influences toward technology adoption and can also affect decisions to discontinue technology adoption (Parthasarathy & Bhattacherjee, 1998). Because of these social factors, it is critical for cloud computing providers to nurture a good reputation and maintain high customer satisfaction.

The Technology Acceptance Model (TAM) was developed by Davis in 1986 to model patterns of user adoption of information systems (as cited in Davis, Bagozzi, & Warshaw, 1989). The TAM is used to evaluate the perceived usefulness, the perceived ease of use, and the attitude toward using a technology. These results are used to determine the intention for a user to adopt the technology, and are compared to the actual technology usage (Davis et al.). When researchers use the TAM, the perceived ease of use or user friendliness and usefulness or value to the user are often found to be major factors in adopting a form of technology (Straub & Burton-Jones, 2007). In one study by Wu and Lederer (2009), the ease of use and usefulness both were found to have a significant effect on technology adoption, though the amount of free will that a user had in making the decision also was found to be a significant influence on technology adoption. In another example, in adopting mobile data services in China, ease of use and brand experience, or attitude toward the technology, were given as prime drivers behind adopting this technology (Qi, Li, Li, & Shu, 2009). These examples indicate that the factors influencing technology adoption decisions can be complex and may vary from one situation to another.

Normally, when a person or organization sees an advantage to accepting a new form of technology, there is an incentive to accept it. An example is a study by Lease (2005) that covers reasons why computer security managers adopt biometric security technologies. Another example is where Glynn et al. (2005) uses adoption theory to evaluate open source software adoption. These authors express concern that much adoption theory research is at the individual level rather than at the organizational level. Rogers (2002) stated that prior experience with a technology could influence technology adoption decisions, both positively and negatively. Customer relationship management can also influence adoption decisions (Richard & Thirkett, 2007). Also, Sabherwal, Jeyaraj, and Chowa (2006) found that user-related and contextual issues were critical to information systems adoption success.

Applications

Wang, Archer, et al. (2006) explored factors driving the marketplace adoption of business-to-business electronic marketplaces (EMs), using multiple perspectives, to see which factors appear to have the most effect on electronic marketplace adoption. These authors evaluated factors from both the buyers' and the suppliers' perspectives and found that facilitating conditions and institutional influence followed closely by performance expectancy, had the highest effect on suppliers' adoption decisions, while performance expectancy had the highest effect on buyers' adoption decisions. The effort expectancy had a low effect on adoption decisions by either group in the study by Wang, Archer, et al. This indicates that performance is an important factor in adoption decisions regarding electronic marketplaces for both suppliers and buyers, but these two groups can have different perspectives on market decisions.

Hansen (2004) performed a case study to evaluate the application of adoption theory to designing, implementing, and managing Web applications and their resulting information systems in a university setting. He found that when people found an application useful and easy to use, they were likely to adopt it. This demonstrates the tendency for people to adopt a new technology if they see a benefit to themselves of doing so.

In another Internet setting, Lin and Yu (2006) evaluated factors influencing successful consumer adoption of the Internet for shopping. Factors covered included usefulness of the internet, user anxiety, playfulness, and novelty seeking. Perceived usefulness, user playfulness and novelty seeking all showed a positive association with the adoption of Internet shopping, while user anxiety showed a negative association with adopting Internet shopping. Myers and Ogunc (2008) determined that a prior positive experience with Internet shopping could have a positive effect on adoption of future Internet shopping. Similar positive Internet experiences could lead to a positive decision to adopt cloud computing.

In another study of Internet-based business application adoption, Da Costa Hernandez and Mazzon (2008) found factors that influence people to adopt Internet banking. These factors include the compatibility with their lifestyle, security and privacy, control, self-efficacy, image, ease of use, and technical support. All of these factors have minor, but positive effects on the adoption decision. Although cost issues were evaluated, from a consumer's point-of-view, cost is not necessarily a driving factor behind choosing Internet banking. Market research can positively affect Internet technology adoption decisions (Schillewaert, De Ruyck, & Verhaeghe, 2009). Another survey on Internet banking adoption was performed by Shi, Shambare, and Wang (2008). These authors found that social pressures for conformity and coercive pressures both influence people to adopt Internet banking. Even though these pressures existed, Shi et al. found little relation between mimetic or status-related issues and the adoption of Internet banking. While ease of use is often a reason given for adopting new technology, adopting technology based on external pressure, as cited by Shi et al., is a less commonly cited reason. Also, the reasons for an organization to adopt cloud computing or some other technology may differ from the reasons for individual people to adopt new technologies.

Adoption theory is also applied to adopting specific technologies. For example, Godbole (2007) evaluated issues and strategies related to adopting nanotechnology for use in wireless communication devices. He looked at barriers to making the transition, and strategies to overcome these barriers. The primary barriers to adoption of this technology were risks and costs. The strategies for adopting nanotechnology involved a top down approach where the devices were designed using nanotechnology, a bottom up approach where nanotechnology-based components were developed for incorporation into wireless devices, and combined approaches. In addition, Lease (2005) applied adoption theory to adopting biometric technology for computer security.

These are examples of methods to incorporate new technical approaches into existing applications. In the same manner, adopting cloud computing can be approached by finding methods to incorporate its capabilities into meeting the computing needs of an organization, in a manner that cloud computing adds value to the organization, be it in cost-savings, added capabilities, meeting needs better, or in other manners.

Further research on the success of information systems adoption was performed by Sabherwal et al. (2006). The research findings indicated that ease of use and perceived usefulness of the application were more closely related to successful adoption than was user satisfaction. This indicates that when an application is useful and easy to use its likelihood of being successfully adopted increases, while user satisfaction is less important. The conclusions of this study were compatible with many of the other technology adoption studies.

CHAPTER 3. METHODOLOGY

Problem

The process of purchasing, maintaining and administering computing assets requires a large investment of financial and manpower resources for a business, government, or university. One option that centralizes computing assets and can lower costs and manpower requirements for these organizations is the use of centralized computing assets provided as cloud computing. The research identified and evaluated factors that contribute to organizational decisions to adopt cloud computing.

Cloud computing systems require a large information technology investment, both financial and manpower. Although the investment is large, multiple benefits are offered. For example, cloud computing can provide a centralization of computing and information management functions, providing economy of scale, efficient resource usage, and the availability of the resources to a large user base (Armbrust et al., 2009; Buyya et al., 2008; Liu & Orban, 2008). All of these features are attractive to organizations with limited resources and the need to use their resources wisely.

