



# Cloud Adoption Framework for Small and Medium-Size Enterprises (SMEs) in Ethiopia

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## Declaration

I, the undersigned, declare that the thesis comprises my own work in compliance with internationally accepted practices; I have fully acknowledged and referred all materials used in this Thesis work.

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This is to certify that the thesis prepared by **Birhane W/gebreal**, entitled *Cloud Adoption Framework for Small and Medium-Size Enterprises (SMEs) in Ethiopia* and submitted in partial fulfillment of the requirements for the degree of master of Science (Telecommunication Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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## ABSTRACT

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Cloud Computing (CC) is being accepted as one of the emerging technologies that create a new opportunity for enterprises with limited resources. It is promised that cloud can allow firms to reduce costs and to operate more flexibly than with a traditional Information Technology (IT) infrastructure. However, the promising opportunities go hand-in-hand with several challenges that can pose risks for a firm planning to adopt CC. A number of frameworks and models have been developed by prior studies to support cloud adoption process. However, these models and frameworks have been formulated to the context of developed countries. Though worldwide research may be applicable to at least some extent research regarding the adoption of cloud is not fully generalizable to corporate environment.

In this study, we have proposed a conceptual cloud adoption model grounded by Technology Organization and Environment (TOE) and Diffusion of Innovation (DOI) frameworks. According to this model, six variables are influencing the Small and Medium Enterprises (SMEs)' decision to adopt CC. To test the proposed model, we have used dataset collected from 136 SMEs and analyzed using Multiple Linear Regression (MLR). The analysis revealed that the model is statistically significant [F (6,129) 73.631 and p <0.001]. Four out of the six determinants were found to be significant for their influence of cloud adoption. Moreover, a Cloud Deployment Selection Model (CDSM) has been also proposed to support SMEs' in predicting an appropriate cloud model for their business need. The model is generated by refining the MLR output and using the established principles of Analytic Hierarchy Process (AHP).

## KEYWORDS

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Cloud Computing, Cloud Adoption, TOE, DOI, Framework, AHP, SMEs

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## ACRONYMS

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AHP	Analytic Hierarchy Process
API	Application Programming Interface
ANOVA	Analysis of variance
CC	Cloud Computing
CDSM	Cloud Deployment Selection Model
Capex	Capital Expenses
CSC	Cloud Service Consumer
CSP	Cloud Service Provider
DOI	Diffusion of Innovation
ICT	Information and Communication Technology
IaaS	Infrastructure as a Service
IS	Information System
IT	Information Technology
KMO	Kaiser-Meyer-Olkin
MLR	Multiple Linear Regression
MCDM	Multi-Criteria Decision-Making
NIST	National Institute of Standards and Technology
Opex	Operating Expenses
PaaS	Platform as a Service
PCA	Principal Component Analysis

QoS	Quality of Service
SaaS	Software as a Service
SLA	Service Level Agreement
SEM	Structural Equation Modeling
SMEs	Small and Medium Enterprises
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
TOE	Technology Organization and Environment
UTAUT	Unified Theory of Acceptance and Use of Technology
VIF	Variance Inflation Factor

## INTRODUCTION

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This chapter serves as an introduction for this thesis study. It starts by providing a brief background and continues by discussing the motivation and purpose of the study. Next, the methodology and scope of the research are established. Finally, it provides a quick glance on the thesis structure.

### 1.1 BACKGROUND

Cloud computing is a new paradigm of enterprises' resource computing that offers a number of significant advantages over its preceding computing style. Cloud computing seeks to deliver Information and Communication Technology (ICT) services similar to other utility services (water, power ...etc). Thus, it creates a level of playing field for many firms such as SMEs by providing opportunities of utilizing cutting edge of IT that hitherto were not affordable due to the high cost of owning these technologies [1]. In addition, the feature of rich flexibility, better accessibility and security provided by this emerging technology permits firms to customize services and data for higher availability [2].

Though CC has a number of advantages for enterprises, there is also a number of constraints for adopting it [3]. Service quality, potential outages, loss of control over IT resources, and possible data lock-in in the absence of clearly defined standards are some of the concerns on which enterprises to face. However, scholars have indicated that the perceived benefits appear to outweigh these inherent constraints [4], and appear to compel firms to look towards cloud for their IT resource requirements. Hence by maximizing the perceived benefits of cloud and reducing possible concerns could result in an increased rate of cloud adoption by SMEs.

In order to gain the maximum benefit from cloud computing services, firms need to understand the surrounding influencing issues of cloud services [5]. This can be achieved through all embracing IT adoption research which would help firms to

accept or reject emerging technology [6]. IT Adoption incorporate the firm's policies, strategies, processes, and tasks employed by firm in its efforts to identify, acquire, and diffuse an appropriate technology innovation [7].

Basically, diffusion of innovation is a result of a chain of decisions to the use of new technology. These decisions come usually from a comparison of its ambiguous benefits and corresponding costs of adoption [6]. Prior studies have indicated that, the decision for adopting emerging technology could not be a simple choice. Decision makers have been challenged when it comes to the decision of adopting or not these technologies. The decision to adopt CC or new technologies, has been usually based on experts' experience, vendor's recommendation, or market promotion without pre-adoption analysis to determine whether that particular technology meets the strategic goal of the organization or not. A survey reported in [8] showed that many of the information management practitioners consulted felt that the adoption of cloud services was often an ad hoc and driven mainly by IT in response to changing business needs and overload of computing systems.

Moreover, adoption decisions are also vulnerable to many social influences, both from inside and outside of an organization. For example, technology might not work or it may be too expensive. Destructive social impacts may have a more profound effect on a technology adoption decision than positive social impacts toward technology adoption, and can also affect decisions to terminate its adoption [9]. Hence, it can affect different stakeholders such as Cloud Service Provider (CSP), cloud service broker and organizations or end users. Because of these social factors, organizations should start by carefully assessing situation in their operating environment. This helps in identifying bottlenecks and weaknesses that need to be addressed if the cloud is to be effectively exploited, and clarify what kind of cloud solutions are most favorable.

## 1.2 MOTIVATION

Cloud computing is being accepted as one of the emerging technologies that create a new opportunity mainly for those enterprises with limited resources. It is promised that cloud services can allow firms to reduce costs and to operate more flexibly than

with a traditional IT infrastructure and can enable them to develop new business. However, the promising opportunities of this technology go hand-in-hand with certain challenges that can pose a risk as result of migrating the service to this paradigm. Data privacy, data lock-in and data ownership related issues are concerns that firms to face during cloud adoption.

Though, migration of IT services to cloud can reshape the enterprise's IT landscape and can heavily impact its business strategy and performance. However, switching the service to a wrong cloud model can also result in low performance. Since there are several cloud computing deployment models that firms can adopt and each model architecture offers different advantages and constraints; many firms find it as a great decision challenge when identifying the right model that will optimally address their business needs. Hence, selecting wrong cloud deployment model for cloud service can be operationally costly and potentially could harm a business strategy. Besides to the potential risks and the decision concerns there is a little guidance available from industries and scholars on how to adopt this technology from the firms' context [8].

It is believed that the aforementioned adoption challenges have left the cloud ecosystem from being effectively exploited. Currently, cloud service providers are offering a wide range of cloud-based ICT solutions. However, the acceptance and usage of these services by SMEs in Ethiopia are slow and discouraging. SMEs are being challenged in determining a path to adopt cloud services that would ensure their sustainable presence in the cloud ecosystem. As reported in [10] the cloud adoption rate around the globe varies . The adoption rate of cloud computing in developing countries including Ethiopia is low [3], [10], [11]. Moreover, the low adoption rate and ambiguity from the enterprises side have also challenged the cloud provider side. Providers have been challenged to predict which enterprises will exhibit a propensity for cloud adoption. Hence, providers can't focus their marketing efforts, personnel and budgets on enterprises having high levels of propensity for cloud adoption.

Therefore, the focus of this research is on SMEs within an Ethiopian context. Understanding why and how SMEs are motivated to adopt CC will enable the creation of a more favorable environment for greater adoption and will help in developing strate-

gies to promote the adoption process. To the best of our knowledge based on the literature review, very few studies have been conducted in developing countries like Ethiopia, in particular for the SMEs. Our study tries to bridge this gap by identifying the influential determinants that provide valuable perceptions into the adoption of CC by SMEs in Ethiopia.

### 1.3 PROBLEM STATEMENT

The effectiveness of cloud computing is being limited by many challenges and concerns that affect both firms and cloud providers and influence the adoption rate of cloud services [12]. Adopting cloud computing changes not only the technology used by an enterprise but also the way in which business operations are managed [13]. In addition, switching enterprise resources to a cloud involves decision making at the strategic and operational levels and could potentially impact all aspects of the firm [14].

A number of frameworks and models have been developed by prior studies to support cloud computing adoption process. However, these frameworks and models have been fragmented and sometimes lack theoretical grounding, have focused on specific technical aspects of the adoption process and not providing holistic view of the adoption process. Besides, existing models and frameworks have been formulated for the context of technologically developed environment. To this end there has been very little investigation to determine whether the determinants that affect cloud adoption in developing countries are different.

Moreover, the physical location of cloud provider is overlooked by prior studies. However, it can be an important determinant of cloud adoption process in context of the firms in developing countries like Ethiopia where majority of the cloud providers are over the sea. Storing data in locations within different jurisdictions could cause problems for firms and raises questions regarding data sovereignty and jurisdiction over the stored data [1], [6].

## 1.4 RESEARCH QUESTION

Even though CC is potentially a future key technology for firms to realize increased productivity and enhanced efficiency in businesses operations. However, SMEs in Ethiopia are still in the infancy stage and face many obstacles to adopt [12]. Based on this notion drawn from the literature and conceptual framework, this motivates to the following specific research question.

- What are the determinants that influence the decision of SMEs to adopt CC in Ethiopia?
- What are the effects of firm size in cloud adoption decision?
- How to predict the best fit cloud deployment model that align with the specific need of SME?

## 1.5 OBJECTIVES

### 1.5.1 *General Objective*

The objective of this research is to propose a cloud adoption framework for SMEs.

### 1.5.2 *Specific Objectives*

In order to meet the general objective, the following specific objectives are stated:

- Review theories and frameworks on adopting new technologies and innovations.
- Document a fact finding framework for cloud computing adoption.
- Collect datasets from SMEs for model verification.
- Identify the determinants and their relationship to adopt CC.
- Propose CDSM for SMEs in Ethiopia based on their context.
- Validate the proposed model

## 1.6 METHODOLOGY

To meet the general and specific objectives of the study, the research has been designed in four phases.

In phase one, academic literature on technology adoption frameworks, theories and CC has been studied to identify key factors for successful cloud adoption. An appropriate framework has proposed to tackle the research problem grounded by TOE and DOI frameworks. In phase two, a structured questionnaires were generated based on the proposed framework. The questionnaires have been used to collect the quantitative data from selected SMEs in Addis Ababa. The questionnaires were the major instrument designed for this study to collect data which were used for model verification. Data analysis and modeling verification has conducted at the third phase using MLR. Finally, ones the motivators and inhibitors of CC adoptions were identified by the MLR analysis, a conceptual CDSM has been recommend to predict a cloud deployment model for SMEs by refining the outcome of the MLR analysis and illustrated using case study.

## 1.7 SCOPE OF THE STUDY

The main objective of this study is to propose a cloud adoption framework for SMEs in Ethiopia by analyzing their contexts. There are a number of SMEs in Ethiopia; however, this study has focused on selected SMEs located in Addis Ababa. Additionally, the study explored a number of determinants that affected SMEs adoption decisions, however, major analysis of the study focused on selected determinants that are affecting the cloud adoption decision.

## 1.8 RESEARCH SIGNIFICANCE

This study will help both SMEs and CSPs. It helps SMEs to increase their CC adoption by reducing their risk. SMEs will make an informed decision in the process of adoption of CC by evaluating their pros and cons associated with this technology. The determinants identified are aimed at providing the necessary considerations to be undertaken, be it the motivators or inhibitors that SMEs need to consider in their

investigations of cloud adoption. To this end, the proposed **CDSM** will enable firms to identify the right cloud deployment model for their business need.

Additionally, it helps **CSPs**, by providing them **SMEs** specific determinants which they need to consider in order to adjust their services and rethink their marketing strategies. Furthermore, it will enable service providers to optimize their offerings in order to be more beneficial and less risky. Hence **CSPs** can examining the most important predictors of cloud adoption propensity, they can get interesting insights to the main cloud adoption motivations and orientations of enterprises.

## 1.9 THESIS ORGANIZATION

The rest of the thesis is organized as follows:

Chapter 2 dedicated to cloud computing overview and theoretical background. We first define cloud computing and discuss about its characteristics, delivery models and development models. In addition, we point out the prominent advantages and disadvantages of cloud computing. The conceptual frameworks and theories used for adopting emerging technology and decisions are addressed in this chapter. Finally, the working definition of **SMEs** for this study is define in this chapter.

Chapter 3 provides an overview of previous studies on cloud computing adoption determinants, cloud computing adoption frameworks and Analytic Hierarchical Process.

Chapter 4 outlines the research design, model development, hypothesis development, instrument development, data collection processes, and model testing method used in this study.

Chapter 5 is dedicated to Modeling and Experiment of the study. The proposed model is tested using **MLR** and the **CDSM** is generated and illustrated using case study.

Chapter 6 presents the conclusion, contribution and future work of the study.

## LITERATURE REVIEW

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This chapter is dedicated to cloud computing overview and theoretical background. We first define cloud computing and discuss about its characteristics, delivery models and development models. In addition, we point out the prominent advantages and disadvantages of cloud computing. The conceptual frameworks and theories used for adopting emerging technology and decisions are addressed in this chapter. Finally, the working definition of [SMEs](#) for this study is define in this chapter.

### 2.1 CLOUD COMPUTING DEFINITIONS

There are numerous definitions given to [CC](#) by different industries and authors, for example; HP defines it as “Everything as a Service” [15], while Microsoft perceives the value of [CC](#) as “Cloud + Client,” emphasizing the importance of the end user [16]. T-systems define cloud computing as the renting of infrastructure and software, as well as bandwidths, under defined service conditions [17].

Most scientific works based their cloud definition by the National Institute of Standards and Technology ([NIST](#)) cloud definition [18], we also adopt this definition. [NIST](#) define [CC](#) as: “A model for enabling ubiquitous, convenient, on- demand network access to a shared pool of configurable computing resources (e.g. Networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”.

According to [18] definition, the basic actors in the cloud computing context are [CSPs](#) and Cloud Service Consumer ([CSC](#))s, despite that there might be service brokers involved based on the architecture of cloud services. The [NIST](#) definition incorporates all the aspects of [CC](#) mentioned above. Moreover, it also provides a further characterization of cloud computing by defining its essential characteristics, service models and deployment models as shown in [Figure 2.1](#).

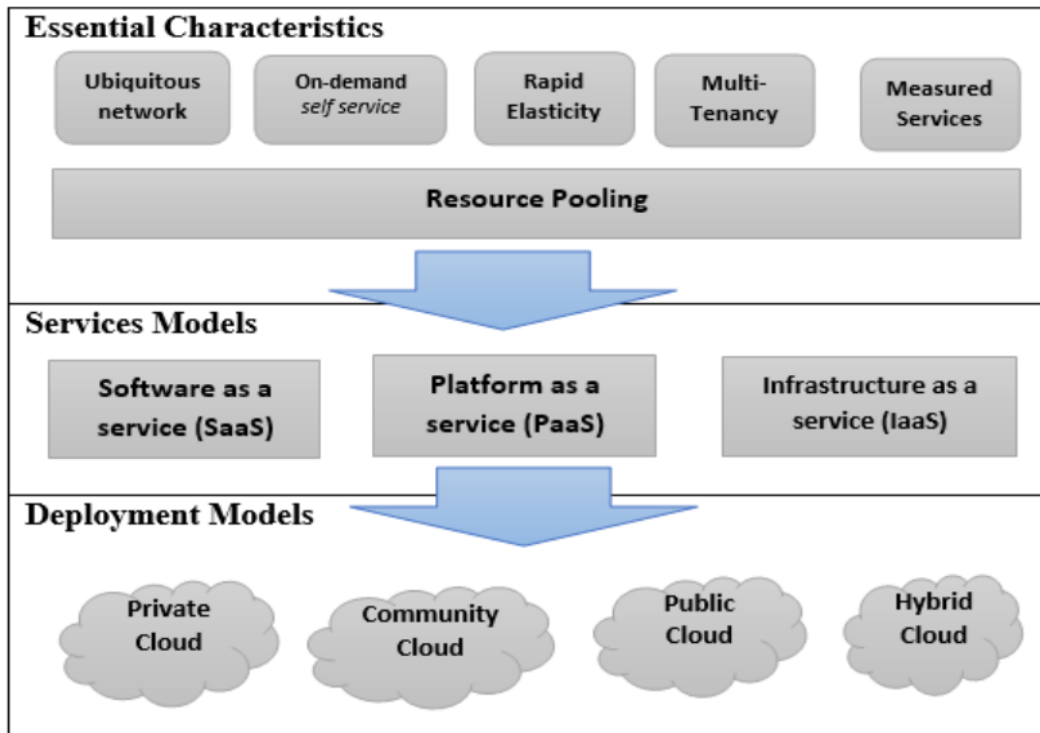


Figure 2.1: Cloud Computing Definition Adopted from[18]

## 2.2 CLOUD COMPUTING ESSENTIAL CHARACTERISTICS

The advantage of cloud is far beyond cost savings for firms. It impacts firms enormously in variety of ways due to its enabling features as depict below. It enables firms to focus on their core business objectives while details of running the IT infrastructure will be left to the providers.

- **Measured Service:** cloud systems automatically control and optimize resource use by leveraging metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported by providing transparency for both the provider and the consumer of the utilized service. Cloud consumers want the option of usage -based (or pay - as - you - go) pricing in which their price is based on the resources actually consumed, rather than being locked into a fixed pricing arrangement. Measuring resource consumption and appropriately charging cloud consumers for their actual resource consumption encourages them not to squander resources and release unneeded resources so they can be used by other cloud consumers.

- **On-demand Self-Service:** consumer can unilaterally provision computing capabilities according to their demand at particular timeslots, and are able to obtain computing capabilities, such as software, storage, or CPU time automatically from a service provider without human interaction.
- **Ubiquitous Access:** unified access to computing capabilities are available over the internet permits the usage of heterogeneous thin clients, such as mobile phones or laptops.
- **Pooled Resources:** multi-tenancy that enables sharing of pooled resources and costs across a number of users, with different physical and virtual resources dynamically assigned and reassigned according to user demand.
- **Rapid Elastic:** quick scale up or scale down of resources through elastic provisioning or the release of capabilities in near real time. It provides scalable on demand computing capabilities.

## 2.3 CLOUD DEPLOYMENT MODELS

The [NIST](#) cloud definition has four deployment models [16] as described below..

