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Cloud Computing: TOE Adoption Factors By Service Model In Manufacturing

Michael McKinnie

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Cloud Computing: TOE Adoption Factors By Service Model In Manufacturing

By

Michael R. McKinnie

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree

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ACCEPTANCE

This dissertation was prepared under the direction of the *Michael R. McKinnie* Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Executive Doctorate in Business in the J. Mack Robinson College of Business of Georgia State University.

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ABSTRACT

Cloud Computing: Toe Adoption Factors By Service Model In Manufacturing

By

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Organizations are adopting cloud technologies for two primary reasons: to reduce costs and to enhance business agility. The pressure to innovate, reduce costs and respond quickly to changes in market demand brought about by intense global competition has U.S. manufacturing firms turning to cloud computing as an enabling strategy. Cloud computing is a service based information technology model that enables on-demand access to a shared pool of computing services provisioned over a broadband network. Cloud is categorized across three primary service models, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), differentiated by the cloud provider's level of responsibility for managing hardware services, development platforms and application services.

While prior research in cloud computing has sought to define the concept and explore the business value, empirical studies in the Information Systems literature stream are sparse, limited to exploratory case studies and SaaS research. Using the Technology, Organization, and Environment framework as a theoretical foundation, this research provides a holistic cloud adoption model inclusive of all cloud service layers. The study analyzes factors influencing organizational cloud adoption utilizing survey data from 150 U.S. manufacturing firms.

The results find organizational innovativeness as a crucial factor to cloud computing adoption in manufacturing. An inverse factor relationship suggests the more innovative the firm culture, the less likely it is to adopt cloud. Other significant adoption factors include trust and technical competency. Findings also suggest variations in adoption influences based on the cloud service model deployed. The study has strategic implications for both researchers and managers seeking to understand the antecedents to adoption, and for practitioners developing an organizational cloud strategy spanning multiple cloud service models. For vendors, the study provides insights that can be leveraged to inform product design, solution strategy, and value proposition creation for future cloud service offerings.

I CHAPTER 1: INTRODUCTION

I.1 Manufacturing Context

Organizations are actively considering the adoption of cloud computing as a strategy for cost reduction and to enable business agility (Lacity & Reynolds, 2014). IDC reports that 41% of manufacturing firms in the United States are accessing cloud delivered IT resources (Parker, 2011). Why the move towards cloud in manufacturing? U.S. manufacturing has been in decline since the mid to late 1990's due to numerous forces including cheaper overseas labor and more open trade agreements. The Great Recession further decimated U.S. manufacturing output, and the recovery has been slow, hindered by widening trade deficits and stagnating growth in domestic demand. Based on data from the Bureau of Labor Statistics (BLI), 5.7 million manufacturing jobs were lost in the United States from a cyclical peak in March 1998 to 2013, attributed primarily to trade deficits with China and Mexico and the Great Recession (Scott, 2015). BLI further reports a 21% decrease in manufacturing output as a percent of the national gross domestic product during this period.

U.S. manufacturers compete in a global marketplace driven by demands for product quality, industry requirements for operational efficiency, and market desires for greater customer focus. Cloud computing offers a mechanism for the manufacturing sector to manage IT related costs through the reduction or elimination of large capital expenditures on data centers, infrastructure investments, and perpetual software licenses. Resources tied up in the acquisition and maintenance of excessive computing capacity can be redeployed as cloud enables closer alignment between IT expenses and workload demands. Manufacturers polled by IDC cited reducing hardware spend as the number one business benefit for adopting cloud (Parker, 2011). In addition to cost drivers, the flexibility of the cloud computing model better positions firms to take advantage of new opportunities and lowers the exit costs for failed projects. Manufacturers seeking to benefit from new trends like reshoring, insourcing, and the internet of things (IoT) will leverage the cloud for enhanced agility. Reshoring involves the migration of production from China, Mexico, and other countries with low production costs back to the United States for logistical reasons, higher quality, and greater responsiveness. Boston Consulting Group reports a 20% year over year increase in manufacturing firms moving production from China to the United States with over 54% of large firms polled expressing an interest in reshoring (BCG, 2014).

I.2 Cloud Computing Background

From a business perspective, cloud computing provides a technology model for delivering IT resources and applications over the web and on-demand. The on-demand characteristic of cloud computing refers to the allocation of computing resources such as network bandwidth, server capacity, storage, and applications on an as-needed basis typically in a self-service arrangement with the cloud service provider. Cloud computing is dimensioned across three primary service models or types: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS), and can be deployed over a public cloud, private cloud or in a hybrid cloud configuration. Regardless of service model, the technical foundation of cloud computing leverages the core concepts of virtualization, multi-tenancy and web services to enable efficient and cost-effective provisioning of technology services (Marston et al., 2011). Virtualization describes the process of representing computing resources that appear real or physical to the user but are managed and created through software. Vendors have successfully virtualized operating systems, applications, servers, networks, and computers. The technology has existed since the 1960's but current day computing capabilities, performance, and lower costs have brought virtualization to the forefront of the contemporary computing paradigm (Marston et al., 2011). For example, instead of purchasing separate servers for each department in an organization, IT may deploy virtualization to partition one larger, more powerful server into multiple simulated servers. Each department is assigned its own virtual server, usually at a lower cost than the equivalent physical box. This arrangement offers several benefits such as enhanced resource utilization and flexibility by separating the computing environment from the physical servers.

The concept of having multiple customers on the same shared server accessing a single instance of the application software is referred to as multi-tenancy. It is conceptually similar to multifamily housing where tenants rent partitioned spaces of the same building. The third enabling concept of cloud computing is web services. Web services provide a standardized mechanism for computing resources to interact over a network. Cloud computing utilizes these three enabling technologies, virtualization, multi-tenancy and web services over high speed, broadband networks to provide an array of IT services through an invisible, location independence mechanism referred to as the cloud.

The evolution of cloud computing over the past few years is one of the major advances in the history of computing changing the way information technology services are invented, developed, deployed, maintained and purchased (Marston et al., 2011).

Cloud has even been described as the 5th utility behind water, gas, electricity, and telephone (Buyya et al., 2009).

I.3 Cloud Computing Adoption

Cloud computing is experiencing a stellar adoption rate. According to Goldman Sachs, the IT industry is 6-7 years into a twenty-plus year cloud computing cycle that will bring about unprecedented change for firms (Goldman Sachs, 2015). For new investments, many IT executives are deploying “cloud first” strategies to lead with cloud solutions over traditional on-premise IT. Cloud first offers organizations additional flexibility, quicker deployment, and lower ongoing maintenance and support. These benefits enhance the firm’s agility. Firms that have not yet embraced cloud to that degree pursue a “cloud also” policy, meaning that for each new IT application or resource evaluated, a comparable cloud-based solution should also be considered. In a recent survey of manufacturers, 61.6% indicated the adoption of a “cloud also” policy as their strategy for net new IT investments and 56.8% for replacing current IT services (IDC, 2015). In contrast, an earlier IDC manufacturing survey indicated that only 2.1% of firms polled were not intending to adopt cloud computing, confirming the high level of perceived benefits of cloud by the majority of respondents in the manufacturing sector (Parker, 2011). See Figure 1, Cloud adoption in manufacturing. Global public cloud IT services spending will grow from about $57 billion in 2014 to over $127 billion in 2018, six-times the overall market’s growth rate (IDC, 2014), approaching $191 billion by 2020 (KPMG, 2014).

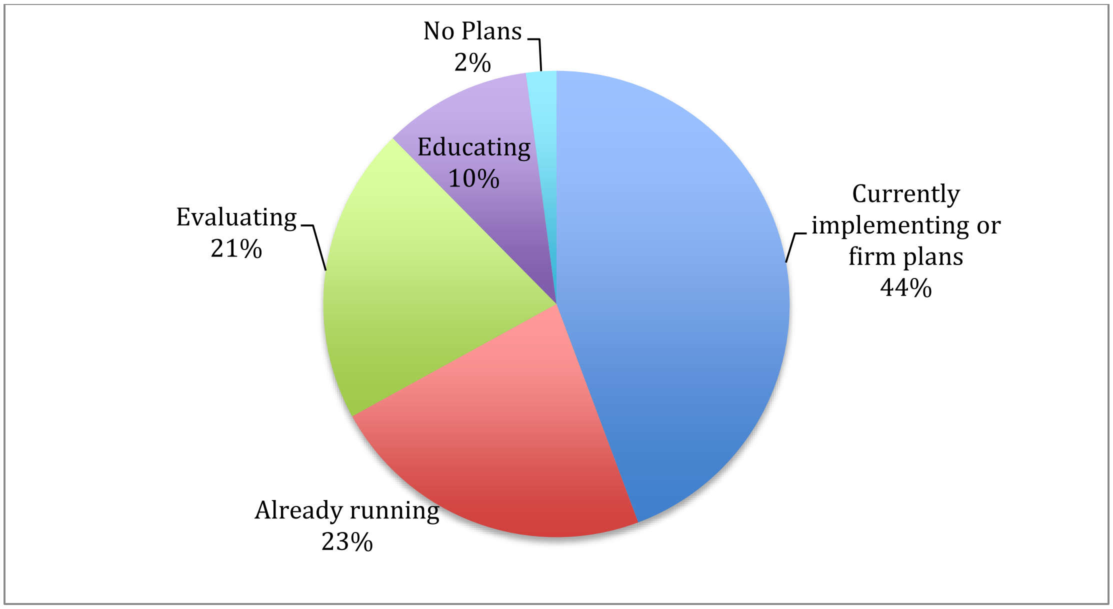


Figure 1 Cloud Adoption in Manufacturing (IDC, 2011)

The literature cites several factors driving the momentum in organizational adoption of cloud computing: IT cost reduction, better business focus achieved from turning IT asset management over to a cloud service provider, computing elasticity, and expanded access to technical and industry expertise (Lacity & Reynolds, 2014; Iyer & Henderson, 2012; Nkhoma & Dang, 2013). These reasons encompass expected and realized adoption benefits across an array of industry sectors. For manufacturing, cloud computing also enables firms to capture and analyze real-time data from embedded sensors in plant equipment, machinery, and materials for preventive maintenance and logistics optimization. Once in the cloud, ubiquitous access to applications and analytics will facilitate enterprise collaboration and provide transparency and visibility into demand planning and supply chain management processes resulting in increased agility (Xu, 2012).

I.4 Cloud Adoption Challenges

Despite the growing awareness of cloud computing's benefits, many organizations cautiously approach cloud computing due to numerous potential adoption challenges. Among the concerns are connectivity to on-premise applications, potential outages, loss of control over IT resources, and possible vendor lock-in in the absence of clearly defined standards (Marston et al., 2011). Through professional experience in working with firms considering adopting cloud computing, I have gained a greater sensitivity to the lack of understanding about cloud in the marketplace. Management knows it should be pursuing cloud but is not sure of how to navigate the process and often lacks awareness of the potential issues first time adopters are likely to face. For instance, migrating storage and backups from on-premise to an IaaS cloud service is an initial step taken by some practitioners. It can reduce hardware costs and provide greater flexibility. However, data governance issues and concerns of vendor lock-in due to proprietary storage formats may complicate even this seemingly low-risk strategy. A review of existing cloud research suggests that adoption challenges may differ by cloud service model – IaaS, PaaS, and SaaS. In an exploratory study, Loebbecke identified the service model dimension as a critical factor in designing a cloud readiness program for an extensive portfolio of IT applications at a major German manufacturer (Loebbecke et al., 2012). Certain existing IT services proved more ready for migration to the cloud than others. SaaS users face potential issues with application ownership and control, system reliability and security (Benlian & Hess, 2011; Janssen & Joha, 2011) while IaaS adopters contend with cost and service stability (Shin et al., 2014). A gap in the literature exists for studies that examine the organizational adoption of cloud computing encompassing the holistic notion of cloud service model.

I.5 Theoretical and Conceptual Framework

The Technology-Organization-Environment (TOE) framework (Tornatzky et al., 1990), has been used as a lens for studying IS adoption at the organizational level. TOE posits that successful adoption is not just a function of appropriate technology, but suggests that factors across technological, organizational and environmental contexts influence successful IS adoption at the organizational level. Oliveira used TOE to survey Portuguese manufacturing and service firms for key determinants of firm level cloud adoption (Oliveira et al., 2014). The study identified cost, technical readiness and management support as adoption factors; however, the research design failed to analyze the significance of these factors by cloud service model. Further transparency into the cloud adoption construct is required to elucidate possible adoption variations by service type.

This research conceptualizes cloud adoption through the TOE framework as a lens. The research model evaluates a theoretically informed combination of proven constructs adapted for cloud computing across technological, organizational and environmental contexts of the firm to identify salient factors that influence cloud computing adoption for IaaS, PaaS, and SaaS. To empirically test the model, I survey IS executives and senior managers from manufacturing firms across the United States. Influencing factors are then tested for both relevance and significance.

I.6 Motivation and Significance

The motivation of this study is to examine organizational level cloud adoption by service type for manufacturing firms. As cloud computing becomes the predominant platform for all computing services, a greater understanding of cloud adoption from multiple perspectives is warranted. Firm management has already begun using cloud services, is in the adoption process, or plans to adopt at some future date. Vendors see the rapid upswing in cloud services spending from analysts' reports along with lofty market projections for the future. Firms, such as Netsuite, Workday, and Salesforce, have seemingly leapfrogged many of the traditional providers of application software by offering location independent, easy to use, robust applications which do not require lengthy and expensive implementations, massive hardware expenditures, or a large staff of IT professionals to design, develop, test, maintain, and support complex business applications. Modular application development environments based on open standards enable a new wave of software developers to create new applications much faster without the worries of managing and maintaining the underlying infrastructure. And on-premise datacenters are being replaced with subscription-based computing services which can quickly scale to accommodate workload peaks or a flurry of new application users. For the CIO, CTOs and IS Managers, who recognize the need for an enterprise cloud strategy which provides considerations of all cloud service layers that may be deployed across the firm, this study provides informative insight.

The research questions are:

> *What technological, organizational and environmental factors influence organizational adoption of cloud computing for U.S. manufacturers? Do these factors differ by cloud service model?*

This study extends the coverage on cloud computing to provide particular insight into the adoption of cloud by service model – IaaS, PaaS, and SaaS. It contributes to IS adoption theory by validating the application of the TOE framework to cloud computing and providing a deeper understanding of relevant constructs for organizational cloud adoption. For practitioners, the study offers additional insight into the key factors of adoption and how they may differ by service model. This understanding will help inform the development of new cloud strategies and the assessment of existing programs that may involve more than one service model. For vendors, the study informs their product strategy by uncovering the adoption factors most important to existing and potential customers. It also provides insight into the structuring and design of more complex, enterprise offerings, which may bundle two or more combinations of Infrastructure as a Service, Platform as a Service, and Software as a Service in an enterprise offering.

I.7 Summary

This chapter introduces cloud computing from a business perspective, describes the basic cloud service models – IaaS, PaaS, and SaaS, and discusses cloud's core foundational concepts of virtualization, multi-tenancy and web services. It situates cloud adoption in the context of manufacturing firms within the United States and provides insight into its rapidly growing adoption. The Technology-Organizational-Environment theory is introduced as a theoretical framework for analyzing organizational cloud adoption, research methods discussed, and research questions addressed. The remaining chapters are outlined as follows. Chapter 2 provides a review of the current literature on the cloud computing model, cloud adoption, and organizational adoption theory. Chapter 3 introduces the research model and hypothesis development. Chapter 4 outlines the research methodology, instrument development, and data collection. Chapter 5 presents an analysis of the data and reports results. Finally, Chapter 6 offers the study conclusion, limitations, contributions and topics for future research.

II CHAPTER 2: LITERATURE REVIEW

This section begins with a more in-depth, technical definition of the cloud computing model, explaining the core characteristics, cloud service models, and various deployment models. An alternative definition of cloud computing is discussed, and a working definition is adopted from the cloud computing literature that will be used throughout the study. I conduct a focused review of the cloud computing literature situated primarily in the Information Systems research stream with an emphasis on adoption. The section concludes with an analysis of the TOE theory and its suitability for the study.

II.1 Cloud Computing Model

II.1.1 Definitions

Cloud computing involves the deployment of information technology applications, platforms and infrastructure over a network. The services are typically offered on-demand, are location independent, and are deployed via a pay-as-you-go utility model. According to the National Institute of Standards and Technology (NIST), the cloud is defined as a computing model that enables ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (Mell & Grance, 2011; Dillon et al. 2010; Ren et al., 2012). The configurable resources vary and may include networks, servers, storage, applications, and services. Five essential characteristics comprise the cloud computing model as depicted in Figure 2. Resources are pooled together and offered elastically, allowing companies to remedy an ongoing IT issue of overprovisioning of computing resources. Elasticity describes the capability of cloud to scale allocated computing resources up or down based on workload demand enabling the matching of resources to demand. Resource elasticity is fundamental to cloud computing's value proposition from an economic perspective (Venters & Whitley, 2012; Marston et al., 2011). The services are measured, so the consumer only pays for usage, and cloud services are available on-demand across a broad network.

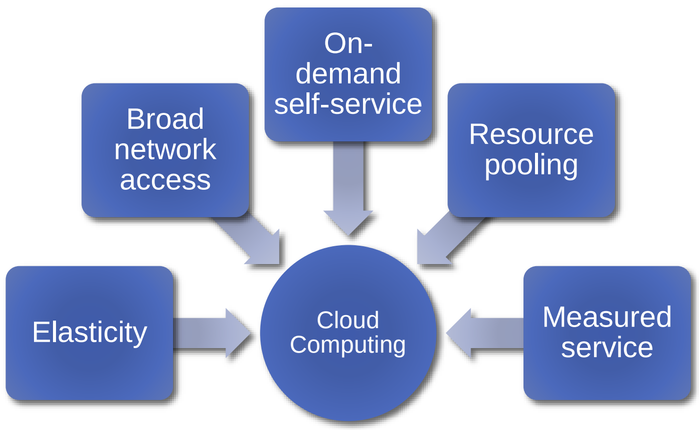


Figure 2 Characteristics of Cloud Computing

While the NIST definition is considered as a baseline reference, alternative definitions of cloud computing also exist. Motivated by the dream of utility computing, the Berkeley View of cloud computing evolved from months of research into intelligent machine usage and cloud computing brainstorming by a group of researchers at the University of California at Berkeley (Armbrust, et al. 2009). The Berkeley view defines cloud computing as the combination of two components: first, applications delivered as internet based services (Software as a Service) and secondly, the backend hardware and systems software in datacenters which render these services (the cloud). Once this service is offered on a pay-as-you-go basis, it is referred to as utility computing. As a result, cloud computing is the sum of SaaS and utility computing. The Berkeley view consciously disregards terms such as Infrastructure, Hardware, or Platform as a service due to the difficulty in defining what constitutes an infrastructure or a platform. The Berkeley model considers SaaS providers as cloud users and SaaS end users as their customers as depicted in the model in Figure 3.

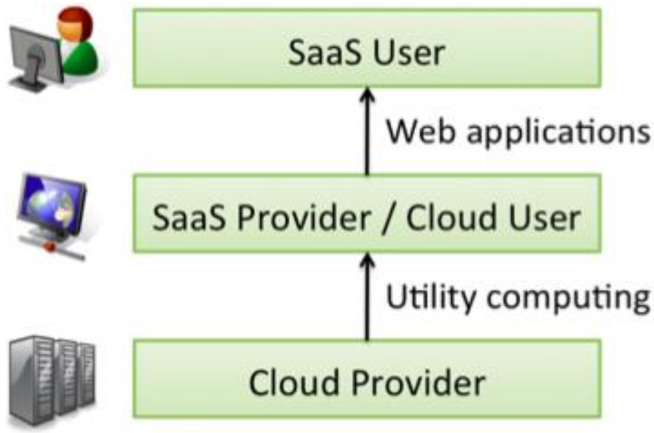


Figure 3 Berkeley Cloud Model.

The Berkeley conceptualization of cloud is narrower in focus favoring an infrastructure or datacenter based perspective like Amazon Web Services.