In performing this research effort, using a quantitative approach, factors that can lead to the adoption of cloud computing were identified. Purposive sampling was used (Swanson & Holton, 2005). A validated survey instrument developed by Lease (2005) was employed. The population explored included chief information officers (CIOs), information technology (IT) and information systems (IS) managers and other managers that are involved in policy-making decisions for computing systems. Conclusions were drawn from reviewing the factors that can lead to the adoption of cloud computing. Insights into the effects of these factors on decisions regarding the value of cloud computing to organizations were drawn.

Purpose and Research Framework

The purpose of this study is to evaluate reasons for adopting cloud computing to satisfy some or all of the computing needs of an organization. The research goal is to supply decision makers, both potential or current cloud computing customers and providers, with information to enable them to make informed decisions about providing and employing cloud computing to meet current and future organizational computational resource needs.

The process of purchasing, maintaining and administering computing assets requires a large investment of financial and manpower resources for a business, government, university, or other organization. One option that centralizes computing assets and can lower costs and manpower requirements for an organization is to use centralized computing assets provided as cloud computing. The factors that contribute to organizational decisions to adopt cloud computing were identified and evaluated. This study is being used to identify trends influencing decisions for adopting cloud computing, and in so doing, improve the computing environment options for both providers and users of computing services. To evaluate these reasons, the factors: perceived cost effectiveness, need, reliability and security of cloud computing are being evaluated in terms of how they will influence an organization's decision to adopt cloud computing.

Research Questions

Question 1

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its cost-effectiveness?

Question 2

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of the need for cloud computing?

Question 3

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its reliability?

Question 4

Is a CIO/IT or other manager's decision to recommend cloud computing technology independent of his/her perception of its security effectiveness?

Research Hypotheses

Based on these research questions, the study tested the following hypotheses:

Hypothesis 1

Ho1: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness.

Ha1: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its cost-effectiveness.

Hypothesis 2

Ho2: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of the need for cloud computing.

Ha2: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of the need for cloud computing.

Hypothesis 3

Ho3: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its reliability.

Ha3: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its reliability.

Hypothesis 4

Ho4: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its security effectiveness.

Ha4: A CIO/IT or other manager's decision to recommend cloud computing technology is significantly independent of his/her perception of its security effectiveness.

Research Design

Cloud computing is an approach to provide computing resources to a large number of users or organizations while concentrating the overhead for providing, maintaining, and administering the computer systems to a central provider. Additionally, it is being investigated as a way to minimize costs, maximize reliability, and meet organizations' needs for computing resources, while maintaining security for the systems and the data stored on them.

Methodology

To address these issues, the research was conducted as a quantitative investigation with a validated survey instrument, used by Lease (2005) for a study titled "Factors Influencing the Adoption of Biometric Security Technologies by Decision Making Information Technology and Security Managers." Permission in writing to modify, use, and print Lease's instrument for this cloud computing research effort has been obtained from the author and is included in Appendix A. The purpose of the investigation is to identify factors that influence organizational management to adopt cloud computing.

Specific Research Design

The study population consisted of a purposive sample of professionals performing decision making roles within organizations that use computing resources as part of their business operation. The sample size, for a quantitative survey, was determined to be at least 30 participants, as specified when using the central limit theorem (Chang, Huang, & Wu, 2006). However, a larger participant pool was sought for increased statistical validity.

Sample

The target population was managers of information technology or related fields within organizations who play a role in information technology procurement decisions. The sampling frame was obtained using a purposive sampling method and was a list of people holding such roles. The participants were accessed online, by referral from an Upstate New York professional organization. The survey was hosted over the Internet by SurveyMonkey, which is a professional Internet-based survey organization. All participation was anonymous, with only one survey response permitted by participant. Survey respondents were able to enter the website multiple times until they completed and submitted the survey. The minimum sample size, *n*, was at least 30 responses. Although this was the minimum, the goal was to have more respondents to increase statistical accuracy. Thirty-eight completed responses were obtained.

Instrumentation/Measures

The potential participants received the survey site Web address by e-mail. As part of the invitation, the participants received instructions on completing the survey, an informed consent form, and an assurance of confidentiality. Participants were also offered a copy of the research results as an inducement.

Surveys were distributed and collected electronically via SurveyMonkey. Respondents logged onto the SurveyMonkey website to access and complete the survey. Each participant filled out a research participant consent form prior to accessing and completing the survey. Appendix A contains the survey instrument, modified from the instrument administered by Lease (2005), with a similar format. The SurveyMonkey website gathered and recorded the responses in a file accessible to the researcher.

Data Collection

Data was collected from an Internet-based survey administered via SurveyMonkey. Initially, the data was stored on SurveyMonkey's server, and then downloaded to the researcher's computer after data collection. Files were subsequently deleted from the SurveyMonkey website. The responses from completed surveys were used for data analysis. The survey instrument has 16 Likert (1932) format semantic differential items addressing issues related to cloud computing. Following the example of Lease (2005), the survey instrument is organized into several sections. One section, containing four items, addresses security issues related to cloud computing. Another section, containing three items, covers perceptions of the need for cloud computing. A third section, containing three items, covers the manager's perception of cloud computing reliability. The fourth section, containing three items, covers the participant's attitude about the cost effectiveness of cloud computing. The remaining section, with three items, covers the manager's overall perception of cloud computing. These five sections all employ a five-point semantic differential Likert scale, with values ranging from 1 for *Strongly Disagree* to 5 for *Strongly Agree*. Although the survey questions had a slightly different format when presented online, the content of the questions was the same.

Data Analysis

Statistical data analysis was performed using ANOVA analysis of the independent and dependent variables. The independent variables are cost effectiveness, need, reliability and security effectiveness. The dependent variable is adoption decision. The relationship between each independent variable and the dependent variable was analyzed.

Validity and Reliability

The original questionnaire, as developed by Lease (2005) was successfully field tested for face and content validity with ten senior managers, using two sequential field tests, with suggestions for improvement of the survey instrument and survey instructions from the managers incorporated for the second test. Subsequent to the successful field testing, Lease pretested the survey instrument for reliability using a test-retest sequence with 36 participants. For the retest, the questions were reordered. There was 100% participation in the retest, with a Cronbach's alpha of .94 calculated based on the 16 Likert (1932) scale questions, indicating that the tests are highly correlated. Since the survey instrument for this cloud computing research effort is very similar to the previously validated survey instrument, the previously confirmed field test validity has a high probability of being valid for this proposed effort. In addition to the previous work on survey instrument validity, the validity and reliability of the survey responses were analyzed for validity and reliability by comparing responses to similar questions worded in different manners.