### 2.3.1 *Public Cloud*

A public cloud is a [CC](#) infrastructure offered by service providers and made available to any organization or individual, mainly offered over the Internet [1], [6]. These resources are controlled and managed by service provider located off-site relative to end user. A public cloud offers on demand and high scalability services. However, there are several concerns associated with this computing. Data location represents one of the main issues in public cloud, as data is stored beyond the enterprise premises. In addition, to provide high availability and business continuity, service providers store data in multiple sites possibly in different territory; while many countries have established regulations on specific data or industries that cannot store data outside their territory.

Moreover, storing data in locations within different jurisdictions could cause problems for cloud consumers [1], [6] and raises questions about which state has juris-

diction over the stored data. Besides, it is argued that the risk of breach data and unauthorized access concerns for many enterprises when they are considering a migration to public cloud. Public clouds use a multi-tenant approach which could lead to data breaches [6].

### 2.3.2 *Community Cloud*

A cloud service that is provided exclusively to a specific community comprising consumers of different organizations sharing similar concerns. One or more firms being part of that community, a third party, or a combination of both may be the owner, manager, and operator of that cloud; and it may be located on or off the premises of the collaborating organizations [18].

### 2.3.3 *Private Cloud*

A cloud setup that is delivered solely to a single organization that may comprise multiple consumers, such as different business units. The organization itself, a third party, or a combination of both may be the owner, manager, and operator of that cloud and it may be located on or off the premises of that organization [18]. Running a private cloud offers the highest level of control over aspects such as performance, security concerns, reliability of mission-critical tasks, but does not allow to eliminate up-front investments in contrast to public clouds.

### 2.3.4 *Hybrid Cloud*

A cloud platform that is a combination of two or more of other deployment models. Each of the clouds being part of the hybrid cloud remains a discrete entity; although being able to move data and applications to the other clouds by applying appropriate technology [18]. Hybrid cloud deployment model can be beneficial in specific scenarios [18]. In case of a bursting scenario, for instance, a private cloud can acquire more resources from a public cloud. In order to optimize resource utilization, a hybrid cloud permits keeping core business activities in a private cloud, while moving other, less critical activities into a public cloud. However, hybrid cloud requires interconnection among different cloud providers. While the interconnection among different providers is remain another challenge for CSPs and CSCs.

## 2.4 CLOUD SERVICE MODELS

Three service models are extensively used by the cloud community to categories the cloud computing services [18], [19] as described below.

- **Software as a Service (SaaS):-** cloud services applications are released in a hosting environment, which can be accessed through networks from various clients. CC users do not have control over the cloud infrastructure that often employs multi-tenancy system architecture to achieve economies of scale and optimization.
- **Platform as a Service (PaaS):-** PaaS is a development platform supporting the full "Software Lifecycle" which allows to develop cloud services and applications (e.g. SaaS) directly on the PaaS cloud. Hence, PaaS offers a development platform that hosts both completed and in-progress cloud computing applications.
- **Infrastructure as a Service (IaaS):** -users can directly use IT infrastructures (processing, storage, networks, and other fundamental computing resources) provided in the IaaS cloud. Virtualization is extensively used in IaaS cloud to integrate/decompose physical resources in an ad hoc manner to meet changing resource demands from cloud users.

## 2.5 ADVANTAGES OF CLOUD COMPUTING

A number of prior studies shows that cloud has reshaped existing computing technology to support business in the following dimensions:

- **Scalability:** scalability represents one of the main features of cloud that allows computing resources provisioning and released based on user demand. Scalability can support enterprises to expand their IT capacity rapidly with a very short lead time [2], [6], [20].
- **Better IT utilization:** as author [1] pointed out that only 10-30% of data centers' computer power is used in off-peak, while features of cloud such as virtualization and pool resources could provide a better utilization of IT resources. This

is because the cloud environment provides a shared pool in which resources are provisioned and released in respect to end user needs.

- **Accessibility:** CC is location independent [18], allowing users access anywhere, anytime, subject to an internet connection. In addition, in a cloud environment all computing operations will be performed in cloud, so the user can access from any device through web browser or other thin client interfaces [1], [18]. Thus, CC offers more mobility to users, enabling them to access computing resources anytime, anywhere and on any devices.
- **Faster access to IT resources:** cloud deployment model such as public cloud could offer faster access to a variety computing services with no or minimum upfront cost [20].
- **Innovation:** CC represents a change in the way computing services are provisioned. It has been argued that rather than focusing on the management of physical resources, IT staff will be freed up to focus on application and service development, encouraging greater innovation [20].
- **Green IT:** cloud environments can offer a greener environment because they enable multiple users to share common resources by serving according to users' need. Hence, many data centers can be consolidated into one, reducing the energy required for computing power and cooling [18].
- **Economic benefits:** one of the main reasons for enterprises to move to cloud is the associated economic benefits. The cost of getting reliable IT services was a barrier to many SMEs in traditional IT environments [20].

Moving to cloud could reduce costs of using IT services because the operating and maintenance costs of underlying infrastructure might be moved to CSP in public clouds, while some operational costs remain in enterprise in PaaS and IaaS. In addition, enterprises using a private cloud could benefit from CC by consolidating servers or data centers, which will be reflected in saving on costs of energy consumption, cooling and floor space. Furthermore, it is argued that public and hybrid cloud offer opportunities to transfer Capital Expenses (Capex) to Operating Expenses (Opex). As a consequence of transferring Capex to Opex,

enterprise will pay the cost of computing services in the same manner as they pay for other utility services.

- Better IT capability: it is believed that building a secure IT environment for some firms particularly SMEs could be beyond their resource capabilities due to the prohibitive cost of IT expertise as well as computing resources [16], thus CC enables enterprises to have better computing capability.
- Better business continuity plan: it is considered that firms specially SMEs are challenged in delivering 24/7/365 uptime service delivery due to their limited resources. In this case cloud can provide a better business continuity thorough backup and disaster recovery as service [1].

## 2.6 CHALLENGES OF CLOUD COMPUTING

Though there are many potential advantages that firms get by adopting cloud, but this does not lead to inexorable conclusion of its superiority as an IT model for firm's businesses. In addition to the data security and privacy risks inherent in cloud technology, its characteristics and features also cause of a number of challenges that must be considered. These include questions regarding data sovereignty and jurisdiction.

### 2.6.1 Security Challenges

Security has played an important role in hindering the acceptance of cloud services. Storing and processing organizational vital data outside of its premises appears daunting to many firms. Running remotely on a collection of machines can cause serious threats to organization's data. The multi-tenancy model and collective computing resources in cloud has introduced new security challenges that require advanced security techniques to tackle. Due to sharing of computing resource vulnerability of data privacy and confidentiality is in question. For example, during data retrieval of a customer other data can be exposed. Customer concerns arise when their sensitive data and mission-critical applications migrated to a cloud where providers cannot guarantee the effectiveness of their security and privacy control.

#### A. Confidentiality

Preventing sensitive information from reaching unauthorized people, while making sure that the authorized people can get an access to it, is one of the requirement of system security. In cloud environment, data stored beyond the company firewall is threatened by unauthorized access. Thus data privacy in cloud computing is a big issue [6]. Data breaches could lead to loss of reputation, brand damage and loss of customers etc. This brings a dual responsibility in that enterprises should set policies and procedures that ensure the privacy of their data. While providers should maintain the safety of data, and convince users that their data is secure and protected.

#### B. Integrity

Integrity involves maintaining the consistency, accuracy, and trustworthiness of data over its entire life cycle. Data must not be changed in transit. An unauthorized access and alteration of data in the storage cloud and alterations to data through what is known as a man in the middle attack when data is intercepted when it travels between the users and service providers are two issues related to storing data in cloud in terms of integrity [6].

#### C. Availability

Availability in cloud relates to ubiquitous access to data and applications for authorized users anytime, anywhere, on any devices. It is a major concern due to the nature of cloud, whereby all services are made available mainly over internet [6], which renders connectivity is a major issue particularly with public and hybrid cloud [18]. In addition, enterprises rely on CSP to store their data, backup and restore, which exposes them to high risk of losing data if the CSP goes out of business or is affected by natural disasters. Moreover, because CC is a shared resource environment where huge data and applications are hosted in a cloud, it is prone to attacks such as denial of service (DoS) attack [6].

### 2.6.2 Economic Challenges

The perceived cost efficiency of cloud computing is the fundamental rationale for moving to cloud environment for firms, However, studies shows that there are many factors that need to be considered when deciding to migrate.

#### A. Costing Model

Migration to the cloud business model can significantly reduce the [IT](#) infrastructure cost, however it does raise cost of data communication. The cost of shipping an organization's data to and from the public and community cloud and the cost per unit of computing resource used is likely to be higher in many cases [[21](#)]. This cost is particularly prominent if the consumer organization uses the hybrid cloud deployment model where the organization's data is distributed among a number of deployment model. Thus, on-demand cloud computing resource usage makes sense only for CPU intensive jobs [[21](#)].

#### B. Charging Model

The elastic computing of resource pool has made the cost investigation significantly more complex than standard data centers, which often calculates their cost based on utilization of static computing. Moreover, creating virtual server has become the unit of cost analysis for the client organizations rather than the underlying physical server. Because cloud resources are distributed and continuously scaled to meet variable demands, it is a challenge to the [CSP](#) to manage physical resources and estimate the actual cost of providing the service.

For [SaaS](#) cloud providers, the cost of developing architecture in which a single instance of a software application serves multiple customers within their offering can be very substantial. This include reconstruction of the software that was originally used for single customer, the cost of providing new features that allow for intensive customization of software, performance and security enhancement for concurrent multi-user access, and dealing with complexities induced by changes in the software. Consequently, [SaaS](#) providers need to consider the exchange between provision of multi-occupancy and the cost reduction yielded by multi-occupancy. Therefore, a strategic and feasible charging

model for SaaS provider is critical for the gainfulness and supportability of SaaS cloud providers in cloud environment [21].

#### c. Hidden Costs

According to [22] 79% of companies are concerned about the hidden costs of cloud services. According to this report SaaS model is regarded as having fewer hidden costs. The rationality is that takes the responsibility of associated costs and risks such as those pertaining to data backup, recovery and upgrading. SaaS costs are identified upfront, and the only risk factor is that the CSPs could change prices after subscribers or users need to change providers, or actual usage exceeds predicted consumption, resulting in higher charges. In PaaS and IaaS, user needs to consider additional costs including backup, disaster recovery, security control and costs related to controlling resources. In addition, cloud user needs to estimate the expected cost of transferred inbound/outbound data.

#### d. Migration Costs

Although cloud computing is usually associated with no or minimal upfront costs, enterprises with a large IT infrastructure could face some challenges when migrating their IT services to the cloud environment. Migration costs include replacing existing hardware that is incompatible with cloud technology, recoding legacy applications to work with the cloud and providing training for IT staff to enable them to deal with cloud technology.

### 2.6.3 Regulatory Challenges

Regulatory risks are understood as the legal problems related to data that has been stored or processed across multiple countries that have different jurisdictions. Data sovereignty and jurisdiction challenges is one of the top challenges for adopting cloud service [23].

#### 2.6.4 *Quality of Service Challenges*

Cloud computing is an operation model that integrates many technological advancements like virtualizations, multi-tenancy web services, and Service Level Agreement (SLA) management for enterprise applications. This integration has simplified the capacity provisioning process. However, it has also poses several challenges in Quality of Service (QoS) management. This includes the challenges of performance, reliability, and interoperability offered by an application and by the platform or infrastructure that hosts it.

##### A. Cloud Interoperability

CSPs usually offer proprietary applications to access their cloud. However, consumers might want open Application Programming Interface (API) or standard APIs to become tenants of multiple clouds. This is a challenge for cloud providers because this requires an agreement among cloud providers and an upgrade of their proprietary applications to meet the standard. At present, each cloud offering has its own way on how cloud clients, applications, and users collaborate with the cloud, leading to the "Foggy Cloud" phenomenon [21]. This extremely prevents the advancement of cloud ecosystems by constraining cloud data lock-in.

##### B. Reliability

Any CSP faces a major question in the form of reliability of the services. Private clouds are always more reliable as all the service providing equipment's, set-up and data is within the organization. Public clouds, however, do not offer that level of reliability as it depends on the availability of the service provider as well as the internet connection. Hybrid clouds provide a medium level of reliability as it combines the features of both public and private clouds as the most accessed data is kept within the organization [24].

##### C. Performance

Cloud computing characteristics such as elasticity and accessibility promise to provide a reliable service with high performance. However, according to [25],

reliability and performance were considered the third major risk of adopting cloud computing (55%) after security and integration with existing infrastructure, 63% and 57% respectively. The performance varies from high to low on private and public cloud respectively.

### 2.6.5 Organization Challenges

Migrating of IT based services to the cloud can presents organizational challenges. Those challenges include possible threats to business reputation because the CSP could provide a low level of service, data could be breached to competitors or the CSP could be terminated or acquired. In addition, as CC changes the way of provisioning IT services, enterprises have to expect a major change in their IT strategy, including IT architecture, data strategy, IT management and IT/ business alignment. Consequently, SLA will be defined, business continuity strategy should be change and define, the IT roles and responsibilities will change, requiring a new skills set and training, which has resource implications for organizational strategy.

#### A. SLA

Cloud consumer organizations do not have control over the IT computing resources, however they demand a guarantee to quality, accessibility, dependability and performance of provided resources. CSPs usually publish a SLA, so that their consumers are aware of the availability of service, QoS, downtime compensation, and legal and regulatory clauses. Alternatively, customer-specific SLA may be signed between a CSP and a consumer.

However, the demands of consumers vary significantly. It is not possible to fulfill all consumer expectations from the service provider's perspective, and hence, a balance needs to be made via a negotiation process. At the end of the negotiation process, the provider and the consumer commit to an agreement. This SLA serves as the foundation for the expected level of service between the consumer and the provider. QoS attributes are generally part of SLA. However, these attributes change constantly, and to enforce the agreement, these parameters need to be closely monitored. In addition, advanced SLA mechanisms need

to always consider and incorporate user feedback and customization highlights into the SLA assessment framework [26].

#### B. Disaster Recovery

Growing reliance on crucial computer systems means that even short periods of downtime can result in significant financial loss, or in some cases even put human lives at risk [27]. With migrating to cloud as result of system consolidation, systems are exposed for single point of failure. Cloud services shall remain available to a user even in catastrophic situations and shall have the capability to recover to a safe mode. Hence building a recovery site for business continuity a must option. Any offering that does not replicate the data and application infrastructure across multiple sites is vulnerable to failure.

Table 2.1 summarizes the likelihood of the difference in terms of cloud deployment models.

Table 2.1: Cloud Deployment Model Comparisons Adopted from [25], [28], [29]

Criteria	Public cloud	Private cloud	Hybrid cloud
Confidentiality	L	VH	H
Integrity	L	VH	H
Availability	VH	M	H
Scalability	VH	M	H
Performance	L	H	M
Reliability	L	H	M
Control over re-sources	L	VH	H
Firms capability to manage IT	L	VH	H
Data Location	VL	VH	M
Data privacy	L	VH	M

*Continued on next page*

Table 2.1 – *Continued from previous page*

<b>Criteria</b>	<b>Public cloud</b>	<b>Private cloud</b>	<b>Hybrid cloud</b>
Short lead time	VH	Low	M
Focus on core business	VH	Low	H
Data and Application Integration	VH	H	VL
Portability	VH	H	VL
Reduce startup cost	VH	L	M
Changing Capex - Opex	VH	VL	L
Reduce total cost of ownership	VH	L	M
Cost of use	Pay-as-you-use	High cost of initial set up	Pay-as-you-use
Cloud bursting	Not supported	Not supported	Supported
Note: VH=very high(5) , H=high(4), M= medium(3), L=low(2), VL=very low(1)			

## 2.7 SMALL AND MEDIUM-SIZED ENTERPRISES

The definition of enterprises varies significantly with place and the economy concerned. It uses a number of variables to classify firms, many coming from various governmental and official sources such as SME agencies, ministries, government institutions and national statistical institutions and bureaus around the world.

According to [30] in Ethiopia, there is no single definition of SMEs and there is inconsistency among different governmental organizations (e.g. Ministry of Trade, Central Statistics Agency, and Federal Micro and Small Enterprises Development Agency) in

defining SMEs. For the purpose of this study the criteria in Table 2.2 are considered to define SMEs in Ethiopia as reported by [31].

Table 2.2: SMEs Definitions Adopted from [31]

Firm category	categorization criteria
Micro Enterprises	enterprises have 1to 5 employees
Small Enterprises	enterprises have 6 to 30 employees
Medium enterprises	enterprises have 31 to 100 employees.

SMEs mainly differ from large firms in terms of size and structure of the firms, which gives some advantages including fast communication among employees and their ability to implement and execute decisions rapidly. On the other hand, they face many challenges. Most of these challenges are due to SMEs' lack of resources. These limitations influence financing, planning and control, training and development, and also using emerging IT that enable them to be competitive. SMEs have less competitive advantage to deliver improved products and services because of limited resources to access modern IT services. These firms are very important for economy of a country. However, SMEs can remain competitive in this a fast-moving and volatile market by increasing the ability to harness new technologies such as cloud computing.

## 2.8 CONCEPTUAL FRAMEWORKS

There are many theories and frameworks in Information System (IS) research, however, in this work we are restricted to theories and frameworks on technology adoption. From the technology adoption theories and frameworks, the mostly used are the Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), DOI and TOE.

Basically IS adoption studies may occur at two levels of enquiry, individual and organizational [32]. At the individual level studies explore an actor's tendency to use an innovation either voluntarily or under the organization's pressure while organiza-

tional level studies address adoption behaviors at a firm level. From aforementioned theories TOE and DOI both work at the firm level, while the rest are at individual level.

### 2.8.1 *Diffusion of Innovation (DOI)*

Diffusion of Innovation theory [33] is a fundamental approach to investigating how a new technology diffuses. It is concerned with the way how a new technological innovation progresses from creation to use. DOI describes patterns of adoption, explains mechanism of diffusion, and assists in predicting whether and how a new invention will be successful. DOI theory posits two categories of factors (innovation characteristics and organizational characteristics) that influence a firm's adoption of innovation.

- Relative advantage - the extent to which an innovation is better than the previous generation's;
- Compatibility - the degree to which an innovation can be assimilated into existing business processes, practices, and value systems;
- Complexity - how difficult it is to use the innovation;
- Observability - the extent to which the innovation is visible to others; and
- Trialability - the ease of experimenting with the innovation.

While the "Innovation Characteristics" explain a portion of the innovation diffusion, these results are primarily based on studies at the individual decision-making level. Although DOI appears to be most applicable to investigate innovation use, researchers still keep searching other contexts influencing organizational innovativeness and combine them with DOI theory to provide richer and potentially more explanatory models [34].