In this study, the authors examine the adoption of cloud services from the perspective of a manufacturing organization, not a hardware vendor. The author will leverage the NIST categorizations for cloud service types: IaaS, PaaS, and SaaS as they are more prominently used in practice. As a working definition, we adopt Marston's encapsulation of cloud's technical attributes and business benefits, defining cloud computing as:

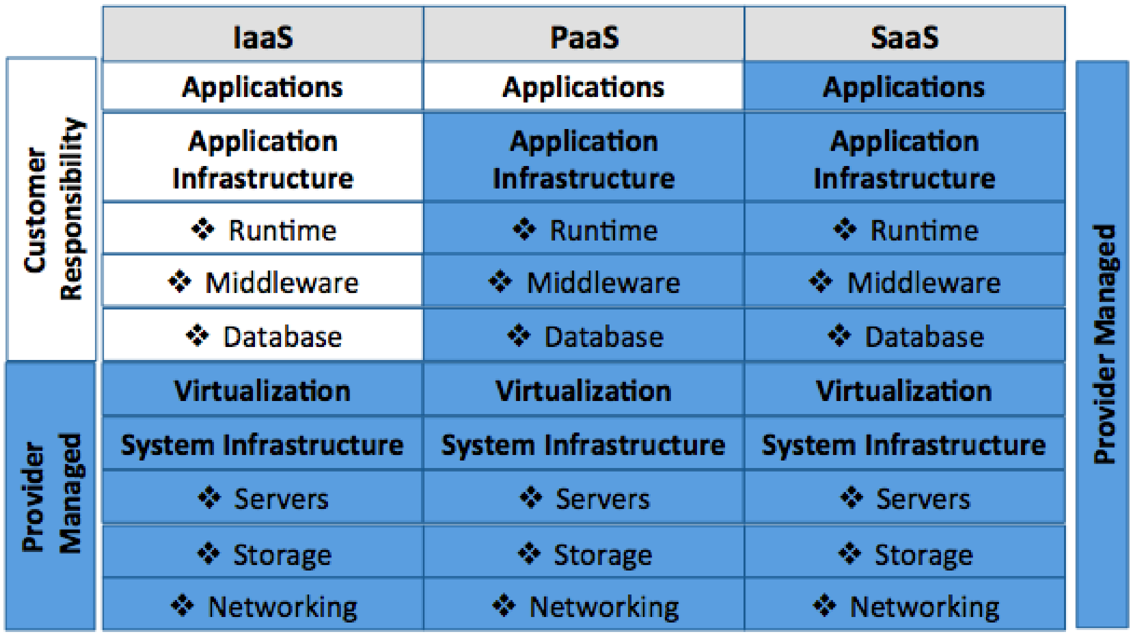
> "It is an information technology service model where computing services (both hardware and software) are delivered on-demand to customers over a network in a self-service fashion, independent of device and location. The resources required to provide the requisite quality-of- service levels are shared, dynamically scalable,

> rapidly provisioned, virtualized and released with minimal service provider interaction. Users pay for the service as an operating expense without incurring any significant initial capital expenditure, with the cloud services employing a metering system that divides the computing resource in appropriate blocks." (Marston et al., 2011).

This definition emphasizes the on-demand nature of the services, rapid provisioning, location independence, elasticity, and subscription modeling.

II.1.2 Service Models

The cloud computing model is categorized into three service models or types: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). (See Figure 4). In industry, practitioners may also refer to the service models as cloud layers or types. Expanding on the foundational NIST definition, many cloud providers have introduced additional cloud services such as Database as a Service (DbaaS) for managing structured data in the cloud, and Business Process as a Service (BPaaS), a cloud deployed business process that is layered on top of the three base cloud pillars. During this study, I will only refer to the three foundational cloud service models. The primary distinction between the service models is the level of ownership and responsibility for the cloud services by the consuming entity.



Source: Adapted from Goldman Sachs Investment Research (2015)

Figure 4 Cloud Service Models

IaaS is a cloud service model where computing resources, networks, and storage are deployed in the cloud and owned and managed by the cloud service provider. The customer pays a monthly fee or subscription for access to these infrastructure services. Vendors in the IaaS market include Amazon, Microsoft, IBM, and Google.

PaaS provides developers with a cloud-based platform for creating or configuring applications, software components, and interfaces. The cloud vendor is responsible for support of the programming environments, operating systems, libraries, services, and tools while the developer controls the applications and data. These middleware components allow PaaS developers to create and deploy custom applications in a fraction of the time required with traditional in-house development. Clients pursue PaaS services to create differentiated, value-added applications that can result in competitive advantage. Vendors like Oracle, Microsoft, and IBM are now offering databases in the PaaS layer for more efficient application development and on a unified platform which can be accessed from anywhere. This ubiquitous nature of PaaS enables developer collaboration from any location in the world and promotes the usage of standardized development tools, processes, and security models. Providers in the PaaS space include Salesforce, Microsoft, Red Hat, Google, Progress, IBM, and Engine Yard.

SaaS is a cloud service model providing the consumer with accessibility to a cloud-deployed application running on the vendor's infrastructure. Application access is typically through a thin client interface like a web browser or a program interface. Under this model, the cloud provider is responsible for everything - the application, the middleware, servers, and storage. SaaS applications are standardized and often deployed in a multitenant environment where several clients share one instance of the software, separated by partitions. This efficient arrangement transfers the non-value add activities like upgrades, patches, environment management and support to the cloud provider, leaving the customer to focus on the important reporting and analysis. Customers may also benefit from a broad user group offering an online knowledge base, domain expertise, and suggestions on ways to maximize the application's value to the business. This pool of users represents the voice of the customer and plays a major role in suggesting functional enhancements for the benefit of all clients. While the baseline application functionality is standardized, some vendors provide light configuration capabilities. In comparison to application outsourcing where the customer purchases a perpetual software license and outsources the hosting and management to a third party or software provider, ownership of SaaS applications remains with the cloud provider. Typically, the customer is only required to procure broadband access and a browser which has enabled SaaS purchases by departments or lines of businesses outside of the IT department. As a result, early SaaS applications targeted sales force automation, marketing, and human resource management. Today, the SaaS market is broad. Applications are available for departmental and enterprise use cases like ERP, supply chain management, and office productivity.

II.1.3 Benefits

Cloud offers rapid provisioning and release of computing resources with minimal management effort resulting in computing elasticity for organizations of all sizes. Rapid provisioning allows cloud services to be deployed in minutes in contrast with the traditional computing deployment models involving an often lengthy process of hardware and software acquisition, installation, setup and deployment. This reduction in acquisition time and effort can lead to much quicker time to value for the cloud solution versus traditional computing models. Also, counter to traditional computing models, with cloud computing the organization is not responsible for owning the infrastructure and only pays for resources consumed in a manner similar to a public utility model like water, electricity and gas (Armbrust, et al. 2010; Buyya et al. 2009). By not owning the resources, organization experience one of cloud's key benefits of transforming historically capital expenses into operating expenses (Marston et al., 2011). Transferring IT resource ownership frees up financial resources for other purposes and greatly increases a firm's IT flexibility by alleviating the need for entering the hardware and infrastructure business. The new ownership arrangement also lowers the barrier to exit troubled implementations. If the cloud service is not a good fit organizationally, the firm may end the subscription subject to the contract arrangements and choose a different cloud service provider.

Other benefits of cloud computing include low entry barriers for small and medium -sized firms and computing resource elasticity. Sophisticated computing resources such as predictive and advanced analytics, ERP applications, and modular development platforms are made available based on resource usage. As a result, the cloud may be used to neutralize the advantage large, multinational, resource rich firms have maintained over smaller, less capitalized businesses as computing power may be accessed via subscription pricing without large upfront cash outlays. Elasticity of the cloud model provides the option of linking available computing resources more closely with the actual demand for those resources. Estimates of server utilization rates range from only 5% to 20% (Armbrust, et al. 2010) which means most businesses currently pay for enormous amounts of unused capacity. Overprovisioning to meet peak demands drives up the initial capital budget and potentially locks firms into a hardware path that may prove obsolete within the coming years due to rapid innovation.

In summary, the cloud computing model enables organizations to utilize computing resources including servers, networks, storage, development platforms and software applications based on requirements and computing demand as a subscription based service. Cloud services are dimensioned across three primary service types: Infrastructure as a Service, Platform as a Service, and Software as a Service with each type reflecting varying levels of control and responsibility between the vendor and the business. The cloud model contrasts the traditional on-premise models where the business maintains complete ownership and control. See Figure 5 for a comparison diagram that maps the cloud service model to the on-premise model. The cloud model offers business flexibility in IT deployment, shorter implementation cycles, better matching of computing resources to demands, CapEx to OpEx expenditures, and more predictable overall IT costs.

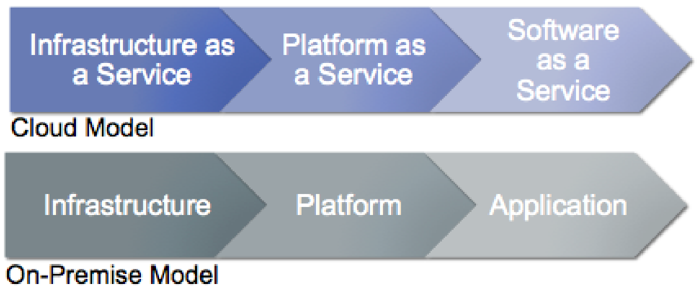


Figure 5 Cloud Service Model Mapping.

II.2 Cloud Computing in Information Systems

Cloud computing is a relatively new, but evolving research domain in information systems. In conducting this study, I searched over 20 top IS journals for relevant research including *MIS Quarterly*, *MISQE*, *Information Systems Research*, *Information & Management*, *Journal of Management Systems*, *Decision Support Systems*, *and European Journal of Information Systems*. The search was further restricted to articles published in 2009 and later as widely accepted or standard definitions of cloud computing were not in use before 2009. Although Salesforce.com began marketing SaaS applications in 1990, Amazon launched Web Services in 2006, and Microsoft introduced the Azure platform in 2008, the cloud computing industry existed in a state of truths mixed with half-truths and hype, and in need of standard nomenclature. Between 2009 and 2010, the National Institute of Technology Standards (NIST) and the University of California at Berkley both penned comprehensive definitions of cloud computing, detailing cloud characteristics, service models, and deployment schemes (Armbrust, et al. 2009; Mell & Grance, 2011).

In reviewing the literature published after 2009, a broad taxonomy of research categories surfaced - cloud computing economics, governance, security, adoption, strategy, and business value. Excluding research on technology adoption which will be examined in the next section, articles relevant to this study clustered around three primary categories – conceptual studies unpacking the cloud model, studies focusing on the value a business may derive from cloud computing and strategy discussions (See Table 1).

In a conceptual study, Marston pointed out the immediate access to computing resources, lower IT barriers to innovation and purchase flexibility as advantages of cloud computing versus traditional on-premise IT models (Marston et al., 2011). Another fundamental difference between cloud computing and prior models is the availability of on-demand computing services. On-demand services enable firms to convert fixed costs to variable ones, offer faster setup times, and remove capacity constraints (Chen and Wu, 2013). Other conceptual differences involve IT resource ownership. With traditional software applications, vendors provide perpetual licenses to the software and client firms are responsible for supplying and maintaining the hardware, infrastructure, data, and application on an ongoing basis. Under cloud, resource ownership stays with the vendor and these responsibilities are provided by a counterparty outside of the firm. This arrangement creates the need for a high degree of trust between the cloud service provider and the firm (Venters & Whitley, 2012). Contingent upon the service model adopted, the dependencies can span the entire computing value chain. While the cloud ownership arrangement can offer lower capital investments and ongoing costs, it opens the firm up to several risks such as limited control, vendor lock-in, and potential system downtime (Chen and Wu, 2013; Venters & Whitley, 2012). For some firms, these risks form barriers to cloud computing adoption.

In the first of a two part companion study on cloud's business value, Iyer and Henderson used visualization patterns to analyze the value proposition of 55 core cloud vendor solutions and their partner ecosystems covering a total 631 firms and representing IaaS, PaaS, and SaaS solutions (Iyer & Henderson, 2010). From these 55 core value propositions, the authors identified seven distinct cloud capabilities executives can leverage in cloud strategy formulation - controlled interface, sourcing independence, ubiquitous access, virtual business environments, addressability and traceabilty, and rapid elasticity.

Table 1 Cloud Categories and Themes

Category	**Study**	**Key Themes**
Conceptual	Marston et al., 2011; Chen & Wu, 2013; Mell & Grance, 2010; Venters & Whitley, 2012; Armbrust et al., 2009	Standard definitions of the cloud model. Main cloud barriers include connectivity, control, outage risks, vendor lock-in, privacy, security, and switching costs. Knowledge of and trust in cloud service provider are critical.
Business Value	Lacity & Reynolds, 2014; Iyer & Henderson, 2012; Iyer & Henderson, 2010	Business value includes organizational agility, cost avoidance, cost savings, rapid deployment, scalability, resource access, management simplicity, and better security and resiliency compared to in-house IT Cloud capabilities can be used to develop cloud strategies for unique competitive benefits
Strategy	Choudhary & Vithayathil, 2013; Richardson et al., 2014; Goutas et al., 2015	Cloud can enable organizational agility and may impact IT organizational structures Leverage points include innovation, optimization, and disruptive strategies Industry characteristics may impact cloud strategies

In their second study, Iyer and Henderson conducted field studies at seven early adopting cloud companies, developed six generic cloud benefits patterns, and identified business related strategic risks which can be managed using cloud (Iyer & Henderson, 2012) (See Table 2). Together, the studies show how cloud capabilities can be combined to drive specific business value and help mitigate strategic business risks.

The cloud computing model enables businesses to combine IT capabilities in ways which can drive innovation, agility, and competitive value. However, some firms approach cloud computing without a strategy (Goutas et al., 2015). Cloud strategy consists of the set of decisions enabling the creation and deployment of on-demand, network based IT resources which position the firm for organizational agility and cost reduction while considering the firm's industry and internal capabilities (Goutas et al., 2015; Iyer & Henderson, 2012). Organizations that recognize the strategic value cloud computing can offer incorporate cloud strategy as a component of their overall business strategy. Manufacturing firms seeking to benefit from the internet of things can rapidly establish proof-of-concepts with minimal capital outlays. Larger firms that operate IT in a shared service model should consider the organizational structure when adopting cloud. Maximizing value to the firm can result from reorganizing IT resources around a structure best suited for the type of cloud service under consideration. Infrastructure or commodity oriented deployments bring value to the firm as a cost center while value added cloud services such as CRM, ERP, and BI, which may be highly customized to firm business processes, are more valuable when IT functions as a profit center (Choudhary & Vithayathil, 2013). In the digital economy, cloud strategy is a component of business strategy.

Table 2 Cloud Business Benefit Patterns (Iyer & Henderson, 2012)

Benefit Patterns	Description
Increased business focus	Transference of routine IT tasks to cloud service providers to enable additional focus on value added business activities
Reusable infrastructure	Deployment of cloud based modular technology infrastructures to enable unique and business model development
Collective problem solving	Leveraging cloud vendor user groups and joint knowledgebase for additional functionality and continuous improvement
Business model experimentation	Development of custom applications and new business options using prebuilt modular functions and libraries provided by the vendor
Orchestrating dependencies	Acquiring pre-integrated application solutions through cloud vendor partner networks to address complete functionality required
Facebook effect	Combining cloud, social, mobile and real-time capabilities for enhanced usability and analytics

II.3 Cloud Adoption

Adoption studies may occur at two levels of analysis, individual, and organization. At the individual level studies explore an actor's propensity to use an innovation either voluntarily or under the organization's compulsion while organizational level studies address adoption behaviors for the group or at a firm level. Furthermore, adoption studies can target different phases on the adoption continuum such as pre-adoption, adoption, post-adoption assimilation, and intent to adopt. Ambiguity in conceptualization of the adoption construct can lead to issues with misinterpretation and misunderstanding of both the research model and results. This section defines adoption and reviews the evolving cloud computing adoption literature.

IS adoption research is grounded in the theoretical framework of diffusion of innovations (Rogers, 1995). From a technology diffusion viewpoint, IT implementation describes the organizational effort focused on diffusing an information technology throughout the firm (Cooper and Zmud, 1990). The outcome of interest is the organization's use of the technology to drive process changes, and alter structures and cultures, referred to as the degree of assimilation of an innovation (Gallivan, 2001). The simple diffusion process involves communicating an innovation through particular channels over time to members of a social system (Rogers, 1995). Researchers in the IS domain adapted simplified diffusion models to reflect the complete, multi-stage information system implementation process - Initiation, Adoption, Adaptation, Acceptance, Routinization, and Infusion (Kwon and Zmud ,1987; Cooper and Zmud, 1990). This six stage model can be aggregated into two phases. The first three stages make up the adoption phase while the second three refer to the post-adoptive stages.

In this study, the term ‘adoption’ is used generically in the context of the organization and is inclusive of varying degrees of the assimilation process (See Table 3). Initiation describes the initial search process where the firm identifies an innovation that addresses a business requirement. Once a decision is made to pursue, the innovation, formal adoption occurs. Next, an information system is modified and installed and users are trained. Together, these three phases represent adoption. Acceptance corresponds to system usage and routinization refers to the application of the innovation in common work processes. Finally, infusion describes the stage where the system is deeply integrated and embedded into business operations. The latter three stages represent the post adoptive stage.

Table 3 Adoption Stage Model

Stage	**Description**
Initiation	A match is found between an innovation and its application in the organization
Adoption	A decision is reached to invest resources to accommodate the implementation effort
Adaptation	The innovation is developed, installed and maintained. Procedures are developed and revised. Members are trained both in the new procedures and in the innovation
Acceptance	Organizational members are induced to commit to the innovation's usage
Routinization	Usage of the technology application is encouraged as a normal activity
Infusion	Increased organizational effectiveness is obtained by using the IT application in a more comprehensive and integrated manner to support higher level aspects of work.

Adoption Stage Model (Gallivan, 2001; Cooper & Zmud, 1990)

In comparison to the vast body of research on IT adoption, the empirical research on the adoption of cloud computing is relatively sparse. A cross section of both qualitative and quantitative studies on cloud adoption is presented in Table 4. Table 4 provides information on the industry sector, phenomenon of interest and cloud service model, highlighting the emphasis on SaaS studies. Most studies focus on cloud adoption at the individual level and are situated in European and Asian contexts. The table organization further highlights the gap in empirical research on organizational cloud adoption in the United States that encompasses the full dimension of cloud service models – IaaS, PaaS, and SaaS.

Loebbecke conducted a qualitative case study of early stage adoption on a cloud readiness model at Continental AG, a large, German automotive manufacturer. Continental developed a framework for assessing the appropriateness of migrating a portfolio of existing on-premise IT services to cloud services across all three service models (Loebbecke et al., 2012). The framework was used to classify IT portfolio as cloud ready based on attributes of vertical integration, the level of standardization, location, and degree of openness of cloud services. Service model was identified as an essential dimension for assessing readiness and the methodology revealed insights on important adoption barriers – compliance and security concerns (Loebbecke et al., 2012).