Ethical Considerations

Consent to perform this study was obtained from the Capella University Institutional Review Board (IRB). No conflict of interest issues were identified. There was minimal risk to potential participants to accomplish this survey. Each participant filled out a research participant consent form prior to accessing and completing the survey.

The study did not collect personally identifiable information. For added security, safe practices for handling data were followed. Initially, the data was stored on SurveyMonkey's server. After completion of data collection, the data was downloaded to the researcher's computer, after which time the researcher requested that SurveyMonkey delete the data from their files. Survey data will be stored on magnetic media in a locked storage area under control of the researcher for at least seven years, at which point it can be destroyed.

CHAPTER 4. RESULTS

Introduction

The purpose of this study is to evaluate reasons for adopting cloud computing to satisfy the computing needs of an organization. The research goal is to supply decision makers, both potential or current cloud computing customers and providers, with information to enable them to make informed decisions about providing and employing cloud computing to meet current and future organizational computational resource needs.

These results have the potential to lay a foundation for further research in cloud computing and other methods of providing centralized computational resources to satisfy the computing needs of a wide group of potential users. The interplay of these factors can demonstrate the relationship between each of the independent factors: security, need, reliability, and cost, with the dependent factor: adoption decision.

The benefit to society is an increased understanding of the factors of most concern for making decisions to adopt a centralized computing provider, such as with cloud computing. This knowledge can provide organizations with the tools needed to find optimum ways to address organizational computing needs. The potential for lower costs, improved computational and information handling capabilities, and greater convenience to the users, can make cloud computing an attractive option to consider.

Data Collection

Potential participants were recruited online by an e-mail invitation from an Upstate New York professional organization to participate in an online survey. The data was collected via an online questionnaire administered by SurveyMonkey. The survey question text is in Appendix A. Forty-two respondents completed the research participant consent form. Of these people, forty participants responded to the survey questions on cloud computing, of which thirty-eight answered all sixteen questions and two respondents each answered fifteen questions. These questions asked participants about their opinions on the security, need, reliability, cost, and the potential adoption decision for cloud computing for their respective organizations. For increased statistical validity, only the data from the respondents that answered all sixteen of the cloud computing survey questions were used.

Data Analysis

Statistical analyses were performed using the Statistical Package for Social Science (SPSS) Version 14.0 analysis software using the completed survey responses. Descriptive statistics were calculated using numerical values for the Likert (1032) scale responses. These values range from 1 for *Strongly Disagree* to 5 for *Strongly Agree* on the Likert scale. Next, factor analyses were performed for data reduction, with a separate analysis on each of the independent and dependent variables. The resulting *z*-scores or standard scores from the factor analyses were used for linear regression and analysis of variance (ANOVA) tests. These regression and ANOVA tests compared *z*-score values for each dependent variable with the values for the dependent variable.

Descriptive Statistics

The descriptive statistics for the different variables or concepts addressed in the survey are listed below, grouped by category. The descriptive statistics for the original responses are listed in Table 1.

Table 1. Descriptive Statistics Original Data

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
technology secure	38	1	5	2.71	.898	.806
concerned about security	38	1	5	4.03	.885	.783
more secure	38	1	4	2.32	.962	.925
not secure three years ago	38	2	5	3.45	.828	.686
need to improve	38	2	5	3.89	.924	.853
need cloud	38	1	5	3.03	1.150	1.324
need benefit of cloud	38	1	5	3.45	1.155	1.335
technology reliable	38	1	5	2.82	1.136	1.289
more reliable	38	1	5	2.61	1.001	1.002
systems reliable	38	1	5	2.89	.981	.962
value for cost	38	1	4	3.39	.755	.570
low maintenance cost	38	1	5	3.50	.980	.959
cost savings	38	1	5	3.39	.855	.732
willing to use	38	1	5	3.39	.974	.948
recommend use	38	1	5	3.34	1.021	1.042
uses proven technology	38	1	5	3.39	.887	.786
Valid N (listwise)	38					

Since two of the security questions were worded in a negative manner, the responses to these questions were modified by subtracting the response value from six (6 – initial value = input value) to obtain the equivalent Likert (1932) scale response for the corresponding positive question. One question was about cloud computing not being secure three years ago. The other asked whether the respondent would be concerned about the security of cloud computing. Since a concern is a negative opinion, results for this question were also reversed. The modified descriptive statistics are listed in Table 2.

These modified values were used for the subsequent factor analysis to ensure comparison of positive statements for each variable.

Table 2. Descriptive Statistics After Data Modification

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
technology secure	38	1	5	2.71	.898	.806
unconcerned about security	38	1	5	1.97	.885	.783
more secure	38	1	4	2.32	.962	.925
secure three years ago	38	1	4	2.55	.828	.686
need to improve	38	2	5	3.89	.924	.853
need cloud	38	1	5	3.03	1.150	1.324
need benefit of cloud	38	1	5	3.45	1.155	1.335
technology reliable	38	1	5	2.82	1.136	1.289
more reliable	38	1	5	2.61	1.001	1.002
systems reliable	38	1	5	2.89	.981	.962
value for cost	38	1	4	3.39	.755	.570
low maintenance cost	38	1	5	3.50	.980	.959
cost savings	38	1	5	3.39	.855	.732
willing to use	38	1	5	3.39	.974	.948
recommend use	38	1	5	3.34	1.021	1.042
uses proven technology	38	1	5	3.39	.887	.786
Valid N (listwise)	38					

Upon visual inspection of the descriptive statistics after data modification, it is apparent that there is considerable similarity in responses on the same topic, such as cost. There are lower mean values for the answers to security and reliability-related questions than for questions related to need, cost, and use or adoption of cloud computing. The standard deviation values for each question or concept are all within the range from .7 to 1.2.

Factor Analysis

There are four independent variables: security, need, reliability, and cost; and one dependent variable: adoption. Since three or four survey questions were asked about each of the independent variables and three survey questions were asked of the dependent variable, data reduction was necessary. This data reduction was performed by factor analysis to prepare for the regression analysis and ANOVA. A factor analysis, specifically a principal component analysis, was used for data reduction, in this case reducing three or four data values to only one or two values. These composite values are called components or factors and contain common variances from the input values.

Although a large sample size is best for factor analysis, there is no agreement on what the minimum sample size should be (Sheskin, 2007). One rule of thumb, according to Bryant and Yarnold (1995), as referenced in Sheskin, is that the number of subjects must be at least five to ten times the number of variables in each analysis. Since each analysis evaluates three or four variables, more specifically responses to three or four different questions about a common topic, such as cost, with 38 subjects, the number of subjects is greater than nine times the number of variables per computation, and satisfies this criterion for factor analysis.

