A Framework to support cloud adoption decision-making by SMEs in Tamil Nadu

Berlin Mano Robert Wilson

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Abstract:

Cloud computing is a disruptive technology which represents a paradigm shift in the way computing services are purchased and maintained within organisations. Due to its benefits like low capital, scalability and high reliability, the cloud infrastructure has the features and facilities to speed up Information Technology (IT) adoption in developing countries. However, moving data and applications to a cloud environment is not straightforward and can be very challenging as decision makers need to consider numerous technical and organisational aspects before deciding to adopt cloud infrastructure. There are existing models and framework available to support different stages of the cloud adoption decision making process. However, they are developed for technologically developed countries and there has been very little investigation done to determine whether the factors that affect cloud adoption are any different for a technologically developing country like India. This research aims to provide a framework to aid cloud adoption among SMEs in Tamil Nadu, a southern state of the Indian Union. The major contribution to knowledge is the framework, based on Scientific Decision Making (SDM) which has been developed to support SME decision makers at all the different stages of the cloud adoption decision making process.

The theories of technology adoption like Diffusion of Innovation (DOI), Technology, Organisation and Environment (TOE) framework along with Multi Criteria Decision Making (MCDM) forms the theoretical underpinnings of the research. The primary data was collected via two web-based questionnaire surveys among SME decision makers from Tamil Nadu. Six determinants of cloud adoption such relative advantage, compatibility, innovativeness, organisation size, external issues and industry type were identified. The findings identify that

organisational factor specific to SME location is a very important decision factor while planning cloud adoption. The proposed cloud adoption decision support framework (CADSF) includes two tools namely; cloud suitability assessment and cloud service identification. The framework provides a preliminary structure for developing a knowledge driven Decision Support System (DSS) to support cloud adoption among SMEs in Tamil Nadu. Finally, based on the findings of the research, it is expected with developments to the existing cloud infrastructure, especially the availability of reliable internet and increased awareness, more SMEs in Tamil Nadu would adopt the cloud computing infrastructure.

List of Publications

Part of this thesis has been published in the following conferences and international symposiums:

Wilson, Berlin M. R., et al. (2014). CMDSSI: A decision support system for cloud migration for SMEs in India. In: Computational intelligence and computing research (ICCIC), 2014 IEEE international conference on, IEEE, 1-6.

Wilson, Berlin M. R., Khazaei, Babak and Hirsch, Laurence (2015). Enablers and barriers of cloud adoption among Small and Medium Enterprises in Tamil Nadu. In: 2015 IEEE international conference on cloud computing in emerging markets (CCEM), IEEE, 140-145.

Wilson, Berlin M. R., Khazaei, Babak and Hirsch, Laurence (2016). 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, 1-4.

Wilson, Berlin M. R., Khazaei, Babak and Hirsch, Laurence (2016). Towards a cloud migration decision support system for small and medium enterprises in Tamil Nadu. In: Computational intelligence and informatics (CINTI), 2016 IEEE 17th international symposium on, IEEE, 000341-000346.

Wilson, Berlin M. R., Khazaei, Babak and Hirsch, Laurence (2016). A cloud migration decision support system for SMEs in Tamil Nadu (India) using AHP. In: International Symposium of the Analytic Hierarchy Process 2016, London, U.K. [online] http://www.isahp.org/uploads/isahp16_proceeding_1144190_001.pdf

Chapter 1: Introduction

1.1 Research Background:

Cloud computing represents a paradigm shift in the way computing resources are purchased and maintained. The concept of cloud computing is not completely new. The evolution of cloud computing can be dated back to 1960's when John McCarthy, a computer scientist introduced timesharing in mainframes (TimesofCloud 2017). Since then, cloud computing has gradually evolved through a number of technological innovations like grid computing, utility computing and virtualisation technologies (Hill et al. 2013). These technologies formed the foundation upon which cloud computing was developed. The term "cloud computing" was first used by Professor. Ramnath Chellapa at a conference held at Dallas, U.S in 1997. He defined cloud as a computing paradigm where the boundaries of computing will be determined by economic rationale rather than the technical limits (TimesofCloud 2017). The symbol of the "cloud" is used to denote the boundary of the cloud environment (Erl, Puttini and Mahmood 2013).

The global computing market is estimated to increase from $67 billion in 2015 to $162 billion by the end of 2020 (Rightscale 2017). According to 2014 Gartner hype cycle report, Cloud is one of the most hyped terms in the history of Information Technology (IT) (Panetta 2017). In recent years, cloud computing has evolved from being a buzz word into being adopted by organisations according to their business needs. Cloud computing users can provision computing resources like hardware, storage, applications and services virtually through the internet on-demand instead of running on premise data centers. Therefore, cloud users will have to pay for only what they use. This feature of the cloud infrastructure

eliminates costs associated with the purchase, implementation and maintaining expensive IT equipment. In addition to cost benefits, migrating existing data and application to cloud infrastructure can bring other benefits like high scalability, reliability, flexibility and improved accessibility to resources (Wang 2011). However, the multi-tenant model of the cloud computing infrastructure can give rise to a number of risk and issues.

A successful cloud computing adoption brings about both technological and organisational changes to the organisation (Bildosola 2015). Therefore, all the different steps and tasks involved in the cloud adoption decision making process should be considered before making the decision to adopt cloud infrastructure. This research is focussed on Small and Medium Enterprises (SMEs) in Tamil Nadu, one of the constituent states of the Indian Union. Tamil Nadu lies in the southern part of Indian peninsula and has a population of 72 million (Devika 2015). Tamil Nadu is the fourth largest economy in India and it is the first state in India to announce a comprehensive IT policy in 1997 even before the National IT policy which was released only in 2000 (Bajwa 2003). Tamil Nadu accounts for 689,000 registered SMEs which is the largest in the whole of the Indian Union (Devika 2015).

1.2 Research Problem:

Small and Medium Enterprises (SMEs) are perceived as the backbone of a country's economy (Iyer et.al 2013). The status of SME sector is no different in India, where more than 40% of the total workforce is employed by SMEs. SMEs contribute nearly 17% to the GDP of Indian economy (Devika, 2015). Innovation in Information and Communication Technologies (ICT) among SMEs has proved to improve the competitiveness of the individual business (Alshamaila and Papagiannidis 2013). Cloud computing is the latest innovation in IT which has attracted public and private sector organisation around the world mainly due to the features it offers to improve the performance and service delivery (Iyer et.al

2013). Cloud computing due to its features like high scalability, reliability, flexibility and improved accessibility to resources, can facilitate adoption and upgradation of IT among SMEs in developing countries (Wilson, Khazaei and Hirsch 2016). By adopting a cloud infrastructure, SMEs with limited IT budget can have access to highly scalable technologies (Kshetri 2012) which will level the playing field and enable SMEs to compete with larger enterprises (Alshamaila and Papagiannidis 2013). Recent research data on cloud adoption trends suggests that developed countries in Europe and U.S have embraced the use of cloud computing infrastructure (Rightscale 2017). However, the level of adoption of cloud computing among SMEs in India is lesser when compared with the developed countries. As the researcher has his origins in Tamil Nadu and is familiar with the state, this study focusses on SMEs in Tamil Nadu. The provisions in Part XI of the Indian constitution allow each state of the Union to have their own laws to govern trade and commerce within the boundary of the state (Lawmin 2017). Therefore, the laws for running a business can vary for each state and a study focussed on one state cannot be accurate for the whole union. It can be inferred from the statistics that Tamil Nadu has one of the most favourable destination for investment and running a business (PTI 2015).

To effectively leverage the benefits of cloud computing, SMEs must be innovative and consider all factors that can affect cloud migration (Alshamaila and Papagiannidis 2013). According to Asian Cloud Computing Association (ACCA), Data security, broadband availability, interoperability and portability are some of the main issues that are faced by organisations in India (ACAA 2016). The above mentioned issues can be considered as factors around the cloud infrastructure, SMEs also face technical, operational and organisation issues while implementing cloud in their business. Therefore, the decision to adopt cloud computing involves decision making at strategic, tactical and operational levels as it impacts all levels of management within the organisation (Andrikopoulos, Strauch and

Leymann 2013). A review of the literature identifies several research works from academia and business focussed on cloud adoption. There are many proposed decision support framework available to support decision makers in cloud adoption. Each of these frameworks covers different aspects of cloud adoption and there is very little literature available which focusses on the whole migration process. Research by are the only studies which aims to covers the whole migration process. A majority of these studies are focussed on organisations from developed countries and it is proved from several empirical studies that environmental factors play an important role in influencing the decision to adopt cloud computing. Therefore, this research aims to fill the gap by developing a framework to support cloud adoption decision support focussed on SMEs in Tamil Nadu.

1.3 Research Aims and Objectives:

The aim of this research is twofold. Firstly, to investigate and analyse the cloud adoption decision factors for SMEs in Tamil Nadu by using the Technology, Organisation and Environment (TOE) Framework. Secondly, to develop a framework to support cloud adoption decision making by incorporating the factors that are identified during the first part of the study. This research aims to answer the following research questions:

RQ1: What are the issues, challenges and other critical factors faced during cloud adoption decision making process by SME decision makers in Tamil Nadu?

RQ2: How can we develop a framework to support cloud adoption decision making process for SMEs in Tamil Nadu?

The following objectives were set to answer the research question:

- Examine the existing approaches available for Cloud adoption. Identify issues in terms of processes and methods for cloud adoption for SMEs in Tamil Nadu,

- Investigate the enablers and barriers of cloud adoption for SMEs in Tamil Nadu,
- Identify the determinants of cloud adoption for SMEs in Tamil Nadu,
- Examine the existing frameworks, models and Decision support systems (DSS) available to support cloud adoption decision making process and identify the tasks and steps that should be considered prior and post cloud adoption, and
- Propose and develop a framework to support cloud adoption decision by SMEs in Tamil Nadu.

1.4 Research Methodology: Overview

To achieve the research objectives, we have used mixed methods as the use of either quantitative or qualitative research method does not fully answer the research objective. The different activities that were carried as part of this research were conducted in three main stages as shown in figure 1.1.

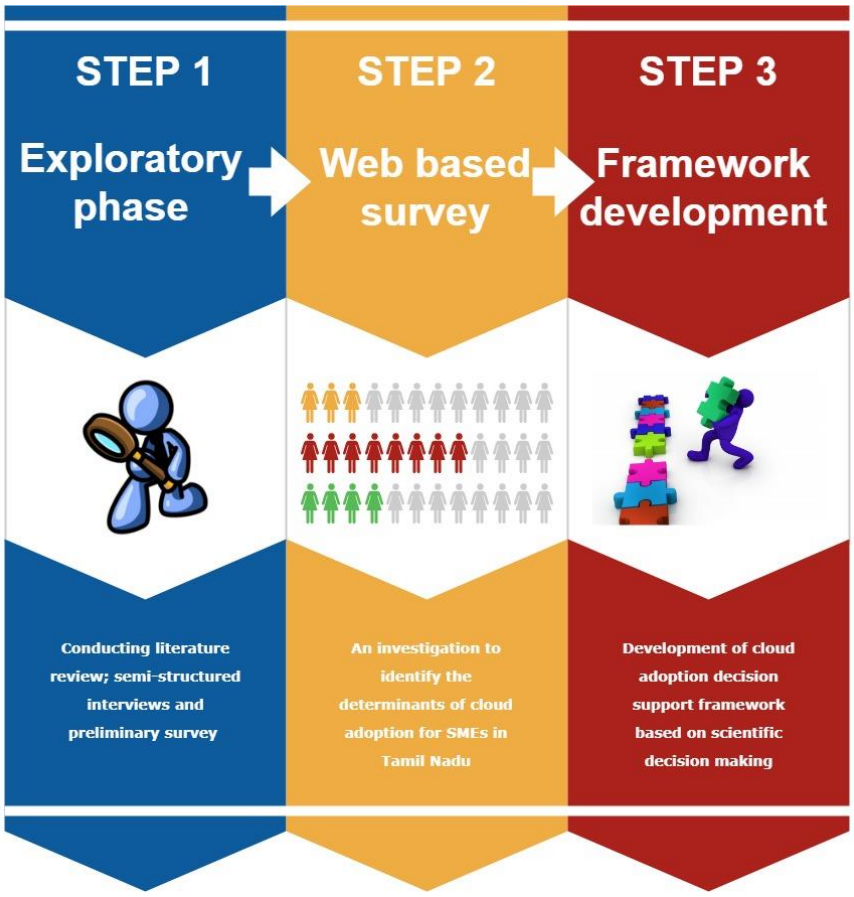

Figure 1.1 Research Stages.