Table 4 Cloud Adoption Studies

Research	Industry	Service Model	Level of Analysis	Theory	Dependent Variable	Study Type	Context
Loebbecke et al. (2012) MISQ	Manufacturing	IaaS, PaaS, SaaS,	Organization	None	N/A	Case Study	German automotive supplier
Oliveira et al. (2014) (I&M)	Manufacturing and Service	Combined	Organization	TOE, DOI	Cloud Adoption	Survey	Portuguese firms
Benlian and Hess (2011) (DSS)	Multiple	SaaS	Individual within an organization	Theory of Reasoned Actions (TRA)	Intent to increase cloud SaaS adoption	Survey	German firms across industries
Wu (2011) (JSS)	High Technology	SaaS	Individual within an organization	TAM and Rough Set Theory (RST)	Behavioral Intention (BI) - SaaS adoption	Survey	Taiwanese companies
Garrison et al. (2012) (CACM)	Multiple	Combined	Firm	Resource Based View	Cloud deployment success	Survey	Global companies
Bhattacherjee et al. (2014) (EJIS)	Higher Education	SaaS	Consumer	Migration Theory	Cloud migration	Longitudinal survey	Korean undergraduate students
Shin, Jungwoo, et al. (2014)) (IEEE TEM)	End users	IaaS	Consumer	Mathematical	Consumer adoption behavior	Survey	Korean consumers of cloud storage
Janssen and Joha (2011) (ECIS 2011 Proceedings)	Public sector	SaaS	Organization	None	N/A	Qualitative Field Interviews	Dutch public sector

Two empirical adoption studies focused on the individual level adoption of SaaS solutions within an organization and a third followed consumer level adoption. Security, privacy, and reliability surfaced as primary risk factors creating barriers to adoption while cost advantages drove opportunity perceptions for individuals at German firms across multiple industries (Benlian & Hess, 2011). In a study of SaaS adoption intentions by individuals at high technology firms, social influence, perceived usefulness, security and trust proved strong determinants of SaaS usage (Wu, 2011). In a migration study of individual adoption of SaaS productivity applications, security concerns, and switching costs were dominant predictors (Bhattacherjee & Park, 2014). All three studies point to security concerns as a major determinant to cloud adoption.

Oliveira combined two organizational IT adoption theories, Technology-Organization-Environment (Tornatzky et al., 1990) and Diffusion of Innovation (Rogers, 1995) to evaluate the factors of cloud computing adoption in both manufacturing and services contexts (Oliveira et al., 2014). Study results indicated that cloud computing's advantages such as enhanced business operations and increased productivity play a more significant role in cloud adoption for manufacturing firms than for services firms. Contrary to the author's hypothesis, security concerns did not appear to inhibit cloud computing adoption for either industry sector. While this study analyzed organizational level cloud computing adoption, it failed to delineate adoption by cloud service model.

In summary, studies on cloud adoption require clear definition of adoption scope and service model coverage. Factor influences may differ for SaaS adoption versus IaaS or PaaS. Security concerns and compliance issues have been identified as barriers that must be overcome for an existing IT service or workload to be cloud ready. While security concerns were posited to have a significant influence on SaaS cloud adoption, results differed for adoption across an aggregated service model of SaaS, IaaS, and PaaS. From the current state of the literature, it cannot be determined whether concerns about security or other factors drive adoption for SaaS cloud services only.

Empirical studies that research adoption across service model are currently missing from the literature. As the research pool on cloud adoption grows, researchers will be better able to contextualize the role and influence of security concerns and cloud vendor trust on organizational adoption and to better identify other common adoption predictors across service models.

The next section provides an overview of the TOE framework and constructs relevant for IS adoption across technology innovations.

II.4 Technology, Organization, and Environment Framework

The Technology, Organization, and Environment (TOE) framework provides a multi-contextual lens for analyzing organizational or firm level IS adoption (Tornatzky et al., 1990; Iacovou et al., 1995). The technological context includes attributes of the IS such as functional capabilities, fit within the firm, and the technical infrastructure. It is inclusive of both human and technological resources (Zhu et al., 2006; Zhu et al., 2010). The organizational context reflects characteristics of the firms such as size, structure, readiness, and climate (Chau and Tam, 1997; Zhu et al., 2010). It can also include managerial structure, the degree of centralization, resources and communication processes (Oliveira et al., 2014). The environmental context reflects attributes external to the firm such as competition, market forces, and regulatory forces. It can also comprise organizations external to the firm with specific expertise to assist in IS adoption (Zhu et al., 2010).

The TOE framework has been used in a variety of IS adoption settings including ERP (Zhu et al., 2010), e-commerce (Mishra et al., 2007), patient tracking RFID (Cao et al., 2014), open systems (Chau & Tam, 1997), and electronic data interchange (Iacovou et al., 1995; Kuan & Chau, 2001) (See Table 5).

Table 5 TOE Studies

Author	Date	Journal	Study	Innovation
Oliveira et al.	2014	Information & Management	Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors	cloud adoption - 369 Portugese mfg and svc firms
Zhu, Y., Li, Y., Wang, W., & Chen, J.	2010	International Journal of Information Management	What leads to post-implementation success of ERP? An empirical study of the Chinese retail industry	ERP
Zhu, K., Dong, S., Xu, S. X., & Kraemer, K. L.	2006	European journal of information systems	Innovation diffusion in global contexts: determinants of post-adoption digital transformation of European companies	e-business
Zhu, K., Kraemer, K. L., & Xu, S.	2006	Management Science	The Process of Innovation Assimilation by Firms in Different Countries: A Technology Diffusion Perspective on E-Business	e-business assimilation
Hong, Weiyin, and Kevin Zhu	2006	Information & Management	Migrating to internet-based e-commerce: Factors affecting e-commerce adoption and migration at the firm level	e-commerce adoption
Zhu, K., & Kraemer, K. L.	2005	Information Systems Research	Post-Adoption Variations in Usage and Value of E-Business by Organizations: Cross-Country Evidence from the Retail Industry	e-business adoption
Zhu, Kevin, Kenneth Kraemer, and Sean Xu	2003	European Journal of Information Systems	Electronic business adoption by European firms: a cross-country assessment of the facilitators and inhibitors	e-business adoption

Within the TOE framework, the factors contained in the three contexts may vary across studies based on the specific attributes of the phenomena (Zhu et al., 2006). Technology readiness, expected benefits, and technical competence are often chosen as factors for the technological context; regulatory influences and competitive pressures for the environmental context; and firm size, management support, and organization readiness for the organizational context. Table 6 contains a representative list of adoption factors by context. Prior research on the phenomena of interest, subject matter expertise, and discussions with domain experts often influence the selection of specific factors by TOE context.

In summary, TOE provides a proven framework for studying organizational IS adoption across a variety of innovations. The framework expands the adoption discussion beyond a technology narrative and incorporates perspectives of the organization and the external environment. Informed by prior research, advice from subject matter experts, and discussions with practitioners, researchers carefully choose TOE constructs for modeling an innovation. TOE has been effectively applied to IS innovations such as ERP, EDI, and e-commerce. Thus far, major IS journals document only one study conducted using the TOE framework for the adoption of cloud computing (Oliveira et al., 2014). It is limited by geographic scope, Portugal, and does not capture or analyze variations in adoption based on cloud service model that restricts the applicability of the results for researchers and practitioners.

Table 6 TOE Constructs by Context

Study			***TOE Context***		
Author	**Date**	**Innovation**	**Technology**	**Organization**	**Environment**
Oliveira et al.	2014	cloud adoption	Technology readiness	Top management support Firm size	Competitive pressure Regulatory support
Venkatesh et al.	2012	interorganizational business process standards	Expected benefits Process compatibility Standards uncertainty Technology readiness	Organizational innovativeness	Relational trust
Mishra et al.	2007	e-commerce internet procurement	Technological resources	Organizational resources	External resources
Hong and Zhu	2006	e-commerce adoption	Technology integration Perceived obstacles	Web spending Web functionalities EDI use	Partner usage
Zhu et al.	2006	e-business	Technology readiness Technology integration	Firm size Global scope Managerial obstacles	Competition intensity Regulatory environment
Zhu and Kraemer	2005	e-business	Technology competence	Firm size International scope Financial commitment	Competitive pressure Regulatory support
Zhu et al.	2004	e-business	Technology readiness	Firm size Global scope Financial resources	Competition intensity Regulatory environment
Zhu et al.	2003	e-business - European firms	Technology competence	Firm scope Firm size	Consumer readiness Competitive pressure Lack of trading partner readiness
Kuan and Chau	2001	EDI	Perceived direct benefits Perceived indirect benefits	Perceived financial cost Perceived technical competence	Perceived industry pressure Perceived government pressure
Tan and Teo	2000	internet banking	Relative advantage Compatibility Complexity Trialability Risk		
Thong	1999	information systems adoption	Relative advantage Compatibility Complexity	Business size	External environment
Chau and Tam	1997	open systems	Perceived benefitsPerceived barriers Perceived importance of compliance	Complexity of IT InfrastructureSatisfaction with Existing Systems Formalization on System Development and Management	Market uncertainty
Iacovou et al.	1995	EDI	Perceived benefits	Organizational readiness	External pressure
Premkumar and Ramamurthy	1995	interorganizational systems		Internal need Top management support	Competitive pressure Exercised power
Orlikowski	1993	CASE tools	Role of IS in firm IS structure and operations IS policies and practices IS staff	Corporate strategies Structure and culture	Customers Competitors Available technology

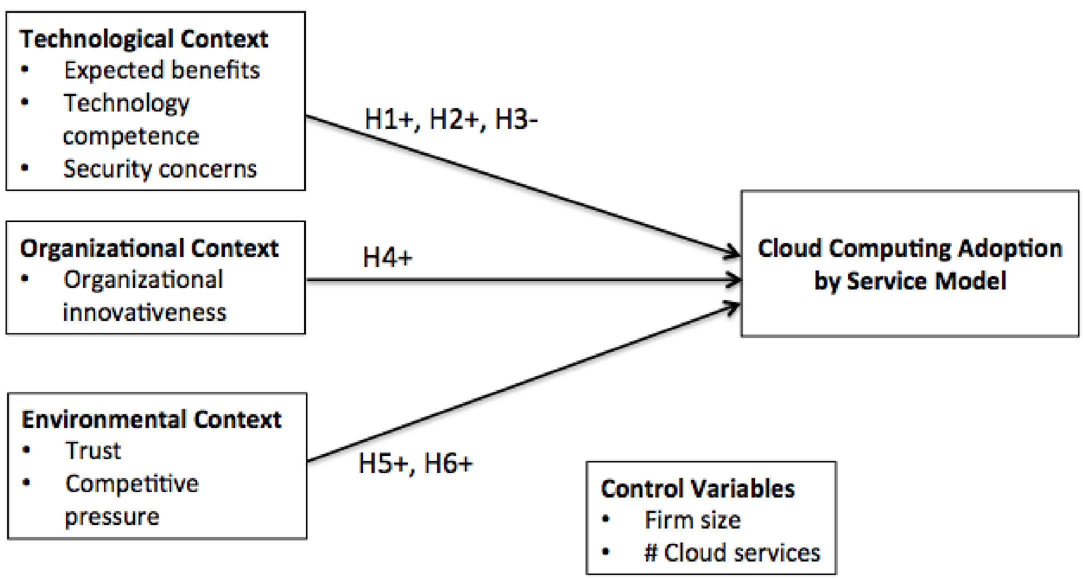
Study			*TOE Context*		
Author	**Date**	**Innovation**	**Technology**	**Organization**	**Environment**
Cooper and Zmud	1990	MRP	Technology complexity Task compatibility	User Organization	Environment

III CHAPTER 3: RESEARCH MODEL AND HYPOTHESIS DEVELOPMENT

III.1 Research Model

Informed by the TOE framework, I present a model of cloud computing adoption as depicted in Figure 6: Research Model. The model suggests six factors across the three TOE contexts which influence firm-level adoption of cloud computing. The conceptualized model is holistic and generalizes adoption for any combination of IaaS, PaaS, and SaaS. Firm size and the number of cloud services adopted are controls.

Figure 6 Research Model



The dependent variable, cloud adoption, is representative of both the stage of assimilation, a measure of the depth of usage within the organization, and the time since adoption, a reflection of the organization's cumulative experience with cloud computing (Gallivan, 2001; Purvis et al., 2001). Cloud computing encompasses a broad range of IT services delivered on-demand and in a cloud deployed format. While the cloud model provides for a set of defining characteristics discussed earlier, the cloud is inclusive of three different service types encompassing infrastructure, platforms, and software. In essence, the service model dimension represents three innovations within the same class, cloud computing. From the literature, the research objective for organizational innovation studies is motivated by identification of the determinants of innovation with respect to a technical domain, detecting the factors of innovative organizations, and evaluating the role of an innovative factor across innovations (Fichman, 2001). Fichman categorized the research styles as technology-focused, innovation-focused and factor-focused. Technology studies are concerned with models that explain innovation across a class of technologies to generalize explanatory factors across the entire class. For these cases, aggregated measures of assimilation such as the Guttman scale are appropriate (Fichman, 2001; Rai et al., 2009; Grover & Goslar, 1993). In this study, the Guttman scale is used to capture the organization's assimilation stage. By combining the measure of assimilation stage with the time since adoption, the model more accurately reflects the extent by which cloud computing is adopted and infused within the organization, and the organization's experience with the innovation. The conceptualization of adoption as the combination of assimilation stage and time since adoption is consistent with prior adoption research in cloud computing (Oliveira et al., 2014), EDI adoption (Chwelos et al., 2001), and RFID adoption (Thiesse et al., 2011).

For conceptualization of the independent variables across the technological, organizational and environmental contexts, I selected constructs drawn from previous TOE research that are likely to influence cloud adoption: expected benefits, technology competence, organizational innovativeness, and competitive pressure (Iacovou et al.,1995; Venkatesh & Bala, 2012; Oliveira et al., 2014; Zhu et al., 2003; Zhu et al., 2005; Zhu et al., 2010; Tornatzky et al., 1990).

In addition, two factors were chosen that are particularly relevant to cloud computing adoption – security and trust. Cloud computing is conducted over the internet and involves the relocation of organizational information to an outside third party, the cloud service provider. This service provider is typically an IT vendor that specializes in the provisioning of cloud-based software services, infrastructure services, middleware services or a combination of the three. Furthermore, cloud is often deployed in a multi-tenant environment, meaning numerous organizations' cloud applications run on the same infrastructure, which heightens concerns about data security and breaches (Oliveira et al., 2014). The cloud model also requires lots of trust between the organization and the cloud provider. In a study to determine the major factors influencing the adoption of SaaS applications in high technology enterprises, Wu identified security and trust as significant determinants (Wu, 2011). Garrison surveyed senior managers from 314 global firms across multiple industries finding trust as a factor most likely to enable successful cloud deployment across service models (Garrison et al., 2012).

In conclusion, the proposed research model depicts the relationships between select constructs across the technology, organization, and environment contexts expected to influence cloud computing adoption for the full spectrum of cloud services, hardware, middleware, and software. Control variables for firm size and the number of cloud service types adopted allow for focused analysis of the relationships between independent and dependent variables. The organizations' stage of cloud service assimilation and time since the service was selected are captured by the dependent variable, cloud adoption.

Table 7 contains a summary of the constructs used in the research model.

Table 7 Model Summary

Construct	Definition	Reference
Technological Context		
Expected benefits	The expected direct and indirect benefits a firm anticipates receiving from the adoption of cloud computing. The advantage an organization gains through the adoption of cloud services over the current systems or processes in use.	Lacity & Reynolds (2014); Venkatesh & Bala (2012); Zhu et al. (2006b); Chwelos et al. (2001)
Technology competence	An organization's internal IS capabilities inclusive of technology infrastructure and IT human resources	Zhu et al. (2006b); Zhu & Kraemer (2005); Zhu et al. (2003); Lu & Ramamurthy (2011)
Security concerns	The degree to which the cloud is deemed insecure for transmitting and storing data	Zhu et al. (2006b); Oliveira et al. (2014); Benlian & Hess (2011)
Organizational Context		
Organizational innovativeness	The organization's orientation toward innovation; the openness to new ideas based on the firm culture	Venkatesh et al. (2012); Hurley & Hunt (1998)
Environmental Context		
Trust	Trust between the client organization and the cloud service provider. Involves perceptions of trustworthiness and reliability on the provider's part in communications and relationships, technical capabilities, resources, and infrastructure	Garrison et al. (2012); Venkatesh & Bala (2012); Zaheer & Venkatraman (1995)
Competitive pressure	Pressure felt by the firm from industry competitors	Zhu et al. (2003); Zhu & Kraemer (2005); Oliveira et al. (2014)
Control Variables		
Firm Size	Size of the firm based on number of employees and revenue.	Zhu et al. (2003); Zhu & Kraemer (2005); Oliveira et al. (2014)
# Cloud Services	Represents a count of the cloud service types adopted, reflecting the firm's breadth of experience with multiple service models	New control measure

Construct	Definition	Reference
Dependent Variable		
Cloud Computing Adoption	Represents the stage of assimilation of a cloud service (IaaS, PaaS, or SaaS) within the organization using a seven-stage model and the time since the innovation was adopted	Rai et al. (2009); Fichman & Kemerer (1997); Purvis et al. (2001); Thiesse et al. (2011); Chwelos et al. (2001)

III.2 Hypothesis Development

This section provides a description of each TOE context and the hypotheses defining the relationships between model constructs. The model relationships between independent and dependent latent variables are designated as positive or negative.

III.2.1 Technological Context

The technological context represents attributes of the information system that may impact adoption and includes the availability of those requisite technologies both inside and outside the firm (Tornatzky et al., 1990; Zhu et al., 2010). Perceived or expected benefits describe the advantages a firm anticipates procuring through the adoption of a new IS innovation over the current systems or processes in use (Chwelos et al., 2001). These benefits include both the direct savings and efficiencies brought about by the new system as well as the indirect impacts accruing to the firm. A firm must be motivated to adopt the new technology to overtake the existing forces of inertia. Where the expectations are low, firms are not projected to pursue a new innovation but take a wait and see posture until they acquire additional knowledge of the potential benefits. Cloud computing offers adopting firms the following advantages: (1) cost savings; (2) cost avoidance; (3) rapid deployment and enhanced scalability; (4) increased systems security and resiliency; (5) simplified management of IT resources; and (6) the ability to free up in-house IT resources and focus them on strategic activities (Lacity & Reynolds, 2014). Firms with a greater awareness of cloud computing benefits are more likely to adopt cloud services.

H1*: Expected benefits will positively impact cloud computing adoption.*

Several past studies have posited technical readiness as a key determinant of IS adoption across multiple innovations including cloud computing and e-business (Zhu et al., 2006; Zhu et al., 2006b; Oliveira et al., 2014). During the early days of the internet, metrics such as percentages of employees with internet access or the number of resources with access to personal computers indicated the potential penetration and adoption of e-business applications. However, in most current U.S. companies, broadband internet capabilities are assumed the standard, rendering the former notion of readiness no longer relevant. IT capability points to the firm's technological foundation. Readiness in the cloud computing era includes a firm's knowledge and capability to support open architectures, and to manage orchestration and data management services, network communication services and applications services in a heterogeneous computing environment (Lu & Ramamurthy, 2011). Experience and facility with computing services are important in cloud computing as infrastructure, platforms and applications are rendered as services. Consistent with previous studies, the research model conceptualizes technology competence as the combination of IT capabilities and the availability of resources within the firm with expertise in foundational cloud knowledge (Zhu et al., 2003; Zhu and Kraemer, 2005). Firms with higher levels of knowledge in cloud computing, networks, intranets, and APIs are better positioned to make sense of and adopt a new cloud computing technology.

***H2**: Technology competence will positively impact cloud computing adoption.*

Cloud computing is deployed over the Internet and is not limited to the transmission of information and data over internal networking and communication systems. Cloud datacenters are normally located off-premise to the host organization and firm information resides on shared infrastructure resources with other customers in a multi-tenant arrangement. This separation of the data center from the host firm's premise is typical for cloud computing deployments; however, firms may deploy other arrangements such as hybrid clouds, private clouds, and managed private clouds. Security refers to an organization's concerns about data leakage, loss of privacy, and the acquisition of confidential or proprietary firm and customer information by an outside party. Cloud computing configurations are susceptible to denial of service (DoS) attacks where hackers render a cloud service unavailable either temporarily or indefinitely. The lack of access to information, applications, or data can be a cause of great concern to the firm. Cloud data may be compromised by viruses, malware, and botware that infect the cloud resources (Bhattacherjee & Park, 2014). Due to concerns about data, outages, breaches, and loss, security has been identified as a key determinant of cloud adoption in previous studies on cloud computing (Benlian & Hess, 2011; Wu, 2011; Oliveira et al., 2014; Chen & Wu, 2013; Choudhary & Vithayathil, 2013). In most cases, concerns about security create a barrier to cloud adoption.