### 2.8.2 *Technology Organization Environment Framework*

TOE framework provides a multi-contextual lens for analyzing a firm level IS adoption [35]. It categorizes the factor which influence technology adoption in organization into three categories:

- Technological context describes characteristics of the technologies that will influence decisions about IT adoption, such as technology readiness, perceived benefits, and concerns about the technology.
- Organizational context addresses the behaviors and characteristics of the organization that will also influence IT adoption decisions.
- Environment context is the arena in which a firm conducts its business, its industry, competitors, and dealings with government.

### 2.8.3 *DOI and TOE*

The DOI theory's internal and external organizational characteristics include the same measures as TOE's organizational context, and the technological context is implicitly the same idea as that of DOI. There are also vital differences between the two frameworks. TOE does not specify the role of individual characteristics whereas the DOI theory suggests the inclusion of top management support in the organizational context. Similarly, DOI does not consider the impact of the environmental context, but the TOE framework helps to provide a more comprehensive perspective for understanding IT adoption by including the technological, organizational, and environmental contexts, thus the theories meaningfully complement each other [36].

### 2.8.4 *Analytic Hierarchical Process*

Selecting a cloud deployment model for an enterprise that fits best to its context can be regarded as a complex decision making process. It involves multiple criteria, alternative and may also involve a number of decision makers. It is very important that an informed decision making must be made at the initial adoption stage. The decision should allow firms to select the most effective and efficient cloud strategy for their business. Hence, the problem requires an elaborate and systematic approach.

And the approach should let decision participants involved in this process to evaluate different alternatives by considering multiple sets of factors, and expressing their preferences on factors that affect the choice of cloud deployment.

**AHP** is a practical and effective method used for solving a wide variety of Multi-Criteria Decision-Making (**MCDM**) problems. It helps decision makers in solving structured problems, problems that require an assessment. The **AHP** process provides the decision makers with ranking of alternatives with preference of the decision maker business. To obtain rational decisions using **AHP**, decision makers need to conduct some steps. To obtain rational decisions using **AHP**, decision makers need to follow five steps as presented in **Figure 2.2**.

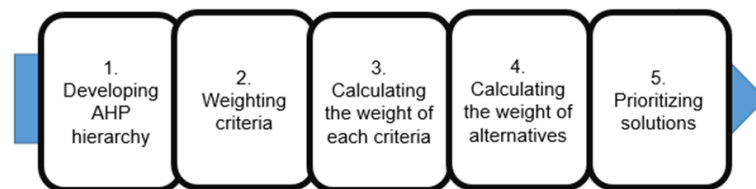


Figure 2.2: Steps in **AHP** Analysis

The **AHP** based decision start by developing the problem hierarchy which can be layered as:

- Objective layer: - presents the objective of the **MCDM**.
- Criteria layer: - comprises the business requirements that creates the ambiguity for decision makers. Basically these parameters include tradeoff between decisions.
- Sub criteria layers: - further decomposes the criteria layer.
- Alternative layer: - list of possible solutions to fulfil the business requirement.

The evaluation of the components of the hierarchy involves pairwise comparison of the criteria. In pairwise comparison, decision maker compares one criteria against another criterion for a particular alternative and indicates the relative importance by using scale of absolute numbers between 1 and 9. The scale of relative importance used in **AHP** according to [37] is showed in **Table 2.3**.

Table 2.3: Scale of Relative Importance used in AHP Adopted from [37]

Scale	Definition
1	Equal importance
3	Slightly more important
5	Essential or strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values

The pairwise comparisons performed by the decision maker are constructed as an  $n \times n$  matrix. Consider matrix.

$$A = \begin{pmatrix} 1 & \dots & a_{ij} & \dots & a_{1n} \\ \dots & 1 & \dots & \dots & \dots \\ 1/a_{ij} & \dots & 1 & \dots & \dots \\ \dots & \dots & \dots & 1 & \dots \\ 1/a_{1n} & \dots & \dots & \dots & 1 \end{pmatrix} \quad (2.1)$$

where  $a_{ij}$  expresses the relative importance of  $X_i$  over  $X_j$ . In pairwise comparison matrix if decision maker indicates the preference as 9, it indicates the criteria is extremely important than the other.  $1/9$  indicates that the criterion is extremely less important than the other. Once the pairwise comparison matrix is constructed the local priority can be identified by obtaining the priority vector.

The most popular method to estimate the priority vector is the method proposed by [38], called the Eigenvalue method. According to the Eigenvalue method, the priority vector  $w$  is calculated as the eigenvector of  $A$  and  $\lambda_{\max}$  the maximum eigenvalue of  $A$ .  $\lambda_{\max}$  is calculated by solving Equation 2.2 [39].

$$AW = \lambda_{\max}W \quad (2.2)$$

where

$$\sum W_i = 1$$

The next step in [AHP](#) is to calculate the consistency index (CI) to check for inconsistencies in pairwise comparisons. The consistency index (CI) is calculated using [Equation 2.3](#) [39].

$$CI = (\lambda_{\max} - n)/(n - 1) \quad (2.3)$$

where  $n$  is the number of compared elements. Once equation (3) is calculated, consistency ratio (CR) can be calculated by using [Equation 2.4](#) [39].

$$CR = CI/RI \quad (2.4)$$

where RI is the random index which can be obtained from the [Table 2.4](#).

Table 2.4: Random Consistency Index (RI) for Different Values of N Adopted from [37]

Matrix size (n)	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41

If the consistency ratio (CR) is less than 0.1, it means the calculated priorities are consistent. If the consistency ratio is larger than 0.1, re-evaluation is required which usually will need the whole pairwise comparison checked by the decision maker.

The beauty of the [AHP](#) is that a number of decision makers can be participate in making the choice of alternatives. However, factor preferences may have varied from one panel member to another, hence; there is need to aggregate results for all participants. This can be achieved by computing geometric mean method (GM), using

Equation 2.5, below. As indicated in [40] geometric mean method procedure is preferred over arithmetic mean due to its ability to reduce very high or low values, which might bias arithmetic mean, and hence less affected by extreme values.

$$GM = \sqrt[n]{\prod_{k=1}^n a_{ij}(k)} \quad (2.5)$$

where:

$n$  is number of expert or decision makers

$a_{ij}(k)$ = numerical value of expert  $k$  in the corresponding pairwise matrix ( $i$ -th row and  $j$ -th column).

Once the pairwise comparison is done at each layer the final task is to compute the global weight to rank the alternatives using Equation 2.6.

$$A_i = \sum_{x=1}^k W_x T_{ix} \quad (2.6)$$

Where  $A_i$  is value score for alternative  $i$ , and  $W_x$  is weight priority for criteria  $x$  ( $1 \leq x \leq k$ ) and  $T_{ix}$  is relative weighting of alternative  $i$  supports factor  $x$  and  $K$  is the number of criteria.

## RELATED WORKS

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This chapter is dedicated to related works. It presents previous studies on cloud computing adoption using different adoption theories, and application of [AHP](#) in different prior studies that need [MCDM](#).

### 3.1 CLOUD COMPUTING ADOPTION

There is a growing body of research on the cloud computing. Most of the researches on cloud computing focus on the technological aspects such as virtualization, security, and scalability of the technologies. The following are researching that focus on cloud computing adoption using different adoption theories.

A [TOE](#) based study was conducted by [\[16\]](#) to investigate the major factors affecting cloud computing adoption among [SMEs](#). Data was collected by conducting semi structured interviews with nine companies. The study shows factors, relative advantage, uncertainty, geo-restriction, compatibility, complexity, trialability, size, top management support, prior experience, innovativeness, industry, market scope, supplier efforts and external computing support are affecting cloud computing adoption.

A Triple-T model is proposed in [\[4\]](#) to study empirical analysis for the factors affecting the adoption of cloud computing initiatives by information technology executives using multi perspective approach. The model is an integration of the social exchange theory and the technology acceptance model, in order to evaluate cloud computing adoption process from a multiple perspective. This research investigates whether the ambiguous benefits of cloud computing outweighs its disadvantages. A total of eight benefits (cost reduction, short time to market, automation, space savings, scalability, flexibility, remote implementation and broad access) and eight disadvantages (control issue, standards issue, privacy issue, loss of data, indeterminacy, business continuity issue, the patriot act and lack of privacy) were identified.

And the study concluded that organization who adopt will have a net balance of benefits.

The authors in [41] have used Political, Economic, Social, and Technological (PEST) analysis to identify issues associated with cloud computing adoption by enterprises. The study investigates specifically with SMEs and how to cope with these barrier issues. The analysis, conducted by scoping published literature, only provided external issues associated with cloud adoption disregarding the impact on organizations' behavior.

A cloud adoption research study in [42] has investigated factors that influence the adoption of cloud service on the context of Korea. The study was grounded by TAM framework. The study was focused on one of the cloud delivery model (IaaS) and key influencing factors were identified that affect the decision behaviors. The study finally revealed that only perceived security had significant effect on company's decision to adopt IaaS while perceived scalability and perceived ease of use did not have a considerable impact on adoption of IaaS.

A study conducted documented in [43] on factors affecting cloud computing in developing economies specifically to SMEs, shown that meta-factors like cost saving in IT purchases and operation, improved communication, scalability, business continuity and increase in productivities are drivers for adoption. And the main barriers of adoption cloud computing are lack of skill and knowledge, poor connectivity, security and data privacy, lack of trust and difficulty in integrating with in-house systems. Moreover, the study indicates that top management support, triable of cloud services, resistance to new technology, presence of existing infrastructure and compatibility with cloud services, competence of cloud provider and vendor support are the most influential organizational factors used in the adoption decisions.

A cloud adoption study in [44] has investigated the extent of cloud adoption and the perception of employees in IT and Telecommunication firms in context of Nigeria. The study indicates that the inspiring factors for cloud adoption includes increased focus on primary services, increase productivities and simple service provision. And aspects that sluggish adoption of cloud computing include; poor awareness of cloud

computing, power interruption, complexity of cost, poor connection, security and privacy.

A research conducted by [45] on sectorial adoption analysis of cloud computing through examining the dissatisfied landscape has identified four key adoption barriers. These barrier factors were vendor related risks, security related risks, no-gain risk and efficiency related risks. The study was conducted in context of four industry sectors (SMEs education, Banks and hospitals). The study indicates that the major risk associated within the SMEs is the vendor related risks and then the security risks. While in the education sector the major risk associated was also the vendor related risks and then the efficiency risks and security risks. In the hospital and banking sector, the major risks were the security risks.

A framework is proposed in [46] that combines cloud readiness prediction and recommendation on the context of Ethiopian organizations using a multi-perspective approach. The framework was grounded by three theories (TAM, TOE and DOI). The authors developed an expert system that combines cloud readiness prediction and recommendation, and provides an automated solution. The proposed theoretical framework is used as a foundation for predictive analytics and provides recommendation related to the appropriate cloud deployment and cloud service model. The study identified 12 readiness factors in order to determine organizational cloud readiness; however, the research design does not analyze the significance of these factors by firm size. Further transparency into the cloud adoption construct is required to clarify possible adoption variations by firm size. This is because firm size is typically associated with successful IS adoption [47]. Larger firms are considered better suited to adopt a new IS due to the availability of slack resources and increased financial commitments [48].

A grounded theory based study was conducted in [12] that investigated factors on adoption issues for Ethiopian public and private enterprises. The study has revealed that Ethiopian enterprises are yet to adopt cloud computing as an IT provisioning method and they lack awareness of the advantages and disadvantages of adopting cloud. The enterprises are concerned with challenges like security, privacy and trust issues as well as government telecommunications infrastructure policies and cloud technology

skills acquisition. Moreover, as reported in [49] the propounds that the capacities and influence of cloud computing to companies in the developing world are inconsistent. the study indicates, the greatest barrier to adoption and effective utilization of cloud computing on the level of penetration of the PC and on the availability of good internet connection. The study did not examine or identify organizations' cloud adoption decisions but highlighted it as an area that needs further research.

Moreover, as it can be seen from Table 3.1 the research factors used by different scholars in investigating the adoption determinants are different. This indicate that the adoption of cloud computing can be affected by different factors in different context.

Table 3.1: Summery of Adoption Related Works

Theoretical Model	Research factors	References
TOE and DOI	External support; competitive pressure; decision maker's innovativeness; decision maker's Cloud knowledge; employee's Cloud knowledge; firm's information intensity; relative advantage; complexity; compatibility; security and privacy; trialability; and cost.	[50]
TOE and DOI	Relative advantage; uncertainty; compatibility; complexity; trialability; size; top management support; innovativeness; prior IT experience; competitive pressure; industry; market scope; supplier effort; and external computing support	[51]
TOE	Relative advantage; complexity; compatibility; top management support; firm size; technology readiness; competitive pressure; and trading partner pressure.	[52]

*Continued on next page*

Table 3.1 – Continued from previous page

Theoretical Model	Research factors	References
TOE and DOI	Relative advantage, complexity, Technology readiness, Top management support, Firm size, Competitive pressure and Regulatory support.	[53]
TOE and DOI	Relative advantage, compatibility, Security Concerns, Cost Saving, Technology Readiness, Top Management Support, Competitive Pressure and Regulatory Support	[54]
TOE	RA, Compatibility, Existing Infrastructure, Complexity, Firm Size, M-Support, Skill, Competition, regulations, Security, Network, Electric Power, Cost, Consistency, Availability, Risk of Failure	[55]
TOE-DOI	RA, complexity, compatibility, M-support, firm size, TR & External pressure,	[56]
DOI	Business process complexity, entrepreneurial culture, compatibility, application functionality	[57]

Although there is a growing body of research on the cloud computing and its applications penetrating to the organizational setting, many existing works are on the context of developed countries. In contrast, little has been studied regarding the use of cloud computing in developing countries particularly the SMEs perspective where its many benefits have been widely publicized. There is a lack of studies examining the adoption of cloud computing considering organizations with in the developing countries like Ethiopia. Although worldwide research may be applicable to these countries to at least some extent, research regarding adoption of cloud technologies is not fully generalizable to the corporate environment. The rationality for this is that the influencing factors can vary based on firm's technological, organizational and environmental contexts [49], [58]. For example, firm may operate at different level of technological reediness or countries regulations that can motivate or inhibit to harness the adoption process.

Moreover, there may be determinants that can be overseen by other context, but that can be an important factor in some firm context. Based on our knowledge from the literature review, most studies did not consider the location of the CSP as determinants of cloud adoption while the location can be an influential factor in developing countries like Ethiopia considering most of the CSPs are over the sea.

### 3.2 ANALYTIC HIERARCHICAL PROCESS

As discussed previously, cloud services have many pros and cons with many attributes and sub-attributes which makes the selection of best fit deployment for SMEs a complex task. This problem in the literature is defined as MCDM, where decision makers choose or rank alternatives on the basis of an evaluation of several criteria. Decision making involves managing trade-offs among a number of criteria that are in conflict with each other.

There are numbers of MCDM techniques such as Multiple Attribute Utility Theory (MAUT), outranking approach, AHP, Technique for Order of Preference Similarity to Ideal Solution (TOPSIS), and decision matrix. However, it has been argued that the AHP approach is more explanatory, reliable and accurate than other weighting methods [59]. In addition, AHP provides methods to check the consistency of data entered by decision makers [60]. In contrast, one of the disadvantages of AHP is that the number of pairwise comparisons may be large if there are a large number of factors [61].

AHP is one of the most impressive MCDM techniques used for solving multi-criteria and complex decision problems. According to the method, the decision maker provides judgments concerning the relative importance of each criterion and afterwards decision maker determines a preference for each alternative choice with regard to each criterion. The outcome of the method is the attribution of a score for every alternative choice based on the overall preferences expressed by the decision maker.

As it is shown in Figure 3.1, the overall goal, that is the issue the decision maker has to deal with, is stated in the first level of the hierarchy, whereas the criteria that affect the decision are depicted in the next level. The last level of the hierarchy contains

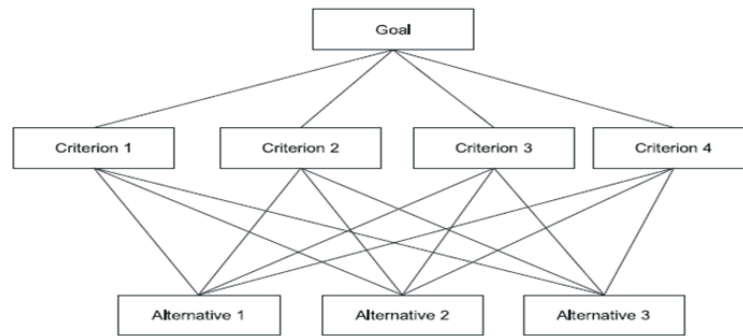


Figure 3.1: General Structure of a AHP Adopted from [62]

the alternative choices for the problem. These choices will be evaluated according to the criteria that have been chosen.

AHP has been used to solve a wide range of problems. Among many others, applications of the AHP are met in problems of resource allocation [63], cloud provider's selection [64], ranking of CC services [65] and selecting cloud deployment model [66]–[68].

The fact that CC adoption determinants are influenced by firms context, the criteria for selecting the cloud deployment is also expected to vary. Hence it is important to study the criteria with related to the cloud adoption determinants. In this study the AHP model was devolved based on the output of the context of Ethiopian SMEs analyzed by hybrid of TOE and DOI adoption frameworks.

## RESEARCH METHODOLOGY

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This chapter outline the research methodology to tackle the research problem. The outline includes three stages. In stage one an appropriate research model has developed based the knowledge developed in [Chapter 2](#) and [Chapter 3](#) and the research motivation. And an appropriate hypothesis has developed for the research model. In stage two methods and Instrument has developed to test the proposed model and generated hypothesis. In stage three data processing methods has developed for model verification.

### 4.1 RESEARCH MODEL

As stated in [Chapter 2](#) TOE and DOI are the two conceptual frameworks that are widely used in firm level adoption studies. And these conceptual frameworks are meaningfully complement each other [36]. It is also stated that prior studies have indicated diffusion of innovation depends on different factors [4], [16], [41]. Consequently a number of scholars have tried to determine the factors that influence the diffusion process of cloud computing [41]–[57]. Also according to the literature, the attributes of innovation and change characteristics variables are dominantly used factors. Relative advantage, business concern and organizational innovativeness have the most significant influence on cloud adoption decisions. In addition to these three factors, technological readiness, and external pressure are also important factors in the context of cloud computing. In addition, as stated in [Chapter 3](#) this research has considered the physical location of the cloud provider is an important determinant of cloud adoption in contexts to the developing countries' firms where majority of the cloud providers are over the sea.

Hence, to study the adoption of cloud computing by [SMEs](#), a new conceptual model was developed combining two different theoretical models as shown in [Figure 4.1](#).