Exploratory Phase: The first stage of the study was mostly exploratory in nature aimed to understand the perception, issues and cloud adoption decision factors for SMEs in Tamil Nadu. We used semi-structured interviews and web based survey methods during this phase.

Survey (Stage 2): The findings of the initial exploratory phase were incorporated into a survey questionnaire and a web based survey was conducted among decision makers from SMEs in Tamil Nadu.

Development of the Cloud adoption decision support framework (CADSF) (Stage 3): The final stage involves development of CADSF using Multi Criteria Decision Making (MCDM) methods to support cloud adoption decision making process for SMEs in Tamil Nadu. A prototypical implementation of the framework is also completed during this stage.

1.5 Ethical Considerations in the research:

We have followed the ethical procedures of Sheffield Hallam University for all the activities conducted in this research. A research ethics form was submitted to the ethics committee before conducting the main study. The ethical implications to the participants of the semi-structured interviews and survey were also considered and data was collected according to the ethical regulations of Sheffield Hallam University.

1.6 Research Contributions:

This research makes both practical and theoretical contributions to the growing body of knowledge on cloud computing adoption. Firstly, this research is the first empirical investigation that examines cloud adoption among SMEs in Tamil Nadu. Through this investigation, we have created empirical evidence of the determinants of cloud adoption for

SMEs in Tamil Nadu. The major practical contribution of this research is achieving the research aim of developing a framework to support cloud adoption decision making by SMEs in Tamil Nadu.

The summary of the contributions of this research are listed below:

- A critical review of the existing frameworks, models and DSS available to support cloud computing adoption (Section 2.9).
- An investigation into the factors that influence the adoption of cloud computing infrastructure among decision makers from the SME sector in Tamil Nadu (Chapter 5).
- The development of a framework to support cloud adoption decision making which covers all the different steps and tasks that need to be considered during cloud adoption (Chapter 6).
- A prototypical implementation of the framework into a knowledge driven DSS (Section 6.5).

1.7 Organisation of the thesis:

This thesis consists of seven chapters. A summary of the contents of the thesis is discussed in this section.

Chapter 1: Introduction:

This chapter gives the brief introduction to the research thesis by discussing the research problem and an overview of the adopted research methodology. The main aims and objectives of this research and the organisation of the thesis is also discussed in this chapter.

Chapter 2: Literature Review:

Chapter two can be divided into parts: The first part of this chapter provides an overview of the cloud computing infrastructure. The benefits and issues of cloud computing

according to literature are also discussed in the first part of this chapter. The second part of this chapter examines the existing literature on cloud adoption focussing the SME sector. The existing framework, models and tools to support cloud adoption is critically analysed in this chapter.

Chapter 3: Theoretical foundations of the framework:

The theoretical principles that helped in designing this research are discussed in this chapter. This chapter discusses human decision making process and scientific decision making (SDM) model. The different MCDM methods are discussed in this chapter. We have also critically reviewed the different theories of technology adoption that are used in IS research. The conceptual framework based on TOE framework and the hypotheses developed are outlined in this chapter.

Chapter 4: Research Methodology:

This chapter provides a detailed explanation of the research methodology adopted in this research. This chapter also provides a brief review of the different research philosophies and research methods that are employed in computer science research. Appropriate justification is given for the choice of methodology employed in this research. Data collection and data analysis methods used are also explained in this chapter.

Chapter 5: Data Analysis:

This chapter presents the findings of stage 1 (Exploratory phase) and stage 2 (Survey) of this research. Descriptive analysis of the questionnaire is presented in this chapter.

Chapter 6: The proposed framework to support cloud adoption support framework (CADSF)

This chapter presents the development of the proposed CADSF. This chapter discusses the steps and tasks that are involved in the cloud adoption decision making process. The results of the case study completed to test the usefulness of AHP for cloud adoption is

presented in this chapter. Prototypical implementation of CADSF is also included in this chapter.

Chapter 7: Conclusion and future work:

This is the final chapter of the thesis. The major findings of this research and how it helped achieve the research objective are discussed in this chapter. The implications of the findings of the research to researchers, SME decision makers and cloud service providers are discussed in Chapter 6. Finally, this chapter concludes by addressing the limitations of the research and listing out areas for future research.

Chapter 2: Literature Review

2.1 Defining cloud computing:

Cloud computing can be defined as an Information Technology (IT) infrastructure by which computational resources like storage, network, and processor are delivered as a service rather than as a product (Hill et al. 2013). Since services are offered by the provider like utilities (gas and electricity), user of a cloud service only pay for what is used (Wang 2011). It also means that if extra computational resources are required, users can provision it on demand. Though the level of adoption has increased considerably in recent years, cloud computing as a technology innovation is said to be still in its formative stage (Ruparelia 2016). There are several definitions for cloud computing based on its characteristics and user's perspective (Vasquero et al. 2009). Perhaps the most widely used and cited definition is the one by US National Institute of Standards and Technology (NIST). According to NIST (Mell and Grance 2011),

"Cloud computing is a model for enabling 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. This cloud model promotes availability and is composed of five essential characteristics, three service models and four deployment models"

The essential characteristics a cloud infrastructure should possess as explained by NIST are explained in the following section (Mell and Grance 2011):

On-demand Self Service: A cloud computing infrastructure should provide cloud users sufficient agility and autonomy to request for more computational resources and users should be able to provision resources dynamically without human intervention with minimum effort.

Broad network access*:* Broad network access refers to the ability of a cloud service to be widely accessible. A cloud infrastructure must be available over the internet accessible through devices like personal computers, mobile phones and tablets.

Resource Pooling: This characteristic brings together cloud enabling technologies such as grid computing and virtualisation. A cloud provider pools its IT resources to serve multiple cloud service consumers by using multi-tenancy models which relies on the use of virtualisation technologies.

Rapid Elasticity: This characteristic of cloud computing refers to the ability of a cloud infrastructure to request for additional resources according to the needs of the consumer. As discussed in the previous section, the boundary of the cloud environment should be limitless and users should be able to scale up or scale out seamlessly.

Measured service: The measured service characteristic refers to the ability of a cloud provider or cloud consumer to keep track of the usage of the IT resources. In the same way as energy usage is monitored and controlled, cloud providers dynamically optimise the underlying infrastructure and provide a transparent metered service at the level of abstraction relevant for the consumer.

According to NIST, these five characteristics are very essential for a service to qualify as a cloud service. In addition to big market players like Amazon, Microsoft and Google

many local providers have started to offer cloud based services to consumers. As a result, if a service has close resemblance to cloud it is being classed part of cloud domain and marketed as a cloud service. It should be understood that if a service provider cannot provide one of the above said characteristic, then that service cannot qualify as a cloud service (Ruparelia 2016).

2.2 Cloud Actors:

The NIST cloud computing reference architecture defines five main actors in cloud computing. In this context, an actor is a person, entity or an organisation that participates and carries out responsibilities related to a cloud based activity. The five actors are as follows (Erl, Puttini and Mahmood 2013) (Mell and Grance 2011):

Cloud Consumer: The cloud consumer is the principal stakeholder for the cloud computing service. A cloud consumer is a person or organisation that has formal arrangements with a cloud provider to use the IT resources made available by the provider. Usually cloud consumers make a formal contract and can specify the technical expertise expected from the cloud provider on a Service Level Agreement (SLA).

Cloud Provider: The person or organisation that provides cloud service is the cloud provider. Cloud provider normally owns the IT infrastructure required for providing the service, also runs and maintains the cloud software that provides the service. Additionally, Cloud provider is responsible for making arrangements with the cloud consumer to deliver the cloud service through network access.

Cloud Auditor: A cloud auditor is usually a third party organisation which conducts assessments of the cloud infrastructure. The main responsibility of the cloud auditor is to evaluate the security protocols, privacy impacts and performance of the cloud infrastructure. The purpose of the cloud auditor is to provide cloud consumers an unbiased assessment of cloud provider's infrastructure.

Cloud Broker: Cloud brokers are an entity or organisation that manages the use, performance and delivery of cloud services.

Cloud Carrier: Cloud carriers are the intermediaries responsible for providing connectivity between cloud consumers and cloud providers. As cloud is operated over the internet, this role is assumed by network and telecommunication providers.

2.3 Cloud computing Service Models:

A cloud service model represents how different types of IT resources are offered as service by the cloud service providers (Alharbi 2017). There are three fundamental cloud service delivery models as described by NIST. They are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) (Mell and Grance 2011).

2.3.1 Infrastructure as a Service:

IaaS is a model in which IT infrastructure ranging from processing power to storage are offered by the service provider on demand over the internet (Opara-Martins 2017). The cloud consumer does not control or manage the underlying cloud infrastructure but has control over the operating systems, storage and applications (Marinescu 2017). The ability to provide unlimited scalability on an on-demand basis through resource virtualisation and pay per use billing model makes IaaS a competent type of cloud service for any type of business. Some of the major providers of IaaS services are Amazon, Rackspace, GoGrid, AT&T and IBM. The major benefit of IaaS is that organisations can use IaaS to quickly deploy new versions of the applications without having to go through any purchase and configuration delays (Wang et al. 2017). IaaS is considered as the bottom layer of cloud computing systems (Buyya, Broberg and Goscinski 2011). IaaS model is particularly useful when the demand is volatile or when the organisation is expanding rapidly and the management does not want to invest in computing infrastructure (Marinescu 2017).

IaaS can be viewed as an extension to traditional IT infrastructure, with the difference of not having to buy and manage expensive IT hardware. (Ruparelia 2016). Due to the characteristic of the virtual infrastructure, IaaS has lower risk of vendor lock-in problems. IaaS requires higher expertise and it is considered a high cost cloud based infrastructure. Therefore, such a type of cloud infrastructure is most suited for large enterprises (Erl, Puttini and Mahmood 2013).

2.3.2 Platform as a Service:

PaaS offerings provide services for the user to develop and deploy applications in the cloud environment. PaaS allows the cloud consumer to maintain the complete application development cycle from designing the application to deploying the application (Mell and Grance 2011). PaaS provides application development platforms which can be remotely accessed over the internet and connect to locally executed frameworks and IDEs allowing fast development and deployment of applications (Opara-Martins 2017). Some of the well-known PaaS providers are Google's Google App Engine, Microsoft Azure and Force.com (Wang et al. 2017).