***H3**: Security concerns will negatively impact cloud computing adoption.*

III.2.2 Organizational Context

The organizational context reflects characteristics of the firms such as size structure, organizational readiness, and climate (Chau and Tam, 1997; Zhu et al., 2010). It can also include managerial structure, the degree of centralization, resources and communication processes which serve to impact or influence an organization's adoption of an innovation (Oliveira et al., 2014). Within this context, I examine a construct that reflects the organization's attitude towards the adoption of a new innovation – organizational innovativeness.

Organizational innovativeness refers to the firm's orientation toward innovation, and the openness to new ideas based on the firm culture (Hurley & Hult, 1998). Organizations that are willing to experiment with new technologies, processes and methods will be less averse at trying a new computing model. Innovative firms are more likely to recognize the potential benefits of cloud computing and envision the impact it may have on their organization. This propensity for the acquisition of new ideas and better ways of doing things can permeate throughout an organization, which can result in greater employee acceptance of a new information system. Firms with this orientation and culture towards innovation will probably consider adopting new technical innovations (Venkatesh & Bala, 2012).

***H4**: Organizational innovativeness will positively influence cloud computing adoption*

III.2.3 Environmental Context

The environmental context reflects the external environment in which the firm operates and includes competitive, market, and regulatory forces. It can also include the availability of organizations external to the firm with specific expertise to assist in IS adoption (Zhu et al., 2010). In this context, I explore two constructs that relate to cloud computing adoption – trust and competitive pressure.

The construct 'trust' refers to the level of trust between the client organization and the cloud provider in an ongoing cloud computing relationship. It involves perceptions of trustworthiness and reliability on the vendor's part in communications and relationships, technical capabilities, resources, and infrastructure (Garrison et al., 2012; Zaheer & Venkatraman, 1995). Service level agreements are established to dictate the terms of the agreed upon services, but these are of no utility at a moment of technical failure. The firm acquiring cloud technology is vulnerable to the cloud provider and must anticipate that the selected vendor will operate in accordance with the contract and the best interest of the host firm. Due to the nature of the cloud computing model, a possibility exists that the cloud service provider may expose, either directly or inadvertently, intimate knowledge of the client firm's business processes, data, and technology platforms (Rai et al., 2009). Higher levels of vendor trust should enhance adoption of cloud technology.

H5*: Vendor trust will positively influence cloud computing adoption*

Pressure to adopt an innovation based on another firm's decision to implement has been widely researched in the IS literature (Oliveira, 2014; Zhu & Kraemer, 2005; Zhu et al., 2006; Premkumar & Ramamurthy, 1995). Competitive pressure refers to the external influence competitors exert on a firm to adopt cloud computing. Cloud computing may be strategic to a firm resulting in a short-term competitive advantage for early adopters if it enables differentiation or results in a lower cost structure (Swanson, 1994). Organizations that invest in and create superior relationships with a cloud provider can create competitive advantage, even though the cloud service is offered and available to other firms (Garrison et al., 2012). The external influence of peer firms believed to be benefitting from cost reductions or experiencing other advantages due to cloud computing may influence a firm's decision to procure cloud services.

H6*: Competitive pressure will positively influence cloud computing adoption*

III.2.4 Control Variables

To focus the analysis on the independent constructs identified above, I control for organizational size and the number of cloud service types adopted. Firm size is typically associated with successful IS adoption (Gurbaxani and Whang 1991, Zhu et al. 2003). Size refers to the relative size of an organization as represented by resources including employees, assets, and intellectual property. Larger firms are considered better suited to adopt a new IS due to the availability of slack resources and increased financial commitments (Iacovou et al.,1995; Zhu et al., 2010). The number of cloud services represents a count of the cloud service models a firm has adopted. This metric reflects the breadth of total experience an organization has with cloud computing across one or more of the three service models: IaaS, PaaS, and SaaS. It is included as a mechanism to control for firms with deep experience and expertise across the class of innovations as compared to those adopting cloud computing for the first time. Without this control, firms with multiple cloud service models may report higher degrees of adoption due to prior cloud experience. I control for industry effects through the research design as outlined in the methodology, Section 4.1. By isolating the analysis to one industry, manufacturing, domiciled in the United States, the design allows for control of extraneous industry and geographic factors (Zhu & Kraemer, 2005).

IV CHAPTER 4: RESEARCH METHODOLOGY

This chapter outlines the research design, instrument development, participant selection, and data collection processes used in this cloud computing adoption study.

IV.1 Research Design

The intent of the study was to identify the salient factors affecting cloud computing adoption at the organizational level for manufacturing firms in the United States. While qualitative case designs providing rich detail and descriptions have been used to research cloud adoption in a manufacturing context (Loebbecke et al., 2012), I followed a quantitative approach to establishing a basis for greater generalization in the analysis of the phenomena. Survey research is recommended in MIS studies when the phenomena of interest is studied in their natural setting, occurs in the current time or recent past, the researcher has no control of the independent and dependent variables, and the research focuses on 'what' is happening (Pinsonneault & Kraemer, 1993). For analysis of situations involving contemporary phenomena where interventions are not used, the quantitative survey method is appropriate (Yin, 2009).

Since the research explores adoption from the firm perspective, an organizational level unit of analysis is utilized. Study participants were required to be CIOs, CTOs, IS managers, supervisors, and consultants at manufacturing firms domiciled within the United States. This requirement allowed for a specific focus on adoption phenomena without the potential impact of industry or geographic effects. These individuals serve as key informants for their organizations and were required to be knowledgeable of cloud computing adoption at the organizational level. In light of the variety of definitions of cloud computing and the potential confusion on terminology around cloud service models, the online survey provided respondents with the NIST definition of cloud computing (Mell & Grance, 2011) and a description of each service model – IaaS, PaaS, and SaaS. This measure was implemented to establish a common understanding of specific terms used throughout the survey and to set boundaries around the survey scope. Participation was limited to individuals from the information technology or information systems organizations within their respective firms for two reasons. First, representatives from general management or lines of business units probably would not have the technical knowledge required to complete the survey, especially in a manufacturing environment. This assumption may have been different in other industries such as high technology. Second, IT organizations have visibility of the entire technology landscape and are better positioned to provide an enterprise adoption perspective. The IT function supports infrastructure, application development platforms, databases, networks, mobile computing and software applications. These measures helped to enhance the content validity of the study.

Data collection was performed via an on-line, web based survey instrument. Respondents were screened using the Qualtrics online research panel platform. The survey instrument was architected for deployment through a smartphone or tablet device in addition to laptops and desktop interfaces. This measure was taken in the event potential respondents would be averse to participating in research on innovative technologies that failed to utilize technologically savvy methods. The web provided an efficient mechanism for data collection from a broad spectrum of respondents representing manufacturing firms geographically dispersed throughout the United States.

Subjects whose organization had experience with more than one cloud service model were required to choose the one for which they believed had provided the firm the greatest business value. All questions were directed towards this area of cloud computing adoption. The survey captured the subject's selected cloud service entry as a variable to ensure that participants remained focused on the selected cloud service. Subsequent survey questions referred to this selection by name throughout the duration of the survey.

IV.2 Instrument Development

Informed by prior research in IS adoption and cloud computing, I developed an instrument to collect empirical data on cloud computing adoption within U.S. manufacturing firms. Leveraging existing scales enhances the reliability in the measurement of latent constructs and provides a reference for comparison with other studies (Straub, 1989). In some cases, scale items had to be adapted for cloud computing. The cloud computing literature, industry knowledge, and consulting studies informed the specific item development for the construct expected benefits. The constructs expected benefits, technology competence, security, organizational innovativeness, trust, and competitive pressure were measured using a 7 point Likert-type scale ranging from "strongly-disagree" to "strongly agree."

For the construct cloud adoption, a seven-item Guttman scale was employed to assess the assimilation stage of the cloud service innovation. While some adoption studies use a dichotomous variable, a multi-item scale better represents the level of adoption of an innovation. Once an innovative technology like cloud computing is introduced to an organization, it progresses through several stages. The scale incorporates multiple stages of assimilation from awareness and interest to adoption, and routinization. The notion of assimilation represents the extent to which the technology innovation is diffused across the organization (Purvis et al., 2011). Once adopted, the technology becomes routinized within the organization and deployed across a broad range of use cases (Gallivan, 2001). Rai used a similar scale when measuring electronic procurement innovation (Rai et al., 2009) and Fichman deployed a Guttman scale in assessing the adoption of software process innovations (Fichman & Kemerer, 1997). Table 8 lists the measurement items and Table 9, the assimilation scale.

Once developed, the survey instrument was subjected to a series of pretests. In the first phase, three subject matter experts (SMEs), a researcher, and a manufacturing industry technologist reviewed the overall content for readability, format, and understanding. Based on recommendations from cloud SMEs, the wording of Security construct items was modified for enhanced clarity. After multiple iterations of testing, a final survey version emerged for usability testing. This second testing phase focused on the survey ease of use, logic, and programming flow. Members of the Qualtrics team involved with the project spent several days attempting to break the online survey and validate logic paths. In total, 50 usability tests were conducted before releasing the survey into production.

Table 8 Measurement Items

Construct	**ID**	**Item**
Technological Context		
Expected Benefits		
	EB1	The use of cloud computing will help us reduce or avoid costs
	EB2	The use of cloud computing will help us deploy solutions quicker
	EB3	Cloud computing allows you to manage business operations in an efficient way
	EB4	The use of cloud computing services improves the quality of operations.
	EB5	Using cloud computing allows you to perform specific tasks more quickly
Technology competence		
	TC1	Data management services and architectures (e.g., databases, data warehousing, data availability, storage, accessibility, sharing, etc.)
	TC2	Network communication services (e.g., connectivity, reliability, availability, LAN, WAN, etc.)
	TC3	Application portfolio & services (e.g., ERP, ASP, SCM, reusable software modules/components, APIs, emerging technologies, etc.)
	TC4	IT facilities' operations/services (e.g., servers, large-scale processors, performance monitors, etc.)
	TC5	Our organization has the in-house expertise to implement cloud computing
Security		
	SC1	The degree to which your company is concerned about the security of data stored in the cloud
	SC2	The degree to which your company is concerned about the security of data transmission to and from the cloud
	SC3	The degree to which your customers are concerned about the security of data stored in the cloud
	SC4	The degree to which your customers are concerned about the privacy of data stored in the cloud
Organizational context		
Organizational innovativeness		
	OI1	My organization readily accepts innovations based on research results
	OI2*	Management in my organization actively seeks innovative ideas
	OI3	Innovation is readily accepted in this organization.
Environmental context		
Trust		
	T1	The cloud vendor and our organization have a high level of mutual trust
	T2	The cloud vendor is well known for fair dealing
	T3	The cloud vendor stands by its word
Competitive pressure		
	CP1	Organization thinks that cloud computing has an influence on competition in their industry
	CP2*	Our firm is under pressure from competitors to adopt cloud computing.
	CP3	Some of our competitors have already started using cloud computing

Controls		
Firm size		
	FS1	Number of employees at firm
	FS2	Annual Revenue in the previous year
# Cloud Services		
	CSV	Count of the number of cloud service types deployed
Dependent variable		
Cloud computing adoption		
	CC1	Cloud Assimilation
	CC2	Time since adoption

* Items not used in final model

Table 9 Cloud Assimilation Scale

Stage	Criteria to enter stage	Survey Item
1. Awareness	Key decision makers are aware of technologies	Informant is familiar with <XXX> technologies.
2. Interest	The organization is committed to actively learn more about <XXX> technologies.	Informant is aware of plans to use <XXX> technologies within the next 12 months.
3. Evaluation/ trial	The organization has acquired specific innovation-related products and has initiated evaluation or trial.	The location has acquired <XXX> technologies. The location is evaluating or trialing any <XXX> technologies.
4. Commitment	The organization has committed to use <XXX> technologies in a significant way.	Specific <XXX> technologies are planned, in progress, implemented, or canceled.
5. Limited deployment	The organization has established a program of regular, but limited, use of <XXX> technologies for its potential use cases.	Organization uses <XXX> technologies for between 5 percent and 25 percent of its potential use cases.
6. Partial deployment	The organization has established a program of regular, but limited, use of <XXX> technologies.	Organization uses <XXX> technologies for between 25 percent and 50 percent of its potential use cases.
7. General deployment	The organization has reached a state where <XXX> technologies are used on a substantial fraction of its potential use cases.	Organization uses <XXX> technologies for more than 50 percent of its potential use cases.

Note: The Guttman scale captured each informant's response for a specific cloud service model; <XXX> was replaced with IaaS, PaaS, or SaaS based on the cloud service type that brought the most business value to the organization as reported by the informant.

IV.3 Selection of Survey Participants (Sample)

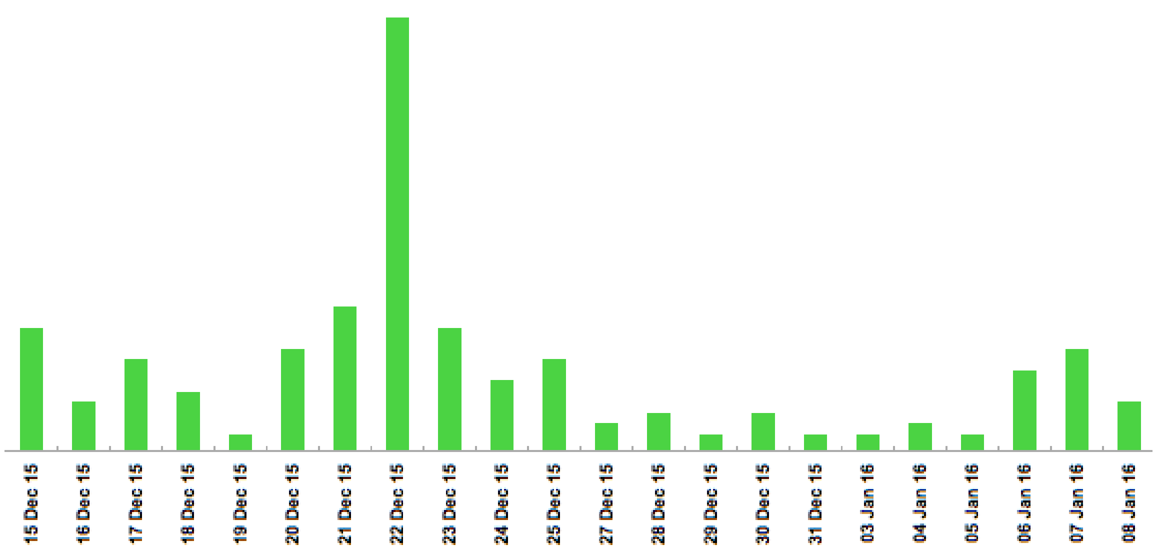
Due to time, cost, and resource accessibility constraints and other factors, the study population was limited to IS professionals in U.S. firms who have chosen to participate in online research panels. The selected sampling strategy was to generate a target of 50 completed survey responses for each cloud service type – IaaS, PaaS, and SaaS for a total sample of 150. This non-proportional quota based sampling approach was chosen to provide equal representation across cloud service models in a time constrained survey period. The method is less restrictive than proportional quota sampling where the proportion of respondents in each subgroup would reflect the population (Bhattacherjee, 2012). There are several cloud adoptions studies in the literature which focus on software as a service, but very few that cover platform and infrastructure. While the non-proportional quota approach may influence the generalizability of results, the cumulative results of many studies of cloud adoption will enlighten the understanding of cloud computing by both practitioners and researchers (Stone, 1978).

This study was designed to focus on cloud computing adoption within a specific industry sector – manufacturing. A Qualtrics research panel of technology executives and managers was used to identify and invite potential subjects to participate in the survey. A total of 1,070 respondents launched the survey. In the first section of the survey, respondents were screened for industry sector and organization location. Those not in U.S. manufacturing firms were eliminated, resulting in 863 responses. Participants were provided definitions of cloud computing and three service models, IaaS, PaaS, and SaaS, and asked to confirm knowledge of their organization's usage of at least one of the cloud areas. Twenty three percent of the respondents did not report knowledge of their firms' efforts to adopt cloud computing and were removed from the survey, leaving 660 valid responses. After the screening section, subjects were asked to acknowledge a "consent to participate" yielding 513 respondents, which represented a raw response rate of 47.9%. For several reasons including quality checks embedded within the instrument, incomplete responses, and informants unable or unwilling to answer all required questions, 363 respondents failed to complete the survey. A total of 150 respondents completed the survey, yielding a 14% final response rate.

IV.4 Data Collection

A soft launch of the survey was executed on December 15, 2015, where data was collected from 13 respondents. Based on an initial review of the data, the online survey was updated to include quality checks and modifications to facilitate easier back-end analysis, then reopened for the full launch. Sixty-one completed survey responses were recorded over the next seven days, and the SaaS and IaaS quotas were met by the end of December. PaaS responses trailed at only 30 completes. During the first week of January, the quotas were reopened to allow additional responses in the SaaS and IaaS categories to reach the target. Final counts were IaaS – 60, PaaS – 31, SaaS – 59 for a total of 150 responses. Figure 7 below depicts the number of completed survey responses by date.

Figure 7 Completed Survey Responses by Date



The study targeted key informants for each participating firm who would serve as the voice of the company with regards to cloud computing adoption. This assumes both the technical knowledge of cloud, understanding of the firm's existing infrastructure and systems, and visibility of cloud projects within the organization. Over 76% of responders represent an executive or managerial role within the information systems and technology organizations. The remaining 23% were supervisors or consultants. Regarding IS experience, over 80% of the respondents have been in their current position for over 5 years. By design, all firms are domiciled in the U.S. and 89% reported having centralized IT operations. The distribution between small and medium sized versus larger enterprises was slightly skewed towards the large firms, with 55% of firms having > 1,000 employees and 45% with less than 1,000. Sample characteristics are shown in Table 10: Sample Characteristics.

Table 10 Sample Characteristics

(N=150)

	N	Percent
Industry		
Manufacturing	150	100
Cloud Service Type Selected		
IaaS	60	40
PaaS	31	20.7
SaaS	59	39.3
Firm Size		
# of Employees		
1 - 49	10	6.7
50 - 999	57	38.0
1,000 - 4,999	49	32.7
5,000 or more	34	22.6
Annual Revenue		
< 6 million	32	21.3
6 - 25 million	26	17.3
25 - 125 million	31	20.7
125 million - 1 billion	27	18.0
> 1 billion	28	18.7
Missing	6	4.0
Firm Scope		
IT Organizational Structure		
Centralized	134	89.3
Decentralized	16	10.7

(N=150)

	N	Percent
Informant Position		
Title		
CIO, CTO, VP of IS or IT	32	21.3
IS or IT Manager or Director	83	55.3
IS or IT Supervisor	20	13.3
IS or IT Consultant	15	10.0
Tenure in position		
Less than 5 years	28	18.7
5-10 years	52	34.6
10-15 years	42	28.0
Over 15 years	28	18.7

Role in cloud computing adoption (more than 1 role allowed)

Decision Maker	86	38.4
Decision Influencer	74	33.0
Decision Implementer	39	17.4
User	25	11.2
Total	224	100.0

Assimilation stage

N	Valid	150
	Missing	0
Mean		2.82
Std. Error of Mean		0.176
Median		1.5
Mode		1
Std. Deviation		2.158
Variance		4.659
Range		6
Minimum		1
Maximum		7

Frequencies: Assimilation stage

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	75	50.0	50.0	50.0
	2	12	8.0	8.0	58.0
	3	9	6.0	6.0	64.0
	4	8	5.3	5.3	69.3
	5	21	14.0	14.0	83.3
	6	15	10.0	10.0	93.3
	7	10	6.7	6.7	100.0
	Total	150	100.0	100.0	

When adopting cloud computing, firms may utilize different strategies based on specific project requirements, in-house skill sets, technical strategy and overall business strategy. Organizations often adopt more than one cloud service model. In the survey, sample respondents were allowed to select more than one cloud service their organization had adopted. On average, each firm has explored or is currently using an average of 1.77 cloud service types meaning their view of cloud computing crosses multiple tiers or cloud layers. Software as a Service is the predominant cloud layer used among the manufacturing firms surveyed. Of the 150 respondents, 93 firms adopted IaaS, 68 adopted PaaS, and another 104 adopted SaaS. Figure 8 displays the cloud service types used.