According to this model, six variables are influence the **SMEs'** decision to adopt cloud computing:

- Relative advantage
- Business concern
- Organizational innovativeness
- Technological readiness
- External pressure; and
- Physical location

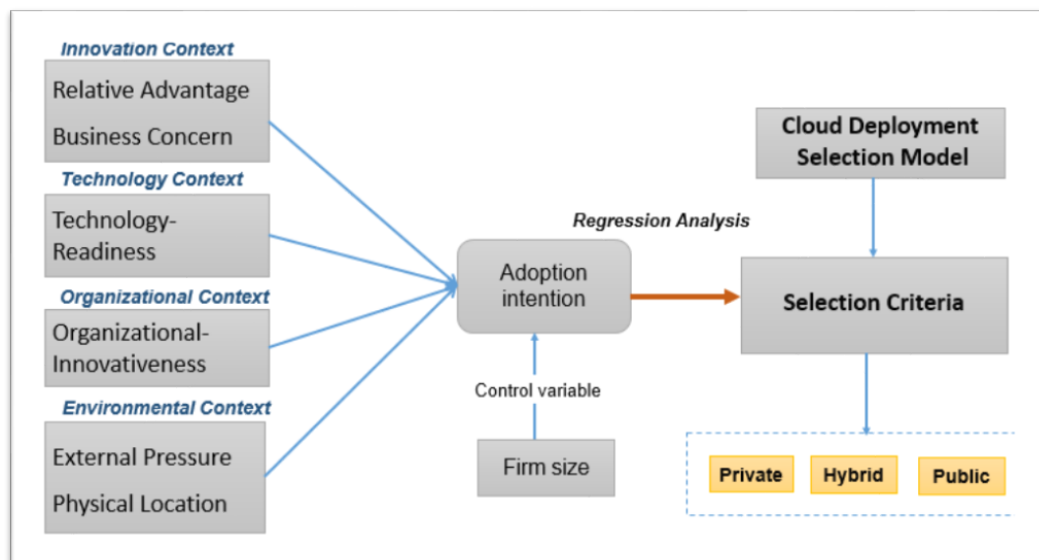


Figure 4.1: Proposed Conceptual Framework for Cloud Adoption

A firm size is one of the most critical determinants in innovation diffusion profile [33]. It has been considered to be an important predictor of ICT innovation adoption in [51]–[53], [55], [56]. Hence, this research considers that if these six determinants influenced the adoption of cloud by **SMEs**, this influence would vary based on firm size. Therefore, firm size is focused on three categories micro, small and medium as indicated in Table 2.2 and is considered as a control variable within the study.

The dependent variable, cloud adoption intention is sought to measure the perceptions of **SMEs'** decisions towards cloud adoption. The proposed research model depicts the relationships between selected constructs across the DOI and TOE contexts

expected to influence the cloud adoption. The control variable (firm's size) allow for focused analysis of the relationships between independent and dependent variables. Besides, the output of the regression analysis will refine to generate a context based criteria and sub criteria for cloud deployment selection model. The research model depicts that if the firm's size influence the CC adoption, the CDSM will vary among the SMEs size (micro, small and medium).

#### 4.2 HYPOTHESIS DEVELOPMENT

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

- Relative Advantage

Relative benefits describe the benefits a firm anticipates in procuring the adoption of a new IS innovation over the current systems or processes in use [69]. These benefits include both direct savings and efficiencies brought by the new system as well as the indirect impacts accruing to the enterprise. Prior studies have presented relative advantage as one of the most important attributes of innovation adoption [4], [6], [16], [20], [41]. As stated in Chapter 2 cloud computing has numerous advantages that can be entertain by firms who adopt the technology.

H1: Expected benefits will positively impact cloud computing adoption.

- Business Concerns

Business concern is a critical factor that affect an organization's decision to adopt CC for numerous reasons. The importance of this determinant related to innovative technology has been shown in previous studies [48]. This factor refers to perceived problems or risks that a firm can encounter by adopting an innovation. Some of the business concerns related to cloud includes data lock-in, confidentiality, poor QoS, bandwidth bottlenecks, and reliability [5].

When SMEs decision is made to cooperate with a certain cloud provider, firm needs to upload data and perform operations on provider's cloud platform. Hence firm not only relies heavily on the single CSP but also runs the risk of breaches of confidentiality. Moreover, since CC relies heavily on Internet to transfer data and provide services, there is a possible bandwidth bottlenecks and infrastructure level issues that may occur due to different degrees of infrastructure completeness. Hence, with this uncertainties QoS between service providers and firms are difficult to predict, measure, and maintain [5]. The levels of performance, reliability, and availability offered by an application, platform or infrastructure has great significance on the adoption [70].

As reported by [70] QoS in developing countries is affected by number of factors. This includes (1) lack of basic infrastructure such telecommunications, electricity; (2) Low coverage of broadband network; (3) Major CSPs are overseas companies hence there is a lack of control of an organization 's assets and required higher bandwidth internet. Thus the argument above leads to the following hypothesis:

H2: Business concerns will negatively impact cloud computing adoption.

- Technology Readiness

Technology context refers to the technological characteristics available in the organization for adoption of emerging technology. It includes both structural aspects and specialized human resources. Structural aspects refer to the platform or technological infrastructure (e.g., installed network technologies and enterprise systems) within the firm that cloud services can complement or replace. Specialized human resources are the people within the organization who have the knowledge and skill to implement cloud services [35], [69]. Together they enhance technological readiness of an organization. Therefore, firms with a higher degree of technological readiness are better positioned for cloud adoption. Hence,

H3: Technology readiness will positively influence cloud computing adoption.

- Organizational innovativeness

Organizational innovativeness refers to organization's orientation toward innovation, and the openness to new concepts based on the organization values [71]. This tendency for gaining of new ideas and better ways of doing things can infiltrate throughout an organization, which can result in greater employee acceptance of a new information system. Firms with this orientation and values towards innovation will probably consider adopting new technical innovations [71].

H4: Organizational innovativeness will positively impact cloud computing adoption.

- External pressure

External pressure refers to factors outside an organization such as competitors, government regulations and industry. This can be seen from three pressure perspectives (pressure from trading partners, competitive pressure, regulations and government policies) [71]. Trading partner pressure suggests that perceived pressure from upstream and downstream business partners influences a firm to adopt new technology in order to maintain cooperative relationships. Competitive pressure is perceived pressure from business competitors that forces a firm to adopt new technology for the sake of maintaining competitiveness. Regulations and government policies refers that governmental support requires a firm to adopt new technology.

H5: External pressure will positively impact cloud computing adoption.

- Physical location

Physical location of data is a critical factor that affect an organization's decision to adopt cloud for several reasons. As stated in Chapter 2 there is no agreed international policies or regulations for data protection in cloud environment and it could be risky for firms to migrate computing services to cloud if the cloud provider is located outside of their territory. As reported in [72] some cloud providers store user data in another country without disclosing this to the end users which could result in loss of privacy. Furthermore, majority of the CSPs like Google, Microsoft, Amazon and IBM are overseas companies. Hence, cloud services could require higher bandwidth, which has direct impact on the cost and quality of service. On the other hand, local CSPs like telecom operators are preferable by SMEs than overseas CSPs because of their local existence, last mile internet connectivity and strong SLA experience

[73]. Hence physical location of CSP determines cloud adoption of firms. Thus the argument above leads to the following hypothesis.

H6: Physical location will positively impact cloud computing adoption.

Table 4.1 presents the summary of the main constructs considered for the research.

Table 4.1: Summary of Constructs Used in the Research Model

Construct	Item	References
Relative Advantage	RA1: 'Reduce information technology costs (like maintenance)' RA2: 'Ensure fast time to market' RA3: 'Ensure high scalability of IT resource' RA4: 'Outsource IT services and focus on core competencies' RA5: 'Lack of internal IT resources'	[2], [5], [7], [41]
Business Concern	BC1: 'Customer or confidential information leakage' BC2: 'Difficult to integrate with previous IT systems' BC3: 'Cannot provide solid quality guarantee' BC4: 'Poor network transfer speed' BC5: 'Confined to a particular provider, difficult to switch (data Lock-in)' BC6: 'Loss of control over IT resources'	[1], [5], [53], [74]
T-Readiness	TR1: 'The organizations connectivity to the internet is adequate for cloud computing services'	[52]–[55], [75]

*Continued on next page*

Table 4.1 – *Continued from previous page*

Construct	Item	References
	TR2: 'Within this company the necessary skills to implement cloud computing exists' TR3: 'Our organization knows how IT can be used to support operations'	
O-innovativeness	IO1: 'Our organization readily accepts innovations based on research results' IO2: 'Management in my organization actively seeks innovative ideas' IO3: 'Innovation is readily accepted in this organization'	[74], [75]
External Pressure	EP1: 'Our organization thinks that cloud computing has an influence on competition in this industry' EP2: 'Cloud providers pressuring our organization to buy their cloud computing products' EP3: 'Some of our competitors have already started using cloud computing' EP4: 'Policies and regulations of the government are in favor of adopting cloud computing solution'	[53], [54], [75]
Physical Location	PL1: 'Our organization feels secure storing data in Cloud if the data center is located in Ethiopia'	Added

*Continued on next page*

Table 4.1 – Continued from previous page

Construct	Item	References
	PL2: 'Our organization feels a loss of privacy if the Cloud services run from a different country, as different privacy legislation applies'  PL3: 'Our organization feels locating cloud service on long geographical distance (overseas) will have an impact on quality of service'.	
Firm Size	Size of the firm based on number of employees and revenue.	[53], [75]
Adoption intention	AD1: 'Our organization intends to adopt cloud computing'  AD2: 'Our organization feels that the organizations need can be met by Cloud computing'  AD3: Our organization will take steps to adopt Cloud computing in the future'  AD4: Our organization will adopt Cloud computing within the next 12 months'	[53], [76]

#### 4.3 TESTING PROPOSED CONCEPTUAL FRAMEWORK

To test the proposed conceptual framework and generated hypothesis we collected data from Ethiopian SMEs. A survey questionnaire was used to collect relevant data to test the framework and identify cloud adoption determinants. The questionnaire survey approach was also considered because many studies based on diffusion of innovation in the IS domain have used this approach to identify the determinants influencing the adoption of cloud services and to test adoption conceptual frameworks [50]–[55].

#### 4.3.1 Questionnaire Design

The study has developed an instrument aimed to capture respondents' opinions to determine determinants that influence decision to adopt cloud computing. A closed-ended question style was employed that allowed respondents to select the answer that best fit their opinion. This type of question style was selected because it is easy to answer and can be completed within a short period of time. In addition, it is easy to code and analyses. However, closed-ended questions have limitations in allowing participants to respond to questions exactly as they would like to answer them.

The questionnaire was divided into two sections. The first section included questions relating to demographic information of each respondent's organization. The second section contained items used to study determinants concerning the adoption of cloud by SMEs. Table 4.2 presents summary of the number of instrument used on this research.

Table 4.2: Summary of the Questionnaire Instrument

Construct	Code	Scales used	No. of questions
Adoption Intention	AD	7-point Likert	4
Relative Advantage	RA	7-point Likert	5
Business Concern	BC	7-point Likert	6
Technological Readiness	TR	7-point Likert	4
Organization innovativeness	IO	7-point Likert	3
External Pressure	EP	7-point Likert	4
Physical Location	PL	7-point Likert	3

#### 4.3.2 Sampling Design

Different studies have indicated the importance of sample design. It is agreed that proper sampling is important in generalizing the result of data analysis for pop-

ulation. As recommended in [77] the minimum sample size required in order to perform a factor analysis is 50. To determine the minimum sample size requirement for factor analysis a more rigorous method has proposed in [78]. As illustrated in [78] the sample size (N) is a function of the square of the number of variables (V) plus a modifier of 50 to 100 to be added in order to ensure reliability when the sample sizes are small. This approach yields the following Equation 4.1:

$$N > V^2 + 75 \quad (4.1)$$

and using seven variables and a modifier  $(50+100)/2=75$

$$N > 7^2 + 75 = 124$$

The research adopts this sampling approach. Hence, the study consists of sample 145 Ethiopian SMEs which are collected by stratified sampling through ethio telecom enterprise interface and ICT Expo Ethiopia 2018.

#### 4.4 DATA ANALYSIS

In order to test the hypothesis developed several procedures and analyses were used. For analysis we used a statistical software package called IBM SPSS v25 to provide descriptive and relating statistics for the required analyses and tests. Once we completed the data aggregation task in Microsoft Excel, the results data then loaded into the SPSS. To drive statistical significant conclusion, the desired confidence level must be set first. In this work, we set the confidence level to 95% as recommended by [79].

##### 4.4.1 Data Screening

The collected data has been processed using number of approaches to fulfill the requirement for multivariate analysis. Data were screened for missing data and inclusive criteria.

#### 4.4.2 *Outliers*

Outliers are extreme data points that are very different from the rest of the data which can have an influence on conclusions drawn. In this work for each independent variable, outliers were identified by using boxplots in the IBM-SPSS tool.

#### 4.4.3 *Normality*

Normality is one of the assumptions required for several model tests [77], [79]. The normality distribution for all the determinants used in this research was checked using skewness and kurtosis data analysis. Skewness is measure of the symmetry of a distribution in comparison to a normal distribution. The skewness measure value could be positive, negative or zero. A positively skewed distribution has relatively few large values and tails off to the right, and a negatively skewed distribution has relatively few small values and tails off to the left. Zero value skewness indicate the data is perfect normal distribution. On the other hand, Kurtosis measures the peakedness or flatness of a distribution by comparing with a normal distribution. The Kurtosis measure value could be positive, negative or zero. A positive value indicates a relatively peaked distribution, and a negative value indicates relatively flat distribution. Zero value kurtosis indicate the data is perfect normal distribution

To decide where the data is normally distributed or not using the two data analysis method a threshold value has recommended in [77]. According to the recommendation in [77] skewness and kurtosis values between -1.96 and +1.96 are considered to approximate normal distributions. In this work all the independent variables were checked for normal distribution using the skewness and kurtosis analysis. Moreover, the normality test of the dependent variable was tested using Shapiro-Wilk test of significance [77].

#### 4.4.4 *Data Reliability Measures*

In order to use the collected data for model testing and verification the data was checked from reliability perspective. Reliability is concerned with how much random error in a measurement. Basically it refers to the consistency of measures. Consistency can be over a time (test-retest reliability) or across items (internal consis-

tency). Internal consistency refers the consistency of people's responses across items on a multiple-item measures. In general, all items on such measures are supposed to reflect the same underlying construct, so people's scores on those items should be correlated with each other.

Cronbach's alpha coefficient is commonly used by researchers to measure reliability of internal consistency of data. It defines whether different items that intend to measure a construct actually measure that specific construct. In this work a reliability coefficient of 0.70 or higher was considered acceptable as recommended in [77]. Moreover, the inter-item and item-total correlation should be more than 0.3 and 0.5 respectively as noted in [77].

#### 4.4.5 Data Validity Measures

Once the data was verified for reliability, the next task was to validated the data measures. In this study, content validity of the research instrument was established in developing this instrument, through literature review and extensive process of construct selection and refinement. The selected constructs were used to measure the research determinants (AD, RA, TR, IO, EP and BC) adopted from prior research and adapted to suit the context of this study. In addition, the instrument was reviewed for content validity by 5 SMEs, and three M.Sc. students from Addis Ababa University. The selected items of the instrument were also reviewed by two academics from Addis Ababa University and were indicated to be relevant. Based on the suggestions of the three aforementioned parties the research instruments were modified.

Furthermore, construct validity involves of two other components, convergent and discriminant validity. Construct validity of measures was verified by means of Principal Component Analysis (PCA). The purpose of PCA was to evaluate whether all the items intended to measure each construct loaded highly onto their expected theoretical constructs [77]. Convergent validity assesses whether items supposedly measuring the construct cluster together to form that construct. Discriminant validity defines whether a construct is different to another construct [77].

The PCA process started with the impost of fitness of the data for factor analysis. There are two main areas to stress in describing whether a particular data set is

suitable for factor analysis (sample size and the strength of the relationship among the items).

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, and Bartlett's test of Sphericity significance level were two methods used to assess the factorability of the data. The KMO is a summary statistic that ranges from 0.0 to 1.0 where higher values indicate an adequate sample size suitable for factor analysis [79], [80]. As recommendation in [79] a minimum value of 0.6 was used as a cut-off point to assess the suitability of the sample size. The significance level ( $p < .05$ ) of Bartlett's test of Sphericity shows that there are adequate relationships between items and that factor analysis is appropriate [79].

Once the PCA execution was performed and the items were validated, for each construct a summated scale (composite value) was created for model test. In this study the composite values were calculated based on the average of variables in the scale as recommended in [77].

#### 4.5 MULTIPLE LINEAR REGRESSION

The final step of the analysis was to use multivariate analysis to estimate the relationship between the dependent and independent variables based on the composite value. The direct relationships between independent and dependent variables towards the adoption of cloud computing by SMEs were examined using MLR. A simultaneous entry method was chosen to perform this analysis, since all the independent variables were considered to be equally important and grounded by conceptual framework. The relative contribution of each determinant towards cloud adoption was assessed based on this method.

##### 4.5.1 *Assumptions of the MLR Analysis*

Prior study has recommended to perform pre data analysis for number of assumptions before executing the regression analysis. In this study, all assumptions of multiple regression analysis were checked including sufficient sample size, multi collinearity, outliers, normality, linearity and homoscedasticity using different methods.

- Sample size

Proper sample size is needed in executing MLR analysis. As reported in [80] an appropriate number of cases required for the MLR analysis was determined based on the formula presented in Equation 4.2.

$$N > 50 + 8m \quad (4.2)$$

where  $m$  = number of independent variables; and  $N$  = number of cases required. Since there were six independent variables, a minimum 98 cases were required. Our study has included 136 cases.

- Linearity

It implies that the relationship between the dependent and independent variables are linear, and the errors are random [80]. One simple way to diagnose potential linearity bias is to review the scatter plot graph of standardized residuals against standardized model predicted values ( $z_{pred}$  vs.  $z_{resid}$  in IBM-SPSS tool) [80].

- Normality

MLR requires the normality assumption to be met. Otherwise, the coefficient and confidence intervals calculation will not be accurate. Additionally, certain significant tests rely on the assumption of normally distributed errors. One of the common contributors to non-normality is outliers. The common normality tests include the review of histograms and P-P plots [80].

- Homoscedasticity

When the variance of errors is not persistent at different values of the predictor variable, the coefficient estimation and confidence interval calculation may not accurate. It indicates giving too much weight to a small subset of observation data with large variance of errors. To diagnose a homoscedasticity situation, we can use a scatterplot for the criterion variable against each predictor variable or a plot of the standardized predicted value against standardized residual values [80].

- Independence

Independence means each predictor or determinant variable is independent with other predictor or determinant variables. Durbin–Watson statistic is one method to determine whether sample objects are independent to each other by checking whether their corresponding residuals are independent. The test result can have a value between zero and four. A value of two indicates that residuals are independent. Nevertheless, when the test value is less than one or greater than three, it illustrates the violation of the independence assumption [79].

- Multi collinearity

The multi-collinearity assumption indicates the high correlation that may exist among independent variables. It is expected to have less correlation among independent variables, and high correlation between dependent and independent variables.