Consumers may be able to extend the existing toolset by installing their own tools, but control over the overall infrastructure is retained by the cloud provider. Consumers have control over application development, configuration and deployment within the provisions provided by the cloud provider. This layer of cloud computing is similar to traditional web hosting where consumer's servers have development platforms installed on them. The main difference between traditional web hosting and PaaS is that, PaaS allows rapid scalability (Ruparelia 2016). Like IaaS, PaaS will also require staff with IT expertise to develop and deploy applications (Erl, Puttini and Mahmood 2013).

2.3.3 Software as a Service:

SaaS offers application running on a cloud infrastructure to consumers accessible from different types of devices through the internet (Alharbi 2017). In SaaS, there is no need to install and run the application on the user's computer and the maintenance, application capabilities and upgrade procedures are managed and carried out by the cloud service provider. Therefore, traditional desktop applications like the word processing and spreadsheets can be accessed as a service over the internet (Buyya, Broberg and Goscinski 2011). This service delivery model abstracts the user from the infrastructure and platform by concentrating on the application level. Users can access a SaaS application hosted by the cloud provider on a pay-per-use basis. In this model, the user has control only over their data and the cloud service provides maintain full control of the underlying cloud infrastructure. Examples of a SaaS application are Google's Gmail, Microsoft's Hotmail and Google docs (Wang et al. 2017).

The SaaS is not suitable for application which requires real time response or those when data is not allowed to host externally (Marinescu 2017). In cloud computing, the IT infrastructure can be grouped into two categories. All the physical devices such as servers, network, storage, and databases are denoted as "Infrastructure". When the "Infrastructure" is combined with the operating system and middleware, then it is denoted as "Platform". Therefore, both IaaS and PaaS belong to the IT infrastructure stack (Ruparelia 2016). The difference between SaaS, PaaS, and IaaS and on premise application is shown in the following table 2.1.

Category	On-premise	SaaS	PaaS	IaaS
Hardware	*Software and Hardware resides at the location of the user, typically on an in-house datacenter*	*Software and Hardware resides at the premise of the cloud vendor.*	*Same as SaaS.*	*Same as IaaS.*
IT Staff	*Requires recruiting or hiring expert IT staffs for implementing, managing and upgrading IT requirements.*	*End user oriented. Non-technical experts can configure and manage the solution with the assistance of a cloud provider.*	*Need expert IT staff and developers to facilitate the service. Companies can outsource or hire experts from the cloud provider (will have associated costs).*	*Same as PaaS. Requires high level IT skills to manage operating systems, virtual machines and networks.*
Implementation time	*Can take months depending on budget and availability of infrastructure.*	*Can be configured and made available in a few hours.*	*Depending on expertise can be implemented in a few days.*	*Same as PaaS.*
Maintenance and operational Costs	*High upfront costs and ongoing maintenance costs. Usually requires upgrade to infrastructure periodically.*	*Pay as you go fee structure, easy contract options. No maintenance costs (managed by vendor).*	*No upfront costs, involves operational costs (include hiring developers). No maintenance costs (managed by vendor).*	*Costs for purchasing virtual machines and involves operational costs (staffs to manage virtual machines and developers). No maintenance costs (managed by vendor).*
Scalability	*Depends on the infrastructure and*	*Can scale up and down*	*Same as SaaS.*	*Same as SaaS.*

Category	On-premise	SaaS	PaaS	IaaS
	system architecture	*automatically made available through vendor (depends on the SLA)*		
Upgrades	*Customer responsibility and can be expensive*	*Free and usually taken care by vendor.*	*Same as SaaS.*	*Same as SaaS.*
Customisation	*Very flexible, can be customised for needs*	*Point and click customisation.*	*Flexible*	*Flexible and highly customisable.*
Remote access	*Works inside company network.*	*Accessed through internet and available from anywhere through internet browser.*	*Same as SaaS.*	*Same as SaaS.*
Security	*Customer's responsibility for security.*	*Limited control over security. Usually managed by vendor.*	*Same as SaaS.*	*Customer has control over system security.*

Table 2.1: Difference between on premise, SaaS, PaaS and IaaS application

In addition to the above mentioned three fundamental categories, other sub services of cloud computing have emerged in recent years based on their specialisation. The sub services are commercially referred based on the computing capability by simply adding the suffix "aaS". Examples are Storage as a Service (STaaS), Hardward as a Service (HaaS), Database as a Service (DBaaS) and Composite as a Service (CaaS) (Opara-Martins 2017). Ruparelia (2016) argues that due to the evolving nature of the cloud infrastructure, the definition for cloud service model should be redefined and introduces two new service delivery models to fit all the different types of cloud services used by businesses. They are Business Process as a Service (BPaaS) and Information as a Service (INaaS) (Ruparelia 2016).

Business Process as a Service (BPaaS): BPaaS functions as a replacement for an existing business process in an organisation. BPaaS is a combination of Business Process Outsourcing (BPO) with Software as a Service (SaaS).

Information as a Service (INaaS): INaaS provides information relevant to an individual or organisation to their business, process or tasks. Payments for both these models are based on pay per use basis. For our investigation we include only the three service delivery models defined by NIST.

2.4 Cloud delivery models:

A cloud deployment model represents the type of cloud environment which hosts the cloud service. According to NIST, there are four types of cloud deployment models. They are explained in the following sections (Mell and Grance 2011).

2.4.1 Public cloud:

A public cloud is a cloud computing infrastructure which is publicly accessible. Users of the public cloud can be general public or an organisation. The IT resources of the public cloud are managed, maintained and owned by the cloud providers (Hill et al. 2013). Public cloud services are delivered to the user through one of the service models discussed in the previous section. Public cloud support multi-tenancy model which is the usage of same infrastructure by different consumers. Users of public cloud agree for the data to be stored in public cloud data centers. To provide high availability, public cloud providers store data in multiple data centers which sometimes can be in different countries. This introduces legal issues as different countries have different data protection laws. The laws of the country where the data center is located may govern the data when it is stored in a country different from where is organisation operates. This is one of the major concern of using public cloud and multi-tenancy model (Ruparelia 2016). Due to the low cost approach, Public cloud is

regarded as most suited for SMEs as cloud providers are responsible for ongoing maintenance of the cloud and its resources (Erl, Puttini and Mahmood 2013) (Mell and Grance 2011).

2.4.2 Private cloud:

As the name suggests, Private cloud is managed and maintained for use by a single organisation. In a private cloud, cloud resources may be located either on premise or off premise. The private cloud user might employ a third party to maintain the infrastructure. Even though the private cloud is managed for use by a single organisation, it should still have the five characteristics of a cloud computing infrastructure (Mell and Grance 2011). According to Wang et al. (2017), security and privacy concerns are the major motivation behind building and running a private cloud.

2.4.3 Hybrid cloud:

The latest buzz in the field of cloud computing is the use of hybrid cloud model in enterprises. Research data shows that 58% of enterprises are looking to use hybrid cloud model for the business requirement (RightScale 2017). A hybrid cloud is cloud computing infrastructure comprising of more than one type of deployment model (Mell and Grance 2011). For example, an organisation may use private cloud for data that is sensitive and public cloud for other aspects of business (Erl, Puttini and Mahmood 2013). However, usage of more than one type of deployment model introduces issues of portability and interoperability. Portability refers to the ability of a computer program to be able to operate on different platforms. If portability does not exist, it increases the risk of vendor lock-in which may potential leave the cloud user stuck with a particular provider (Bernstein, Vij and Diamond 2011).

2.4.4 Community cloud:

A community cloud is a type of cloud computing environment similar to public cloud except it is limited to a specific community of users or organisation sharing same interest. Such a type of cloud infrastructure can be on premise or off premise and maintained by one or more collaborating organisations. Examples of such type of cloud are government infrastructure and research grids which serve particular group of users (Mell and Grance 2011).

2.5 Advantages of cloud computing:

The decision to migrate data and application to a cloud infrastructure can bring about many benefits to an organisation. The most advertised benefit of cloud computing is the economic benefit it brings by moving to a pay per use billing model. From the cloud user's perspective, the cloud is a point of access for all their resources, anytime and from anywhere as long as the internet is available. Cloud providers are very reliable as they have better security mechanisms than individual organisations (Hill et al. 2013). New applications and technologies can be tested on cloud without having to build the infrastructure in-house and cloud providers can provide limitless scalability according to the users demand. The other drivers of cloud computing are discussed in the following sections.

2.5.1 Better IT utilisation:

According to researchers, even at peak usage only between 10-30% of the IT resources will be utilised. A user might use 60% of CPU memory, 20% of the total available network bandwidth and 10% of the processor at peak usage time. In a traditional IT environment, this results in under used IT resources. Even though the IT resources are not utilised to their full potential, organisation still have to pay for 100% of the resources (Ruparelia 2016). This problem is solved by cloud computing. Cloud computing provides a shared infrastructure where IT resources can be provisioned based on demand of the

organisation. This also improves the efficiency of the system as the cloud infrastructure can scale up or scale out at peak usage time. The boundary of a cloud environment is defined by the user. Cloud infrastructure provides user access to highly scalable technologies as discussed in the previous section. Netflix, Instagram and Twitter are all well-known examples of services running through cloud infrastructures and these businesses have expanded without any interruption based on the demand.

2.5.2 Price models:

This is one of the most attractive benefit of cloud computing. Cloud computing enables businesses to simply sign up and start using the service without having to invest on buying expensive IT hardware. A cloud user is billed based on the pay-as-you-use billing model. This brings a change in the business model of the organisation as cloud adoption results in IT changing from Capital expenditure (Capex) to Operational expenditure (Opex). There are different types of price models followed by the cloud providers. Some of the well-known price models are subscription based price model, utility based model and consumption based model (Ruparelia 2016).

2.5.3 Improves agility and accessibility:

One of the main characteristic of a cloud computing infrastructure is "broad-network access". A cloud service is usually accessible across different devices through a web browser. A cloud user can go online with less time to market. Thus, cloud is more agile and readily available (Wang 2011).

2.5.4 Back up and Disaster recovery:

Data stored in a cloud environment is replicated in multiple data centers and some cloud service providers have data centers across the world. This feature of cloud computing minimises the risk of loss of data and can ensure business continuity at times of natural

disasters. Therefore cloud computing can offer better back and disaster recovery services (Ruparelia 2016) (Erl, Puttini and Mahmood 2013).

2.5.5 Green Cloud:

Green Computing can be defined as the eco-friendly use of computer and its resources (Techopedia 2013). Green Computing involves designing, manufacturing and use of computer and its resources so that it will have less impact to the environment (Garg and Buyya 2011). A study conducted by Accenture has identified that companies can cut down the consumption of electricity and reduce carbon emission by 30% when they move their in-house data centers to a cloud platform. In traditional computing systems where organisations have their data centers in-house, dedicated servers can be used for different application and usually vertical scaling is used which can result in less utilisation of the resource and increase in power consumption. In organisation, data administrators might not be held accountable for increase in power consumption and the only concern for data administrators would be high availability of the resource (Holler 2009). However, in cloud infrastructure the provider has less number of servers with high efficiency and resource utilisation. According to google, if an organisation chose to migrate to a cloud model based on Google App Engine, they can reduce direct energy supply for servers and for server cooling by 70-90% with only 2-3% increase in energy usage by the applications using the internet (Google 2012).