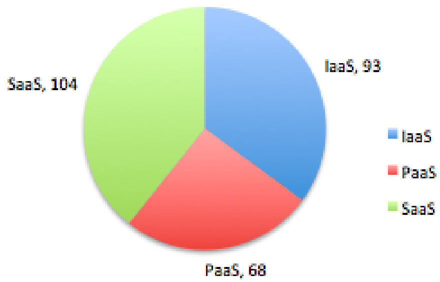


Figure 8 Cloud Service Types Used

* Note: Total count exceeds (N=150) as organizations may adopt multiple service types

Those respondents whose organizations adopted multiple cloud services were asked to choose the cloud computing service type providing or expected to provide the most benefit to their organization. This selection was stored as a variable for the remainder of the survey. Using the stored selection, subsequent survey questions referred to the selected cloud service type by name to ensure the respondent's attention was focused on one cloud service throughout the questionnaire.

V CHAPTER 5: DATA ANALYSIS AND RESULTS

This chapter provides an analysis of the survey response data and a discussion of the results. Section 5.1 further profiles the survey respondents and compares early responses to late responses to identify bias. Sections 5.2 and 5.3 evaluate the measurement model and structural model. Results are presented in Section 5.4 and include an analysis by service model. Section 5.5 provides a discussion of the results.

Several statistical methods for analyzing the data were contemplated including regression models, PLS-SEM, and CB-SEM. Structural Equation Modeling (SEM) was selected for its ability to evaluate both the structural and measurement models simultaneously. In the most basic sense, SEM is a multivariate statistical method that combines facets of factor analysis and regression into one process. SEM identifies relationships between constructs and among measured variables. Once the decision was made for SEM over other regression techniques, the goal was to select the most appropriate SEM method in light of the exploratory research questions assessing cloud computing adoption factors. Of the two SEM variants PLS (partial least squares)-SEM was chosen for its ability to shine in exploratory research while CB (covariance-based)-SEM is preferred for confirmatory research where theory and measures are well developed (Gefen et al., 2011). PLS-SEM utilizes algorithms to maximize the explained variance of endogenous latent variables using sequential least square regressions (Hair et al., 2012). Furthermore, the methodology excels in handling complex relationships with large numbers of latent variables (Ringle et al., 2012) and information systems researchers have begun to deploy PLS-SEM more and more over the last 15 years. In an analysis of published studies in *MIS Quarterly*, PLS-SEM was used in 65 journal articles between 1992 and 2011 with an uptick in usage over time (Ringle et al., 2012). PLS-SEM is used in cloud computing studies to model predictors of organizational cloud adoption and applications of PLS-SEM in cloud computing research include identifying predictors of cloud adoption (Oliveira et al., 2014), and to assess the opportunities and risks in adopting SaaS (Benlian & Hess, 2011).

V.1 Survey Respondents

In the study design, I deployed a non-proportional quota based sampling approach to provide equal representation across the three cloud service models – IaaS, PaaS, and SaaS, targeting 50 responses in each category. Of the 1,070 subjects who started the survey, 150 completed it in its entirety generating a final response distribution across the three cloud service models of IaaS – 60, PaaS – 31, and SaaS – 59. The research design controlled for industry and location as all collected responses represented U.S. manufacturing firms. There were no restrictions on firm size or the number of cloud layers adopted – both were captured as control variables.

During the data collection period, quotas for IaaS and SaaS were applied once target thresholds were reached. An absence of PaaS participants forced a reopening of the proportional quota to reach the target total completed response objective of 150. To check for biases between the first group of responders not under a quota, and the second group of responders, some of whom were restricted by quota, I divided the responses into two groups of 75 each based on survey completion date.

A t-test of independent samples was conducted to assess whether or not significant differences exist between the two groups of respondents relative to the dependent variable, cloud adoption. There was no significant difference in cloud adoption scores for group 1 first responders (M=2.76, SD = 2.039), and group 2, the second wave (M= 2.88, SD = 2.284; $t(148) = -.339$, $p= 0.735$ two tailed). For test results, see Appendix B: Survey Group Respondents.

Section 5.2 examines the measurement model in detail for the full data sample (IaaS, PaaS, SaaS) and two subgroups. The first subgroup consists of 60 IaaS responders. According to a recent IDC study on worldwide cloud adoption in manufacturing, adoption thus far has primarily benefited IT operations, suggestive of a cloud strategy focused on cost and efficiency (IDC, 2015). An earlier study on business strategies for cloud computing in manufacturing reported hardware cost reduction as the number one benefit manufacturing firms are pursuing (Parker, 2011). Infrastructure as a Service supports the hardware cost reduction strategy by allowing firms access to networks, storage, and servers as an operating expense without major upfront capital investments. IaaS also supports cost management strategies by alleviating the need to purchase excess computing capacity. Companies often struggle with how much computing power is required in support of a workload, grossing the required compute power up by a factor of 1.x. With IaaS, the customer no longer has to over-provision hardware resources as they become elastic and more closely track actual demand. For these reasons, this group is classified as cost-driven innovators of cloud adoption in the manufacturing context.

The second subgroup is comprised of 59 SaaS and 31 PaaS responses. Manufacturers acquiring SaaS for ERP, supply change management, materials management, and CRM seek additional value these applications can generate when cloud deployed such as location independence, global reach, and connectivity to suppliers and business partners. Cloud supports collaboration not previously available with on-premise applications where data structures were onsite and not easily accessible to other applications. The internet of things (IoT) is expected to drive PaaS adoption as manufacturers leverage sensor data on connected products, plant equipment, and raw and finished goods inventory (IDC, 2015). In the context of manufacturing, I combine SaaS and PaaS responders, classifying them as value-driven innovators. Analysis of the measurement model in Section 5.2 and the structural model in Section 5.3 employ the same subgroup structure.

V.2 Measurement Model

As discussed above, structural equation modeling was chosen as the appropriate analysis methodology for the study. Due to the exploratory nature of the research, PLS-SEM is the selected variant. Analysis of both the measurement model and structural model was performed in SmartPLS v 3.2.3 (Ringle et al., 2015). Other statistical analyses were performed using IBM SPSS v23. The measurement model is comprised of both reflective (mode B) and formative (mode A) constructs. Constructs are classified as formative when indicators are not necessarily interchangeable, causality flows from the indicator to the construct, and minimal indicator covariation exists while reflective constructs contain interchangeable items and causality proceeds from construct to the indicator (Hsieh et al., 2011; Diamantopoulos & Winklhofer, 2001). Five constructs are modeled as reflective – competitive pressure, expected benefits, organizational innovativeness, security concerns and trust. Formative constructs are firm size, cloud adoption and technical competency. Cloud services types is a single item measure designed for this study to represent the number of cloud service models the firm has adopted. Along with firm size, cloud services acts as a control variable in the model. See Appendix C: Model Measurement Types for details.

The reflective models were measured for internal consistency, indicator reliability, and both convergent and discriminant validity while the formative models were measured for convergent validity, collinearity and significance. The measurement model is displayed below in Figure 9: PLS-SEM Model. Firm size and cloud services, the control variables, are denoted as clear circles.

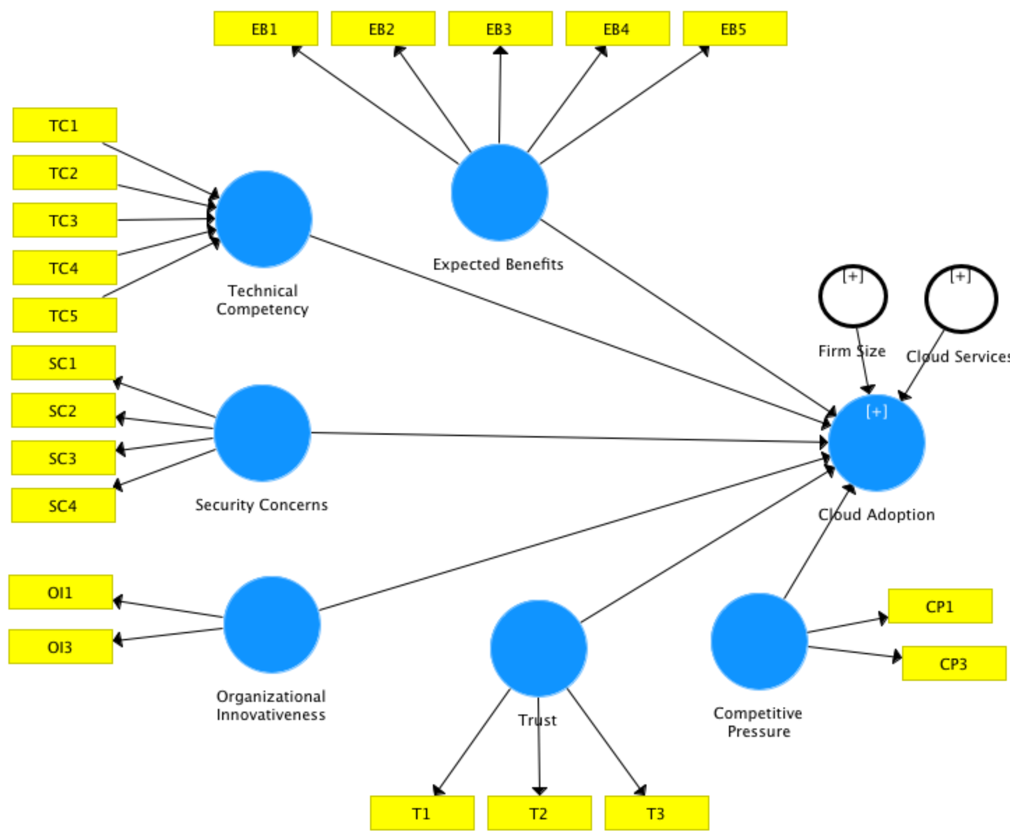


Figure 9 PLS-SEM Model

V.2.1 Reflective Model

In evaluating the reflective model, I executed the PLS algorithm with the following parameters: path weighting of 300 iterations and convergence set with a stop criterion value of $10^{\wedge -7}$. Full convergence occurred in less than 300 iterations, indicating the model achieved a stable solution.

During the initial model evaluation, an issue surfaced with the reliability of item #2 of the competitive pressure construct, and it was removed from the model. While its inclusion resulted in a nominal increase in R2, its reliability did not exceed the minimal threshold of 0.40 (Hair et al., 2012). Indicator reliability is a measure of variance or randomness of the error term corresponding to a particular item in the construct (Bagozzi & Yi, 2012; Hair et al., 2013). CP item #2 specifies that the focal firm is under pressure from competitors to adopt cloud computing. The literature suggests that competitive pressure has traditionally influenced an organization's decision to adopt an IS innovation (Zhu et al., 2006; Zhu & Kraemer, 2005; Zhu et al., 2003; Premkumar & Ramamurthy, 1995; Orlikowski, 1993). For manufacturing firms, competitive pressure may not have risen to the point where firms experience specific pressure from known peers. Firms acknowledge cloud's influence on competition in the industry, cp item #1, and have knowledge of other firms pursuing cloud, cp item#3, but do not feel investments in cloud computing are necessary to avoid a disadvantageous position (Drnevich & Croson, 2013). A similar issue appeared with item #2 of the organizational innovativeness construct that states the organization's management actively seeks innovative ideas. The indicator's reliability proved marginal, and the item was removed from the model. All other constructs showed good indicator reliability.

Internal consistency reliability is a construct level measure used to ascertain the degree to which multiple items measure the same idea or construct. I assessed internal consistency in the measurement model with both tests of composite reliability and Cronbach alpha, which is deemed a more conservative measure of internal consistency (Hair et al., 2013). All reflective constructs exceeded the 0.708 threshold for acceptable composite reliability and Cronbach alpha readings. Convergent validity measures how well the construct reflects the variation of the indicators expressed as the average variance explained (AVE). AVE measures over 0.50 represent good convergent validity (Bagozzi & Yi, 1988; Hair et al., 2013). The proposed reflective model contains good convergent validity.

Table 11 provides a summary of the reflective model measurement assessment. The indicator reliability results for the full model and sub-models are reported in the Appendix D: Indicator Reliability. Overall, the reflective model meets the evaluation criteria and shows good internal consistency, indicator reliability, and convergent validity.

Table 11 Reflective Model Summary

	Full Model			IaaS			SaaS + PaaS		
Latent Variable	CR	CA	AVE	CR	CA	AVE	CR	CA	AVE
Competitive Pressure	0.880	0.787	0.780	0.796	0.742	0.675	0.894	0.770	0.808
Expected Benefits	0.914	0.682	0.689	0.911	0.895	0.673	0.920	0.895	0.698
Organizational Innovativeness	0.932	0.872	0.872	0.914	0.837	0.843	0.932	0.860	0.872
Security Concerns	0.916	0.733	0.730	0.940	0.917	0.797	0.803	0.887	0.514
Trust	0.930	0.816	0.814	0.915	0.903	0.783	0.933	0.894	0.822

CR = Composite Reliability, CA = Cronbach Alpha, AVE = Average Variance Extracted

Discriminant validity empirically describes the extent to which a construct differs from other constructs with regards to the phenomena for which it is intended to capture (Hair et al., 2013). For discriminant validity testing, the Fornell-Larcker criterion was used to compare each construct's AVE with the squared correlations of the construct and other latent variables. As shown in Appendix E: Discriminant Validity, the full model, and both subgroups reported good discriminant validity.

V.2.2 Formative Model

The formative measurement model is evaluated based on an assessment of relevance, significance and multicollinearity of items comprising the formative constructs. Unlike reflective constructs, formative construct indicators may exhibit extreme levels of correlation with one another and result in redundancy. Variance inflation factor (VIF) measures the severity of collinearity among formative indicators. VIF values less than 5 indicate that items within a construct exhibit acceptable levels of collinearity (Hair et al., 2013). Latent variables firm size, technical competency and cloud adoption measured VIFs of < 5 signifying that collinearity between indicators does not reach critical levels. See Table 12: Collinearity Results.

Table 12 Collinearity Results

Construct	Indicators	Full Model VIF
Firm Size		
	FS1	1.335
	FS2	1.335
Technical Competency		
	TC1	3.084
	TC2	1.985
	TC3	1.989
	TC4	2.627
	TC5	1.990
Cloud Adoption		
	CC1	1.000
	CC2	1.000

The next step in the formative model evaluation is an analysis of indicator statistical significance and relevance. In PLS-SEM, a nonparametric bootstrapping procedure is executed to assess each item's coefficient for significance. The bootstrapping process generates subsamples of observations randomly drawn from the sample without replacement and performs model estimations of standard errors of coefficient estimates to assess statistical significance in the absence of parametric distributional requirements (Hair et al., 2013). I executed the process using 500 subsamples, system settings of no sign changes, and confidence intervals set to Bias-Corrected and Accelerated (BCa) Bootstrap for a 1-tail test at the 5% significance level. All indicators were assessed at the 5% significance level ($t > 1.65$). Indicators for firm size, the control variable did not prove significant but are retained for control. Two items of the technical competency construct, TC3 and TC5, were not significant but are supported by prior research on technical competency and are retained in the model (Zhu et al., 2006b; Zhu & Kraemer, 2005; Zhu et al., 2003; Lu & Ramamurthy, 2011). See Table 13: Outer weight significance testing.

Table 13 Outer Weight Significance Test (full model)

Formative Construct	Indicators	Outer Weights	Standard deviation	t value	Significance level
Firm Size					
	FS1	-0.194	-0.726	0.356	NS
	FS2	1.083	0.773	0.368	NS
Technical Competency					
	TC1	-0.775	0.362	2.138	***
	TC2	1.265	0.333	3.801	***
	TC3	0.298	0.267	1.117	NS
	TC4	-0.550	0.309	1.777	**
	TC5	0.140	0.316	0.442	NS
Cloud Adoption					
	CC1	0.521	0.259	2.011	***
	CC2	0.863	0.177	4.861	***
Note: Based on t-values, 1-tail; NS = not significant					
*p<.10; **P<.05; ***p<.01					

V.3 Structural Model

After proper validation of the reflective and formative modes of the measurement model in Sections 5.2.1 and 5.2.2 above, an analysis is performed of the structural model to assess collinearity among constructs, relevance and significance of model relationships, and the overall predictive ability. PLS-SEM enables analysis of the structural or inner model of all hypothesized latent variable relationships whether exogenous or endogenous. The process assumes correct specification of the model through assessment and validation of the measurement model and specifies the parameter estimates in a way that maximizes the overall explained variance. The PLS-SEM algorithm is different from CB-SEM, which estimates parameters to minimize the differences in theoretical and sampled covariance matrices using the chi-square statistic to assess goodness of fit (Hair et al., 2013).

The first step in structural model assessment is to evaluate collinearity among constructs based on the variance inflation factor (VIF). Constructs exhibiting a VIF above 5.0 may need to be eliminated or combined with other similar constructs (Hair et al., 2013). VIF is computed for each of the six predictor constructs of the cloud adoption dependent variable. Expected Benefits shows the highest collinearity of the predictors with a value of 2.4. All VIF values are below the 5.0 threshold as reported in Table 14, suggesting no issues with multicollinearity in the structural model.

Table 14 Structural Model Collinearity – Full Model

Predictor Latent Variables	Cloud Adoption VIF
Cloud Services	1.134
Competitive Pressure	2.028
Expected Benefits	2.423
Firm Size	1.154
Organizational Innovativeness	2.256
Security Concerns	1.146
Technical Competency	1.044
Trust	2.373

Next, the structural model path coefficients are examined for significance and relevance. Path coefficients model the hypothesized relationships between constructs. To assess the significance of these relationship estimates, I executed a nonparametric bootstrapping procedure with 500 subsamples, system settings of no sign changes, and confidence intervals set to Bias-Corrected and Accelerated (BCa) Bootstrap for a 1-tail test at the 5% significance level. The results are displayed in Table 15.

Table 15 Structural Model Path Coefficients – Full Model

	Path Coefficient	Standard Deviation	t-value	Significance Level
Cloud Services -> Cloud Adoption	0.128	0.073	1.758	**
Competitive Pressure -> Cloud Adoption	0.021	0.074	0.280	NS
Expected Benefits -> Cloud Adoption	0.139	0.104	1.336	*
Firm Size -> Cloud Adoption	0.062	0.067	0.933	NS
Organizational Innovativeness -> Cloud Adoption	-0.427	0.123	3.473	***
Security Concerns -> Cloud Adoption	-0.109	0.080	1.361	*
Technical Competency -> Cloud Adoption	0.197	0.077	2.553	***
Trust -> Cloud Adoption	0.305	0.111	2.735	***

Note: Based on t-values, 1-tail; NS = not significant

*p<.10; **P<.05; ***p<.01

Three paths proved significant at the 1% level, organizational innovativeness, technical competency, and trust while the control variable, cloud services, is significant at the 5% level. Expected benefits and security concerns are only mildly significant at the 10% alpha level while competitive pressure and firm size were insignificant. In addition to statistical significance, an examination of the relevance of model relationships is required for proper interpretation of results and identification of relationships which merit managerial attention (Hair et al., 2013). Based on the path coefficients, the primary driver of cloud adoption is the firm's level of organizational innovativeness (OI = -0.427) followed by trust (T = 0.305), and technical competency (TC = 0.197). Organizational innovation is a construct not frequently used in the IS adoption literature, so the magnitude of the beta coefficient is a surprise. Its inclusion in the model was based on speculation that traditional TOE factors in the organization context such as top management support, financial resources, and organizational readiness would not adequately predict cloud computing adoption since vast financial and organizational resources are not required for cloud (Mishra et al., 2007; Zhu et al., 2006; Premkumar &

Ramamurthy, 1995). Even more surprising is the inverse relationship detected, meaning as the level of innovativeness increases, the level of cloud adoption decreases. Within the manufacturing context, more innovative firms appear to be less likely to adopt cloud. Another highly influential factor is trust in the cloud service provider. Concerns about security did not matter as much.