Two of the most popular measures of examining multi collinearity among independent variables are tolerance and Variance Inflation Factor (VIF). Tolerance is the direct measure of collinearity, while VIF is the inverse of tolerance value. A high level of tolerance and a low level of VIF mean a low degree of multi collinearity. The recommended threshold for tolerance is 0.1 which is equal to the value of 10 for VIF. Any value tolerance value lowers than 0.1 and VIF value higher than 10 is not recommended [77].

- Outliers

In this study outliers were checked by inspecting Cook's distance. Cook's distance is a better solution to guarantee an acceptable p-value for significant tests [79]. The distance can be calculated by Equation 4.3, and classified as outliers and should be excluded.

$$\text{Cook's distance} > 4/(N - k - 1) \quad (4.3)$$

where N is the sample size, k is the number of predictors

## MODELING AND EXPERIMENT

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This chapter presents the analysis of the various methods used to test the proposed cloud adoption model. The analysis comprised four stages. The first stage focused on the data screening and descriptive statistical analysis. The second stage examined data validation, reliability analysis and factor analysis. Based on satisfactory results from stage two, multiple regression analysis was used in the third stage to test the proposed research model and assess the research hypotheses. Finally, the [CDSM](#) model is depicted and the analysis of a case study to illustrate the process and application of [CDSM](#) is presented.

### 5.1 DATA SCREENING

Data screening is the process of ensuring data is clean and ready to go for further analysis. Data must be screened to ensure the data is usable reliable valid for testing a causal model theory. In this study data screening process was done in two stages, in terms of case screening and variable screening. In case screening the data set was analyzed for missing values, firm size, cloud knowledge of respondents. Based on a case-screening test (16) responses values were excluded from the data set. Furthermore, all the items were checked for outliers and (9) were removed due to [MLR](#) assumption violations.

The skewness and kurtosis have been used to test the data with reference to the normal distribution. The result of skewness and kurtosis presented in [Table 5.1](#) show that the data scores for most of the variables were slightly negatively skewed while all the variables have a negative kurtosis which shows that the distribution was flat comparing to the normal distribution.

To interpret the results of skewed data we have applied the “rule of thumb” recommend in [76] by calculating z-scores. The rule of thumb states that if the results of skewness and kurtosis divided by its standard error produce z-scores between -1.96

Table 5.1: Skewness and Kurtosis Values of Adoption Determinants

Variable	N	Skewness		Kurtosis	
		Statistic	Std. Error	Statistic	Std. Error
RA	145	-0.263	0.201	-0.722	0.4
BC	145	0.141	0.201	-0.365	0.4
TR	145	-0.098	0.201	-0.521	0.4
IO	145	-0.036	0.201	-0.675	0.4
EP	145	0.089	0.201	-0.551	0.4
PL	145	-0.241	0.201	-0.708	0.4

and 1.96 the data can be considered normally distributed. The z-scores results for variables under investigation were within the range of the rule of thumb (-1.308 to 0.70 on skewness and -1.80 to -0.86 at kurtosis). Hence, the data could be considered as normal distributed for the further experiment.

## 5.2 DESCRIPTIVE ANALYSIS

Descriptive statistics are used to describe the basic features of the data in a study to provide simple summaries about sample and the measures. In this study descriptive statistics were used to summarize the basic features of data. However, descriptive statistics gives some information like variability, average score, it does not give much information about the hidden patterns of the data, and therefore, methods like correlation analysis and principal component analysis were used.

As it can be seen from Appendix A.2, the mean of data ranges from 2.869 to 5.262. It can be seen that six of the survey items scored more than 5, 14 of them scored nearly four which is neutral. and the standard deviation ranged from 1.0688 to 1.9588. The higher the standard deviation, the higher the dispersion of the data.

If we see from business concern construct, the BC2 an item related to cloud interoperability concern has scored the smallest mean (3.639). This could be an indication that Ethiopian SMEs have less business concern by the cloud difficulty to integrate

with previous IT systems. Similarly customer or confidential information leakage (BC<sub>1</sub>=4.869 mean) remained the biggest business concern from the SMEs side. On the other hand, the cost reduction opportunities provided by cloud computing was found to be the top motivator for cloud adoption (RA<sub>1</sub> =5.159 mean). In addition, the analysis result revealed that firms did not believe their connectivity to the internet is adequate for cloud computing services (TR<sub>1</sub>=2.869 mean). The result also revealed that SMEs have agreed that they can adopt cloud computing if the cloud provider is located in Ethiopian territory (PL<sub>1</sub>=5.248 mean). The result can be an indication of cloud computing concerns regarding data sovereignty and jurisdiction for data stored in different territory.

Moreover, from respondents perspective as it can be seen from Appendix A.2 majority of the respondents were owners of SMEs (40.7.8%); 23.7% of respondents were IT experts, 20.7% were IT managers and (15.2%) IT officers and others. On the other hand, the highest responding organizations were micro (44.8%; n=65), whereas small businesses represented 33.1% (n=48), followed by medium with 22.1% (n=32).

### 5.3 DATA RELIABILITY AND VALIDITY ASSESSMENT

This section presents the results of the reliability and validity assessment of items used to measure the research determinants.

#### 5.3.1 Data Reliability Assessment

As discussed in Chapter 4, the reliability of any instrument needs to be evaluated before it used for model verification or testing. The reliability of the instrument should be evaluated by checking the Cronbach's alpha, item-total correlation and inter-items correlations of items that measure constructs.

Table 5.2 summarizes the reliability test of the data. Number of cases, the Cronbach's alpha, item-total correlations and alpha if item deleted are summarized in this table. Inter-items correlations are summarized in Appendix A.3. As it already stated in Section 4.4.4 the Cronbach's value of above 0.7 is acceptable, while the item-total correlation and inter-item correlation should be more than 0.5 and 0.3 respectively in order to consider it as an acceptable.

Hence, BC2 was deleted because of its inter-items correlations value (see Appendix A.3) and its item-total correlation value is low (.328) as shown in Table 5.2. This means that this item is not measuring the same construct that is being measured by other items of this construct. As it can be seen from Table 5.2 after the item is deleted an improvement of reliability Cronbach's alpha to 0.833 can be observed.

Similarly, the item EP4 has a low correlation with other items. Deleting these items also had a significant influence on the reliability of the instrument which can be viewed in the Table 5.2.

Table 5.2: Data Reliability Measures

Construct's Name	Number of Observation	Item-Total Correlation	Cronbach's Alpha if item deleted	Item for deletion	Cronbach's Alpha
RA					0.813
RA1	145	0.573	0.785	None	
RA2	145	0.63	0.768		
RA3	145	0.595	0.779		
RA4	145	0.568	0.787		
RA5	145	0.644	0.764		
BC					0.815
BC1	145	0.561	0.79	1	
BC2	145	0.328	0.833		
BC3	145	0.726	0.755		
BC4	145	0.729	0.75		
BC5	145	0.589	0.784		
BC6	145	0.551	0.794		

*Continued on next page*

Table 5.2 – Continued from previous page

Construct's Name	Number of Observation	Item-Total Correlation	Cronbach's Alpha if item deleted	Item for deletion	Cronbach's Alpha
TR					0.763
TR <sub>1</sub>	145	0.554	0.752	None	
TR <sub>2</sub>	145	0.622	0.652		
TR <sub>3</sub>	145	0.668	0.602		
IO					0.752
IO <sub>1</sub>	145	0.561	0.695	None	
IO <sub>2</sub>	145	0.567	0.685		
IO <sub>3</sub>	145	0.624	0.631		
EP					0.772
EP <sub>1</sub>	145	0.646	0.679	1	
EP <sub>2</sub>	145	0.688	0.653		
EP <sub>3</sub>	145	0.645	0.677		
EP <sub>4</sub>	145	0.337	0.822		
PL					0.75
PL <sub>1</sub>	145	0.66	0.583	None	
PL <sub>2</sub>	145	0.533	0.721		
PL <sub>3</sub>	145	0.552	0.698		

### 5.3.2 Data Validity Assessment

As discussed in [Chapter 4](#), the constructs of the model are consisting of different items and should be evaluated for validation of the data. Construct validity is evaluated by checking the discriminant and convergent validity of the model. Convergent validity is the extent to which the indicators of a specific construct converge or share a high proportion of variance in common. On the other hand, discriminant validity measures the extent to which a construct is truly distinct from other constructs both in term of how much it correlates with other constructs and how distinctly measured items, measure a single construct [77].

As it already stated in [Section 4.4.5](#), in this study we have used the [PCA](#) to for data validation. Moreover, as noted in [Section 4.4.5](#) to execute the [PCA](#) the [KMO](#) sampling adequacy should be above 0.6 and the Bartlett's test of Sphericity should  $p < 0.05$ . The [KMO](#) and Bartlett's test of Sphericity indicates the data has an adequate sample size and it is factorable.

The [KMO](#) values for both the independent and dependent variables exceed the threshold value(0.6) see [Table 5.3](#). Bartlett's test of Sphericity indicates statistical significance ( $p < 0.001$ ). The results indicate that there is a significance relationship and appropriate sample size to execute [PCA](#)

Table 5.3: Results of KMO and Bartlett's test of Sphericity

Testing Method		Independent variable	Dependent variable
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.731	0.728
Bartlett's Test of Sphericity	Approx. Chi-Square	1384.371	312.514
	df	276	6
	Sig.	0.000	0.000

Based on the pre-request analysis which was satisfactory the PCA was executed to validate the data and to perform data reduction. The first step in PCA is determining the number of components to keep. These components are likely the ones that have been influencing the adoption process of cloud computing. The components are identified based on their Eigenvalue score, which is  $\geq 1$ . The eigenvalue greater than one is significant. Eigenvalue greater than 1 means that each item should account for the variance of at least a single construct.

The results of the initial PCA for the independent variables are presented in scree plot [Figure 5.1](#). Six factors(F1 to F6) with eigenvalues greater than one were extracted. These 6 factors have explained 67% of the variance. The X-axis represents the possible factor that can be extracted from the data using PCA. Basically maximum number of factors that can be extracted is equal to the number of independent variables. The Y-axis represents the eigenvalue value or it conceptually represents that amount of variance accounted for by a factor. As it can be seen from [Figure 5.1](#) the first factor(F1) accounts 4.5 eigenvalue or 20% of the variance. The first principal component(F1) is the linear combination of variables that has maximum variance (among all linear combinations). It accounts for as much variation in the data as possible(20%). Moreover, each factors F2 to F6 accounts an eigenvalue greater than one. However factors F7 to F22 has scored an eigenvalue which is less than that can be accounted by single construct.

Component matrix, presented in [Table 5.4](#) shows that each variable's loadings on each component before rotation is applied. The result only shows each item's loadings on each component, which does not show conceptual meaning and is very difficult to interpret. The problem with this analysis is that some of the variables are highlighted(loaded above |0.3|) in more than one column. Hence, rotation was required to yield a more interpretable and meaningful patterns.

Table 5.4: Result of PCA Component Matrix without Rotation

Item	F1	F2	F3	F4	F5	F6
RA1	0.54	0.348	0.388	-0.013	-0.133	-0.018

*Continued on next page*

Table 5.4 – Continued from previous page

Item	F1	F2	F3	F4	F5	F6
RA2	0.516	0.045	0.515	-0.002	-0.258	0.29
RA3	0.469	0.323	0.435	0.025	-0.15	0.112
RA4	0.489	0.37	0.333	-0.11	-0.045	0.225
RA5	0.448	0.246	0.49	-0.136	-0.173	0.392
BC1	-0.415	0.51	0.137	-0.385	-0.05	0.064
BC3	-0.695	0.376	-0.145	-0.233	-0.066	0.186
BC4	-0.669	0.408	-0.097	-0.252	-0.037	0.195
BC5	-0.553	0.391	0.031	-0.13	0.019	0.265
BC6	-0.546	0.342	-0.05	-0.16	0.036	0.208
TR1	-0.24	-0.06	0.158	0.727	0.08	0.205
TR2	-0.409	0.073	0.137	0.667	-0.024	0.21
TR3	-0.439	0.032	0.194	0.698	-0.094	0.094
IO1	0.517	0.198	-0.289	-0.015	0.441	0.187
IO2	0.511	0.047	-0.24	0.122	0.426	0.32
IO3	0.461	0.113	-0.338	0.059	0.5	0.362
EP1	0.42	0.185	-0.513	0.208	-0.465	-0.124
EP2	0.38	0.42	-0.558	0.079	-0.262	-0.184
EP3	0.314	0.481	-0.407	0.147	-0.427	-0.115
PL1	0.02	0.503	0.266	0.054	0.402	-0.524
PL2	-0.002	0.562	0.229	0.231	0.135	-0.422
PL3	-0.003	0.557	0.333	0.081	0.326	-0.344

- Varimax Rotation

As it can be seen from [Table 5.4](#) the output of the [PCA](#) is not interpretable. To make the factor loading interpretable the factors shall be rotated [[77](#)]. One of the most common method to solve problem in factor rotation in [MLR](#) is the varimax rotation

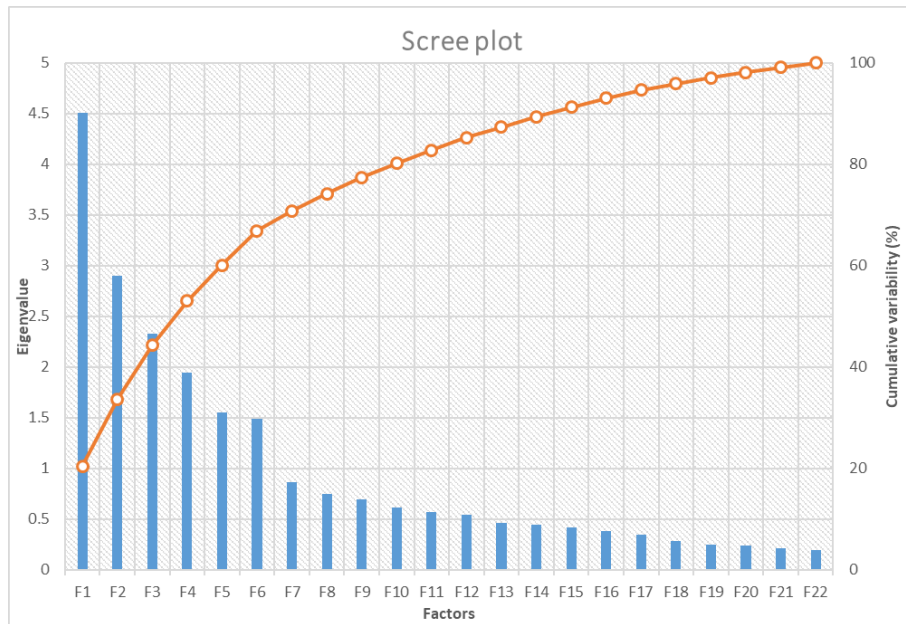


Figure 5.1: Scree Plot of PCA for Independent Variables

[77]. With this rotation method the factor pattern can be clarified by "rotating" the factors in F-dimensional space.

The results of varimax rotation is presented in Table 5.5. The result of PCA with varimax rotation has indicated a clear solution of six factors with eigenvalues greater than one. The review of the pattern matrix Table 5.5 shows that all the items are loaded highly on their respective determinants (RA, BC, TR, IO, EP and PL). All items' factor loadings were significant and higher than 0.5 as recommended in [77]. Moreover, all cross loadings are  $< |0.3|$ . Thus the items under each constructs are measuring the same construct. The variance analysis revealed that 92.5 of F1, 93.4 of F2, 94.8 of F3, 91.5 F4, 88.4 of F5 and 89.5 of F6 is accounted by BC, RA, EP, TR, PL and IO respectively. The rest variance is the effect of the other items on that factor. For instance the relative advantage items have negative effect on factor F1 as it can be seen Table 5.5.

Table 5.5: Result of PCA Rotated Component Matrix

Item	F1	F2	F3	F4	F5	F6
RA1	-0.167	<b>0.661</b>	0.152	-0.108	0.275	0.04
RA2	-0.215	<b>0.804</b>	-0.038	0.034	-0.113	-0.034
RA3	-0.12	<b>0.697</b>	0.071	-0.021	0.192	0.021
RA4	-0.006	<b>0.687</b>	0.058	-0.129	0.14	0.184
RA5	0.034	<b>0.832</b>	-0.04	-0.044	-0.056	0.097
BC1	<b>0.705</b>	0.104	-0.043	-0.166	0.21	-0.161
BC3	<b>0.823</b>	-0.212	0.008	0.048	-0.013	-0.148
BC4	<b>0.824</b>	-0.158	-0.029	0.031	0.021	-0.14
BC5	<b>0.749</b>	-0.03	-0.055	0.164	0.045	-0.014
BC6	<b>0.691</b>	-0.123	-0.054	0.085	0.036	-0.023
TR1	-0.045	-0.043	-0.084	<b>0.822</b>	0.014	0.058
TR2	0.133	-0.067	-0.056	<b>0.795</b>	0.034	-0.089
TR3	0.089	-0.094	-0.032	<b>0.819</b>	0.075	-0.193
IO1	-0.103	0.086	0.16	-0.168	0.101	<b>0.763</b>
IO2	-0.176	0.122	0.088	0.016	-0.047	<b>0.772</b>
IO3	-0.097	0.046	0.063	-0.065	-0.037	<b>0.836</b>
EP1	-0.188	0.028	<b>0.86</b>	-0.012	-0.12	0.075
EP2	-0.041	-0.02	<b>0.812</b>	-0.171	0.11	0.178
EP3	0.063	0.13	<b>0.859</b>	-0.013	0.08	0.07
PL1	0.027	0.024	-0.053	-0.058	<b>0.866</b>	0.025
PL2	0.057	0.112	0.147	0.135	<b>0.743</b>	-0.093
PL3	0.162	0.156	-0.022	0.061	<b>0.775</b>	0.074

The results of the PCA for the dependent variable is shown in Figure 5.2. The X-axis represents the dependent variable item or the possible factor that can be extracted,

where as the Y-axis represents the eigenvalue. The PCA revealed the presence of one factor with an eigenvalue greater than one.

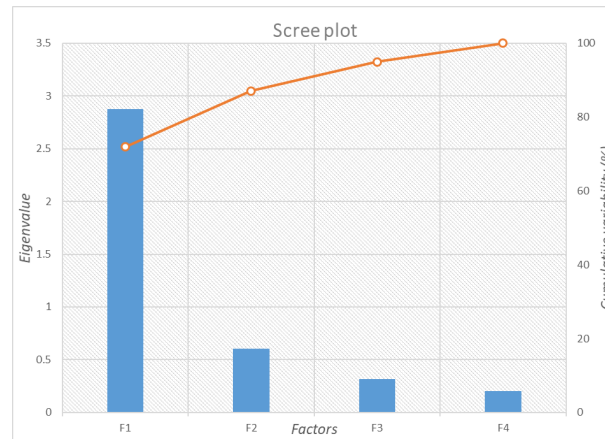


Figure 5.2: Scree Plot of PCA for Dependent Variable

## 5.4 HYPOTHESES TESTING

This section presents the results of the multiple regression analysis that was used to test research hypotheses. It presents an assessment of the possible linear relationships that might exist between the independent variables and the dependent variable.