2.6 Issues with cloud computing:

2.6.1 Security issues in the cloud:

The adoption of cloud computing by moving data and application to a third party cloud providers data center increases security concerns as the responsibility of the data is shared between cloud provider and the consumer. For example, consider a small organisation using google spreadsheets to maintain and manager their customer's personal information. As the data resides in an external data center, it becomes a joint responsibility of google and the

small organisation to protect their client's personal information. It is difficult to establish a security infrastructure unless the cloud provider and cloud consumer happen to support the same security infrastructures. Security issues in the cloud remains as the main factor affecting cloud adoption.

2.6.2 Interoperability issues:

Portability of a computer application or data refers to the ability to move the application or data from desktop to cloud or from one cloud provider to another (Bernstein, Vij and Diamond 2011). In this context, Cloud Interoperability can be defined as the ability to write code that works with more than one cloud provider simultaneously, regardless of the differences between the providers. Interoperability is one of the major issues that organisations face while migrating applications to cloud. Mirfakhrai et.al (2012) has developed a conceptual framework to prevent interoperability issues. Mirfakhrai et al. (2012) argues that to eliminate these problems, it is important to develop a central unit between the providers that can act in between cloud providers to manage the transactions. The central unit can act like an adapter which converts service request from one provider to a standard which can be accepted across all cloud providers. This model is not practically suitable as it increase the security threat in Cloud. However, in place of central unit Cloud Standards can used to address cloud interoperability issues.

The common strategy used for interoperability in Public cloud is standardising exchange mechanisms and interfaces in the cloud Teckelmann et.al (2011) and Lewis (2013). Standardisation in Cloud computing refers to the use of common APIs, architectures and technical standards which can be established and approved by an organisation like ISO (International Organisation for Standardisation) or ANSI (American National Standards Institute) Hofer and Karagiannis (2011). Organisations like Cloud Computing Interoperability Forum, Cloud Security Alliance, Distributed Management Task Force are working on

developing standards for different aspects of cloud computing. Some of the clouds computing standardisation efforts by organisations are shown in the following table 2.2 Lewis (2013).

Project Name	**Focus**
Cloud Computing Interoperability Forum	*Common, agreed-on framework/ontology for cloud platforms to exchange information in a unified manner. Sponsors of the Unified Cloud Interface Project to create an open and standardized cloud interface for the unification of various cloud APIs*
Cloud Security Alliance	*Recommended practices for cloud-computing security. Working on Version 3 of the Security Guidance for Critical Areas of Focus in Cloud Computing. Non-profit organization that includes Google, Microsoft, Rackspace, Terremark, and others.*
Cloud Storage Initiative	*Adoption of cloud storage as a new delivery model (Data-Storage-as-a-Service). Initiative sponsored by the Storage Networking Industry Association (SNIA), the creator and promoter of The Cloud Data Management Interface (CDMI). SNIA includes members from NetApp, Oracle, and EMC*
DeltaCloud	*Abstraction layer for dealing with differences among IaaS providers. API based on Representational state transfer (REST) with a small number of operations for managing instances. Currently have libraries for seven providers including Amazon EC2, Eucalyptus, and Rackspace.*
Distributed Management Task Force (DMTF)	*Management interoperability for cloud systems. Developer of the Open Virtualization Framework (OVF). Also runs the Open Cloud Standards Incubator.*
Open Cloud Computing Interface	*REST-based interfaces for management of cloud resources including computing, storage, and Bandwidth. Working group of the Open Grid Forum.*
Cloud Computing Interoperability Forum	*Common, agreed-on framework/ontology for cloud platforms to exchange information in a unified Manner. Sponsors of the Unified Cloud Interface Project to create an open and standardized Cloud interface for the unification of various cloud APIs.*

Table 2.2: Cloud standarisation efforts by different organisation (Lewis 2012)

Some the common examples of standards to support interoperability are Amazon Web Security Identity Access Management (AWS IAM), Amazon Machine Image (AMI), Virtual

Hard Disk (VHD) and Representational State Transfer (REST). AWS IAM is used by amazon to authenticate users within AWS account. Eucalyptus also supports AWS IAM. AMI is a virtual machine that can be deployed in EC2 and eucalyptus and openstack support AMI. Similarly, VHD is the virtual file format used by Microsoft Azure which is supported in EC2 as well (Lewis 2013).

2.6.3 Regulatory and Legal Issues:

In a public cloud, cloud service provider may store consumer's data in a data center outside the country where the consumer operates and sometimes the location of the data center can be in a different continent which can be outside the jurisdiction where the company operates (Erl, Puttini and Mahmood 2013). Public cloud users will often be unaware of the physical location of the IT resources and where the data are stored by the cloud service provider. For some organisation, it can be a major issue as it can present serious regulatory and legal concerns for the organisation. According to Data Protection Act (DPA) in UK, it requires personal data of consumers be kept within the United Kingdom. Therefore, an organisation using personal data of consumers may not be able to use public cloud providers operating from outside the United Kingdom (Hill et al. 2013). Additionally, data stored in a foreign country must also comply with the laws of the country where the data center is located. For example, US Patriot act allows government and security agencies to have easy access to data that are stored in cloud provider's data center anywhere inside U.S (Wang 2011).

2.7 Towards cloud adoption:

Cloud computing as described in the previous section is a computing paradigm that facilitates IT adoption among businesses in developing countries. In developed countries like UK, USA and Europe, enterprises large and small have embraced the technology and have started to use cloud computing according to the needs of the business. According to Gartner

hype cycle, cloud computing was a "technology trigger" in the year 2008. Till 2010, cloud computing remained a buzzword in Information technology and was a trendy topic among CIO's in businesses. Cloud computing as a "technology trigger" has matured into a technology for mainstream adoption much earlier than the initial projection by Garnter (InsightExtractor 2017). It was predicted by Gartner in 2013 that cloud computing will be available for mainstream adoption in the next 5-10 years. However, hype cycle of 2015 did not feature cloud computing (Panetta 2017). Technology trigger or a new technology trend will be removed from the hype cycle before the predicted timescale only for two reasons. If the technological advances in the field are considered positive and if the innovation has advanced, it can be removed from the hype cycle and can be considered it has exited the curve to the right. The second reason is if the technology trigger has been a failure and discarded by enterprises as not living up to the hype (Panetta 2017). From recent cloud adoption trends (RightScale 2017), its clearly understood that cloud has been widely accepted and has surpassed initial expectation with some CIO's suggesting cloud computing will become the standard for IT infrastructure in the next few years. This clearly shows the evolving nature of the technology and the need for more research in the field.

Globally, cloud computing market has seen exponential growth in the last five years. The total spent on public cloud services is expected to be more than $141 billion by the year 2019. According to a recent survey by Cloud Industry Forum (CIF), the cloud adoption by enterprises in UK has increased from 48% in 2010 to 84% in 2015. According to 2016 survey by rightscale (RightScale 2016), adopters of cloud computing in the United Kingdom use more than one cloud provider. The cloud adoption trends in the rest of Europe and the US are very similar to United Kingdom. In America, according to a survey (Lamson 2015), 90% of large enterprises and 72% of medium enterprises have already adopted the use of cloud computing and its services. In Germany, 86% of enterprises are already using cloud

computing and 65% of medium enterprises have adopted cloud computing. However adoption of cloud computing in developing economies is less when compared with developed countries. This is due to a number of factors will be discussed in the following section. For example, the total market share of public cloud services in India by end of 2016 was £1.26 billion and forecasted to reach £2 billion by the end of the year 2020 (InternationalTrade 2016). These numbers are similar when compared with other developing countries like Brazil, South Africa and Nigeria. Though the level of cloud adoption by businesses is increasing every year, the level of growth is at a much slower pace when compared to developed economies.

2.7.1 Indian SME sector:

This study is focussed on the SMEs sector belonging to Tamil Nadu, a southern state of the Indian Union. Literature review reveals that there is very little literature available on cloud adoption by SME sector and the SME sector is under researched. The term SME has several different definitions in different countries. The World Bank uses three important criteria for the definition of SME is the size of the business (number of employees), total assets (total capital), and total annual sales (total turnover) (Berisha and Shirokha 2015). The following table 2.3 shows the definition of SMEs by World Bank standards.

Enterprise Indicators	**Number of Employees**	**Total assets**	**Total annual turnover**
Micro Enterprises	*up to 10*	*<= $100,000*	*<= $100,000*
Small Enterprises	*between 10 and 50*	*between $100,000 and $3,000,000*	*between $100,000 and $3,000,000*
Medium Enterprises	*between 50 and 300*	*between £3,000,000 and 15,000,000*	*between £3,000,000 and 15,000,000*

Table 2.3: Definition of SME according to World Bank

In India, definition for SME is based on the definition by Indian Ministry of Micro, Small and Medium Enterprise (MSME). According to MSME act of 2006, businesses are classified based of the initial investment made by the enterprise on plant, machinery and equipment's to run the business (DCMSME 2015). The following table 2.4 shows the different classifications of SMEs.

Particulars	**Investments in Plant & Machinery (Manufacturing Enterprises) in Indian rupees**	**Investments in Equipment's (Service Sector Enterprises) in Indian rupees**
Micro Enterprises	*<= 25 lakhs*	*<=10 lakhs*
Small Enterprises	*> 25 lakhs & <=50 lakhs*	*> 10 lakhs & <= 200 lakhs*
Medium Enterprises	*> 50 lakhs & <= 1000 lakhs*	*> 200 lakhs & <= 500 lakhs*

Table 2.4: Definition of SME according to Indian Ministry of MSME (1 lakh INR = £1000)

In the case of developed countries like United Kingdom and the USA, number of employees in the organisation is one of the major criteria for classification of micro, small, medium and large enterprises. In India, the capital investments made for the business determines the category the business will fall under. The level of IT adoption among SMEs in India is low when compared to developed countries. Even though the capital investment and annual turnover is less, SMEs from certain sectors like manufacturing and textile industry can have more employees. Therefore, number of employees will not be an appropriate criterion for the classification of enterprises.

The impact of size of the organisation on the level of adoption needs to be investigated for SMEs in Tamil Nadu. While reviewing the literature, it was identified that the level of cloud adoption drops significantly even in a developed economy like USA when

the size of the organisation is less than 100. Survey results by (Lamson 2015) shows that only 37% of small businesses have adopted cloud computing by the end of 2015. These shows even with availability of required infrastructure and favourable legislation, small businesses have still not adopted cloud and there is scope for research focussing the size and type of industry the SME belongs. Also there are no significant publication focussing just the SME sector between 2008 and 2012.