Since there are no mediating variables in the model, the analysis is limited to direct effects of latent predictor constructs on the endogenous variable, and indirect effects are not considered.

The coefficient of determination or R2 is used to assess the overall predictive accuracy of the model. As calculated in PLS-SEM, R2 = 0.19 for the full model reflecting all cloud service models – IaaS, PaaS, and SaaS. Over 19% of the variation in cloud adoption by U.S. manufacturing firms is explained by the model. I performed a final analysis to evaluate the effect of removing an exogenous latent variable from the model.

The effect size, denoted by f^2 signifies a construct's overall contribution to an endogenous construct's R2 value. Effect sizes of 0.02, 0.15, and 0.35 correspond to weak, moderate, and strong effects (Hair et al., 2012; Cohen, 1998). Organizational innovativeness reports an effect size close to medium while technical competence and trust have small effect sizes. Effect size values are displayed below in Table 16.

Table 16 Effect Size

Predictor Latent Variables	Cloud Adoption f^2
Cloud Services	0.018
Competitive Pressure	0.000
Expected Benefits	0.010
Firm Size	0.004
Organizational Innovativeness	0.100
Security Concerns	0.013
Technical Competency	0.046
Trust	0.048

V.4 Sub-group Results (IaaS, PaaS, SaaS) and Comparative Analysis

This section provides high-level results of the sub-group analysis, concentrating on structural model findings for cost and value-driven cloud adoption innovations by manufacturers. Table 17 summarizes the structural model results. Full details of the reflective and formative measurement models by sub-group are presented in Appendix F – Appendix J.

V.4.1 IaaS: Cost-driven

The most significant adoption driver for the infrastructure as a service group is organizational innovativeness, followed by technical competency. Organizational innovativeness is also an important predictor for the full model. Technical competency proved significant at the 1% alpha level, but with an inverse relationship, suggesting firms with lower levels of technical competency are more likely to adopt IaaS cloud services. The finding of this inverse relationship between technical competency and adoption is counter to the prevailing literature (Venkatesh & Bala, 2012; Zhu & Kraemer, 2005; Zhu et al., 2003). While trust proved significant in the full model, cost driven firms were less concerned with developing trusting relationships with the cloud service provider. This could be indicative of the level of standardization in cloud infrastructure services in comparison to applications and development platforms which offer a spectrum of modifications from interface personalization to full custom development. Firms viewing IaaS as a commodity cloud service may see little differentiation between service providers, placing less emphasis on trust.

V.4.2 SaaS + PaaS: Value driven

For value seeking firms adopting SaaS and PaaS, organizational innovativeness is significant, followed closely by trust in the cloud service provider. In this case, trust is extremely critical as focal firms share intimate business knowledge with their cloud providers and must rely on these providers to host business critical applications. Manufacturers involved in developing custom applications are dependent on PaaS vendors for new IoT-centric application platforms as over 50% of all new PaaS programs are expected to support the IoT by 2020, according to Gartner (Natis et al., 2015).

Table 17 Structural Model Summary – Comparative Analysis

	Full Model R2=0.191		Cost (IaaS) R2=0.219		Value (SaaS+PaaS) R2=0.247	
	Path Coeff.	Sign. Level	Path Coeff.	Sign. Level	Path Coeff.	Sign. Level
Cloud Services -> Cloud Adoption	0.128	**	0.111	NS	0.220	**
Competitive Pressure -> Cloud Adoption	0.021	NS	-0.017	NS	0.020	NS
Expected Benefits -> Cloud Adoption	0.139	*	0.050	NS	0.125	NS
Firm Size -> Cloud Adoption	0.062	NS	0.150	NS	0.025	NS
Organizational Innovativeness -> Cloud Adoption	-0.427	***	-0.408	***	-0.447	***
Security Concerns -> Cloud Adoption	-0.109	*	-0.023	NS	-0.204	**
Technical Competency -> Cloud Adoption	0.197	***	-0.290	***	0.136	NS
Trust -> Cloud Adoption	0.305	***	0.141	NS	0.352	***

Note: Based on t-values, 1-tail;
NS = not significant
*p<.10; **P<.05; ***p<.01

V.4.3 Group Comparisons

Competitive pressure from other firms to adopt cloud computing did not show statistical significance for the full model nor foe either of the two sub-groups. This finding is consistent with results from a cloud adoption study of Portuguese manufacturing and service firms where competitive pressure did not show significance (Oliveira et al., 2014). The construct, expected benefits, was mildly significant for the full model (p<0.10), but not significant for either subgroup. Organizational innovativeness demonstrated strong significance and relevance for all groups, but with an inverse effect. Manufacturers are concerned about security for value-driven adoption, SaaS plus PaaS, but less so in aggregate across all service models. Technical competency displayed different effects for each group modeled. The construct showed strong significance for the full model (p<0.01), strong significance but with an inverse relationship for IaaS, and no significance for the SaaS + PaaS subgroup. Finally, trust in the cloud service provider displayed strong relevance and significance (p<0.01) for the full model and value-driven adopters but is statistically insignificant for cost driven adopters.

V.5 Results and Discussion

This section contains a discussion of the results for the full model and the two sub-groups categorized by cost and value. Chapter 6 concludes with a summary of the results, contributions for researchers and practitioners, and study limitations.

Table 18: Results Summary

H#	Hypothesis	Full Model (IaaS+PaaS +SaaS)	Cost driven (IaaS)	Value driven (SaaS + PaaS)	SaaS
H1:	Expected benefits will positively impact cloud computing adoption				Supported **
H2:	Technology competence will positively impact cloud computing adoption	Supported ***	**Supported *** **		Supported ***
H3:	Security concerns will negatively impact cloud computing adoption			Supported **	
H4:	Organizational innovativeness will positively influence cloud computing adoption	**Supported *** **	**Supported *** **	**Supported *** **	
H5:	Vendor trust will positively influences cloud computing adoption	Supported ***		Supported ***	
H6:	Competitive pressure will positively influence cloud computing adopt				
	Note: items in bold reflect an inverse relationship * p<0.10, ** p<0.05; *** p<0.01				

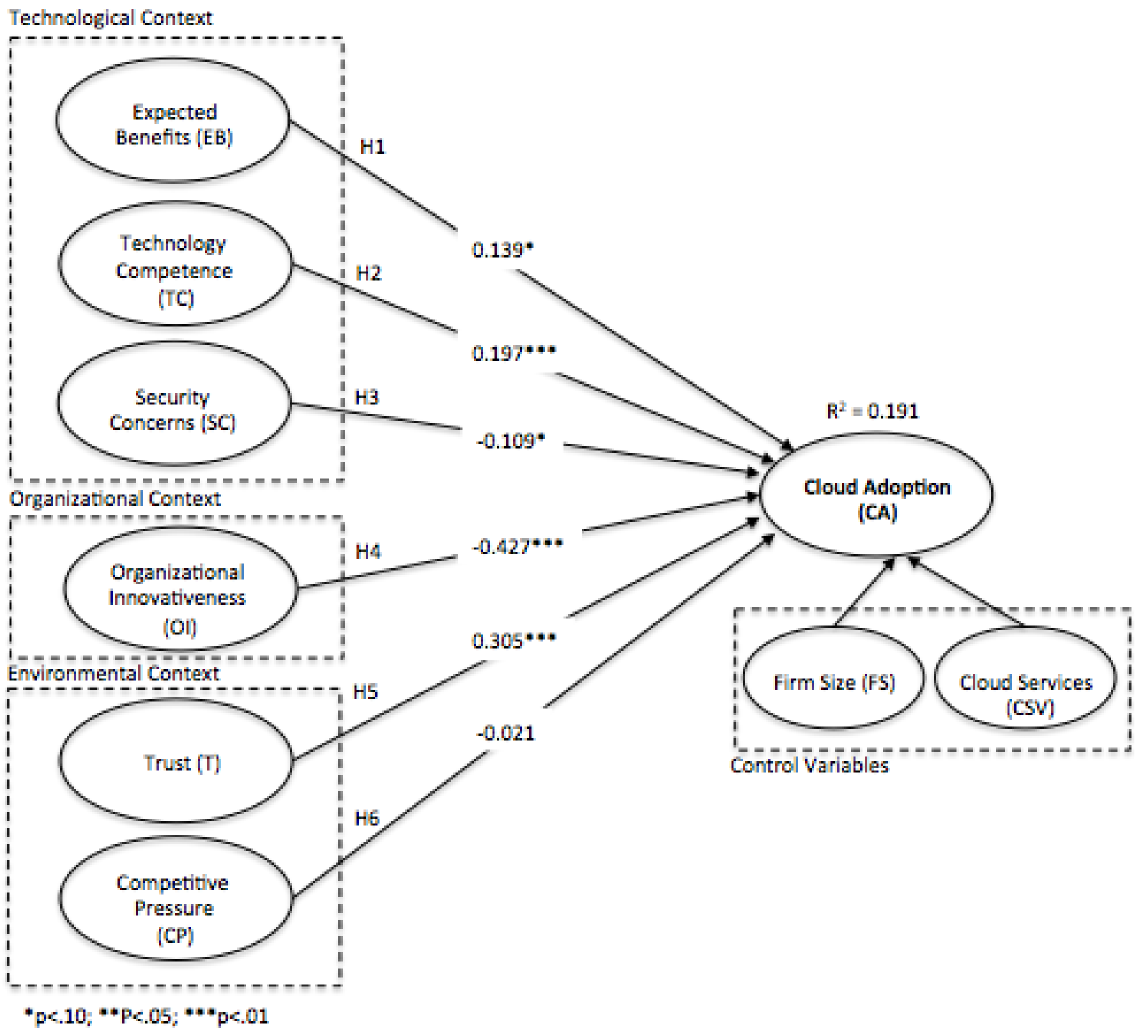
V.5.1 Full Model Results

In research and practice, little attention is given to the specific layers or service models of cloud computing – IaaS, PaaS, and SaaS. The intent of this research was to assess the factors influencing cloud computing adoption through the lens of a well researched and validated IS framework, the Technology - Organization – Environment framework, and to better understand potential variations in adoption drivers based on cloud service model deployed. To accomplish this research objective, I developed a multi-contextual, conceptual model of cloud computing adoption based on cloud computing research and prior TOE adoption studies.

In the technological context, the model posited that expected benefits, technology competence, and security concerns would influence adoption. Within the organizational context, I limited the focus to one construct, organizational innovativeness. Due to the core cloud model characteristics such as on-demand access, subscription pricing, measured service, and elasticity, typical organizational factors like financial commitments, and organizational resources are posited as less influential and were not included in the model. Cloud does not require major capital investments, overcoming the capital constraints usually associated with acquiring an IS innovation. Ease of accessibility to cloud computing enables departments, business units, or individuals to experience cloud services with or without the support of top management. Many cloud vendors offer free trials allowing firms to use cloud services in a low risk environment. In identifying specific factors for inclusion in TOE models, the nature of the innovation and prior research informs the researchers decision in developing a parsimonious model. As a meta-framework, TOE is empirically supported by the literature; however, the measures vary within the three contexts from study to study (Rowe et al., 2012; Zhu et al., 2006). Of the 16 TOE studies referenced in the literature review, Table 6, only two studies included top management support as an organizational factor. Top management support was not a significant adoption factor in the Oliveira study of 140 Portuguese manufacturing firms, and I did not include the construct in this research study (Oliveira et al., 2014). Firm size was included as a control variable. Under the environmental context, trust in the cloud service provider and pressure from other competitors in the industry rounded out the model predictors. Control variables were the firm size and the number of cloud layers with which a firm has experience. The research design limited the study scope to manufacturing firms domiciled in the U.S., controlling for industry and country effects.

Overall, the full model results provide support for three of the six hypotheses ($p < 0.01$). Organizational innovativeness (H4) had the strongest influence on cloud adoption, followed by trust (H5), and technology competency (H2). Expected benefits (H1), and security concerns (H3) were only mildly significant. Competitive pressure (H6) did not prove significant. The PLS model results are displayed in the diagram in Figure 10. Across all cloud service types, IaaS, PaaS, and SaaS, the model accounts for 19% of the variation in cloud adoption by US manufacturing firms.

Figure 10 PLS Analysis Results – Full Model



Organizational Innovativeness

Innovativeness is the notion of openness to new ideas as an aspect of a firm's culture (Hurley & Hult, 1998). For many firms, it's a property attributable to the CEO or founder. Firms with innovative founders tend to be more innovative. In his integrated model of IS adoption, Thong found that innovativeness (an aspect of CEO characteristics), positively influenced the likelihood and extent of IS adoption (Thong, 1999). Organizational innovativeness exemplifies a firm's culture and disposition to seek and acquire innovations (Venkatesh & Bala, 2012). This study extends the research on organizational innovativeness in information systems, identifying it as an antecedent to cloud adoption. The findings reveal the existence of an inverse relationship where the less innovative a manufacturing firm is, the more likely it is to pursue cloud adoption. Firms whose cultures are less open to new innovations and who do not readily seek or accept innovation, may be more likely to search out cloud computing. In a study on grid computing adoption in German companies, Messerschmidt found that both organizational and individual innovativeness enhance adoption intents, ascribing more weight to personal innovativeness (Messerschmidt & Hinz, 2013). Our manufacturing survey respondents report a strong firm bias against innovation, but as the primary decision makers and influencers of cloud computing adoption, appear to seek out innovative solutions on behalf of the firm. Lian's research on cloud computing adoption in Taiwanese hospitals localized the positive impact of CIO innovativeness to early adopters only (Lian et al., 2014). The manufacturing sector leverages external innovation via cloud computing for advanced use cases like product development, lifecycle management, manufacturing operations and the internet of things (Gartner, 2012). The lack of organizational innovativeness may be indicative of the manufacturers appetite for external innovation. More research in this area is recommended.

To help firms make more sense out of cloud computing, researchers developed a framework for cloud dimensioned by a series of technical and service desires (Venters & Whitley, 2012). A firm's desire for certain characteristics of an innovation leads it to adopt. Creativity, a service desire, describes a firm's aspiration for a cloud service which enables creativity and innovation by reducing innovation transaction costs and providing access to value networks (Venters & Whitley, 2012). As search costs are reduced and the knowledge to manage and integrate complex system combinations are transferred to cloud service providers, cloud computing proves attractive to firms. Manufacturers with less innovative cultures still require the need for business agility as more agile firms are able to respond to changes in the competitive environment in an effective manner while simultaneously maintaining production operations (Mathiassen & Pries-Heje, 2006). The results of this study show that those firms with less in-house creativity and innovative cultures are more apt to pursue cloud computing as a source of innovation. Through cloud manufacturers have access to the latest hardware and software innovations. User groups and online forums provide firms access to a worldwide knowledgebase of cloud users across a variety of industry sectors. Information gained from these sources can be combined with deep firm expertise to develop innovative solutions unique to the firm's business model.

Trust

Cloud computing requires a higher degree of dependency on vendor managed services versus in-house management dictating an ongoing relationship between a focal firm and its cloud service provider. While service level agreements (SLAs) and contractual arrangements explicitly specify vendor responsibilities for services provided, the risk of loss revenue, ruined reputation, and regulatory infraction looms large for the client firm in the event of an outage or data breach. Trust encapsulates the notion of intimacy, reputation, and fairness beyond the documented contract and is an important predictor of cloud adoption. In an open-ended question soliciting additional risks or concerns firms have with cloud computing, survey participants reported "lack of control," "migration to a virtual infrastructure," "potential downtime", and "rising costs from cloud service providers" as crucial anxieties. Most of the volunteered responses speak to vendor performance and follow through on promised cloud services. Firm relationships with cloud service providers that are based on trust allow the firm to more fully realize the technical and economic benefits promised by cloud computing (Garrison et al., 2012). The findings suggest that noneconomic, sociological factors such as trust in the cloud service provider play an important role in facilitating adoption of a relationship based cloud computing technology (Zaheer, & Venkatraman 1995). Being known for fair dealings with customers is a crucial requirement for cloud providers to firms adopting cloud computing.

Technical Competency

In this study, technical competency is conceptualized along two dimensions – IT infrastructure capabilities and knowledge and expertise in cloud computing. Infrastructure capabilities are evidenced by the firms' assessment of proficiency in managing data management services and architecture, network communication services, application portfolio and services versus its peer firms (Lu & Ramamurthy, 2011). Prior research indicates that technology competence and readiness are important influencers on IS adoption (Oliveira et al., 2014; Zhu & Kraemer, 2005). Consistent with prior studies, our results indicate a significant relationship between technical competency and the adoption of cloud computing. While confirmatory with the IS literature, the findings contradict practitioner hype that predicts cloud computing will lead to the demise of the IT organization. IT departments may need to retool and acquire different skill sets, but the CIO, CTO and the IT organization should not be considered obsolete. IT will be called upon to navigate this latest wave of complex IS innovation, crafting cloud strategies that position the firm for future success.

Expected Benefits

The anticipated benefits of the adoption of a new IS over the existing practices or processes have a long history of driving technology adoption across a broad range of innovations including interorganizational business process standards (Venkatesh et al., 2012), EDI (Kuan & Chau, 2001; Iacovou et al., 1995), and open systems (Chau & Tam, 1997). This study reveals expected benefits as a mildly significant predictor of cloud computing adoption ($p < 0.10$). Firms seeking ways to reduce and avoid technology costs, quicken deployments, enhance efficiency and improve quality look to cloud computing over traditional on-premise solutions. Of the benefits expected, cost savings is usually cited as the most important, especially in industries like manufacturing where IT is traditionally relegated to cost efficiencies and business process automation. An IDC study on cloud computing in manufacturing cited cost reductions as the number one benefit for firms adopting cloud (Parker, 2011). Oliveira found cost savings as an important factor explaining the relative advantage of cloud computing (Oliveira et al., 2014). Contrary to these studies, cost did not surface as the primary expected benefit. Of the five indicators used to measure expected benefits, the cost was least important. This may be indicative of the current state of cloud computing adoption. In the first wave, cost reduction drove adoption. As cloud computing matures and awareness of its benefits increases, firms understand that agility and operational quality through standardization are more important drivers than cost savings.

Security Concerns

Much of the extant literature on cloud computing suggest security as a key barrier to cloud adoption (Loebbecke et al., 2012; Benlian & Hess, 2011; Bhattacherjee & Park, 2014). Concerns regarding data breaches, transmission failures, and the potential loss of firm and customer data are discussed in both the academic literature and in practice. In this study, security concerns surfaced as only mildly significant ($p<0.10$) and less relevant than other contributing factors. This could be due to the increased understanding and awareness of the security measures deployed by cloud service providers that are in many cases, more secure, less costly, and more resilient than security practices found at host firms (Lacity & Reynolds, 2014). The level of security and resiliency in today's cloud offerings is echoed by this study's participants who described security as a cloud computing advantage using phrases such as " very secure", "better data security", and additional "peace of mind" from deploying cloud services. Further research is needed to adequately assess the role of security in cloud adoption at the organizational level.