This factor analysis evaluated responses to each of the questions for a specific variable, such as cost, to generate one or more composite resultant *z*-score values per participant for input into the subsequent analyses. A *z*-score is a standardized score using standard deviation units, which facilitates subsequent regression and ANOVA analysis. The standard score variables generated by the factor analysis signify how far, in standard deviation units, a value is from the mean. A positive z-score is generated when a value is above the mean. Conversely, a negative z-score is generated when a value is below the mean.

During the factor analysis with principal component analysis, Varimax rotation was employed if more than one significant component was identified. This rotation generated optimum values from the significant components identified in the factor analysis. A significant component has an eigenvalue of at least 1.0. Lower valued components were discarded.

Principal component analysis shows the covariance relationship between the variables being evaluated and generates factors based on their correlations (Johnson & Wichern, 1998). A correlation of at least .30 between constituent members is desired to generate strong components. Varimax is a form of orthogonal rotation that generates a simple factor structure by maximizing the squared factor loading variances (Sheskin, 2007). Since the security data was the case where more than one significant component was extracted during the factor analysis, it was the only data to undergo Varimax rotation.

For each factor analysis, there are multiple tables. The correlation matrix shows the relationship between the three or four concepts being compared. The communalities table shows the variances extracted from each concept for use in the component(s). The total variance table shows the variance contribution to each component, while the component matrix (or matrices) table(s) shows the contribution of each concept to the resultant component(s), before and, if appropriate, after rotation. Overall, these tables show the relationships between the different concepts being compared, the variance extracted from each, and the resultant component matrices. If multiple significant components were extracted, results after Varimax rotation are also shown.

The results of the factor analyses follow, in the following order, with the four independent variables: security, need, reliability, and cost followed by the dependent variable: adoption. The security factor analysis is below.

Factor analysis: Security.

Table 3. Security Correlation Matrix

		technology secure	not concerned security	more secure	secure three years ago
Correlation	technology secure	1.000	-.078	.798	.475
	unconcerned security	-.078	1.000	.105	.131
	more secure	.798	.105	1.000	.386
	secure three years ago	.475	.131	.386	1.000

Table 4. Security Communalities

	Initial	Extraction
technology secure	1.000	.888
unconcerned security	1.000	.961
more secure	1.000	.797
secure three years ago	1.000	.528

Extraction Method: Principal Component Analysis.

Table 5. Total Security Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.132	53.311	53.311	2.132	53.311	53.311	2.127	53.168	53.168
2	1.041	26.018	79.329	1.041	26.018	79.329	1.046	26.161	79.329
3	.656	16.410	95.739						
4	.170	4.261	100.000						

Extraction Method: Principal Component Analysis.

Table 6. Security Component Matrix (a)

	Component	
	1	2
technology secure	.915	-.225
unconcerned security	.101	.975
more secure	.892	-.033
secure three years ago	.700	.196

Extraction Method: Principal Component Analysis.
a 2 components extracted.

Table 7. Security Rotated Component Matrix (a)

	Component	
	1	2
technology secure	.929	-.158
unconcerned security	.030	.980
more secure	.892	.032
secure three years ago	.684	.246

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 3 iterations.

The factor analysis results from the security questions show significant correlations, greater than .30, between three concepts: "technology secure," "more secure," and "secure three years ago," from the survey responses. Each of these concepts is related to the existence of effective security measures for cloud computing. However, all three concepts have a low correlation with "unconcerned security." Because of the correlation between the three related security concepts, the principal component analysis was able to group input primarily from the three strongly correlated questions into one component, factor 1. This factor accounts for about 53% of the variance related to security issues for cloud computing. Conversely, the second component, factor 2, receives its input primarily from the other concept, "unconcerned security," which indicates a respondent's interest in cloud computing security. This factor accounts for about 26% of the variance related to cloud computing security, primarily the concern about security. This second factor, with an eigenvalue of 1.04, is just above the cutoff of 1.0 to even consider it in an analysis. Since it is considerably smaller than the first factor, the Varimax rotation converged to an optimum value after only three rotations.

The next analysis shows the need for cloud computing.

Factor analysis: Need.

Table 8. Need Correlation Matrix

		need to improve	need cloud	need benefit of cloud
Correlation	need to improve	1.000	.664	.704
	need cloud	.664	1.000	.764
	need benefit of cloud	.704	.764	1.000

Table 9. Need Communalities

	Initial	Extraction
need to improve	1.000	.766
need cloud	1.000	.813
need benefit of cloud	1.000	.842

Extraction Method: Principal Component Analysis.

Table 10. Total Need Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.421	80.714	80.714	2.421	80.714	80.714
2	.347	11.570	92.284			
3	.231	7.716	100.000			

Extraction Method: Principal Component Analysis.

Table 11. Need Component Matrix (a)

	Component
	1
need to improve	.875
need cloud	.902
need benefit of cloud	.918

Extraction Method: Principal Component Analysis.
a 1 components extracted.

There is no rotated component matrix since only one component was extracted. The correlations between the different concepts related to the need for cloud computing are quite high, with the lowest correlation being .664. As shown in the component matrix, there is large similarity between constituent concepts, with over 87% of the component shared with each variable. As a result, only one component has an eigenvalue above 1.0 and only a single component is extracted, containing similar input from each constituent concept. This factor accounts for over 80% of the variance related to the need for cloud computing.

The next analysis relates to cloud computing reliability.

Factor analysis: Reliability.

Table 12. Reliability Correlation Matrix

		technology reliable	more reliable	systems reliable
Correlation	technology reliable	1.000	.434	.370
	more reliable	.434	1.000	.727
	systems reliable	.370	.727	1.000

Table 13. Reliability Communalities

	Initial	Extraction
technology reliable	1.000	.471
more reliable	1.000	.806
systems reliable	1.000	.762

Extraction Method: Principal Component Analysis.

Table 14. Total Reliability Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.039	67.964	67.964	2.039	67.964	67.964
2	.692	23.081	91.045			
3	.269	8.955	100.000			

Extraction Method: Principal Component Analysis.

Table 15. Reliability Component Matrix (a)

	Component
	1
technology reliable	.686
more reliable	.898
systems reliable	.873

Extraction Method: Principal Component Analysis.
a 1 components extracted.