2.7.2 ICT adoption in Indian SMEs:

The SME sector is considered as the backbone of the Indian economy with more than 40% of the total employed workforce in the country working in the SME sector (Iyer et al. 2013). India is currently ranked second in the world for the number of SMEs in the world. With more than 48 million SMEs (both registered and unregistered), the Indian SME sector is home to diverse variety of industries such as textiles, auto ancillary, food processing, agro based, tanneries to name a few. Though the SME sector employs majority of the working population, the contribution made by the SME sector to the Indian economy is very less when compared with other countries. According to Iyer et.al (2013), Indian SMEs contribute between 10-20 % to the total Gross Domestic Product (GDP) of the Indian economy. For example, the total annual turnover by SMEs in UK is £1.8 trillion which is more than 47% of turnover by private sector. These figures are similar to majority of countries in the European Union. China, the only country which has more SMEs than India gets 60% contribution to the total GDP by SMEs. The successes of SMEs in China are mainly because smaller firms are keener to adopt suitable and available technologies to maximise business opportunities. Low levels of technology adoption remain one of the main reasons behind inefficient productivity in the SME sector. According to an INTUIT study in collaboration with MSME focussing on MSME sector highlights cost, lack of skilled manpower, lack of awareness of benefits of technology, poor infrastructure are the major barriers for adoption of any type of

technology in businesses. Indian SMEs are traditionally late adopters in adopting a new technology. According to Iyer et.al (2013), there are two main reasons behind SMEs being late adopters of a new technology. The first reason is the management's resistance to move from human resource driven manual process to system driven processes. The second is the high upfront investment required to have an IT infrastructure setup and running. As Indian economy has been opened to Foreign Direct Investments (FDIs) on most of the fields, SMEs in India face the threat of competing with large global companies. Innovation in IT among SMEs has proved to increase productivity and can enable SMEs to compete with large enterprises. Innovation in IT represents the change in practice or a new operational idea on how IT is maintained and managed. To leverage the benefits of technology and to take the business to the next level, cloud computing offers a platform which offers flexibility and affordability in technology adoption.

However, the user friendly, pay-per-use cloud computing is not suitable for all SMEs as most of them may not be cloud ready due to poor broadband infrastructure. According to Asian Cloud Computing Association (ACCA), India is ranked at 12^{th} position for the readiness of businesses for cloud adoption for the year 2016. This ranking by ACCA places India behind Indonesia, Thailand and Philippines. In 2011, India was ranked at 9^{th} position and the ratings since 2011 shows that there has been very less improvements in favourable conditions for cloud computing for SMEs in India (ACCA 2016).

2.7.3 External factors that affect cloud adoption in Indian SMEs:

India's poor broadband infrastructure is one of the major barriers of cloud adoption among SMEs. The vastness of the country and the cost for implementing the infrastructure is cited as the main reason for poor broadband. In urban India, Internet access is predominantly financed by private sector companies where Return of Investment (ROI) is high. However, in rural areas where SME population is high the penetration of broadband is less (2%). Reliable

internet access is mainly through Digital Subscriber Line (DSL) technology using copper cables (Daheria 2014). The average broadband speed in India is 2.8 Mbps (Megabits per second) with a maximum peak time speed of 21.2 Mbps. These speed statistics is one of the lowest in the Asia Pacific region. According to a UN commissioned broadband report, India is currently ranked 131 out of 180 countries for total broadband connections (UNBroadbandCommision 2014). Although 100% foreign direct investment is allowed in telecom, several political scams and tax issues have affected investments. The National Optical Fibre Network (NOFN) project aims to provide 2 Mbps broadband access to 250,000 gram panchayats (village/ small town) by laying 600,000 km of fibre across the country by the year 2020. This project (£1.9 billion) is mainly funded by the central government. Unavailability of compatible devices, lack of useful applications, limited digital literacy, limited affordability are some of the reasons highlighted as major challenges faced by telecommunication companies in India (Daheria 2014).

The second major barrier that SMEs in India face is poor power grid quality. Power shortage is a major issue faced by majority of the states in India. According to a recent government estimate, there are still more than 10,000 villages with no supply of electricity in various parts of the country (Doshi 2016). A recent Washington post article titled "India's huge need for electricity is a problem for the planet" states there are nearly 300 million people in India living without electricity. India currently ranks 3rd behind China and USA for largest emission of greenhouse gases. Though, India is a signatory participant in the global initiative to address climate change in 2015, very little steps have been since to improve the current status (Gowen 2016). Above mentioned reasons, validates the electricity problems faced by the country and for datacenters to run effectively power grid quality, green policy and sustainable power is vital. This is another reason for SMEs not adoption technology as maintaining IT hardware needs uninterrupted power supply. However, for SMEs who run

their own datacenter, cloud offers a better platform as they can outsource data and application to a cloud datacenter which eliminate the need for electricity for running datacenters and cooling equipments.

The third major barrier for adopting cloud related technologies is the international connectivity. Logistics in India is not very effective and has its own challenges. The main reasons behind this are poor quality infrastructure, too many parties involved, regulatory issues and low levels of technology adoption (Loginext 2016). Data center risks are another factor which affects the cloud adoption of SMEs in India. Some of the major data center risks are server failure, network connection failures, undetected smoke, ineffective employee monitoring and management and external hackers.

The last and important factor which affects cloud adoption is privacy and government regulatory issues relating to cloud adoption. India currently does not have a separate legislation to govern data protection or privacy related issues. However, amendments are made in the Information Technology (IT) act of 2000 to deal with issues relating to data protection and privacy. With regards to cloud computing, this is a major issue as when deciding to adopt cloud computing, SMEs adopt a new business model of migrating data to a third party datacenter thereby loosing full control over data. There are currently no regulations to safeguard businesses. Cloud service providers or users can be taken to court in case of security breaches. However, India does not have express judiciary and it can take years for SMEs to get due compensation. Moreover, the penalties for any breaches are in the range of 200,000 INR to a maximum of 500,000 INR (between £2000-5000 approximately) which may be insignificant amounts when compared to the damage caused to a business due to a security breach (Bajwa 2003).

2.8 Existing literature relevant to cloud adoption among SMEs:

Since 2009, several research works have been carried in both academia and businesses focusing on cloud migration for the SME sector. Initial studies were focused on identifying the perception, benefits and risks of cloud adoption within organisations. A review of the existing literature reveals several empirical studies which have examined the factors that affect cloud adoption within organisation. Recent research studies have moved towards developing a decision model for cloud adoption. In this section, a critical review of the existing literature is presented. The main aim of this section is to identify what is already known and also to identify the methodology adopted in other similar researches. Existing research literature on cloud adoption is discussed in the following four sub-sections: Factors that affect cloud adoption, Benefits and risks of cloud adoption, Organisational readiness for cloud environment and decision support.

2.8.1 Factors that affect cloud adoption:

A number of studies have been carried out to identify the factors that influence cloud adoption within organisations (Low, Chen and Wu 2011, Feuerlicht and Margaris 2012, Alshamaila and Papagiannidis 2013, Makena 2013, Mohlameane and Ruxwana 2014, Awason (2014), Gangawar, Date and Ramaswamy 2015). These studies have employed different theories of technology adoption at organisation level. Technology acceptance model (TAM), Diffusion of Innovation (DOI) and Technology, Organistion and Environment (TOE) Framework are some of the theories used to study factors that affect cloud adoption at organisation level. Low, Chen and Wu (2011) implemented a questionnaire based survey to understand the determinants of cloud adoption at larger firms in Taiwan. Their study was based on TOE framework and since 2011 many researches have adopted similar methodology to investigate SME sector in different countries. Low, Chen and Wu (2011) revealed relative advantage, top management support, firm size, competitor and trading partner pressure will have a significant effect on the adoption of cloud computing in organisations. Alshamaila and

Papagiannids (2013) used a similar TOE approach and adopted a qualitative approach focusing on SMEs in North East of England. In addition to the factors identified by Low, Chen and Wu (2011), they have explained uncertainty of the new technology, innovativeness of the individual business, prior-experience, and market scope as the factors that affect cloud adoption. There are similar other studies focusing on enterprises in Portugal, Germany and Saudi Arabia which have employed either DOI or TOE to understand the factors that affect cloud adoption (Stieninger and Nedbal 2014, Neves et al. 2011 and Alkhater, Wills and Walters 2014).

One particular trend that emerges is that studies focusing SMEs from developing economies like Nigeria, South Africa, India, Vietnam and Ghana (Abubaker 2016, Adam 2014, Rath et al. 2012, Makena 2013, Mohlameane and Ruxwana 2014) have identified issues like Broadband availability, high bandwidth costs, low awareness of the benefits of the technology and lack of expertise as major factors that affect cloud adoption. In developed countries, SMEs are more agile and can readily react and adopt new technology due to availability of relevant infrastructure. Therefore, it is clear from these studies that cloud adoption brings both organisational and technological change to an organisation. The factors clearly depend on the environment as we can see they can differ based on the geographical location of the SME.

There are several other empirical studies which have investigated the factors that affect cloud adoption through questionnaire surveys or interviews. In these studies, questionnaire or interview questions did not adopt any methodology similar to previously mentioned studies. The result of these studies shows that the data collected have focused on one particular factor. For example, result of the study by targeted at SMEs in Latvia by (Budniks and Didenko 2014) only shows a positive trend in cloud adoption and does not

highlight any influencing factors. Therefore, determinants of cloud adoption can be better understood if one of the theories of technology adoption is employed.

2.8.2 Benefits and risks of cloud adoption:

In general, SMEs have limited IT budget and expertise when compared to larger enterprises (Alshamaila and Papagiannidis 2013). Therefore, SMEs face several issues and risks while adopting a new technology innovation. Though a successful cloud adoption can result is various benefits to the organisation, there are several risks involved in cloud migration. According to (Chao et al. 2014), the main factor that restricts the growth of cloud adoption is the risks associated with the adoption. The degree of risk associated with the cloud adoption depends on the type of deployment and service model adopted. As a result, the type of risks varies for each and every adoption. For existing IT infrastructure, a potential cloud adoption introduces technical risks like compatibility, interoperability and portability, reliability and performance related issues. Some legacy application may need to be redesigned or redeveloped to make them compatible to a cloud environment. This will increase the total cost of migration (Khajeh-Hosseini 2013). Several individual studies have discussed the cost and risk analysis of cloud adoption for each cloud service delivery models. Some of the examples are (Khajeh-Hosseini et al., 2011; Yam et al., 2011; Johnson & Qu, 2012; Khajeh-Hosseini et al., 2012; Martens and Teuteberg, 2012; Azeemi et al., 2013; Madria and Sen, 2015). Some studies have highlighted the mitigation approaches for each risk factor. The mitigation approaches for each risk factor.

2.8.3 Organisational readiness for cloud:

Evaluating organisational readiness to move to the cloud environment is another important research area. Khajeh-Hosseini (2011) proposed a cloud adoption toolkit which supports cloud adoption decisions. The framework included stakeholder impact analysis and technology suitability analysis. Through a flow of steps and answering questions from seven

technical areas, decision makers can identify the suitability of the cloud environment for their business. The limitation of this framework is that it focused on a particular cloud service model (IaaS). Alemeve and Getahun (2015) have proposed a theoretical framework based on DOI, TOE and TAM. Their framework can only be used to understand the factors that affect cloud adoption. Perhaps, the most interseting study relating to cloud suitability assessment is by Colicchio, Giovanoli and Gatziu (2015). They have proposed a cloud suitability assessment for SMEs in Switzerland focusing on ECM and collaboration software. It is a questionnaire based tool which identifies the suitability of cloud based on questions at 9 criteria's. Based on the result, the suitability of the cloud environment is suggested to the user. This framework is limited to ECM and collaboration software. However, through investigation of the factors that affect cloud adoption, this framework can be extended for any cloud service model. From cloud providers perspective to attract businesses to purchase their product, big cloud providers like CISCO, IBM, Microsoft and Oracle have developed their own framework to access organisational readiness for cloud environment.