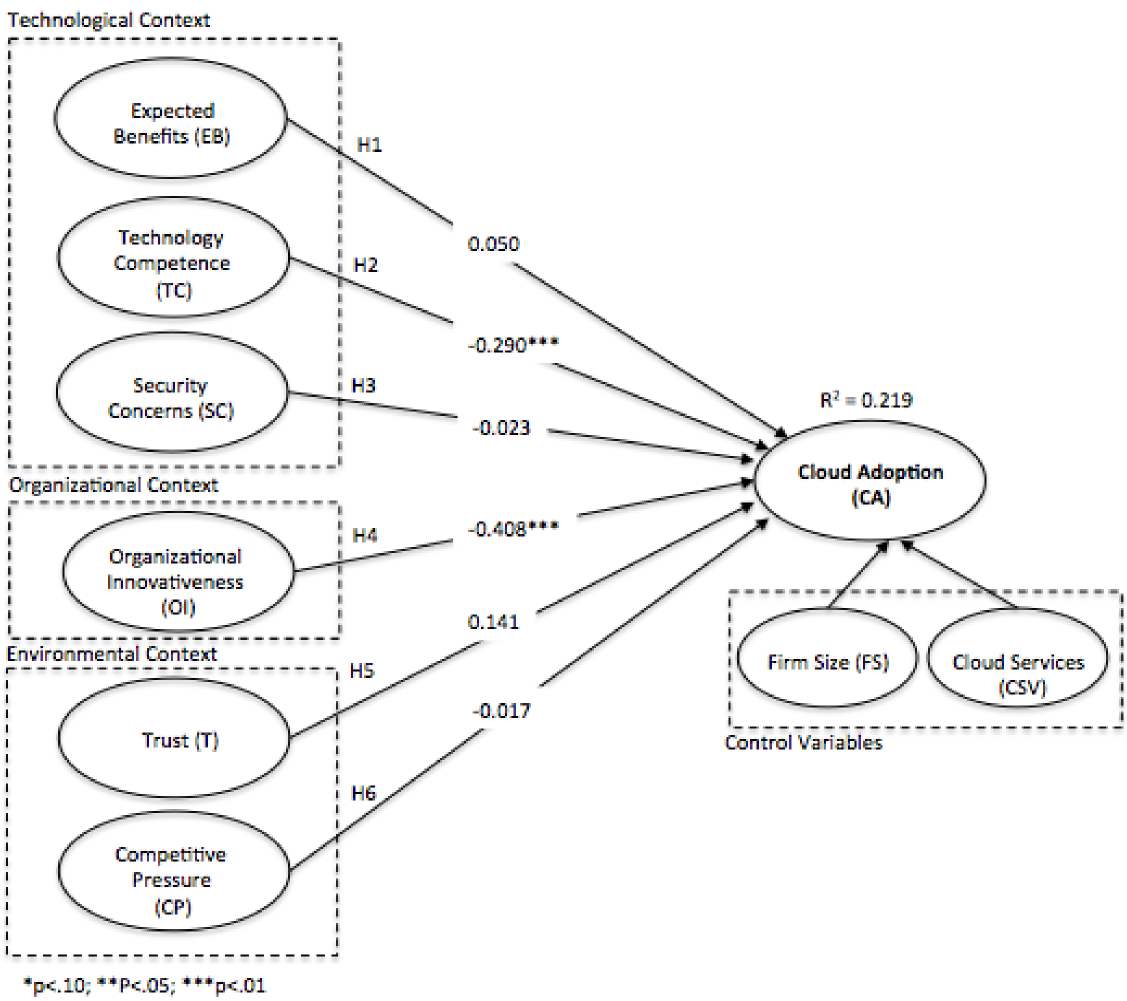
V.5.2 IaaS: Cost Driven

As depicted in the diagram in Figure 11, only two of the six hypotheses were supported. Organizational innovativeness (H4) showed the strongest influence on cloud adoption, followed by technical competence (H2). Both factors reported high relevance with an inverse relationship: the less innovative and technically capable the firm is, the more likely it is to adopt IaaS. The model recorded an R2 of 0.219 for this subgroup, about 15% better than the full model. IT capabilities and expertise in cloud computing are more important drivers in cloud infrastructure adoption than for software application adoption. In many sectors, firms with IT knowledge and capabilities are better able to recognize and take advantage of new technology innovations. Zhu found technology competence as a significant driver of e-business adoption in a study on innovation diffusion in global contexts (Zhu et al., 2006). Additionally, IT infrastructure capability, the organization's capacity to manage and deploy shareable IT platforms, has been identified as an antecedent of organizational agility (Lu & Ramamurthy, 2011). However, the results of this research suggest that manufacturing firms pursue infrastructure as a service to compensate for the lack of technical breadth or depth of knowledge in data management, networking, operations, applications, and cloud computing. Firms are dependent on the cloud service provider for infrastructure-based agility, substituting the external cloud vendor's skills and technical knowledge of cloud computing for the acquisition and development of in-house cloud capabilities. For application software cloud services which can require configuration and integration to existing applications, in-house technical competency appears complementary for U.S. manufacturers. To confirm this substitution – complementary finding for technical competency within the service model combinations, an additional PLS-SEM model run was executed isolating the SaaS adopters only. See Appendix K. Hypothesis (H2) is supported for SaaS reporting a high positive path coefficient of 0.403, $p<0.01$.

V.5.3 SaaS + PaaS: Value Driven

The final sub-group composed of SaaS and PaaS responders recorded the highest coefficient of determination (R2=0.247) for the proposed adoption model. For these value driven innovators, three of the six hypotheses were supported. Organizational innovation (H4), trust (H5), and security concerns (H3) are significant drivers of SaaS and PaaS adoption. Innovativeness and trust are also important factors in the full model and are discussed in Section 5.5.1 above. This section focuses on concerns application users and developers have regarding security and privacy. SaaS offers cloud deployed software applications and PaaS

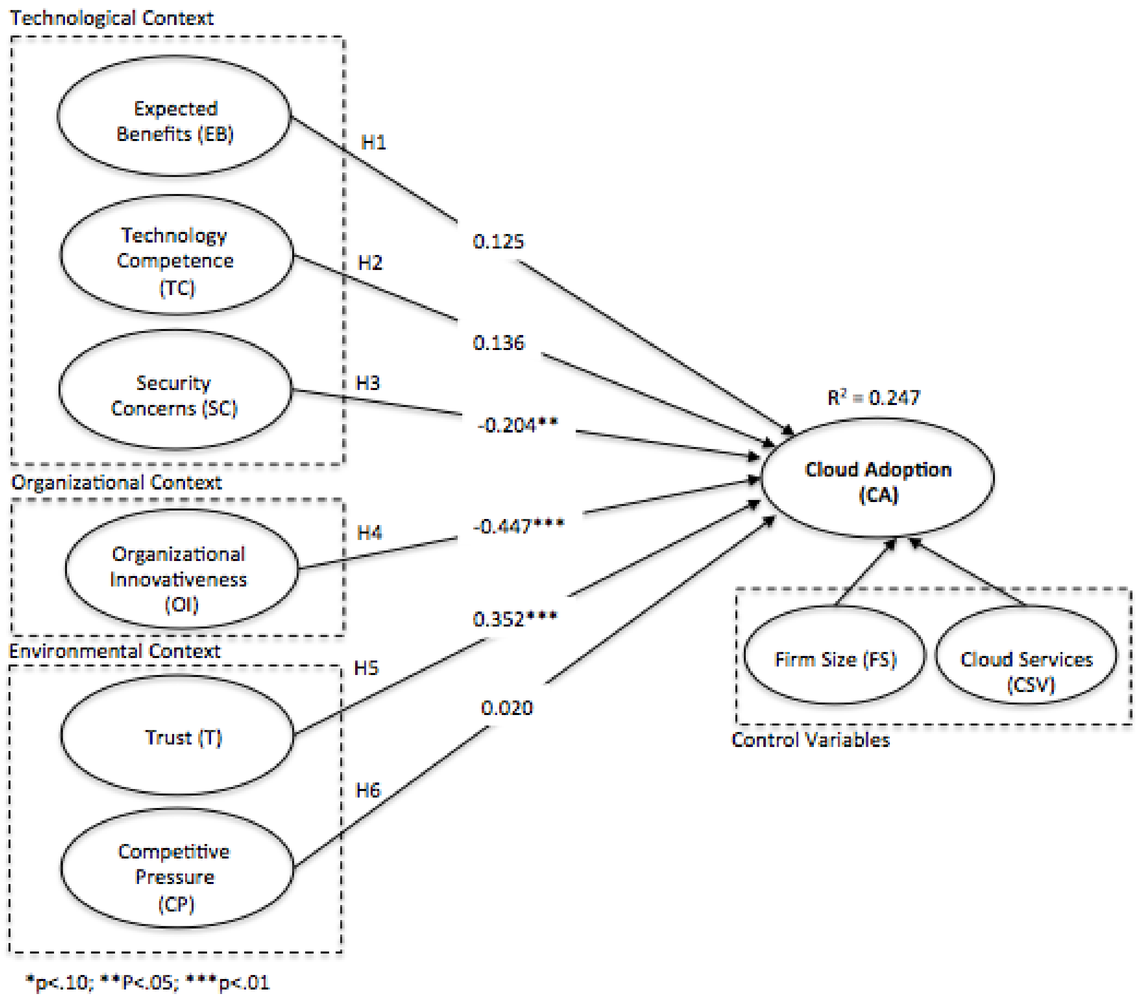
Figure 11 PLS Analysis Results – IaaS



provides a cloud platform for developing and deploying applications and services. Cloud applications often involve the transmission and storage of company data, market data, financial information, and sensitive internal and external customer data at one or many offsite cloud data centers managed by a cloud service provider. Application level security has long been a concern in the IS space as evidenced in previous e-business adoption studies (Zhu et al., 2006b). Concerns around security of externally managed and housed data are new to the cloud computing phenomena (Oliveira et al., 2014; Benlian & Hess, 2011).

The empirical evidence in this study suggests that security concerns are significant and relevant for SaaS and PaaS adopters, but not for IaaS adopters. This finding may help researchers understand the discrepancy in the role of security in previous cloud adoption studies. In analyzing security across a sample of manufacturing and service sector firms in Portugal, Oliveira did not find security as an adoption inhibitor (Oliveira et al., 2014). The study doesn't specify whether the adoption phenomenon is SaaS, PaaS, IaaS, or a combination. On the contrary, a SaaS adoption study surveying 349 IT executives in Germany identified security and privacy concerns as the main barrier to increased software as a service adoption (Benlian & Hess, 2011). SaaS adoption involves cloud-specific security risks (technical risks, legal risks, and policy and organizational risks), security risks not particular to cloud (network outages, unauthorized access, and lost backups), and subjective security risks (feelings of control) (Wu, 2011). While additional research is required to further validate the impact of security on PaaS adoption, the results of this study indicate that the determinants of cloud computing adoption vary by cloud service model.

Figure 12 PLS Analysis Results – SaaS+PaaS



VI CHAPTER 6: CONCLUSION

VI.1 Summary of Results

This research began with an objective of conducting an empirical analysis of cloud computing to uncover salient factors influencing the adoption of cloud at the organizational level. A secondary purpose was to better understand how these factors varied by cloud service model as many firms explore more than one cloud layer. A taxonomy of cloud services types was selected based on the National Institute of Standards and Technology's three service model cloud framework – infrastructure as a service, platform as a service, and software as a service (Mell & Grance, 2011). Unlike previous cloud adoption studies that concentrate on one service such as SaaS, or fail to distinguish what type of cloud service is under investigation, this study intentionally sought to develop a general model of adoption appropriate for gaining insight into the adoption phenomena regardless of service dimension.

The research is framed in the context of manufacturing sector firms domiciled in the United States. U.S. manufacturers have experienced a decline in growth and domestic demand since the mid 1990's attributed to numerous forces including more open trade, cheaper overseas labor, and the Great Recession. Manufacturing firms seeking to become more competitive on a global basis are investigating cloud computing as a mechanism to manage costs and enhance business agility.

Informed by academic research on technology innovation, IS adoption, and cloud computing, and supplemented by numerous personal discussions with organizations in the process of adopting cloud services, I developed a six-factor model of cloud adoption. The Technology-Organization-Environment framework provided a multi-contextual lens by which to analyze adoption factors in a holistic manner. Utilizing quantitative research methods, I collected data via an online survey from 150 key informants of manufacturing firms with representation across IaaS, PaaS, and SaaS cloud services. Due to challenges and constraints in acquiring the targeted number of responses for the PaaS cloud service, cloud services were aggregated and classified according to one of two innovation drivers – value and cost. The data were analyzed for the full model and each subgroup. Previous surveys on cloud computing adoption in manufacturing identify hardware cost reduction as a key determinate of cloud adoption, suggesting a cost driven adoption strategy (Parker, 2011). Other firms looking to leverage cloud computing for value added applications involving enterprise business functions like supply chain, materials management, CRM and ERP, combined with firms seeking additional value promised by the internet of things are classified as value seekers. In this study, SaaS and PaaS cloud service adopters are combined and classified as value-driven innovators, while IaaS adopters are referred to as cost innovators.

The full model (IaaS, PaaS, and SaaS) results suggest organizational innovativeness as the most significant and relevant adoption factor. The factor relationship is an inverse one indicating the more innovative the firm culture, the less likely it is to adopt cloud. The lack of organizational innovativeness may be a predictor of the manufacturers' appetite for external innovation obtained through cloud computing for use cases like product development, lifecycle management, manufacturing operations and the internet of things (Gartner, 2012). Other significant factors for the full model include trust and technical competency. For the cost driven innovator group (IaaS), important factors are organizational innovativeness and technical competency. All other factors were not significant. Finally, organizational innovativeness, trust, and security concerns are influential adoption factors for the value driven group (SaaS and PaaS). The influence of security concerns is twice as great for the value-driven adopters versus the aggregated full model. The results clearly indicate variations in the significance and relevance of adoption factors based on the chosen cloud service model.

VI.2 Contributions and Implications for Researchers

This research provides substantive contribution to the cloud computing adoption literature stream. First, it serves as an empirical study of organizational adoption of cloud services in aggregate and on the basis of the service model dimension. Secondly, the study brings to light key factors of adoption within the TOE framework as applied to the cloud computing innovation. Finally, the research offers a generic framework for organizational cloud computing adoption encompassing multiple cloud layers. These contributions will be discussed in detail in the following sections.

VI.2.1 Organizational-level Cloud Adoption by Service Model

This study extends the research on cloud computing as the first theoretically informed, empirical analysis on cloud adoption by cloud service model. Cloud computing is dimensioned into a taxonomy of three service models – IaaS, PaaS, and SaaS. The existing literature stream is populated with conceptual studies providing coverage of cloud service models but is sparse in empirical studies (Marston et al., 2011; Chen & Wu, 2013; Armbrust et al., 2009). Several prior empirical cloud information system studies are exploratory in nature and not theoretically informed (Lacity & Reynolds, 2014; Loebbecke et al., 2012; Iyer & Henderson, 2012; Marston et al., 2011).

Other studies either concentrate on only one cloud layer such as software as a service or aggregate all service models so that no distinction exists to inform the reader of the boundary conditions for the research results (Oliveira et al., 2014; Benlian & Hess, 2011).

This research study utilizes the TOE framework as a theoretical lens to guide model development, data collection, and analysis of the adoption phenomena. TOE is a proven framework in IS research and has been successfully applied in IS adoption studies across a broad spectrum of applications including ERP, EDI, and e-business (Zhu et al., 2010; Kuan & Chau, 2001; Zhu et al., 2006). By collecting and analyzing survey data from 150 manufacturers, this study is one of the first theoretically informed, empirical organizational adoption studies based on firms within the United States. The results provide researchers a holistic view into the cloud adoption phenomena from an infrastructure, platform, and application perspective.

VI.2.2 TOE Factors of Cloud Adoption

This study extends the research on cloud computing by identifying salient adoption factors relevant to cloud adoption. In the TOE framework, the Technological context includes attributes of the innovation, the Organizational context describes firm related factors, and the Environmental context includes factors external to the firm that may influence adoption. In most IS adoption studies, the organizational context incorporates characteristics associated with the firm and the organization's level of support for a new innovation. Typical organizational factors include top management support, financial resources, and organizational readiness (Mishra et al., 2007; Zhu et al., 2006; Premkumar & Ramamurthy, 1995). Although not widely used in TOE adoption studies, innovativeness appeared as an organizational factor in a study on inter organizational business process standards and was included as the only organizational factor in this research model (Venkatesh & Bala, 2012). Innovativeness describes the notion of openness an organization may have to new ideas and is an aspect of a firm's culture (Venkatesh & Bala, 2012; Hurley & Hult, 1998). The rationale for its inclusion in the conceptual model stems from differences between cloud computing and other IS innovations. Unlike traditional on-premise implementations requiring massive commitments of financial and human resources, cloud services may be procured on a subscription basis, removing typical acquisition constraints. This would appear attractive to innovative firms seeking to experiment with new systems and applications for creative, value-driven purposes.

The findings of this research identify organizational innovativeness as the primary factor in cloud computing adoption for U.S. manufacturing firms across all service models based on significance and relevance. The surprise in this finding was the inverse direction of the relationship between organizational innovativeness and cloud adoption. The results imply the less innovative a firm is, the more likely it will pursue cloud computing. This finding may appear intuitive after the fact, but it contradicts the literature on innovativeness (Venkatesh & Bala, 2012; Hurley & Hult, 1998). The direction of this relationship may be characteristic of the U.S. manufacturing industry. U.S. manufacturing firms face constant pressure to provide 24x7x365 support for all IT applications, databases, servers, networks and other infrastructure while leading new projects involving IoT, real time global supply chain management and logistics, CRM projects, and manufacturing quality initiatives in a cost constrained environment. In non-innovative firms where risk taking is not rewarded, the cloud may provide a lower risk route to IS success as most IT asset ownership is transferred to a cloud service provider. For innovative firms, cloud may be viewed as an undesired alternative to in-house development and system maintenance; hence, the inverted adoption relationship. As firms develop more knowledge and experience with cloud, innovative IS organizations may view cloud adoption as a strategic enabler of innovation. Further research is required to determine whether the organizational innovativeness to adoption relationship is different for other industry sectors, requiring additional validation.

The findings also suggest that trust and technical competency are other crucial factors influencing cloud computing adoption. Previous studies confirm the importance of trust between the focal firm and the cloud service provider, and technical competency or readiness as significant adoption factors (Garrison et al., 2012; Venters & Whitley, 2012; Wu, 2011).

When comparing factors across cloud service models, the research results suggest organizational innovativeness is a key adoption determinant for full model and sub-group combinations. For cost driven innovations (IaaS), technical competency surfaced as significant but with an inverse relationship, suggesting that firms with lower levels of technical competency are more likely to adopt cloud. Trust in the cloud service provider drives adoption for value-driven innovations (SaaS+PaaS), consistent with previous research (Garrison et al., 2012; Wu, 2011).

VI.2.3 Cloud Adoption by Service Model

This study offers researchers a generic model for cloud computing adoption that can be applied to instances of a single cloud service model or for any combination of

IaaS, PaaS, and SaaS. Utilizing six predictors and spanning the technological, organizational, and environmental contexts, the model consistently explains 19% to 25% of cloud adoption variation across all groups of analysis and combinations of IaaS, PaaS, and SaaS. The model provides controls for organization size and experience with multiple cloud service models and applies to U.S. firms operating in the manufacturing sector.

VI.3 Contributions and Implications for Practitioners

VI.3.1 Management

This study has strategic implications for practitioners engaged in developing an organizational cloud strategy across multiple cloud service models. Successful adoption is not only a function of selecting the appropriate technical solution; organizational and environmental factors also play critical roles. Cloud strategy is defined as the set of decisions necessary for crafting and implementing a cloud service strategy that results in organizational agility and cost savings (Iyer & Henderson, 2010). Research results suggest that senior management's understanding of the firm's organizational innovativeness, the level of trust in a cloud service provider, technology competence, and concern's about security are all critical in designing a cloud strategy. Firms that allocate resources to developing cloud strategies stand to benefit throughout the assimilation stages. First, a clear cloud strategy may assist in the successful initial adoption of one or more cloud services. Then, once the cloud service reaches post adoptive assimilation stages of routinization and infusion, process changes occur, structures and cultures are altered, and the cloud service becomes embedded in the daily work activities (Gallivan, 2001). The post adoption stages are where the cloud service adoption brings business value to the firm. If a cloud service is unsuccessfully adopted, or not widely diffused within the organization, the business value remains unrealized.

By assessing the level of innovativeness in the firm, management may be able to judge the organization's level of receptivity to the introduction of new cloud services. Less innovative organizations may be more receptive to cloud adoption. In these instances, strategies with more aggressive timelines and near term trials or proof-of-concepts may prove successful. On the other hand, highly innovative organizations may need to be convinced of the value of cloud adoption over a longer timeframe. Communicating how cloud strategy supports long-term business strategy and enables future creativity and innovation may prove necessary with highly innovative firms.