### 5.4.1 Statistical Assumptions Validation for MLR

As discussed in Section 4.5.1, verifying the processed data is fit for MLR analysis is mandatory. Hence, testing the data to met the linear regression assumptions for construct and conclusion validity is needed. Otherwise, the presented statistical results could be misleading. These assumptions included linearity, normality, homoscedasticity, independence and multi collinearity.

- linearity and homoscedasticity test

For analyzing linearity and homoscedasticity we have used the scatterplot graphs of standardized model predicted values against standardized residual values ( $z_{pred}$  vs  $z_{resid}$ ) as shown in Figure 5.3. As it can be seen from the Figure it did not indicate any specific curve and funnel shape, except some outliers which can be removed by Cook's distance. The review of the result

revealed that the data is concentrated rounded the zero both from the X axis and Y axis as recommended in [77]. Hence, the sample data satisfied the MLR assumptions that the six predictor variables had linear relationships with the dependent variable, and residual variances were constant at different levels of the predictor variables. Thus, the model satisfied the linearity and homoscedasticity assumptions.

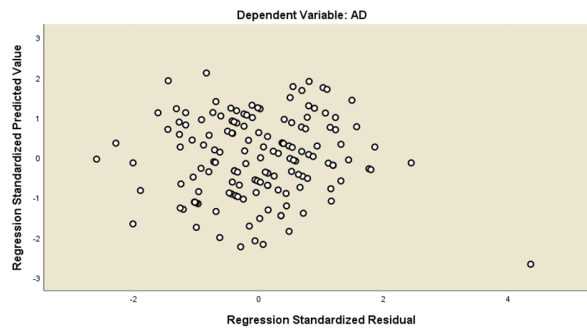


Figure 5.3: Scatterplot of  $z_{pred}$  vs.  $z_{resid}$

- Normality test:

we used both the residual histogram and P-P plot techniques. As it can be seen from residual histogram [Figure 5.5](#), the frequency of data is drawn in y-axis and the regression standardized residual on the x-axis. The review of the histogram normal curves of the model is in symmetrical bell shape.

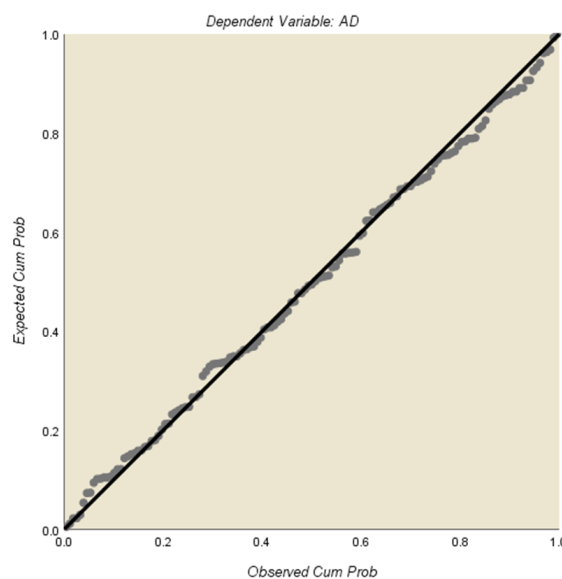


Figure 5.4: Normal P-P Plot of Regression Standardized Residual

Besides, the degree of the actual residual values of the cloud model is coinciding with the respective line of expected values as shown in Figure 5.4. Hence, assumption of residual normality was satisfied.

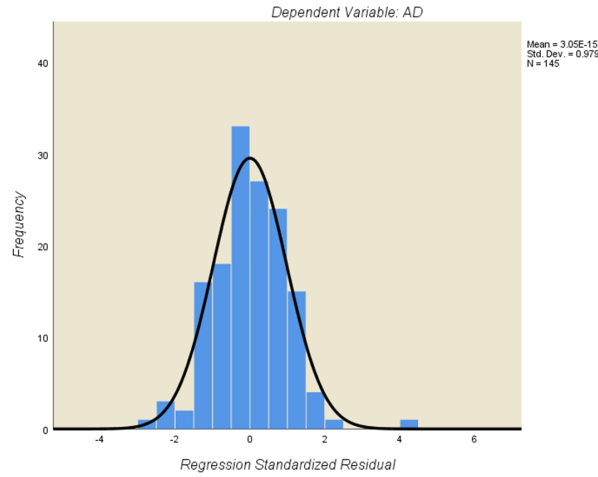


Figure 5.5: Residual Histogram Normality test

Moreover, as discussed in Chapter 4, to test the normality of the dependent variable was checked using Shapiro-Wilk normality test method. As it can be seen from Table 5.6 the significance level is ( $p > 0.05$ ), so we can ignore the null hypothesis that describes the dependent variable is not normally distributed[77].

Table 5.6: Normality test of Dependent Variable

Shapiro-Wilk		
Statistic	df	Sig.
0.983	145	0.078

- Residual independence testing:

As discussed in Section 4.5.1 the Durbin-Watson statistic method was used to test independence assumption and we get a value of “1.75” as shown in Table 5.7 which satisfied the MLR assumption.

- Multi collinearity testing:

Table 5.7: Residual Independence Testing

Model	R	R Square	Adjusted R Square	Durbin-Watson
1	.831a	0.69	0.676	1.756
a. Predictors: (Constant), PL, IO, TR, EP, RA, BC				
b. Dependent Variable: AD				

To perform the multi collinearity testing, we have used **VIF** analysis as discussed in [Section 4.5.1](#). [Table 5.8](#) shows the **VIF** values calculated for the regression models. Since the **VIF** values were from 1.098 to 1.202 that was substantially lower than 5, no multi collinearity concern in this models.

Table 5.8: Collinearity Statistics of Regression Model

Construct	Collinearity Statistics	
	Tolerance	VIF
RA	0.848	1.18
BC	0.84	1.191
TR	0.911	1.098
IO	0.832	1.202
EP	0.91	1.099
PL	0.9	1.111

- Outliers testing:

As mentioned in [Section 4.5.1](#), we use the Cook's distance to test the outliers in this model. Since the sample size was "145", and the number of predictors was "6", the regression analysis should exclude any case with Cook's distance

greater than" 0.028986". As the result, "9" cases were removed from the cloud adoption model.

#### 5.4.2 Testing Significance of the Proposed Model

The overall F-test on the MLR analysis using the entry method was conducted to assess whether the research model with its six research determinants significantly explained the perception of SMEs to adopt cloud. The output indicated that the model is statistically significant [F (6,129) 73.631 and  $p < 0.001$ ]. The  $R^2$  was 0.774, indicating that 77.4% of the variance in the perception of SMEs towards cloud adoption was explained. The overall F-test result indicated that at least one of the determinants are affecting the cloud adoption by SMEs in Ethiopia as shown in Table 5.9.

Table 5.9: Significance of Overall Regression Relationship

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	93.867	6	15.644	73.631	0.000
Residual	27.409	129	0.212		
Total	121.275	135			

#### 5.4.3 Coefficients of Regressors

Once we have determined that at least one of the regressors is important, next question might be which one(s) of the independent variables significantly influenced the perception of SMEs to adopt CC. To answer the question, individual regression coefficients (t-test) was performed. Table 5.10 presented the results of the tests done on the regressed independent factors. As stated in Section 4.4 the confidence interval for this study is 95% or ( $p < 0.05$ ). Hence based on the confidence interval and t-test analysis indicated in Table 5.10 shows that cloud adoption by SMEs is determined by different factors (RA, BC, IO, and PL).

Table 5.10: Coefficients of MLR

Model	B	$\beta$	T	Sig.
(Constant)	2.302		6.574	
RA	0.526	0.632	13.403	0.000
BC	-0.27	-0.378	-7.864	0.000
TR	0.047	0.058	1.302	0.195
IO	0.081	0.108	2.377	0.019
EP	0.028	0.036	0.825	0.411
PL	0.132	0.163	3.61	0.000

Note:  $R^2 = 0.774$ ; adjusted  $R^2 = 0.763$ ;  $F(6, 129) = 73.631$ ;  $P < 0.005$

#### 5.4.4 Cloud Computing Adoption and Firm Size

Analysis of variance (ANOVA) was conducted to assess whether cloud adoption varied between the different size of organization. No significant differences were detected since  $p > 0.05$  as shown in Table 5.11. That is, it is concluded that the variances of cloud adoption among the size of organizations are similar.

Table 5.11: Organization Size and Cloud Adoption

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.135	2	0.067	0.074	0.929
Within Groups	121.141	133	0.911		
Total	121.275	135			

## 5.5 CLOUD DEPLOYMENT SELECTION MODEL

As discussed in Chapter 2 cloud computing has several deployment model. Since each deployment model provides its pros and cons, firms have face decision challenge in selecting the right model that would address their business need. Besides,

selecting the most appropriate cloud deployment model for a firm depends on many criteria that are based on the strategies, requirements, and resources of the firm. Hence, firms must take conflicting criteria into consideration and choose the most suited cloud deployment model based on their needs. Because of the complexity of the problem, there are cases in which cloud deployment model selection problem becomes intractable. Therefore, the firms cannot determine the most appropriate cloud deployment model and thus fail to make the best decision [81].

Moreover, as stated in [Chapter 2](#), since this selection or decision problem is dependent on various conflicting criteria and a decision-maker has to choose the best alternative by satisfying these criteria. Hence, the decision or selection can be modeled as a Multi-Criteria Decision Making problem. In this research, the cloud deployment model selection problem is modeled as a MCDM problem. AHP is used to manage the selection problem. Additionally, to have holistic view on conflicting criteria, we have predicted the most motivator and inhibitor of cloud adoption from the firm context.

As discussed in [Section 2.8.4](#) the first step in AHP involves breaking down of the decision problem and development of the AHP hierarchy. Selecting cloud deployment model for SMEs has selected as the goal of the system. To define criteria, sub-criteria and alternatives which will form the middle and bottom layer of the AHP hierarchy, it is very important to have a clear understanding of the decision problem. From a SMEs perspective, cloud computing offers flexible, reliable and affordable computing services without increasing the IT budget. However, adoption of cloud is not straightforward as cloud adoption brings technological and organizational, and environmental challenges to the organization. Hence, in this work we have identified the cloud adoption determinants using the proposed cloud adoption model. The outcome of the cloud adoption model was refined to build the AHP criteria and sub criteria layer.

Informed by the outcome of the cloud adoption model in [Table 5.10](#) and [Table 5.11](#) and by refining individual item of the determinants construct and based on the literature review, we depict the cloud deployment selection model as in [Figure 5.6](#). The study generates a four layer CDSM for SMEs in Ethiopian by omitting the community cloud deployment from the alternative layer because it is less popular.

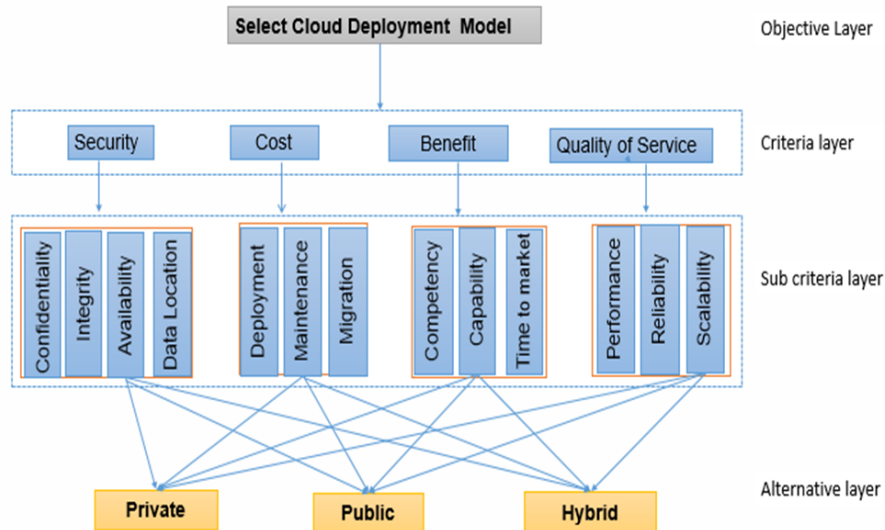


Figure 5.6: Proposed Cloud Deployment Selection Model

### 5.5.1 Application of *CDSM*

To illustrate the process and application of *CDSM*, we used the case study method. The case study was conducted on small scale enterprise operating in providing a telecom Value added Service (VAS). This company was considering whether to move its staging and development environments to cloud. The company stated its current challenge in managing of the service; like performance issues during peak hours and capacity related challenges. Moreover, the company is also planning to extend its services to provide Internet service (ISP). The participant was presented with instructions on how to perform pairwise comparison that was implemented using an excel *CDSM* template then transcribed to super-decision software for analysis. The final problem hierarchy developed was also designed on Super-Decision Software. The participant was requested to compare the criteria according to their relative importance with respect to the parent element (criteria with respect to goal, and sub criteria with respect to criteria) while the weight of the alternatives with respect to sub criteria were adopted from prior studies. The pairwise comparisons were captured using a quantitative questionnaire and the comparisons were measured using a five point Likert scale (1, 3, 5, 7, and 9) as shown in [Figure 5.7](#).

Comparisons wrt "Security" node in "Sub\_Criteria Layer" cluster  
 Availability is strongly more preferable than Confidentiality

1. Availability	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Confidentiality
2. Availability	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Data Location
3. Availability	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Integrity
4. Confidentiality	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Data Location
5. Confidentiality	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Integrity
6. Data Location	>=9.5	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	>=9.5	No comp.	Integrity

Figure 5.7: Pairwise Comparisons Security Sub-criteria

The response data was load to the super decision tool and the decision consistency was checked for each local and global criteria. As it be can seen from Figure 5.8 and Figure 5.9 all decisions were consistent with less than 10% inconsistency.

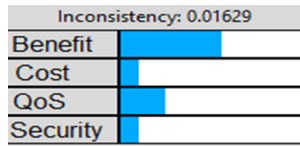


Figure 5.8: Inconsistency of Decision in Main criteria

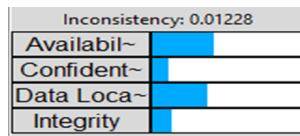


Figure 5.9: Inconsistency of Security Sub criteria

Once all the consistency was checked, the model was executed for full report to provided a systematic approach in selection and evaluation of cloud deployment models. As it can be observed from the case study presented, the model facilitated a rigorous and consensual decision that ultimately led to a selection of the best alternative that best fits the company’s business needs (see Figure 5.10). The analysis of the firm response using the super decision tool recommends to adopt the public cloud (43.22%). As it can be seen from Figure 5.10 the alternatives are ranked based on the business need.




Graphic	Alternatives	Total	Normal	Ideal	Ranking
	Hybrid_Cloud	0.3326	0.3326	0.7696	2
	Private_Cloud	0.2351	0.2351	0.5440	3
	Public_Cloud	0.4322	0.4322	1.0000	1

Figure 5.10: Alternative Rankings

## 5.6 DISCUSSION

This section presents a discussion of the results that developed from assessing the research model, as presented in the modeling and experimentation section .

### 5.6.1 Data Validity

As explained in [Chapter 4](#), several items were used to measure each adoption determinants. To test the data reliability and validity of measures a coefficient of alpha and [PCA](#) was used in this study. All coefficients of alpha score were greater than 0.7 which indicates that the level of internal consistency with in the instrument is adequate [[77](#)]. This output was also supported by the inter and total item correlation and two items were detected and removed due to low correlation. Besides, the [PCA](#) analysis showed that, all extracted factors had an eigenvalue of greater than one and loaded adequately (above 0.5) on their construct. The [PCA](#) analysis was further checked for item cross-loading among constructs; hence, discriminant validity was established. The result of [PCA](#) and coefficient of alpha implied that the research instrument provided a valid measure of all the theoretical determinants which were incorporated into the research model.

### 5.6.2 Proposed Conceptual Frameworks

The findings of this study revealed that the proposed cloud adoption model can successfully assist in predicting the perception of [SMEs](#) toward the adoption of cloud computing in Ethiopia. The outcomes of the [MLR](#) analysis indicated that the proposed model is encouraging and statistically significant [F (6,129) 73.631 and p <0.001] in predicting the perceptions of [SMEs](#) to adopt cloud. The model explained 77.4% of the variance in firms' perceptions as shown from [Table 5.9](#) .

Though there is a general limitation in the study in-line with findings for reference since the research is a new academic study for cloud services adoption of SMEs in Ethiopia, the model explains a large amount of variance for the adoption of cloud compared to other similar studies (39.9% in [50] and 38.1% in [53]) who combined the DOI and TOE conceptual frameworks. These results support the applicability of hybrid conceptual frameworks to predicting the perception of firms towards cloud computing adoption in Ethiopia.

### 5.6.3 Determinants Influencing Cloud Computing Adoption

To answer the research question, "determinants affecting the adoption of cloud computing" we have proposed a cloud adoption framework grounded by two conceptual frameworks. To test the model mathematically, we have used dataset collected from 136 SMEs and analyzed using regression. The MLR analysis using the F-test and t-test revealed that four determinants out of six were found to influence SMEs decision to adopt cloud computing as shown in Figure 5.11. The findings are explained below.

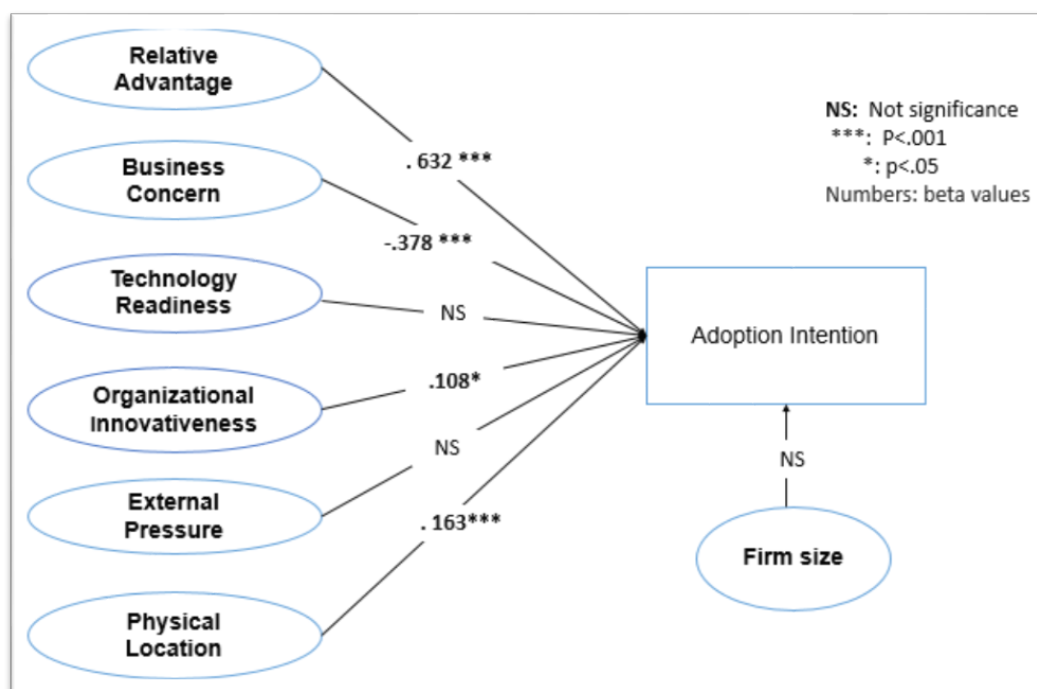


Figure 5.11: Determinants Influencing CC Adoption

- Hypothesis H<sub>1</sub>

There are five variables, which are related to relative advantage. The factor loading results presented in Table 5.5 shows all items which are greater than 0.5, it means that all related factors to this construct are valid. Based on the results in Table 5.10 there is a statistically high relationship between relative advantage and adoption of cloud computing in SMEs ( $p < 0.001$ ). The results of the analysis show that the relative advantage can be one of the effective factors in enterprises, which have a positive impact on cloud computing adoption in SMEs. According to the results, hypothesis H1 is reliable and accepted.