2.8.4 Background on DSS:

In Academia, research efforts in designing a framework to support cloud adoption started in 2009. Decision framework by (Klems et al. 2009) is one of the early attempts for designing a decision framework for cloud migration. Their cost based decision framework can be used to determine the benefits of cloud computing infrastructure instead of a traditional IT infrastructure and decisions can be made based on cost analysis of using services offered by the cloud. However, the cost involved in the actual migration was not investigated in this study. In Academia, since 2013 there are several studies carried out to develop models, frameworks and tools to support cloud migration. Decision makers want to know, where to start and how to plan a successful migration to fully leverage the benefits of

cloud computing. This is the major driver for research towards developing a decision model for cloud adoption.

Kundra (2012) designed a decision framework for U.S federal agencies planning to adopt cloud environment. The Federal cloud computing framework according to Kundra (2012) involves three stages: Select Provision and Manage. Kundra (2012) has designed this framework from a federal agencies point of view on how to plan a successful migration. The essential factors that are needed to be addressed are listed as guidelines and these can be used by any organisation to evaluate if their existing IT system is ready for cloud deployment. It is clear that in this model it is assumed that adapting to a cloud infrastructure is cost effective and the IT infrastructure in U.S can support the technology. The major drawback of this framework is that it cannot be applied to SMEs regardless of the geographical location as cost benefits are very important for SMEs. The infrastructure in place in Tamil Nadu may not support cloud services as penetration of broadband services in rural areas are very less and internet access are available only through 3G and 4G services. The cost of high bandwidth will be an important factor in such circumstances.

Beserra et al. (2012) have proposed cloudstep, a migration strategy to support deployment of legacy applications to a cloud environment. Their step by step decision support framework is based on the technical issues faced by the organisations during the actual migration process. Cloudstep does not cover the whole migration process and can only be used by software developers to complete the migration successfully.

Decision support tools by Khajeh-Hosseini (2013) was one of the publicly available DSS to support system deployment to a public cloud designed and developed by Khajeh-Hosseini (2013) as part of a PhD study. The DSS developed by Khajeh-Hosseini (2013) was available until recently when it was bought by rightscale. Through the DSS, decision maker

can estimate the cost of deploying applications on a public cloud infrastructure. Framework by Song, Leyman and Vasilos (2013) aimed to improve the DSS by Khajeh-Hosseini (2013) by recognising that there are different payment plans available in the pay per use model to provide same service, which means a particular provider might have two or three different charges for the same type of service. Their study aims to rank the services offered by cloud provider in ranking order based on the requirement of the user and the cost of the service. A decision maker can identify the cheapest available cloud service provider according to the requirement of the business by following one of the two models. All of the frameworks mentioned above covers only the technical or economical aspect of the migration.

To cover the whole process of implementing cloud computing within organisations, Multi-Criteria Decision Making (MCDM) or Multi-Attribute Decision Making (MADM) approaches can be followed. Cloud migration decisions are inherently complex since they are influenced by multiple, possibly conflicting factors, such as cost, performance, security and legal concerns. Several researchers have presented their framework based on this concept. MADM for cloud adoption by Saripalli and Pingalli (2011) is one of the early frameworks which used MADM to support cloud adoption decisions. Framework by Saripalli and Pingalli (2011) is a theoretical framework and they have shown the working of the framework for two scenarios of cloud adoption. The MCDM framework by Menzel et al. (2011) allows organizations to create evaluation methods that help to determine what infrastructure best suits their needs by evaluating and ranking infrastructure alternatives using multiple criteria derived from a comprehensive criteria catalogue. Whaiduzzaman (2014) proposed a framework based on MCDM method for cloud service selection. The disadvantage of this framework is that a working implementation is not shown. However, their work can be used to better understand the different MCDM and MADM available to support decision making

problems. Several other researchers have also implemented MADM and MCDM methods to support cloud adoption decisions.

Cloud adoption decision tool by Bildosola et al. (2015) is a questionnaire based tool to suggest a suitable SaaS provider. This tool is targeted for SME population in Spain and based on this tool; SMEs can generate their own road map to implement cloud computing solution in their company. The cloud service provider offered is based on the perception, ratings and experience of previous users of the tool. (Buyya et al. 2013) have proposed a tool to provide ranking of cloud providers based of Analytical Hierarchy Process (AHP).

The different frameworks discussed in this section cover different stages of the cloud migration process. However, there are no DSS available which covers the whole migration process starting from completing a cloud suitability assessment to identifying a suitable cloud provider. From reviewing the different frameworks, the following features are identified as essential for a cloud migration decision support system.

- A user friendly interface which allows the decision maker to navigate the system.
- Existence of a knowledge base which contains information about the CSPs and their service offerings, risks and benefits of each particular type of cloud adoption.
- Ability to complete a cloud suitability assessment for different SME profiles (based on organisation type, size and their requirement).
- Provide decision support for different alternatives considering the relevant attributes.
- Ability to provide a ranking of services offered by different CSPs by considering factors like suitability, reliability, compatibility, geographical location of the data center and security.

2.8.5 Existing literature focusing on Indian SMEs:

In this section, literature on cloud adoption in India is review. The use of cloud computing by Indian businesses has been explored by several studies since 2010 (Rath et al. 2011, Gangawar, Date and Ramaswamy 2015 and Vidhyalakhsmi and Kumar 2016). According to Kshetri (2012), if institutional and economic factors are improved, cloud computing can serve as an important catalyst in driving the economic development of India. Lack of suitable rules to handle cloud computing requirements, jurisdiction of cloud contracts, lack of data protection related regulations for global CSPs and lack of industry bodies for cloud computing are some of the institutional factors that affect cloud adoption in India (Bhat 2013). In addition to institutional factors, issues like security, broadband availability, and relevant software products for India market are some of the issues that government and CSP should improve to increase the level of cloud adoption among businesses in India (Bhat 2013). In 2013, India was ranked 1st for number of cloud based security breaches in the Asia Pacific region (Asperey 2013). A number of studies have investigated the different security and risks involved in cloud adoption (Subhashini and Kavitha 2011) (Bhat 2013). These studies have only discussed the different issues and have not discussed how service delivery and deployment should be selected to avoid these issues. To support cloud migration, (Rashmi, Mehfuz and Sahoo 2012) have proposed a five phased model based on the waterfall model of the software development life cycle. This is a theoretical framework and can only be used to understand the different stages of cloud migration. (Gangwar, Date and Ramasamy 2015) implemented a framework based on TAM-TOE model to determine the determinants of cloud adoption among enterprises in India. Since the study was based on data collected from large enterprises, linking the findings of the study to SMEs may not be appropriate.

Salesforce started their India operations in 2005 and since then, many global CSPs have opened their cloud service operations in India (Kshetri 2012). Cloud computing will play a huge role in the IT adoption of the Indian SME sector. Several empirical studies have investigated the factors that affect cloud adoption in the Indian SME sector. Even though, these studies were carried in the same period (2012-2016), the result of these studies highlights different decision factors for cloud adoption. The data collected for these studies are from SMEs in different states in India. This is the main reason for the difference in the research results. (Kumar and Samalia 2016) have investigated the factors affecting cloud adoption by SMEs in Himachal Pradesh, a state in the northern part of the Indian Union. They identified SMEs perception about cost benefits, technological and security risks, perceived relative advantage, top management support as the determinants of cloud adoption for SMEs in Himachal Pradesh. As part of this thesis, we have done a study focusing SMEs in Tamil Nadu to identify the determinants of cloud adoption. We identified cost benefits of using cloud infrastructure, scalability and agility of cloud services as the key enablers of cloud adoption. Broadband availability, high bandwidth cost and vendor lock-in are the main barrier for cloud adoption. Compatibility to existing system, complexity of the migration process, top management support, government policies and competitor pressure are the major organizational factors affecting cloud adoption among SMEs in Tamil Nadu (Wilson, Khazaei and Hirsch 2015).

There are advantages and limitations for all the frameworks and models discussed in this section. From reviewing the literature, it is clear that frameworks are available to support different stages of the cloud migration decision making process. However the frameworks discussed does not cover the whole migration process. Existing frameworks deals with either only technical factors or economic factors. It is clearly evident from previous research studies that cloud migration can be affected by organisational and external factors. Though, there are

some theoretical frameworks available which covers these factors, those frameworks cannot be used by SMEs for real life scenarios.

2.9 Conclusion:

This Chapter presented a detailed literature review relating to cloud computing adoption by SMEs. We have clearly explained the different service delivery and deployment models of cloud computing. The major advantages which acts as the major drivers for cloud adoption was explained under the heading advantages of cloud computing. The issues with cloud computing adoption like security issues, interoperability issues, regulatory and legal issues were also explained. An extensive review of the existing literature relating to cloud computing adoption by SMEs is presented under the section 2.9. We conclude that while there are different frameworks available to support cloud migration, we did not identify a framework which covers the whole migration process including all factors that affect cloud migration.

Chapter 3: Theoretical foundations of the framework

3.1 Introduction:

In the previous chapter, we presented the technical background of cloud computing with specific importance to SMEs in Tamil Nadu. We also analysed the existing literature relevant to cloud adoption for the SME sector and identified the requirements for a cloud adoption decision support system. This chapter can be divided into two parts. The first part of the chapter discusses the concepts of decision making from the viewpoint of computer science and we have explained in detail the theoretical background of our cloud adoption decision support system. We have discussed the different Multi Criteria Decision Making (MCDM) methods which forms the basis of the decision support framework developed as part of the study.

The second part of the chapter discusses the theories of technology adoption which forms as the theoretical background for identifying the factors that affect cloud adoption among SMEs in Tamil Nadu. We have discussed Diffusion and Innovation (DOI) and Technology, Organisation and Environment (TOE) framework. Based on the literature discussed in Chapter 2 and the TOE framework we have developed the hypothesis for our research.

3.2 Decision making process:

The decision making process can be defined as the *"study of identifying and choosing alternatives based on the values and preference of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case we want only to identify as many of the alternatives as possible but to choose the one that best fits our goals, objectives, desire values and so one"* (Harrison 1999). The process of decision making

involves a series of steps. According to (Keendy and Raiffa 1993), decision making involves the following steps. They are,

- Identifying the decision problem
- Determining the decision alternatives
- Constructing the preferences
- Evaluating the preferences
- determining the best alternative from the available preferences

According to (Tzeng and Huang 2011), decision making is intuitive, when the decision making involves single criteria. However in real life, decision problems usually have multiple criteria's and therefore evaluating the multiple criteria's can complicate the process of decision making.

3.2.1 Human Decision Making:

Decision making is an important activity in all human activities (Golub 1997). Though decision making is an important activity in all fields, it was only in mid-1950's social scientists started to investigate how people make decisions. Since then, many researchers from different fields have tried to establish methods to aid human decision making. Decision making is used in a host of different scientific disciplines like mathematics, statistics, psychology, social sciences, economics and behavioural sciences (Power 2002). Even though the research around human decision making has been around for more than four decades, it has been only in the last two decades the theories on decision making have been grouped together and referred to as Decision science (Ravindran 2008). Decision science refers to the broad interdisciplinary field interested in all aspects of human decision making (Bohanec 2009). The first use of computer systems for decision making was towards the end of World War II when computers became available for non-military tasks. In computer based systems which support human decision making, the primary aim is to aid people to make decisions

effectively (Ravindran 2008). In computer science related fields like artificial intelligence, there are systems which can make autonomous decisions without the help of humans. Such decisions are focused on machine decision making. According to Bohanec (2009), the disciplines addressing human decision making and machine decision making can be classified into categories shown is figure 3.1.