Practitioners also benefit from understanding the variations in key factors influencing cloud adoption by service model. Management contemplating SaaS and PaaS adoption must be prepared for extensive push back and conversations regarding security concerns. Firms who started their cloud journey with IaaS and who may be more comfortable with the vendor provided levels of security should consider educational strategies for line of business leaders prior to expanding cloud into business critical SaaS applications or those developed on a PaaS platform. Business managers and users are not be expected to have the same level of technical cloud computing knowledge and awareness of the latest security practices and ISO certifications that IT might have.

VI.3.2 Vendors

Finally, the study provides vendors with insight into the determinants of firm-level cloud adoption which could be useful in developing cloud solution strategies, designing new offerings and creating compelling value propositions for their cloud offerings. The results of this study indicate that customers adopt more than one cloud service model, reporting an average of 1.77 cloud types per firm and reflecting multi-layer cloud service awareness by subject firms. As customers adopt multiple cloud service layers, vendors must be able to accommodate the integration between a potentially heterogeneous set of cloud platforms. Expecting the customer to provide APIs and integration coding is a risky strategy. Since primary TOE adoption factors tend to vary by cloud service model, vendors who can assist customers in cloud strategy development may be rewarded. Finally, cloud computing is based on a long term, trust relationship between cloud service provider and customer. Trust has consistently appeared in cloud adoption studies reinforcing its importance. Vendors migrating their existing portfolios of software to the cloud should understand the implied expectation of trustworthiness cloud customers expect. Vendor reputation, being well known for fair dealings with their clients, is a key antecedent to cloud service selection from the customer's perspective.

VI.4 Limitations and Future Research

By design, this research was situated in the context of U.S. manufacturing firms. The design offers several advantages such as controls for industry and geographic effects within a stable geopolitical system. Firms in one geography and industry may have similar awareness of cloud offerings, exposure to competitive information, and similar regulatory concerns. However, the design may limit the generalizability to other industries and countries operating under different regulatory bodies. Future research could benefit from a broader, cross-industry study that elucidates TOE factors across industry. Information-based industries like media and high technology may be at different stages of cloud adoption when compared to manufacturing, a sector that has traditionally been slower to replace existing information systems and uptake newer ones.

The data collection process focused on a single key informant for each company. While this method is common in organizational IS studies, the responses all represent one perspective on the firm. Future studies that gather responses from IT and the business units could provide a more holistic view. Perceptions of trust, innovativeness, and security may differ between IT and lines of business. Future research with multiple informants could provide additional validity to the research findings.

As a follow-up to this study, an in-depth, qualitative case analysis of U.S. manufacturing firms might provide additional insight. First, a qualitative study could serve to validate the key factors predicting cloud adoption and provide deep understanding of ‘why’ the significant factors are important in their organizations. Secondly, a case analysis could follow a focal firm’s entire cloud adoption process through each stage of assimilation from awareness through routinization and infusion. This information would be useful to researchers attempting to understand ‘how’ firms adopt innovations such as cloud computing and the sequence of cloud service model selection.

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APPENDICES

Appendix A: Measurement Items

Construct	ID	Indicators
Technological Context		
Expected Benefits		
	EB1	The use of cloud computing will help us reduce or avoid costs
	EB2	The use of cloud computing will help us deploy solutions quicker
	EB3	The use of cloud computing increases the resiliency of our IT services
	EB4	The use of cloud computing will help us focus in-house staff on strategic work
	EB5	The use of cloud computing will enable us to scale IT resources up or down according to demand
Technology competence		Relative to other firms in your industry, please evaluate your organization's IT capabilities in the following areas on a 1-7 scale (1=poorer than most, 7= superior to most).
	TC1	Data management services and architectures (e.g., databases, data warehousing, data availability, storage, accessibility, sharing etc.)
	TC2	Network communication services (e.g., connectivity, reliability, availability, LAN, WAN, etc.)
	TC3	Application portfolio & services (e.g., ERP, ASP, SCM, reusable software modules/components, APIs, emerging technologies, etc.)
	TC4	IT facilities' operations/services (e.g., servers, large-scale processors, performance monitors, etc.)
	TC5	Our organization has the in-house expertise to implement cloud computing
Security		
	S1	The degree to which your company is concerned about the security of data in the cloud
	S2	The degree to which your company is concerned about the security of data transmission to and from the cloud
	S3	The degree to which your customers are concerned about the security of data in the cloud
	S4	The degree to which your customers are concerned about the privacy of data in the cloud
Organizational context		
Organizational innovativeness		
	OI1	My organization readily accepts innovations based on research results
	OI2	Management in my organization actively seeks innovative ideas
	OI3	Innovation is readily accepted in this organization.
	OI4	People are penalized for new ideas that don't work. (Reverse scale)
	OI5	Innovation in this organization is perceived as too risky and is resisted. (Reverse scale)
Environmental context		
Trust		
	T1	The cloud vendor and our organization have a high level of mutual trust
	T2	The cloud vendor is well known for fair dealing
	T3	The cloud vendor stands by its word
Competitive pressure		

	CP1	Organization thinks that cloud computing has an influence on competition in their industry
	CP2	Our firm is under pressure from competitors to adopt cloud computing.
	CP3	Some of our competitors have already started using cloud computing
Controls		
Firm size		
	FS1	Number of employees at firm
	FS2	Annual Revenue in the previous year
Firm scope		
	SC1	My organization provides IT services to internal or external customers outside of the US
	SC2	My company's Headquarters is located outside of the US. (List country)

Appendix B: Survey Group Respondents

Survey Group		N	Mean	Std. Deviation	Std. Error Mean
Cloud Adoption	1st Group	75	2.76	2.039	.235
	2nd Group	75	2.88	2.284	.264

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Cloud Adoptn	Equal variances assumed	2.496	.116	-.339	148	.735	-.120	.354	-.819	.579
	Equal variances not assumed			-.339	146.140	.735	-.120	.354	-.819	.579

Appendix C: Model Measurement Types

Survey Item	Measure Type	Reference
Expected Benefits	Reflective	Venkatesh & Bala (2012)
EB1 The use of cloud computing will help us reduce or avoid costs		
EB2 The use of cloud computing will help us deploy solutions quicker		
EB3 Cloud computing allows you to manage business operations in an efficient way		
EB4 The use of cloud computing services improves the quality of operations.		
EB5 Using cloud computing allows you to perform specific tasks more quickly		
Technology competence	Formative	Zhu et al. (2006b)
TC1 Data management services and architectures (e.g., databases, data warehousing, data availability, storage, accessibility, sharing etc.)		
TC2 Network communication services (e.g., connectivity, reliability, availability, LAN, WAN, etc.)		
TC3 Application portfolio & services (e.g., ERP, ASP, SCM, reusable software modules/components, APIs, emerging technologies, etc.)		
TC4 IT facilities' operations/services (e.g., servers, large-scale processors, performance monitors, etc.)		
TC5 Our organization has the in-house expertise to implement cloud computing		
Security Concerns	Reflective	Zhu et al. (2006b); Oliveira et al. (2014)
S1 The degree to which your company is concerned about the security of data in the cloud		
S2 The degree to which your company is concerned about the security of data transmission to and from the cloud		
S3 The degree to which your customers are concerned about the security of data stored in the cloud		
S4 The degree to which your customers are concerned about the privacy of data stored in the cloud		
Organizational innovativeness	Reflective	Venkatesh & Bala (2012)
OI1 My organization readily accepts innovations based on research results		

	OI3 Innovation is readily accepted in this organization.		
Trust		Reflective	Rai (2009)
	T1 The cloud vendor and our organization have a high level of mutual trust		
	T2 The cloud vendor is well known for fair dealing		
	T3 The cloud vendor stands by its word		
Competitive pressure		Reflective	Oliveira et al. (2014)
	CP1 Organization thinks that cloud computing has an influence on competition in their industry		
	CP3 Some of our competitors have already started using cloud computing		
Firm size		Formative	Venkatesh & Bala (2012)
	FS1 Number of employees at firm		
	FS2 Annual Revenue in the previous year		
Cloud computing adoption		Formative	Venkatesh & Bala (2012); Rai (2009)
	CC1 Cloud Assimilation		
	CC2 Time since adoption		

Appendix D: Indicator Reliability

		Full Model		IaaS		SaaS+PaaS	
Latent Variable	Indicator	Loading	Indicator Reliability	Loading	Indicator Reliability	Loading	Indicator Reliability
Competitive Pressure							
	CP1	0.967	0.935	1	1.000	0.935	0.874
	CP3	0.799	0.638	0.591	0.349	0.861	0.741
Expected Benefits							
	EB1	0.813	0.661	0.853	0.728	0.844	0.712
	EB2	0.933	0.870	0.773	0.598	0.897	0.805
	EB3	0.773	0.598	0.741	0.549	0.799	0.638
	EB4	0.808	0.653	0.895	0.801	0.808	0.653
	EB5	0.791	0.626	0.832	0.692	0.825	0.681
Organizational Innovativeness							
	OI1	0.931	0.867	0.858	0.736	0.962	0.925
	OI3	0.937	0.878	0.974	0.949	0.904	0.817
Security Concerns							
	SC1	0.933	0.870	0.906	0.821	0.847	0.717
	SC2	0.821	0.674	0.899	0.808	0.489	0.239
	SC3	0.809	0.654	0.872	0.760	0.696	0.484
	SC4	0.855	0.731	0.894	0.799	0.784	0.615
Trust							
	T1	0.819	0.671	0.939	0.882	0.840	0.706
	T2	0.969	0.939	0.757	0.573	0.954	0.910
	T3	0.916	0.839	0.947	0.897	0.922	0.850

Appendix E: Discriminant Validity

Discriminant validity (Full Model)

Number	Construct	1	2	3	4	5	6	7	8	9
1	Cloud Adoption	N/A								
2	Cloud Services	0.12	N/A							
3	Competitive Pressure	0.06	0.24	**0.89**						
4	Expected Benefits	0.10	0.21	0.64	**0.83**					
5	Firm Size	0.07	0.11	-0.10	-0.11	N/A				
6	Organizational Innovativeness	-0.10	0.19	0.59	0.67	-0.15	**0.93**			
7	Security Concerns	-0.13	0.01	0.09	-0.02	0.28	-0.01	**0.86**		
8	Technical Competency	0.25	0.06	0.06	0.05	0.09	0.04	-0.06	N/A	
9	Trust	0.17	0.06	0.59	0.67	-0.12	0.66	-0.10	0.14	**0.90**

Note: The diagonal elements in bold are the square root of the average variance extracted (AVE), reported only for reflective measures

Discriminant Validity (IaaS)

Number	Construct	1	2	3	4	5	6	7	8	9
1	Cloud Adoption	N/A								
2	Competitive Pressure	0.08	N/A							
3	Expected Benefits	-0.17	0.22	**0.82**						
4	Firm Scope	-0.15	0.20	0.64	**0.82**					
5	Firm Size	0.15	0.10	0.11	0.02	N/A				
6	Organizational Innovativeness	-0.30	0.19	0.70	0.68	0.02	**0.92**			
7	Security Concerns	-0.05	0.00	0.10	0.02	0.21	0.06	**0.89**		
8	Technical Competency	-0.31	0.00	0.10	0.14	0.01	0.14	0.08	N/A	
9	Trust	-0.16	0.19	0.67	0.74	0.02	0.71	-0.05	0.22	**0.89**

Note: The diagonal elements in bold are the square root of the average variance extracted (AVE), reported only for reflective measures

Discriminant validity (SaaS + PaaS)

Number	Construct	1	2	3	4	5	6	7	8	9
1	Cloud Adoption	N/A								
2	Competitive Pressure	0.18	N/A							
3	Expected Benefits	0.15	0.25	**0.90**						
4	Firm Scope	0.14	0.17	0.65	**0.84**					
5	Firm Size	0.04	0.17	0.11	-0.03	N/A				
6	Organizational Innovativeness	-0.07	0.18	0.50	0.67	-0.15	**0.93**			
7	Security Concerns	-0.23	0.04	0.12	0.02	0.33	0.04	**0.72**		
8	Technical Competency	0.22	0.08	0.32	0.29	0.07	0.24	-0.01	N/A	
9	Trust	0.22	0.00	0.57	0.64	-0.09	0.63	-0.08	0.36	**0.91**

Note: The diagonal elements in bold are the square root of the average variance extracted (AVE), reported only for reflective measures

Appendix F: Formative Model - Collinearity: IaaS, SaaS + PaaS

Sub-model: IaaS, SaaS + PaaS
Collinearity Results

		IaaS	SaaS + PaaS
Construct	Indicators	VIF	VIF
Firm Size			
	FS1	1.550	1.209
	FS2	1.550	1.209
Technical Competency			
	TC1	4.001	2.735
	TC2	1.897	2.259
	TC3	3.974	1.571
	TC4	5.387	2.135
	TC5	3.172	1.768
Cloud Adoption			
	CC1	1.028	1.004
	CC2	1.028	1.004

Appendix G: Formative Model - Outer Weights: IaaS, SaaS + PaaS

Sub-model: IaaS
Outer weight significance testing

Formative Construct	Indicators	Outer Weights	Standard deviation	t value	Significance level
Firm Size					
	FS1	0.942	0.395	2.384	***
	FS2	0.093	0.414	0.225	NS
Technical Competency					
	TC1	0.706	0.497	1.421	*
	TC2	-1.231	0.323	3.815	***
	TC3	-0.203	0.432	0.469	NS
	TC4	0.248	0.594	0.417	NS
	TC5	0.493	0.423	1.166	NS
Cloud Adoption					
	CC1	0.143	0.482	0.482	NS
	CC2	0.966	0.781	3.671	***

Note: Based on t-values, 1-tail;
NS = not significant
*p<.10; **P<.05; ***p<.01

Sub-model: SaaS+PaaS
Outer weight significance testing

Formative Construct	Indicators	Outer Weights	Standard deviation	t value	Significance level
Firm Size					
	FS1	0.197	0.341	0.577	NS
	FS2	0.902	0.349	2.588	***
Technical Competency					
	TC1	-1.005	0.386	2.608	***
	TC2	0.943	0.427	2.206	***
	TC3	0.478	0.292	1.639	*
	TC4	0.204	0.358	0.571	NS
	TC5	0.221	0.333	0.664	NS
Cloud Adoption					
	CC1	0.648	0.329	1.969	***
	CC2	0.805	0.300	2.681	***

Note: Based on t-values, 1-tail;
NS = not significant
*p<.10; **P<.05; ***p<.01

Appendix H: Structural Model Collinearity: IaaS, SaaS + PaaS

Submodel analysis
Collinearity – inner model

	IaaS	SaaS+PaaS
Predictor Latent Variables	Cloud Adoption VIF	Cloud Adoption VIF
Cloud Services	1.067	1.176
Competitive Pressure	2.401	2.067
Expected Benefits	2.565	2.506
Firm Size	1.068	1.249
Organizational Innovativeness	2.664	2.254
Security Concerns	1.094	1.179
Technical Competency	1.070	1.188
Trust	2.993	2.376

Appendix I: Structural Model Significance and Relevance: IaaS, SaaS + PaaS

Structural Model Path Coefficients – IaaS

	Path Coefficient	Standard Deviation	t-value	Significance Level
Cloud Services -> Cloud Adoption	0.111	0.101	1.102	NS
Competitive Pressure -> Cloud Adoption	-0.017	0.138	0.122	NS
Expected Benefits -> Cloud Adoption	0.050	0.162	0.311	NS
Firm Size -> Cloud Adoption	0.150	0.122	1.225	NS
Organizational Innovativeness -> Cloud Adoption	-0.408	0.191	2.135	***
Security Concerns -> Cloud Adoption	-0.023	0.111	0.209	NS
Technical Competency -> Cloud Adoption	-0.290	0.146	1.983	***
Trust -> Cloud Adoption	0.141	0.158	0.892	NS

Note: Based on t-values, 1-tail; NS = not significant

*p<.10; **P<.05; ***p<.01

Structural Model Path Coefficients – SaaS+PaaS

	Path Coefficient	Standard Deviation	t-value	Significance Level
Cloud Services -> Cloud Adoption	0.220	0.114	1.925	**
Competitive Pressure -> Cloud Adoption	0.020	0.102	0.195	NS
Expected Benefits -> Cloud Adoption	0.125	0.124	1.010	NS
Firm Size -> Cloud Adoption	0.025	0.075	0.334	NS
Organizational Innovativeness -> Cloud Adoption	-0.447	0.187	2.394	***
Security Concerns -> Cloud Adoption	-0.204	0.110	1.860	**
Technical Competency -> Cloud Adoption	0.136	0.122	1.120	NS
Trust -> Cloud Adoption	0.352	0.169	2.085	***

Note: Based on t-values, 1-tail; NS = not significant

*p<.10; **P<.05; ***p<.01

Appendix J: Structural Model Effect Size: IaaS, SaaS + PaaS

Effect size

	IaaS	SaaS+PaaS
Predictor Latent Variables	Cloud Adoption f^2	Cloud Adoption f^2
Cloud Services	0.015	0.055
Competitive Pressure	0.000	0.000
Expected Benefits	0.001	0.008
Firm Size	0.027	0.001
Organizational Innovativeness	0.080	0.118
Security Concerns	0.001	0.047
Technical Competency	0.100	0.021
Trust	0.008	0.069

Appendix K: Model Results and Comparison: SaaS

Structural Model Path Coefficients – SaaS

	Path Coefficient	Standard Deviation	t-value	Significance Level
Cloud Services -> Cloud Adoption	-0.059	0.134	0.438	NS
Competitive Pressure -> Cloud Adoption	0.108	0.131	0.825	NS
Expected Benefits -> Cloud Adoption	0.287	0.155	1.85	**
Firm Size -> Cloud Adoption	-0.003	0.098	0.029	NS
Organizational Innovativeness -> Cloud Adoption	-0.241	0.196	1.226	NS
Security Concerns -> Cloud Adoption	0.16	0.125	1.286	NS
Technical Competency -> Cloud Adoption	0.403	0.173	2.331	***
Trust -> Cloud Adoption	-0.073	0.175	0.419	NS

Note: Based on t-values, 1-tail; NS = not significant

*p<.10; **P<.05; ***p<.01

Model Comparisons: IaaS and SaaS

H#	Hypothesis	IaaS	SaaS
H1:	Expected benefits will positively impact cloud computing adoption		Supported **
H2:	Technology competence will positively impact cloud computing adoption	**Supported *****	Supported ***
H3:	Security concerns will negatively impact cloud computing adoption		
H4:	Organizational innovativeness will positively influence cloud computing adoption	**Supported *****	
H5:	Vendor trust will positively influences cloud computing adoption		
H6:	Competitive pressure will positively influence cloud computing adopt		

Note: items in bold reflect an inverse relationship
* p<0.10, ** p<0.05; *** p<0.01

VITA

Michael Raymond McKinnie is an Information Systems professional with over 15 years of client facing experience in the enterprise software space, assisting large global and regional firms in translating corporate strategy into business solutions utilizing technology. He has expertise in both cloud and on-premise solutions across multiple domains including financial and operational performance management, ERP, business intelligence, predictive analytics, and in-memory analytic applications. Notable clients include the Bank of America, Citigroup, Fifth Third Bank, BB&T, General Motors, Mercedes, and Fiat Chrysler.

Mr. McKinnie has delivered presentations at numerous Performance Management, Finance, and Business Analytics conferences and forums including the IBM Performance Management conference in Washington, DC and the SIBOS Financial Industry Conference in Atlanta. He has been a guest lecturer at the business school at Clemson University and a panel speaker at Wake Forest University's MA and MBA business symposium. At Oracle Corporation he taught seminars on banking fundamentals to technical and sales resources supporting financial services accounts. Mr. McKinnie authored the industry briefing, *SAP Currency Management and Optimization – Getting More Bang for Your Buck.*

At IBM, Mr. McKinnie provides technical leadership to large, strategic clients endeavoring to solve complex business problems. He received IBM's Outstanding Technical Achievement Award for his efforts in driving the enterprise adoption of innovative solutions at a large, global client. Prior to IBM, Mr. McKinnie was instrumental in building a financial services industry vertical at both SAP Americas and Oracle Corporation.

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