Although the correlations between the different concepts related to cloud computing reliability are all above .30, the lowest is .370, considerably lower than the highest correlation of .727. As shown in the component matrix, there is significant correlation between two constituent concepts, “more reliable” and “systems reliable” while the other concept, “technology reliable,” has a lower correlation with the other concepts. This equates to over 68% of the component shared with this less-correlated concept and more of the component shared with the other two concepts. While there are two small components accounting for over 30% of the variance, since they have eigenvalues below 1.0, only a single component is extracted. With more variance extracted from two concepts “more reliable” and “systems reliable,” the component contains more input from the concepts with similar variances: “more reliable” and “systems reliable” and less from the concept with dissimilar variances: “technology reliable.” This factor accounts for about 68% of the variance related to cloud computing reliability.

The next analysis relates to cloud computing costs.

Factor analysis: Cost.

Table 16. Cost Correlation Matrix

		value for cost	low maintenance cost	cost savings
Correlation	value for cost	1.000	.713	.673
	low maintenance cost	.713	1.000	.758
	cost savings	.673	.758	1.000

Table 17. Cost Communalities

	Initial	Extraction
value for cost	1.000	.777
low maintenance cost	1.000	.841
cost savings	1.000	.812

Extraction Method: Principal Component Analysis.

Table 18. Total Cost Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.430	80.992	80.992	2.430	80.992	80.992
2	.334	11.139	92.131			
3	.236	7.869	100.000			

Extraction Method: Principal Component Analysis.

Table 19. Cost Component Matrix (a)

	Component
	1
value for cost	.881
low maintenance cost	.917
cost savings	.901

Extraction Method: Principal Component Analysis.
a 1 components extracted.

The correlations between the different concepts related to cloud computing costs are quite high, with the lowest correlation being .673. As shown in the component matrix, there is large similarity between constituent concepts, with over 88% of the component shared with each variable. As a result, only one component has an eigenvalue above 1.0

and only a single component is extracted, containing similar input from each constituent concept. This factor accounts for over 80% of the variance related to the need for cloud computing.

The next analysis relates to the dependent variable, cloud computing adoption.

Factor analysis: Adoption.

Table 20. Adoption Correlation Matrix

		willing to use	recommend use	uses proven technology
Correlation	willing to use	1.000	.785	.597
	recommend use	.785	1.000	.564
	uses proven technology	.597	.564	1.000

Table 21. Adoption Communalities

	Initial	Extraction
willing to use	1.000	.836
recommend use	1.000	.812
uses proven technology	1.000	.655

Extraction Method: Principal Component Analysis.

Table 22. Total Adoption Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.302	76.749	76.749	2.302	76.749	76.749
2	.484	16.138	92.887			
3	.213	7.113	100.000			

Extraction Method: Principal Component Analysis.

Table 23. Adoption Component Matrix (a)

	Component
	1
willing to use	.914
recommend use	.901
uses proven technology	.809

Extraction Method: Principal Component Analysis.
a 1 components extracted.

The correlations between the different concepts related to cloud computing adoption are all at least .564, considerably above the minimum of .30. As shown in the component matrix, there is large similarity between constituent concepts, with over 80% of the component shared with each concept. As a result, only one component has an eigenvalue above 1.0 and only a single component is extracted, containing a similar amount of input from each constituent concept. This factor accounts for over 76% of the variance related to cloud computing adoption.

For all of these analyses, the correlation analysis shows how closely correlated the responses are, with exact correlation having a value of 1.0, such as the correlation of a value with itself. Some correlations of at least .30 are desirable, with even larger correlations preferred for smaller sample sizes (Sheskin, 2007). For all variables except security, all correlations are greater than .30, with only one component extracted for each variable. With security, there is a correlation of at least .30 between the topics, "technology secure," "more secure" and "secure three years ago," with much lower correlation with the "not concerned security." As a result of this lower correlation, two components were extracted, which converged after three iterations of Varimax rotation. However, this second component was determined to be insignificant and was dropped from consideration.

Regression and ANOVA Analyses

The linear regression analysis calculates the coefficient of determination, R^2, and the regression coefficients, B and its standardized version, Beta. R^2 provides the explanatory power of the model, in which R^2 is a model statistic for the explained portion of the shared variation of the two variables combined. Since standardized variables were input for the regression analysis, *B* and Beta have identical values. *B* describes the linear relationship for the predicted change in the dependent variable with a unit change in the independent variable. *B* contains a small constant, plus a corresponding constant to multiply by each factor score. These separate values summed together specify the linear relationship between the independent variable and the dependent variable. As such, the regression analysis can predict the amount of change in the dependent variable in response to changes in the independent variable. When the constant is insignificant and there is only one significant factor score worth considering, this linear relationship is essentially the product of the first factor score and its corresponding *B* coefficient. This analysis is performed using *z*-score, standardized variables generated by the factor analysis.

A large data set is desirable for an accurate regression analysis. However, there is a lack of consensus on what constitutes an acceptable minimum sample size for a regression analysis. One estimated minimum sample size is at least ten subjects per variable (Van Belle, 2002). Since this analysis uses thirty eight subjects and two variables per regression analysis, this equates to 19 subjects per variable. Therefore, this condition has been met.

As was mentioned previously, the regression analysis works with the standardized units, the *z*-scores. The *z*-score, Z, is obtained by the following equation: $Z = (X-\mu)/\sigma$, where X is the specific score, μ is the population standard deviation and σ is the population mean (Sheskin, 2007, p. 46). Since the *z*-score is based on standard deviation units, the regression analysis comparison between independent and dependent variables is based on the changes in the *z*-score, not simply the differences between the variables. This enables the regression analysis to calculate the change in one *z*-score based on a change in another *z*-score, even if the independent and dependent variables have significantly different values.

Correlations indicate the relationships between variables. The model summary shows the R^2 values. The ANOVA shows the significance of the relationship between factors, specifically the possibility of Type 1 errors. This significance is used for hypothesis testing. The coefficients chart lists the *B* and Beta values and their significance.

Separate regression and ANOVA analyses were performed to compare each independent variable with the dependent variable. The first analysis shown here is for security versus adoption. Since two components were generated by the factor analysis, both factors were included in the regression and ANOVA computations.

Security and adoption regression and ANOVA analyses.