Relative advantage is a determinant for the adoption of cloud computing. This finding is consistent with similar studies reported in the literature [4], [51], [52], [54], which state that relative advantage is a significant predictor of organizations' intention to adopt cloud computing. However, the finding is inconsistent with some prior studies like [50], [53] where it was found it to be an inhibitor of cloud computing adoption by firms because of complex charging.

- Hypothesis H2

There are five variables, which are related to business concerns. The factor loading results presented in Table 5.5 shows all items which are greater than 0.5, it means that all related factors to this construct are valid.

Based on the results in Table 5.10 there is a statistically high relationship between business concern and adoption of cloud computing in SMEs ( $p < 0.001$ ). The results of the analysis show that the business concern can be one of the effective factors in enterprises, which have a negative impact on cloud computing adoption in SMEs. According to the results, hypothesis H2 is reliable and accepted.

Business concerns is a facilitator for cloud computing adoption. This result is similar with previous studies reported in [1], [54], [74], where business concern was found as a significant predictor of firms' intention to adopt cloud computing. However, the finding is inconsistent with some other studies like [36], [53] that business concerns like security were not found to inhibit the adoption of cloud computing.

- Hypothesis H3

As reported in [52]–[55], [74] technology readiness could be one of the important factors in adoption of cloud computing. The technology readiness identified by this study contains both the structural aspects and specialized human resources. The structural aspects refer to the platform or the technological infrastructure within the firm that the cloud services can complement or replace. The specialized human resources are the people within the organization who have the knowledge and skill to implement the cloud services. The factor loading results are shown in Table 5.5 indicates all items which are greater than 0.5, it means that all related factors to this construct are valid.

In this study, technology readiness is found to have a positive insignificant ( $p > 0.05$ ) influence as shown in Table 5.10. The finding is inconsistent with similar studies reported in [52], [54], [55]. However, earlier studies have suggested that technology readiness may not necessarily to influence cloud computing adoption [54], [74].

- Hypothesis H4

Earlier studies [57], [74], [75] have recognized the significance of organizational innovativeness in IS adoption. This study extends the research on organizational innovativeness in information systems, identifying it as an antecedent to cloud adoption. The factor loading results are shown in Table 5.5 indicates that all items which are greater than 0.5, it means that all related factors to this construct are valid.

Our study found that organizational innovativeness has significance ( $p < 0.05$ ) influence on adopting cloud computing in Ethiopian SMEs next to data physical location as shown in Table 5.10. The result is supported by prior studies [74], [75], while the result is also not supported by [57].

- Hypothesis H5

As reported in [53], [54], [74], [75] external pressure could be one of the significant determinant in cloud adoption. The external pressure identified by the

study comprises government policy and regulation, competitive pressure and CSP support.

This study did not find external pressure to be a significant influence for SMEs toward adopting cloud computing. This result did not support hypothesis (H5). The finding is inconsistent with similar studies reported in the literature [54], [74], [75]. But, the finding is consistent with prior studies [53], [74] that have suggested external pressure may not necessarily impact cloud adoption.

- Hypothesis H6

As discussed in Chapter 3, the study has considered the physical location of cloud provider as an important factor in cloud adoption. This factor was sought to determine whether Ethiopian SMEs are motivated to adopt cloud computing if the physical location of the data is located in Ethiopia. The physical location identified by the study comprises, jurisdiction over the stored data when cloud services run from a different country, as different privacy legislation applies and quality of service.

The findings of this study revealed that physical location of cloud provider to be a significant ( $p < 0.001$ ) influencer for Ethiopian SMEs toward adopting cloud computing next to business concern as shown in Table 5.10.

#### 5.6.4 *Effects of Firm Size in Cloud Adoption Decision*

To determine if the cloud adoption determinants are vary based on the firm size as stated in the research question, the firm size is included as control variable in the proposed framework. It was assumed that if the hypothesized determinants influenced the adoption of cloud computing by SMEs, the influence would vary based on firm size. The control variable was supposed to allow for focused analysis of the relationships between independent and dependent variables that cloud result in context based CDSM and other analysis. However, the one-way ANOVA result has not supported the assumption. Hence, cloud adoption determinants do not vary based on the firm size in context of Ethiopian SMEs. One of the main reason of this outcome

could be the enterprise definition (firm size) assumed in this research as stated in [Table 2.2](#).

#### 5.6.5 *Predicting Cloud Deployment Model*

To answer the research question, "how firms predict an appropriate cloud deployment for their business need based on the cloud computing adoption determinants", we first perform the regression analysis. The regression analysis provides us holistic view of the determinants that should be accounted by firms. However, the determinant has included a number of conflicting criteria that makes the problem complex. To convert the complex problem to a tractable and easy to solve, we propose a [CDSM](#) to support cloud adoption decisions for [SMEs](#) in Ethiopia using the established [AHP](#). The [CDSM](#) model provided systematic approach in selection and evaluation of cloud deployment models. As it can be observed from the case study presented, the model facilitated a rigorous and consensual decision that ultimately led to a selection of the best alternative that best fits the firm's business needs.

#### 5.6.6 *Implications*

Considering the importance of cloud computing and its low adoption by [SMEs](#) in Ethiopian, there is a great interest for better understanding of what core factors are influencing the adoption process. Within this direction, the proposed cloud adoption frameworks which is basically grounded by two conceptual frameworks, tries to examine these factors in detail. The outcomes of the study have a number of essential implications that may assist [SMEs](#), [CSPs](#) and government to facilitate cloud computing adoption.

Looking from the firms perspective, the rapid and dynamic change of computing increases the pressure on enterprises to make strategic decision. The proposed cloud adoption framework could be set as guidelines which help enterprises to consider potential alternatives and understand the determinants that influence the cloud computing adoption process.

As revealed by the [MLR](#) analysis, cloud relative advantage has an important effect on [SMEs'](#) decision to adopt cloud computing. The result of the [MLR](#) analysis has in-

indicated a positive and significant relationship between cloud relative advantage and cloud adoption intention with 95% of confidence interval ( $\beta = 0.632, t = 13.403, p < 0.001$ ). The inspection of the  $\beta$  weights indicated that, for every unit increase in the cloud relative advantage scores, cloud adoption intention increased, on average by 0.632 units. Hence firms should assess the potential benefits of cloud computing to increase their perception of cloud services. They could use the information about relative advantages and the instrument explained in this research to examine and plan their technology adoption. It can be identified how cloud can enable them to achieve time to market, focus on core competency, increase productivity, gain cost benefits and capability related issues. Firms can use the measurement that is established in this research to identify the strengths and weaknesses of potential services providers.

Moreover, as noted in [Chapter 2](#) cloud computing has a number of deployment models. Since each model architecture offers different pros and cons, firms has been face decision challenge in identifying the right model that will optimally address their business needs. The proposed [CDSM](#) will assist firms by predicating the type of cloud deployment model each firm need in context to its business.

On the other hand, the study has a number of implication from the cloud computing providers perspective. As stated in the findings section, business concern had significant negative relationship with adopting cloud services. This helps cloud providers to realize the fact that there are some important factors which are not related to the technology; but influence the cloud computing adoption decision making process. Hence [CSPs](#) can revise their cloud computing offering and cloud market strategies in such a way that their offer will support [SMEs](#) path to cloud adoption. It is important for service providers to reduce the feeling of ambiguity concerning cloud computing adoption, they need to work on providing reliable and secured cloud services.

In addition, our findings reveal that physical location of cloud provider is an important factor that influences firms' decisions to adopt cloud computing. As stated in [Chapter 2](#) cloud can poses a range of privacy issues that required mitigation. Storing personal information are considered the responsibility of cloud provider. On the other hand, loss of privacy of user's data remain a major concern if the cloud service

is served from a different territory by creating difficulties in determining jurisdiction. Because of this legal issues that are affected by provider location, SMEs are concerned about the location of data storage and there is a strong desire from SMEs' in Ethiopia for cloud computing services to be located within Ethiopian territory.

## CONCLUSION AND FUTURE WORK

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This Chapter presents conclusion, contribution and recommendations for future work.

### 6.1 CONCLUSION AND CONTRIBUTION

In this study we have proposed a conceptual cloud adoption framework for SMEs in Ethiopia grounded by TOE and DOI frameworks. To empirically assess this conceptual framework, we have used dataset collected from 136 firms located in Addis Ababa. The mathematical analysis using MLR revealed that the proposed conceptual model is statistically significant [F (6,129) 73.631 and  $p < 0.001$ ]. The results of the analysis indicated that four determinants (RA, BC, IO and PL) which comprise innovation, organizational and environmental aspects could significantly influence the cloud computing adoption process. On the other hand, the adoption of cloud computing by Ethiopian firms are in its infancy stage. Many of those firms faced decision challenge on identifying an appropriate cloud deployment model that best fits to their business need while considering to implement cloud solution. The AHP decision approach presented in this study attempts to mitigate the complexity of such decision.

SMEs can realize financial and technological benefit of cloud services by speeding up the adoption of cloud service. The study findings provide insights for SMEs and CSPs to decide their strategies and roadmaps on how to accelerate their cloud services adoption by manipulating the aforementioned identified factors to a favorable direction. The study has also revealed that business concern and physical location are the most influencing cloud computing adoption determinants next to relative advantage. This result indicates telecom operators can position themselves within the cloud ecosystem as trusted partners to SMEs because of their physical location and last mile Internet connection.

Moreover, this research makes a number of contributions to knowledge. The knowledge based cloud computing adoption framework proposed in this thesis is a holistic framework which covers the strategic and operational decision making involved in a cloud adoption and considers a range of factors and perspectives involved in cloud computing adoption. The thesis also makes a contribution to the body of knowledge through the investigation of determinants that influence cloud computing adoption in a developing country.

## 6.2 FUTURE WORK

The research might support for future research who are interested to explore more on this field. The elements below might be of some relevance to the constituents mentioned in this aspect:

- Empirically assessing the proposed cloud adoption framework provide findings on determinants that influence the adoption of cloud computing by [SMEs](#). However, the factors influencing the adoption of cloud computing at a particular phase may change over time. Besides, the research model could be examined further by applying Structural Equation Modeling ([SEM](#)), which is a more robust statistical technique that provide an advantage of analyzing complex models, and it examines relationships that are free from measurement error[79]. Thus, further research can be performed in this regard to realize the cloud computing adoption process.
- In this study we have considered the firm size as control variable to provide focused analysis between variables. However, firm type or firm capability could also provide further intensive analysis. Hence, future works can include the firm capability as control variable and revise the firm size definition.
- The research design for the proposed framework was situated in the context of [SMEs](#) in Ethiopia located in Addis Ababa. The design offers several advantages such as controls for firm size and environmental context. Firms in one environment and related scale may have similar awareness of cloud offerings, exposure to competitive information, and similar regulatory concerns. However, the model may limit the generalization to other firm size and territories

operating under different regulatory. Hence performing further researches in this field of study is highly recommended, to test and confirm the proposed conceptual model in other location in Ethiopia, other developing countries contexts or in different firm size.

- In this study, we have addressed the decision challenge of [SMEs](#) on selecting the best fit cloud deployment model by identifying the motivators and inhibitors of cloud computing adoption by firms on their context using the proposed framework. However, the decision challenges of [SMEs'](#) are not only related to cloud deployment, selecting best fit of cloud service model and cloud providers are another challenges that need an investigation. Therefore, studies are welcomed in proposing cloud service prediction model for [SMEs](#) in Ethiopia. The model can be proposed by assessing our proposed framework or analysis of context based benefits, opportunities, costs, and risks (BOCR) with [AHP](#).

## BIBLIOGRAPHY

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- [1] S. Marston, Z. Li, S. Bandyopadhyay, J. Zhang, and A. Ghalsasi, "Cloud computing—the business perspective," *Decision support systems*, vol. 51, no. 1, pp. 176–189, 2011.
- [2] D. C. Wyld, "The cloudy future of government it: Cloud computing and the public sector around the world," *International Journal of Web & Semantic Technology*, vol. 1, no. 1, pp. 1–20, 2010.
- [3] "Access to cloud computing: Challenges and opportunities for developing countries," 2017. [Online]. Available: [https://www.itu.int/dms\\_pub/itu-d/opb/stg/D-STG-SG01.03.1-2017-PDF-E.pdf](https://www.itu.int/dms_pub/itu-d/opb/stg/D-STG-SG01.03.1-2017-PDF-E.pdf).
- [4] M. A. Obeidat and T. Turgay, "Empirical analysis for the factors affecting the adoption of cloud computing initiatives by information technology executives," *Journal of Management Research*, vol. 5, no. 1, pp. 152–178, 2012.
- [5] M. Armbrust, "A view of cloud computing," *Communications of the ACM*, vol. 53, no. 4, pp. 50–58, 2010.
- [6] C. A. M. Alvarez, "Cloud computing: Concerns and challenges for its adoption in smes and large companies in japan," *Master, School of Management Ritsumeikan Asia-Pacific University*, 2011.
- [7] R. Smith, "Computing in the cloud," *Research-Technology Management*, vol. 52, no. 5, pp. 65–68, 2009.
- [8] K. Ferguson-Boucher and N. Convery, "Storing information in the cloud—a research project," *Journal of the Society of Archivists*, vol. 32, no. 2, pp. 221–239, 2011.
- [9] M. Parthasarathy and A. Bhattacharjee, "Understanding post-adoption behavior in the context of online services," *Information systems research*, vol. 9, no. 4, pp. 362–379, 1998.

- [10] A. Gillwald and M. Moyo, "The cloud over africa," *Cape Town*, 2013.
- [11] UNCTAD/IER, "The cloud economy and developing countries," 2013. [Online]. Available: [http://unctad.org/en/PublicationsLibrary/ier2013\\_en.pdf](http://unctad.org/en/PublicationsLibrary/ier2013_en.pdf).
- [12] S. D. Seifu, A. A. Dahiru, J. M. Bass, and I. K. Allison, "Cloud-computing: Adoption issues for ethiopian public and private enterprises," *The Electronic Journal of Information Systems in Developing Countries*, vol. 78, no. 1, pp. 1–14, 2017.
- [13] P. Raj and M. Periasamy, "The cloud challenges for enterprise architects," in *Cloud Computing for Enterprise Architectures*, Springer, 2011, pp. 187–206.
- [14] V. Andrikopoulos, A. Darsow, D. Karastoyanova, and F. Leymann, "Cloudsdf—the cloud decision support framework for application migration," in *European Conference on Service-Oriented and Cloud Computing*, Springer, 2014, pp. 1–16.
- [15] S. Robison, "Everything-as-a-service: A blue sky view of the cloud," 2009. [Online]. Available: [http://www.hp.com/hpinfo/initiatives/eaas/SR\\_EaaS\\_viewpoint.pdf](http://www.hp.com/hpinfo/initiatives/eaas/SR_EaaS_viewpoint.pdf).
- [16] Y Alshamaileh, S. Papagiannidis, and F. Li, "Cloud computing adoption: An exploratory study," in *8th International Conference on Web Information Systems and Technologies (WEBIST)*, Newcastle University, 2012.
- [17] R. M.P. M. Kunesch U., "Cloud computing i. alternative sourcing strategy for business ict," 2010. [Online]. Available: [http://www.t-systems.com/news-media/whitepapers/760948\\_2/blobBinary/White-Paper\\_Cloud-Computing-I.pdf](http://www.t-systems.com/news-media/whitepapers/760948_2/blobBinary/White-Paper_Cloud-Computing-I.pdf).
- [18] P. Mell, T. Grance, *et al.*, "The nist definition of cloud computing," 2011.
- [19] M. Pauly, "T-systems' cloud-based solutions for business applications," *Cloud Computing: Principles and Paradigms*, pp. 299–319, 2011.
- [20] T. Dillon, C. Wu, and E. Chang, "Cloud computing: Issues and challenges," in *Advanced Information Networking and Applications (AINA), 2010 24th IEEE International Conference on, Ieee*, 2010, pp. 27–33.

- [21] S. Ramgovind, M. M. Eloff, and E. Smith, "The management of security in cloud computing," in *Information Security for South Africa (ISSA)*, 2010, IEEE, 2010, pp. 1–7.
- [22] "Research in action white paper: The hidden costs of managing applications in the cloud," 2013. [Online]. Available: <http://www.researchinactionde/images/pdf/05%20RIA%20WP%20Cost%20of%20Cloud%20.pdf>.
- [23] R. Berry and M. Reisman, "Policy challenges of cross-border cloud computing," *J. Int'l Com. & Econ.*, vol. 4, p. 1, 2012.
- [24] N. Phaphoom, X. Wang, S. Samuel, S. Helmer, and P. Abrahamsson, "A survey study on major technical barriers affecting the decision to adopt cloud services," *Journal of Systems and Software*, vol. 103, pp. 167–181, 2015.
- [25] K. Kaur, "A review of cloud computing service models," *International Journal of Computer Applications*, vol. 140, no. 7, 2016.
- [26] A. Dubey, "Cloud computing and its security issues," *International Journal*, vol. 4, no. 7, 2016.
- [27] T. Wood, E. Cecchet, K. K. Ramakrishnan, P. J. Shenoy, J. E. van der Merwe, and A. Venkataramani, "Disaster recovery as a cloud service: Economic benefits & deployment challenges.," *HotCloud*, vol. 10, pp. 8–15, 2010.
- [28] A. Alhammadi, "A knowledge management based cloud computing adoption decision making framework," PhD thesis, Staffordshire University, 2016.
- [29] T. Schaefer, "Selecting the right cloud operating model: Privacy and data security in the cloud," 2014. [Online]. Available: <https://www.isaca.org/Journal/archives/2014/Volume-3/Pages/Selecting-the-Right-Cloud-Operating-Model-Privacy-and-Data-Security-in-the-Cloud.aspx>.
- [30] B. Assefa, A. Zerfu, and B. Tekle, "Identifying key success factors and constraints of ethiopia's mse development: An exploratory research," *Ethiopian Development Research Institute*, 2014.
- [31] Ada, "Small and growing businesses in ethiopia," 2017. [Online]. Available: <https://www.ada-microfinance.org/download/3825/final-report-sgbs-in-ethiopia.pdf>.