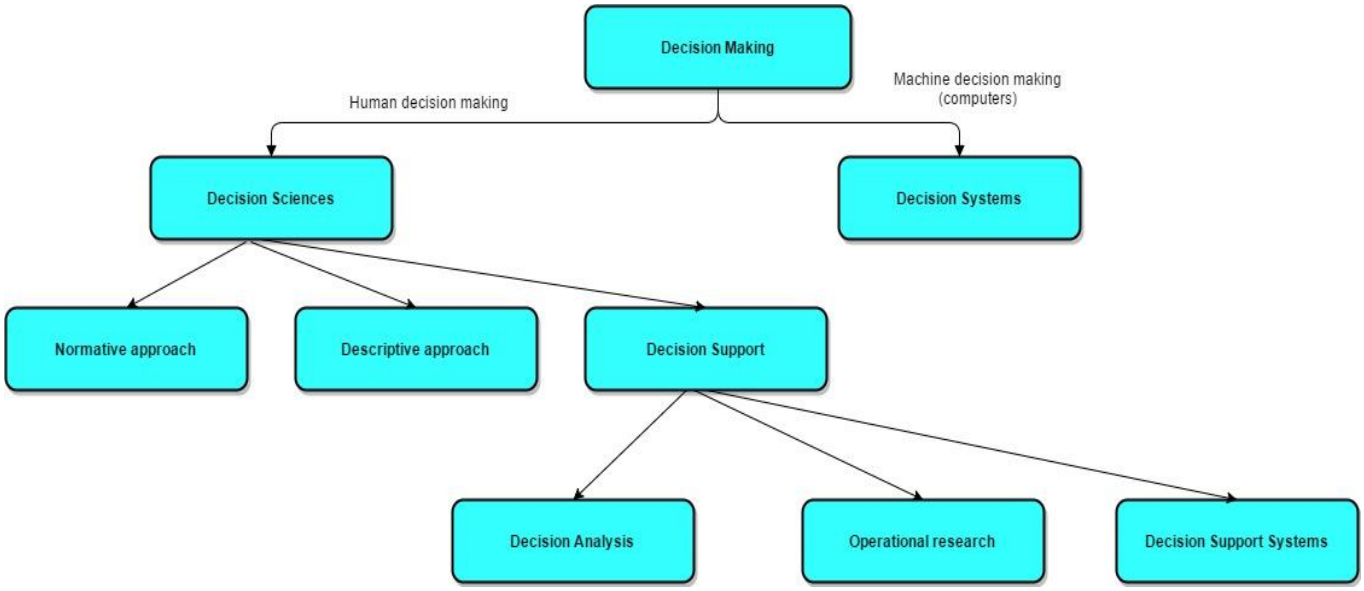

Figure 3.1: Classification of decision making Bohanec (2009).

As this research is focused on supporting cloud adoption decision support for SME decision makers, we limit the discussion to theories that support human decision making.

3.2.2 Normative decision making:

This type of decision making was first developed in economics and was later applied to management through operational research. Normative decision making is often referred to as prescriptive (Golub 1997, Bohanec 2009). Normative or prescriptive approach is based on rational decision making where the decision maker behaves rationally towards the goal by calculating the consequences of each relevant alternative (Harrison 1999). The decision maker then ranks the alternative based on the consequence and finally computes the optimal

decision. The methods based on normative approach are theoretical (Bohanec 2009). Some of the examples are inclusive decision theory, multi-attribute utility theory and game theory.

3.2.3 Descriptive decision making:

This type of decision making is opposite to the formal ways to approach a decision problem. In this approach, the decision maker tends to use the rule of thumb ignoring the formal established steps to approach the problem (Bohance 2009). This approach is mainly used in cognitive sciences. Examples of the methods using this approach are Lexicographic and Maximin (Bohanec 2009).

3.2.4 Decision Support:

Decision support is the focus of computer science researchers and information technologists. The main aim of decision support is to combine use of rational decision making and actual behaviour to improve human decision making. There are three different fields that focus on providing human decision support. They are decision analysis, operational research and decision support systems (Bohanec 2009, Power 2002, Skinner 1999). The backgrounds of each of these disciplines are explained in the next sub-sections.

3.2.5 Decision Analysis:

Decision analysis (DA) is also referred to as applied decision theory (Skinner 1999). It is an interdisciplinary field which examines how to improve decision making. In DA, decision maker approaches the problem systematically by breaking it down into smaller and manageable sub problems. By decomposing the decision problem, decision maker considers all possible alternatives, available information and all available preferences. Decision analysis methods are used at all levels of management for decision making. Decision analysis follows rational approach to decision making. According to Golub (1997), the ten steps of the rational decision making is shown in the figure 3.2.

Figure 3.2: 10 steps of rational decision making (Golub 2009)

DA is the formalisation of the decision making process (Rao 2012). The stages in the decision analysis process can be categorised into the following five steps (Athanasiou and Darzi 2011). They are,

- Identifying and bounding the problem.
- Structuring the problem, using a decision analytical method.
- Acquiring necessary information and populating the model.
- Analysing the problem.

- Investigating the uncertainty associated with the result of the analysis.

Usually the model in step 3 is developed using one of the decision modelling methods or tools. Some of the examples of decision modelling techniques are decision trees, influence diagrams and multi-attribute decision making models.

3.2.6 Operational Research:

The aim of Operational research (OR) is similar to DA which is to provide decision support using analytical methods and mathematical models. The major difference between DA and OR is that in OR the emphasis is on mathematical modelling. The most prominent OR technique is linear programing. Other OR techniques include integer programming, network programming and non-linear programming. For some complex decision problems, finding an optimal solution may not be possible. In such instances, search for an optimal solution is abandoned and a good or acceptable solution is obtained. This is done using heuristics or metaheuristics. (Ravindran 2008).

3.2.7 Decision support systems:

The two above mentioned approaches are interdisciplinary and used by researchers and practitioners from different fields. Similarly decision support systems (DSS) are used in various fields like medicine, artificial intelligence, software engineering and telecommunications. A DSS is an interactive computer based system which will help decision makers in solving structured, unstructured and semi-structured problems (Classification of decision problems explained in Appendix A). DSS uses data, documents, knowledge models and internet to solve problems and help users in making decisions (Burnstein and Clyde 2008) (Wilson et al. 2014). In general, DSS can be defined as a computer system which aids decisions makers in making decisions by providing suggestions, graphical and statistical analysis for any particular problem (Power 2002). Decision makers can be an individual, a team or individuals from different organisations. The goal of the DSS is to improve a

decision by better understanding and preparation of the tasks leading towards evaluation and making the decision (Bohanec 2009) (Wilson et al. 2014). Therefore, the objective of the DSS is only to support the decision make a decision effectively.

When compared with DA and OR, DSS focus on providing decision support with the help of Information Technology (IT) tools. DSS can be used at different levels of the organisation. DSS incorporates the DA modelling techniques (decision trees, Multi Attribute Decision Making and Multi Criteria Decision Making) and OR models (linear programming, integer programming and network programming) to provide decision support. When implemented as a computer program, DSS can store data and information providing means to search relevant data items for the decision maker. By utilising various IT capabilities like tables, databases, on-line analytical processing, DSS can support decision makers make decision effectively. Based on the various applications of DSS, DSS can be classified in five types; (Darsow 2014, Bohanec 2009, Burnstein and clyde 2008, Fulop 2005).

Data driven DSS: This type of DSS uses external and internal company data and provide decision support by allowing decision maker to manipulate the data. Data warehouses are good examples of data driven DSS.

Document driven DSS: This type of DSS provides DSS by utilising documents available in different electronic formats (image, video and webpages).

Model driven DSS: Model driven DSS emphasises access to and allows decision makers to manipulate models (statistical, financial, evaluation and simulation).

Communication driven DSS: This type of DSS supports more than one person working on a shared task by using network and communication technologies. Example of such type of DSS includes video conferencing systems.

Knowledge driven DSS: This type of DSS provide decision support by utlilising problem solving expertise stored as facts, rules and procedures to support a management decision.

3.3 Decision making models:

The above section discussed the theoretical background of human decision making based on the decision science literature. In the context of organisational decision making, it is essential to identify the problems which require decision support. Some decision problem may be trivial and not require a systematic approach for decision making. In organisation, it does not make sense to establish systematic decision making approach for such problems. There are different types of decision problems and we have presented a detailed explanation in Appendix A. In management science, decision making is one of the active research areas and there are different models available to make real life organisational decisions in a structured way by following the principles of rational decision making process as discussed in section 3.2.5. The rational model of decision making (Simon 1997) and scientific decision making model are two models available which decision makers can utilise to make organisational decisions in structured and systematic manner.

The rational model of decision making by Herbert Simon structures the decision making in organisational situations into three phases. They are Intelligence, Design and Choice (Simon 1997). The decision making process starts with the intelligence phase where the reality of the organisation is examined. The intelligence phase involves gathering relevant information and setting objectives to make the organisational decision. The design phase involves creating a model to analyse and evaluate the alternatives available for the particular decision problem. In the choice phase, the best alternative is selected from the available alternatives. DA and OR methods are used to support decision making at all the three stages. As cloud computing is constantly evolving, the rational model of decision making is not

suitable as it do not have steps to implement and manage change. Due to limitations of this method, we have used scientific decision making method to develop the proposed framework in this study.

3.3.1 Scientific decision making:

The scientific decision making (SDM) according to Pease and Bull (2016) follows the similar steps used in scientific method adopted by researchers in all fields. As research is cyclic (Rudestam and Newton 2015), all steps of the scientific method are subject to change apart from the goal of the project. The SDM by Pease and Bull (2016) follows the same principle and the five elements of the SDM are Goal, Model, Data, Evaluation and Revision. The first use of the scientific method for decision making was mentioned by P.L Jacob in his 1990 book "Vison of a flying machine" in which he has presented an investigation of the steps that lead to the invention of the Wright brothers.

Elements	Description
GOAL	The objective of doing research
MODEL	Any and all abstractions of what is being studied
DATA	Observations made to represent the nature for testing the model
EVALUATION	Comparing the model to the data, to decide if the model is acceptable
REVISION	Changing the model if it is not suitable

Table 3.1 Elements of SDM (Pease and Bull 2016 p14)

The five elements of the scientific method and their description are shown in the table 3.1. According to (Pearce and Bull 2016 p22),

"Science is a process, and our ideas keep changing. These changes may be merely refinements of earlier ideas, or they may be complete overhauls in our understanding. Probably the most important single feature to remember about the scientific method is that it is a means by which we can achieve progress".

SDM method is most suitable if the research is trying to improve an existing process. In SDM, except for the goal of the system all the other elements are subject to change similar to scientific method. SDM starts with one or more models of how the investigated project works. The model is compared with data collected from the target and evaluated to identify if the model can be accepted. The model can be accepted or rejected based on the constraint set by the researcher and the process can be repeated over and over after further revisions and enhancements to the model. The process of SDM is shown in the figure 3.3.