Table 24. Security and Adoption Correlations

		adoption factor score 1	security factor score 1	security factor score 2
Pearson Correlation	adoption factor score 1	1.000	.553	-.073
	security factor score 1	.553	1.000	.000
	security factor score 2	-.073	.000	1.000
Sig. (1-tailed)	adoption factor score 1	.	.000	.332
	security factor score 1	.000	.	.500
	security factor score 2	.332	.500	.
N	adoption factor score 1	38	38	38
	security factor score 1	38	38	38
	security factor score 2	38	38	38

Table 25. Security and Adoption Model Summary (b)

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.558(a)	.311	.272	.85327741

a Predictors: (Constant), security factor score 2, security factor score 1
b Dependent Variable: adoption factor score 1

Table 26. Security and Adoption ANOVA (b)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	11.517	2	5.759	7.909	.001(a)
	Residual	25.483	35	.728		
	Total	37.000	37			

a Predictors: (Constant), security factor score 2, security factor score 1
b Dependent Variable: adoption factor score 1

Table 27. Security and Adoption Coefficients (a)

		Unstandardized Coefficients		Standardized Coefficients		
Model		*B*	Std. Error	Beta	*t*	Sig.
1	(Constant)	8.04E-017	.138		.000	1.000
	security factor score 1	.553	.140	.553	3.943	.000
	security factor score 2	-.073	.140	-.073	-.520	.606

a Dependent Variable: adoption factor score 1

The two components from the security data together show an ANOVA significance of .001, or one chance in 1000 of Type 1 error. This means that the data between security and the adoption decision are strongly correlated. The R^2 value from the regression analysis of .311 indicates a shared variation of about 31 percent between the security data and the adoption data. The *B* value of .553 for security factor score 1 means a positive correlation, with the adoption factor score, in *z*-score units, increasing by approximately .553 with a unit increase in the security factor score 1. The *B* value of -.073 for security factor score 2 means a slightly negative correlation, with the adoption factor score, in *z*-score units, decreasing by approximately .073 with a unit increase in the security factor score 2. The individual components, security factor 1 and security factor 2 yield different results. Security factor 1 is essentially the composite of three concepts dealing with the status of cloud computing security. Security factor 2, which is much smaller than factor 1, represents a respondent's interest in cloud computing security.

The security factor 1 regression analysis results show a significance of .000, indicating a probability of less than one in 1000 of type 1 error, or almost no chance of getting these values by random chance, showing a strong correlation between the state of cloud computing security and the decision to adopt cloud computing. However, the security factor 2 regression analysis results show a significance of .606, well above the cutoff of .05, indicating little correlation between a respondent's interest in or concern about cloud computing security and the decision to adopt cloud computing. However, security factor 2, having an eigenvalue of 1.04, is barely above the cutoff value of 1.0 where it would be automatically discarded. With little difference between respondents, and a small *B* value of -.073, with an error of .140 that is greater than *B*, the security factor 2 does not yield explanatory results for the decision to adopt cloud computing. Since its eigenvalue is so small, the effects of security factor 2 can be disregarded as insignificant. The fact that the original data were modified is insignificant here, because the overall standard deviation values are the same with the unmodified data, again showing no explanatory results for the decision to adopt cloud computing.

The next analysis compares the need for cloud computing to the adoption decision.

Need and adoption regression and ANOVA analyses.

Table 28. Need and Adoption Correlations

		adoption factor score 1	need factor score 1
Pearson Correlation	adoption factor score 1	1.000	.580
	need factor score 1	.580	1.000
Sig. (1-tailed)	adoption factor score 1	.	.000
	need factor score 1	.000	.
N	adoption factor score 1	38	38
	need factor score 1	38	38

Table 29. Need and Adoption Model Summary (b)

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.580(a)	.337	.318	.82576807

a Predictors: (Constant), need factor score 1
b Dependent Variable: adoption factor score 1

Table 30. Need and Adoption ANOVA (b)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	12.452	1	12.452	18.261	.000(a)
	Residual	24.548	36	.682		
	Total	37.000	37			

a Predictors: (Constant), need factor score 1
b Dependent Variable: adoption factor score 1

Table 31. Need and Adoption Coefficients (a)

		Unstandardized Coefficients		Standardized Coefficients		
Model		*B*	Std. Error	Beta	*t*	Sig.
1	(Constant)	-6.32E-017	.134		.000	1.000
	need factor score 1	.580	.136	.580	4.273	.000

a Dependent Variable: adoption factor score 1

The need and adoption data together show an ANOVA significance of .000, or less than one chance in 1000 of Type 1 error. This means that the data between need and the adoption decision are strongly correlated. The R^2 value from the regression analysis of

.337 indicates a shared variation of about 34 percent between the need data and the adoption data. The *B* value of .580 for need factor score 1 means a positive correlation, with the adoption factor score, in *z*-score units, increasing by approximately .580 with a unit increase in the need factor score 1.

The next analysis compares cloud computing reliability to the adoption decision.

Reliability and adoption regression and ANOVA analyses.

Table 32. Reliability and Adoption Correlations

		adoption factor score 1	reliability factor score 1
Pearson Correlation	adoption factor score 1	1.000	.513
	reliability factor score 1	.513	1.000
Sig. (1-tailed)	adoption factor score 1	.	.000
	reliability factor score 1	.000	.
N	adoption factor score 1	38	38
	reliability factor score 1	38	38

Table 33. Reliability and Adoption Model Summary (b)

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.513(a)	.264	.243	.86996589

a Predictors: (Constant), reliability factor score 1
b Dependent Variable: adoption factor score 1

Table 34. Reliability and Adoption ANOVA (b)

Model		Sum of Squares	df	Mean Square	*F*	Sig.
1	Regression	9.754	1	9.754	12.887	.001(a)
	Residual	27.246	36	.757		
	Total	37.000	37			

a Predictors: (Constant), reliability factor score 1
b Dependent Variable: adoption factor score 1

Table 35. Reliability and Adoption Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	*t*	Sig.
1	(Constant)	6.28E-019	.141		.000	1.000
	reliability factor score 1	.513	.143	.513	3.590	.001

a Dependent Variable: adoption factor score 1

The reliability and adoption data together show an ANOVA significance of .001, or about one chance in 1000 of Type 1 error. This means that the data between reliability and the adoption decision are strongly correlated. The R^2 value from the regression analysis of .264 indicates a shared variation of about 26 percent between the reliability data and the adoption data. The *B* value of .513 for reliability factor score 1 means a positive correlation, with the adoption factor score, in *z*-score units, increasing by approximately .513 with a unit increase in the reliability factor score 1.

The next analysis compares cloud computing cost to the adoption decision.

Cost and adoption regression and ANOVA analyses.