- [32] M. J. Gallivan, "Organizational adoption and assimilation of complex technological innovations: Development and application of a new framework," *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, vol. 32, no. 3, pp. 51–85, 2001.
- [33] E. M. Rogers, "Lessons for guidelines from the diffusion of innovations," *Joint Commission Journal on Quality and Patient Safety*, vol. 21, no. 7, pp. 324–328, 1995.
- [34] M. B. Prescott, "Diffusion of innovation theory: Borrowings, extensions, and modifications from it researchers," *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*, vol. 26, no. 2-3, pp. 16–19, 1995.
- [35] L. G. Tornatzky, M. Fleischer, and A. Chakrabarti, "The processes of technological innovation. issues in organization and management series," vol. 10, p. 2013, 2013.
- [36] T. Oliveira and M. F. Martins, "Literature review of information technology adoption models at firm level," *Electronic Journal of Information Systems Evaluation*, vol. 14, no. 1, p. 110, 2011.
- [37] S. TL., "Theory and applications of the analytic network process: Decision making with benefits, opportunities, costs, and risks," *RWS publications*, 2005.
- [38] T. L. Saaty, "How to make a decision: The analytic hierarchy process," *European journal of operational research*, vol. 48, no. 1, pp. 9–26, 1990.
- [39] I. Škorčić, B. Pein, and T. Orehovački, "Selecting the most appropriate web ide for learning programming using ahp," in *Information and Communication Technology, Electronics and Microelectronics (MIPRO), 2016 39th International Convention on*, IEEE, 2016, pp. 877–882.
- [40] J. Ngeru and T. K. Bardhan, "Selecting cloud deployment model using a delphi analytic hierarchy process (dahp)," *Industrial and Systems Engineering Review*, vol. 3, no. 1, pp. 59–70, 2015.
- [41] F. T. Neves, F. C. Marta, A. M. R. Correia, and M. d. C. Neto, "The adoption of cloud computing by smes: Identifying and coping with external factors.," 2011.

- [42] K.-K. Seo, "An explorative model for b2b cloud service adoption in korea-focusing on iaas adoption," *International Journal of Smart Home*. [http://dx. doi. org/10.14257/ijsh](http://dx.doi.org/10.14257/ijsh), vol. 5, 2013.
- [43] E. O. Yeboah-Boateng and K. A. Essandoh, "Factors influencing the adoption of cloud computing by small and medium enterprises in developing economies," *International Journal of Emerging Science and Engineering*, vol. 2, no. 4, pp. 13–20, 2014.
- [44] R. Awosan, "Factor analysis of the adoption of cloud computing in nigeria," *African Journal of Computing & ICT*, vol. 7, no. 1, pp. 33–42, 2014.
- [45] E. K. Iyer, A. Krishnan, G. Sareen, and T. Panda, "Sectorial adoption analysis of cloud computing by examining the dissatisfier landscape," *Electronic Journal of Information Systems Evaluation*, vol. 16, no. 3, p. 212, 2013.
- [46] F. Alemeye and F. Getahun, "Cloud readiness assessment framework and recommendation system," in *AFRICON, 2015*, IEEE, 2015, pp. 1–5.
- [47] K. Zhu, K. Kraemer, and S. Xu, "Electronic business adoption by european firms: A cross-country assessment of the facilitators and inhibitors," *European Journal of Information Systems*, vol. 12, no. 4, pp. 251–268, 2003.
- [48] A. Khajeh-Hosseini, D. Greenwood, J. W. Smith, and I. Sommerville, "The cloud adoption toolkit: Supporting cloud adoption decisions in the enterprise," *Software: Practice and Experience*, vol. 42, no. 4, pp. 447–465, 2012.
- [49] N. Kshetri, "Cloud computing in the global south: Drivers, effects and policy measures," *Third World Quarterly*, vol. 32, no. 6, pp. 997–1014, 2011.
- [50] E. O. Yeboah-Boateng and K. A. Essandoh, "Factors influencing the adoption of cloud computing by small and medium enterprises in developing economies," *International Journal of Emerging Science and Engineering*, vol. 2, no. 4, pp. 13–20, 2014.
- [51] Y. Alshamaila, S. Papagiannidis, and T. Stamati, "Cloud computing adoption in greece.," in *UKAIS*, 2013, p. 5.

- [52] C. Low, Y. Chen, and M. Wu, "Understanding the determinants of cloud computing adoption," *Industrial management & data systems*, vol. 111, no. 7, pp. 1006–1023, 2011.
- [53] T. Oliveira, M. Thomas, and M. Espadanal, "Assessing the determinants of cloud computing adoption: An analysis of the manufacturing and services sectors," *Information & Management*, vol. 51, no. 5, pp. 497–510, 2014.
- [54] M. Amini, "The factors that influence on adoption of cloud computing for small and medium enterprises," 2014.
- [55] A. Abdollahzadegan, C. Hussin, A. Razak, M. Moshfegh Gohary, and M. Amini, "The organizational critical success factors for adopting cloud computing in smes," 2013.
- [56] I. Son and D. Lee, "Assessing a new it service model, cloud computing.," in *PACIS*, 2011, p. 179.
- [57] V. Venkatesh and H. Bala, "Adoption and impacts of interorganizational business process standards: Role of partnering synergy," *Information Systems Research*, vol. 23, no. 4, pp. 1131–1157, 2012.
- [58] C. Low, Y. Chen, and M. Wu, "Understanding the determinants of cloud computing adoption," *Industrial management & data systems*, vol. 111, no. 7, pp. 1006–1023, 2011.
- [59] S. Kim, "Hybrid forecasting system based on case-based reasoning and analytic hierarchy process for cost estimation," *Journal of Civil Engineering and Management*, vol. 19, no. 1, pp. 86–96, 2013.
- [60] C. Yang and J.-B. Huang, "A decision model for is outsourcing," *International Journal of Information Management*, vol. 20, no. 3, pp. 225–239, 2000.
- [61] J.-J. Wang and D.-L. Yang, "Using a hybrid multi-criteria decision aid method for information systems outsourcing," *Computers & Operations Research*, vol. 34, no. 12, pp. 3691–3700, 2007.
- [62] F. S. Chan, "Interactive selection model for supplier selection process: An analytical hierarchy process approach," *International Journal of Production Research*, vol. 41, no. 15, pp. 3549–3579, 2003.

- [63] T. L. Saaty, "Decision making for leaders," *IEEE Transactions on Systems, Man, and Cybernetics*, no. 3, pp. 450–452, 1985.
- [64] J. Repschlaeger, S. Wind, R. Zarnekow, and K. Turowski, "Decision model for selecting a cloud provider: A study of service model decision priorities," 2013.
- [65] S. K. Garg, S. Versteeg, and R. Buyya, "A framework for ranking of cloud computing services," *Future Generation Computer Systems*, vol. 29, no. 4, pp. 1012–1023, 2013.
- [66] W. Indriani, N. F. A. Budi, F. Azzahro, A. N. Hidayanto, *et al.*, "Selection of cloud deployment model for ministry of foreign affairs using benefit, cost, opportunity, and risk (bcor) analysis and analytic hierarchy process (ahp)," in *Informatics and Computing (ICIC), International Conference on*, IEEE, 2016, pp. 447–452.
- [67] G. Fatih, A. N. Hidayanto, I. Alfina, and B. Purwandari, "Framework for selecting cloud deployment model in government institutions using bcor, entropy and topsis approach," *International Journal of Innovation and Learning*, vol. 18, no. 1, pp. 81–100, 2015.
- [68] B. M. R. Wilson, B. Khazaei, and L. Hirsch, "Cloud adoption decision support for smes using analytical hierarchy process (ahp)," in *Advances in Information, Electronic and Electrical Engineering (AIEEE), 2016 IEEE 4th Workshop on*, IEEE, 2016, pp. 1–4.
- [69] Y. Zhu, Y. Li, W. Wang, and J. Chen, "What leads to post-implementation success of erp? an empirical study of the chinese retail industry," *International Journal of Information Management*, vol. 30, no. 3, pp. 265–276, 2010.
- [70] M. Mujinga and B. Chipangura, "Cloud computing concerns in developing economies," 2011.
- [71] Y. Zhu, Y. Li, W. Wang, and J. Chen, "What leads to post-implementation success of erp? an empirical study of the chinese retail industry," *International Journal of Information Management*, vol. 30, no. 3, pp. 265–276, 2010.
- [72] P. T. Jaeger, J. Lin, J. M. Grimes, and S. N. Simmons, "Where is the cloud? geography, economics, environment, and jurisdiction in cloud computing," *First Monday*, vol. 14, no. 5, 2009.

- [73] Ovum, "Sme cloud-based services: Overseas successes & australian opportunities," 2014. [Online]. Available: <https://www.nbnco.com.au/content/dam/nbnco2/documents/sme-cloud-based-services-overseas-successes-and-australian-opportunities-report.pdf>.
- [74] P.-F. Hsu, S. Ray, and Y.-Y. Li-Hsieh, "Examining cloud computing adoption intention, pricing mechanism, and deployment model," *International Journal of Information Management*, vol. 34, no. 4, pp. 474–488, 2014.
- [75] M. McKinnie, "Cloud computing: Toe adoption factors by service model in manufacturing," 2016.
- [76] R. Senarathna, "Cloud computing adoption by smes in australia.," Deakin University, Tech. Rep., 2016.
- [77] J. F. Hair, *Multivariate Data Analysis*. Pearson Education, 2014.
- [78] R. M. Thorndike, *Correlational procedures for research*. Wiley, 1976.
- [79] B. G. Tabachnick and L. S. Fidell, *Using multivariate statistics*. Allyn & Bacon/-Pearson Education, 2007.
- [80] A. Field, *Discovering statistics using IBM SPSS statistics*. sage, 2013.
- [81] N. Tanoumand, D. Y. Ozdemir, K. Kilic, and F. Ahmed, "Selecting cloud computing service provider with fuzzy ahp," in *Fuzzy Systems (FUZZ-IEEE), 2017 IEEE International Conference on, IEEE*, 2017, pp. 1–5.



## APPENDIX

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### A.1 RESEARCH INSTRUMENT USED

Dear Participant:

The aim of this study and this questionnaire particularly is to examine determinants that affect and likely to impact the adoption and use of cloud computing technologies by Small and Medium-sized Enterprises (SMEs) in Ethiopia. The general purpose of this study is to place a foundation work for utter understanding of the determinants of cloud computing adoption by SMEs in Ethiopia.

The research is undertaken under the supervision of Dr. Fekade Getahun, for the partial fulfillment of the requirement for Degree of Master in Telecommunication Engineering. You have been selected to participate in this survey because you are enrolling in the Ethiopian SMEs. Your views and perception on the statements outlined in the survey questioner will help us to understand your firm's perspective.

Please complete the questionnaire that requires an approximate 10-15 minutes to complete. Finally, I confirm you that your response will be kept confidential and only used for academic purpose. If you require additional information or have questions, please contact me on +25191151-0160.

Thank you for your participation.

Sincerely,

Birhane W/gebreal

Addis Ababa University

1) What is your job role?

1. IT officer
2. Company owner
3. IT Manager
4. IT expert
5. Others (please specify) \_\_\_\_\_

2) What is the specific sector of your organization?

1. Financial
2. Agricultural
3. ICT
4. Transport
5. Media and Publishing Sector
6. Hotel & Tourism
7. Others (please specify) \_\_\_\_\_

3) What is the size of your organization in number of employees?

1. 1 to 5
2. 5 to 30
3. 31 to 100
4. More than 100

4) Does your organization plan to migrate services and data to cloud computing?

1. Yes
2. No
3. It has already migrated to the cloud
4. Don't know

5) Are you familiar with cloud computing (i.e. Private Cloud, Public Cloud, and Hybrid Cloud)?

1. Informed
2. Professional
3. Expert
4. Don't know

6) On the scale of 1 to 7 where (1= Strongly Disagree, 2= Disagree, 3= Somewhat Disagree, 4= Neutral, 5= Somewhat Agree, 6 =Agree, 7= Strongly Agree), please rate the following reasons for moving to cloud computing in your organization.

Adopting cloud computing will . . . .

Reduce information technology costs (like maintenance )	1	2	3	4	5	6	7
Ensure fast time to market	1	2	3	4	5	6	7
Ensure high scalability of IT resource	1	2	3	4	5	6	7
Outsource IT services and focus on core competencies	1	2	3	4	5	6	7
Help in solving Lack of internal IT resources	1	2	3	4	5	6	7

7) On the scale of 1 to 7 where (1= Strongly Disagree, 2= Disagree, 3= Somewhat Disagree, 4= Neutral, 5= Somewhat Agree, 6 =Agree, 7= Strongly Agree), please rate the factors which might restrict migration to cloud in your organization.

Customer or confidential information leakage	1	2	3	4	5	6	7
Difficult to integrate with previous IT systems	1	2	3	4	5	6	7
Cannot provide solid quality guarantee	1	2	3	4	5	6	7
Poor network transfer speed	1	2	3	4	5	6	7
Confined to a particular provider, difficult to switch (vendor Lock-in)	1	2	3	4	5	6	7
Loss of control over IT resources	1	2	3	4	5	6	7

8) On the scale of 1 to 7 where (1= Strongly Disagree, 2= Disagree, 3= Somewhat Disagree, 4= Neutral, 5= Somewhat Agree, 6 =Agree, 7= Strongly Agree), please rate the extent to which you agree or disagree with the following statements in relation to your organization.

Our organization intends to adopt Cloud computing.	1	2	3	4	5	6	7
Our organization feels that the organizations needs can be met by Cloud computing.	1	2	3	4	5	6	7
Our organization will take steps to adopt Cloud computing in the future.	1	2	3	4	5	6	7
Our organization will adopt Cloud computing within the next 12 months.	1	2	3	4	5	6	7
The organizations connectivity to the internet is adequate for cloud computing services.	1	2	3	4	5	6	7
Within this company the necessary skills to implement cloud computing exist.	1	2	3	4	5	6	7
Our organization knows how IT can be used to support operations.	1	2	3	4	5	6	7
Our organization readily accepts innovations based on research results.	1	2	3	4	5	6	7
Management in my organization actively seeks innovative ideas.	1	2	3	4	5	6	7
Innovation is readily accepted in this organization.	1	2	3	4	5	6	7

Our organization thinks that cloud computing has an influence on competition in this industry.	1	2	3	4	5	6	7
Cloud providers pressuring our organization to buy their cloud computing products.	1	2	3	4	5	6	7
Some of our competitors have already started using cloud computing.	1	2	3	4	5	6	7
Policies and regulations of the government are in favor of adopting cloud computing solution.	1	2	3	4	5	6	7
Our organization feels secure storing data in Cloud if the data center is located in Ethiopia.	1	2	3	4	5	6	7
Our organization feels a loss of privacy if the Cloud services run from a different country, as different privacy legislation applies.	1	2	3	4	5	6	7
Our organization feels locating cloud service on long geographical distance (overseas) will have an impact on quality of service.	1	2	3	4	5	6	7

## A.2 DESCRIPTIVE ANALYSIS

Descriptive Statistics for the Survey Items

Item	N	Minimum	Maximum	Mean	Std. Deviation
RA1	145	1.0	7.0	5.159	1.5077
RA2	145	1.0	7.0	4.821	1.6401
RA3	145	1.0	7.0	5.062	1.5194
RA4	145	1.0	7.0	4.428	1.5975
RA5	145	1.0	7.0	4.738	1.5987
BC1	145	1.0	7.0	4.869	1.5150
BC2	145	1.0	7.0	3.639	1.5156
BC3	145	1.0	7.0	3.945	1.8700
BC4	145	1.0	7.0	4.041	1.7751
BC5	145	1.0	7.0	4.097	1.5782
BC6	145	1.0	7.0	4.269	1.9588
TR1	145	1.0	6.0	2.869	1.0688
TR2	145	1.0	7.0	3.510	1.5371
TR3	145	1.0	7.0	3.662	1.6592
IO1	145	1.0	7.0	4.310	1.6267
IO2	145	1.0	7.0	4.021	1.5744
IO3	145	1.0	7.0	4.228	1.3629
EP1	145	1.0	7.0	3.752	1.3971
EP2	145	1.0	7.0	3.683	1.4658
EP3	145	1.0	7.0	3.407	1.5964
EP4	145	1.0	7.0	3.738	1.2529
PL1	145	1.0	7.0	5.248	1.3669
PL2	145	1.0	7.0	5.166	1.5680
PL3	145	1.0	7.0	4.883	1.5479
AD1	145	1.0	7.0	5.076	1.1123
AD2	145	1.0	7.0	4.959	1.2069
AD3	145	2.0	7.0	5.262	1.1182
AD4	145	1.0	7.0	4.669	1.2079

## Frequencies of respondents' current position

Position	Frequency	Percent(%)
IT officer	10	6.9
Company owner	59	33.8
IT Manager	30	20.7
IT expert	34	23.4
Others	12	15.2

## Frequencies of organizations' industry type

Industry type	Frequency	Percent
Financial	3	2.1
Agricultural	11	7.6
ICT	56	38.6
Transport	14	9.7
Media and Publishing Sector	12	8.3
Hotel & Tourism	14	9.7
Others	35	24.1

## Frequencies of firms' size

Firm type	Frequency	Percent
Micro	65	44.8
Small	48	33.1
Medium	32	22.1

## A.3 INTER-ITEM CORRELATION ANALYSIS OF CONSTRUCTS

Inter-Item Correlation Matrix of RA

	RA1	RA2	RA3	RA4	RA5
RA1	1				
RA2	.416	1			
RA3	.572	.434	1		
RA4	.364	.438	.473	1	
RA5	.444	.641	.376	.498	1

Inter-Item Correlation Matrix of TR

	TR1	TR2	TR3
TR1	1		
TR2	.459	1	
TR3	.531	.604	1

Inter-Item Correlation Matrix of BC

	BC1	BC2	BC3	BC4	BC5	BC6
BC1	1					
BC2	.253	1				
BC3	.457	.257	1			
BC4	.505	.300	.678	1		
BC5	.488	.243	.546	.568	1	
BC6	.306	.210	.467	.443	.258	1

Inter-Item Correlation Matrix of IO

	IO1	IO2	IO3
IO1	1		
IO2	.347	1	
IO3	.480	.546	1

Inter-Item Correlation Matrix of EP

	EP1	EP2	EP3	EP4
EP1	1			
EP2	.592	1		
EP3	.643	.590	1	
EP4	.232	.389	.248	1

Inter-Item Correlation Matrix of PL

	PL1	PL2	PL3
PL1	1		
PL2	.541	1	
PL3	.569	.411	1