Table 36. Cost and Adoption Correlations

		adoption factor score 1	cost factor score 1
Pearson Correlation	adoption factor score 1	1.000	.552
	cost factor score 1	.552	1.000
Sig. (1-tailed)	adoption factor score 1	.	.000
	cost factor score 1	.000	.
N	adoption factor score 1	38	38
	cost factor score 1	38	38

Table 37. Cost and Adoption Model Summary (b)

Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the Estimate
1	.552(a)	.305	.285	.84542354

a Predictors: (Constant), cost factor score 1
b Dependent Variable: adoption factor score 1

Table 38. Cost and Adoption ANOVA (b)

Model		Sum of Squares	Df	Mean Square	*F*	Sig.
1	Regression	11.269	1	11.269	15.767	.000(a)
	Residual	25.731	36	.715		
	Total	37.000	37			

a Predictors: (Constant), cost factor score 1
b Dependent Variable: adoption factor score 1

Table 39. Cost and Adoption Coefficients (a)

		Unstandardized Coefficients		Standardized Coefficients		
Model		*B*	Std. Error	Beta	*t*	Sig.
1	(Constant)	4.76E-017	.137		.000	1.000
	cost factor score 1	.552	.139	.552	3.971	.000

a Dependent Variable: adoption factor score 1

The cost and adoption data together show an ANOVA significance of .000, or less than one chance in 1000 of Type 1 error. This means that the data between cost and the adoption decision are strongly correlated. The R^2 value from the regression analysis of .305 indicates a shared variation of about 31 percent between the cost data and the adoption data. The *B* value of .552 for cost factor score 1 means a positive correlation, with the adoption factor score, in *z*-score units, increasing by approximately .552 with a unit increase in the cost factor score 1.

ANOVA. The ANOVA performed with a regression analysis measures the probability of Type 1 errors. A Type 1 error occurs when a null hypothesis that is true gets rejected in the regression analysis. These errors are caused by residuals or the difference between a predicted score of a variable and the true value causing error in the analysis. All analyses were performed by comparing an independent variable: security, need, reliability, or cost; against the dependent variable: adoption. The probability of Type 1 errors is very low. A probability of .000 was calculated for two cases. These cases were: need versus adoption and cost versus adoption. A probability of .001 was measured for two cases: security versus adoption and reliability versus adoption. All of these results indicate a probability of 0.1 percent or less of a Type 1 error. Since a cutoff of .05 is used to determine statistical validity, the ANOVA reinforces the probability that there is a significant relationship between the four independent variables and the adoption decision.

Review

Based on the regression analysis, there is a significant relationship between each of the independent variables and the dependent variable. The computed *B* value ranges from a low of .513 for reliability to a high of .580 for need, with security and cost being in the middle. The R^2 value ranges from a low of .264 for reliability to a high of .337 for need, with security and cost being in the middle. This indicates that for a unit change in the *z*-score for each independent variable, the dependent variable adoption will have a predicted *z*-score change from a low of .513 for reliability to a high of .580 for need. This data indicates that all of the independent variables significantly influence the adoption decision, with need having the strongest influence and reliability having the weakest influence.

The analysis results confirm the likelihood that a positive relationship exists between the four independent variables: security, need, reliability, and cost; and the decision to adopt cloud computing; and the unlikelihood that they are independent. These results are used to determine whether or not to reject the hypotheses.

Hypothesis Testing

The hypothesis testing shows the likelihood of the data supporting the hypotheses and their related research questions. These models have established a dependency between the independent variables and the dependent variables, with a probability of 1 in 1000 or less that the independent variables are independent of the dependent variable. Therefore, all four models represent a dependency between the independent variables and the dependent variable. With the strong correlation shown between all four of the independent variables and the adoption decision, this means that the variables are not significantly independent. Therefore, the statistics have verified that the independent variables are not significantly independent of the dependent variable.

The comparisons are shown in order of the research questions and their associated hypotheses.

The first research question asks whether a CIO/IT or other manager's decision to recommend cloud computing technology is independent of his/her perception of its cost-effectiveness. The associated Hypothesis 1 (null) states that a CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness. The ANOVA test showed a value of .000, or a less than 1 in 1000 chance that these decisions were independent. This is proof of the dependence of the dependent variable, adoption decision, on the independent variable, cost-effectiveness. As a result, the statistics have verified that the independent variable, cost-effectiveness, is not significantly independent of the dependent variable, adoption decision. Therefore, the CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness, which fails to reject the null hypothesis.

The second research question asks whether a CIO/IT or other manager's decision to recommend cloud computing technology is independent of his/her perception of the need for cloud computing. The associated Hypothesis 1 (null) states that a CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of the need for cloud computing. The ANOVA test showed a value of .000, or a less than 1 in 1000 chance that these decisions were independent. This is proof of the dependence of the dependent variable, adoption decision, on the independent variable, need. As a result, the statistics have verified that the independent variable, need, is not significantly independent of the dependent variable, adoption decision. Therefore, the CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of the need for cloud computing, which fails to reject the null hypothesis.

The third research question asks whether a CIO/IT or other manager's decision to recommend cloud computing technology is independent of his/her perception of its reliability. The associated Hypothesis 1 (null) states that a CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its reliability. The ANOVA test showed a value of .001, or a 1 in 1000 chance that these decisions were independent. This is proof of the dependence of the dependent variable, adoption decision, on the independent variable, reliability. As a result, the statistics have verified that the independent variable, reliability, is not significantly independent of the dependent variable, adoption decision. Therefore, the CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its reliability, which fails to reject the null hypothesis.

The fourth research question asks whether a CIO/IT or other manager's decision to recommend cloud computing technology is independent of his/her perception of its security effectiveness. The associated Hypothesis 1 (null) states that a CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness. The ANOVA test showed a value of .001, or a 1 in 1000 chance that these decisions were independent. This is proof of the dependence of the dependent variable, adoption decision, on the independent variable, security-effectiveness. As a result, the statistics have verified that the independent variable, security-effectiveness, is not significantly independent of the dependent variable, adoption decision. Therefore, the CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its security effectiveness, which fails to reject the null hypothesis.

Summary

The goal of this research effort is to assist organizational decision-makers in their decisions about adopting cloud computing by identifying important factors to consider when making decisions about corporate computing resource policies, specifically the decision to adopt cloud computing. Four important factors that have a potential to influence decision making: cost, need, reliability, and security, were all evaluated in terms of their relationship to cloud computing adoption. The variables were all evaluated independently, with the following hypotheses:

Hypothesis 1

Ho1: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its cost-effectiveness.

Hypothesis 2

Ho2: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of the need for cloud computing.

Hypothesis 3

Ho3: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its reliability.

Hypothesis 4

Ho4: A CIO/IT or other manager's decision to recommend cloud computing technology is not significantly independent of his/her perception of its security effectiveness.

With the strong dependency shown between all four independent variables and the adoption decision, there was shown to be a lack of independence between each of the independent variables and the dependent variable, adoption decision. Therefore, a manager's decision to recommend cloud computing was found to not be significantly independent of his/her perception of any of these variables. This lack of independence resulted in a failure to reject Ho1, a failure to reject Ho2, a failure to reject Ho3, and a failure to reject Ho4. As a result, the decision to adopt cloud computing was found to not be independent of the following factors: its perceived cost-effectiveness, the need for cloud computing, its reliability, and its security effectiveness.

CHAPTER 5. DISCUSSION, IMPLICATIONS, RECOMMENDATIONS

Discussion of Results

This study evaluates management's reasons for adopting cloud computing to satisfy the computing needs of an organization. The goal is to supply decision makers with essential information to enable them to make informed decisions about employing cloud computing to meet organizational computational resource needs. Four variables were evaluated in terms of their relationship to the decision to adopt cloud computing. These variables are cost-effectiveness, need, reliability, and security effectiveness of cloud computing. As a result of the analysis, a strong relationship was found between the decision to adopt cloud computing and all four of the independent variables: the perceived cost-effectiveness of cloud computing, the need for cloud computing, cloud computing reliability, and the security effectiveness of cloud computing.

These results indicate that an adoption decision for cloud computing technology, either for or against, is a complex decision, dependent on multiple factors. As organizations use increasingly complex computations, finding computing platforms and applications that will meet organizational computational goals is also a complex process.

Study Implications

The implications of this study for scholars and practitioners are that non-technical factors influence decision-making managers in forming an adoption decision regarding employing cloud computing technology. Marketing and research on technical applications often focus almost exclusively on the technical capabilities of the applications. However, while technical considerations of the capability of a specific technology are important, it is equally important how incorporating and using new technology fits within the organization's structure, culture, and strategic goals. Cloud computing can address these goals by enabling firms to free up critical organizational computing resources by having the choice to prioritize computational requirements and export some of these requirements to the "cloud."

The results of this research also indicate that for cloud computing vendors to fully satisfy customers' needs for alternate computing environments; they must address the factors identified in this research. The decision on whether or not to adopt cloud computing technology appears to depend on whether the technology is cost effective, satisfies organizational needs, can be relied upon, and employs effective security measures. This market focus could require a more complex interaction between a vendor and a potential customer than simply furnishing a catalog or price sheet. Addressing market needs can include supplying data to current and potential users on areas such as organizational costs of cloud computing, cloud computing reliability, cloud computing security, and how cloud computing can meet organizational needs.

Limitations and Recommendations for Further Research

Limitations

This research was performed via an online survey of decision-making managers either located in Upstate New York or who have a relationship with one or more organizations in the Upstate New York area. There were thirty-eight participants from a variety of organizations. Because of the small sample size, the relationship between each independent variable was only compared with the dependent variable. A larger sample size would be needed to accommodate the additional computational complexity of comparing the different independent variables with each other in terms of their contribution to the cloud computing adoption decision. While many of the same issues can be considered by decision-making managers in other areas of the country, this survey is not generalizable to areas outside of the Upstate New York area.

Recommendations for Further Research

Recommendations for future research are numerous. Expanding the scope of this survey to include other geographical areas could evaluate factors influencing cloud computing adoption in other regions of the United States or in other countries. Surveying a larger sample could enable a more detailed analysis to be performed. With the global nature of computing, research could be performed considering international cloud computing issues. Also, evaluating cloud computing adoption for specific delivery methods, such as commercial, organizational, or private cloud computing, could be done.

Since other geographic areas, within and outside of the United States, could have different organizational situations, they may have different financial, security, reliability, and cost concerns. Rapidly growing economies with limited computing infrastructures could have a different approach to cloud computing adoption than developed nations with extensive existing computing assets. Studies could be performed in other countries to evaluate their cloud computing adoption issues. Such an evaluation could also be performed in a third-world nation with limited computing access but growing computational needs.

Surveying a larger sample size could yield more thorough results. Such results can be obtained if a sufficiently large sample is obtained to enable the interrelations between the different independent variables and the adoption decision to be evaluated. Since the minimum sample size increases with an increase in the number of variables, the sample size must increase sufficiently to support a more complex analysis.

Other potential areas to consider would be the effect of demographic data on cloud computing adoption. Such data could include organizational size or the organizational type, such as business, government, academia, or industry. For example, small firms may view cloud computing differently than large firms.

This study does not address legal issues regarding international cloud computing. However, evaluating the adoption of international cloud computing could be a potential area of further study. Cross national cloud computing, both within partner states, such as the European Union, and between non-affiliated countries, could be evaluated, with potential areas of concern identified, especially legal issues surrounding international data transmission and storage.

Studies could be performed to compare specific cloud computing delivery methods. These studies could include the adoption of commercial clouds, organizational clouds, and private clouds. In studying the cloud computing delivery methods, the factors influencing cloud computing adoption in these different environments could be determined.

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APPENDIX A: SURVEY INSTRUMENT

Below are 16 statements about cloud computing technology (CCT). Please indicate whether you agree or disagree with each statement by selecting the appropriate number on the scale of 1 (*strongly disagree*) to 5 (*strongly agree*) that most closely matches your perception of cloud computing technology. When you are satisfied with your answers, please click the "CONTINUE" button to proceed to the final section of the survey.

Item No.		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I feel that cloud computing technology is secure.	1	2	3	4	5
2	I am/would be concerned with the security of the technology used by the cloud computing system.	1	2	3	4	5
3	I feel that cloud computing technology is more secure than traditional computing methods.	1	2	3	4	5
4	I am willing to use cloud computing technology to meet my organization's computing needs.	1	2	3	4	5
5	Cloud computing technology was not secure three years ago.	1	2	3	4	5
6	My organization needs to improve its computational capabilities.	1	2	3	4	5
7	My organization needs cloud computing technology to meet its IT needs.	1	2	3	4	5
8	Cloud computing technology would/does provide a significant benefit to my organization.	1	2	3	4	5
9	Cloud computing technology is inherently reliable.	1	2	3	4	5
10	Cloud computing technology is more reliable than traditional computing methods.	1	2	3	4	5
11	Cloud computing systems are reliable.	1	2	3	4	5
12	Cloud computing provides a good value for the costs.	1	2	3	4	5
13	The cost of maintenance is lower with cloud computing technology than with traditional computing approaches.	1	2	3	4	5
14	I would consider cloud computing approaches to have considerable cost savings over traditional computing methods.	1	2	3	4	5
15	I would feel comfortable recommending cloud computing approaches in my organization.	1	2	3	4	5
16	I feel that cloud computing uses proven technology.	1	2	3	4	5

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