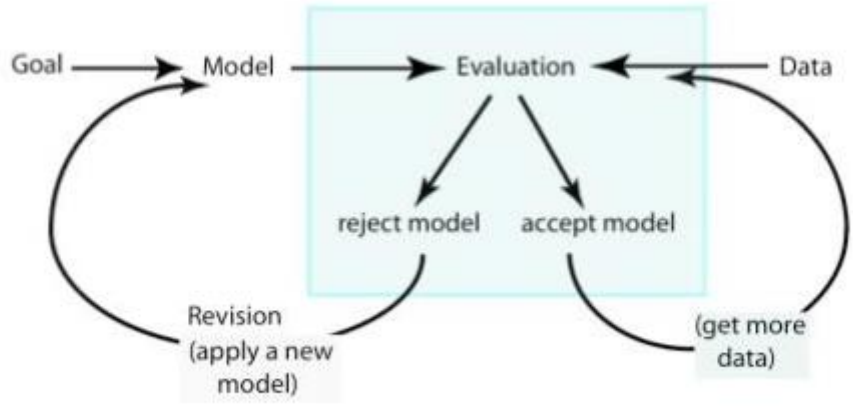

Figure 3.3 Process of SDM (Pierce and Bull 2016)

We have employed SDM for the development of the framework due to the suitability of SDM with the cloud adoption decision making process. The development of the framework, steps involved and the tools of the framework are explained in detail in Chapter 6.

3.4 Multi-criteria decision making methods:

In this section, the different decision analysis methods are discussed. Multi-criteria decision making (MCDM) is one of the most widely used decision analysis method. This section presents the different MCDM methods, procedures and their applications.

MCDM is one of the well-known branches of decision making. Since 1960's, many MCDM have been developed to support decision making when there is more than one criterion or attribute. According to Zimmerman (1996), MCDM can be divided into Multi objective decision making (MODM) and Multi attribute decision making (MADM). MODM studies decision problems in a continuous decision domain and MADM methods are suitable for decision problems with discrete decision spaces. For all MCDM and MADM problems the set of alternatives and criteria are predetermined by the decision maker (Triantaphyllou 2000). In decision science literature, MCDM and MADM are interchangeably used. For simplicity, we refer to the methods described in this section as MCDM methods. Even though, the methods differ in their definition, assumptions and the mathematical procedure used to evaluate the preferences most of the MCDM methods have the procedures and use the same terminology. According to (Pohekar and Ramachandran 2004), the overall procedure of MCDM can be explained using the following flow diagram 3.4.

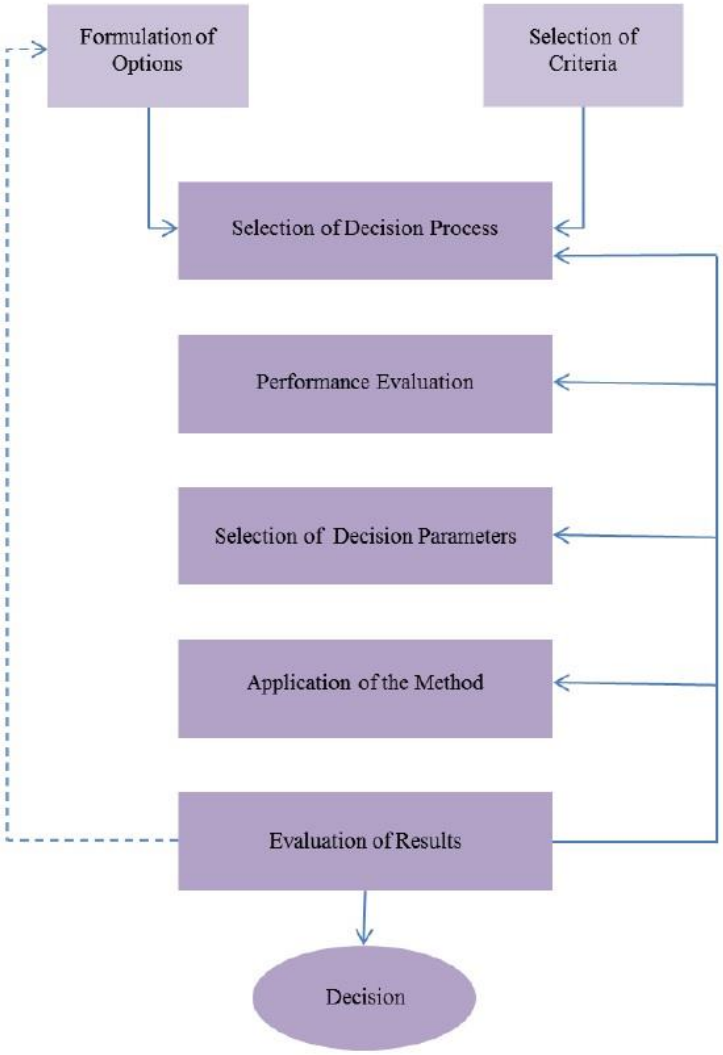

Figure 3.4: Overall procedure of MCDM (Pohekar and Ramachandran 2004)

The common terminologies used in the different MCDM methods are defined below. (Triantaphyllou 2000, Pohekar and Ramachandran 2004, Zimmermann 1996).

Alternatives: Alternatives represents the different options available to the decision maker. As mentioned earlier, alternatives in MCDM are finite and predetermined.

Multiple criteria or attributes: Criteria or attributes are different qualities based on which the alternatives are evaluated. In MCDM criteria is also referred to as goals or objectives.

Conflict among criteria: Since different criteria represent different quality of the alternative, two criteria can conflict with each other. Such instances are referred as conflict among criteria.

Incommensurable units: Each criterion may be quantified using different units of measure. For the process of evaluating the criteria, the ones with different units of measure may not be compared with each other. This is referred to as incommensurable units. For example: when we compare the criteria cost and mileage for buying a car. Both are measured in different units. Cost is measured in GBP and mileage is measured in miles. This makes the MCDM problems hard to solve.

Alternatives performance measure: It is the performance measure which indicates the degree that an alternative achieves its goal.

Criteria weight or Decision weights: Criteria weight refers to the relative importance of each criterion when compared to others. In all MCDM methods, criteria weights are assigned based on the importance of the criteria. This is then normalised to add up to one during the evaluation stage.

Decision Matrix: A MCDM decision problem is usually expressed in a matrix format which is referred to as the decision matrix. Decision matrix A is an m x n matrix where the elements m represents the number of alternatives and n represents the number of criteria.

3.5 Classification of MCDM methods:

Depending on the type of data used, MCMD methods can be classified in deterministic, stochastic and fuzzy MCDM methods. As this research study involves using MCDM to support cloud adoption decision support in a DSS, we consider the classification based on the number of decision makers. As DSS are most likely used by decision makers at

top level management, in this section we explain the different single decision maker deterministic methods. According to (Tzeng and Huang 1991) single decision maker MCDM problems can be classified based on the information available to the decision maker.

3.5.1 Dominance:

It is one of the oldest decision making methods introduced by Fishburne in 1969. According to this method, a pairwise comparison of all the alternatives is performed to identify the best available alternative. Figure 3.5 shows the flow of steps in the dominance method.

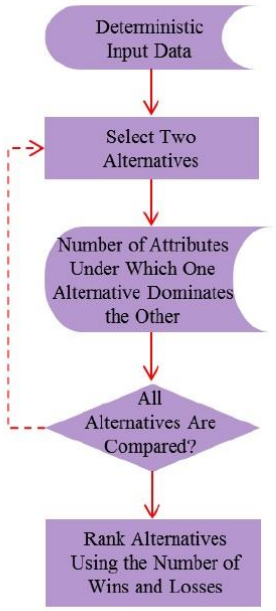

Figure 3.5: Flow of steps in the dominance method (Mokhtari 2012)

In Dominance, two alternatives are compared against each other. The dominant alternative will then be compared with other alternatives to identify the most suitable alternative for the decision problem. The major disadvantage of dominance is that for all semi structured problems due to incommensurable units the dominant alternative cannot be identified.

Therefore, for practical data using this method it may not be possible to identify a unique alternative as the winner (Mokhtari 2012).

3.5.2 Maximin:

Maximin is a risk aversive decision making approach where the decision maker tries to avoid the worst possible outcome. In this approach, the alternatives are ranked based on their weakest attributes to ensure that the worst outcome is avoided. Figure 3.6 shows the flow of steps in the Maximin method.

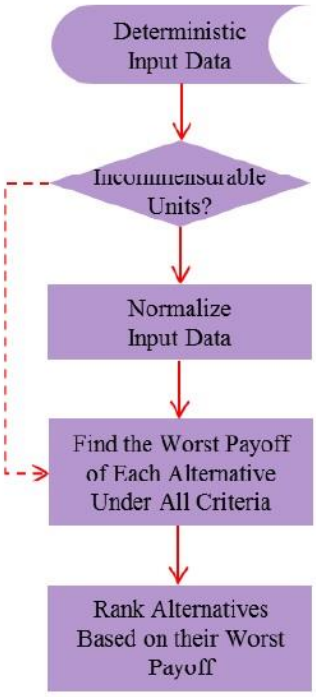

Figure 3.6: Flow of steps in the Maximin method (Mokhtari 2012)

This method is also one of the oldest methods of decision making introduced even before MCDM was researched. Similar to the Dominance method, most of the real life problems do not fit in Maximin as incommensurable units needs to be converted to commensurable unit to be compared against each other. A variation of Maximin can be used by normalising the incommensurable units. Once normalised, the minimum performance of each alternatives under all criteria can be identified. (Mokhtari 2012).

3.5.3 Conjunctive and Disjunctive methods:

In conjunctive and disjunctive methods, satisfactory alternatives are identified as the optimal solution. The decision maker defines the minimum threshold for each of the criteria. In conjunctive method, all the sub-criteria should exceed the performance threshold and in the disjunctive methods at least one of the criteria should exceed the performance threshold. All the other criteria which don't satisfy the requirement are dropped from evaluation. As decision maker needs to define the minimum threshold, decision maker needs to know standard level of information about the decision problem (Thor, Ding and Shahrul 2013).

3.5.4 Lexicographic method:

In the lexicographic method, the decision maker ranks and orders the alternatives based on their importance. Then the alternative with the best score on the most important criteria is chosen as the optimal alternative. In the case of a tie, ranking score of the alternative under the next most important criteria will be chosen as the most suitable alternative. As the decision maker needs to order and rank the alternatives, ordinal information is needed by the decision maker.

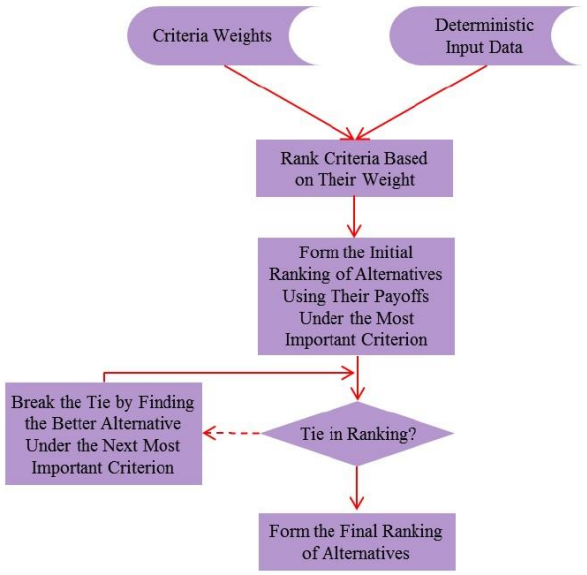

Figure 3.7: Flow of steps in the lexicographic method (Mokhtari 2012)

3.5.5 Simple additive weighting:

Simple additive weighting (SAW) method was first introduced by Churchman and Ackoff in 1945. SAW is one of the simplest types of MCDM and is also known as the scoring method. In the SAW method, weighted sum of the performance score of each alternative under all criteria is obtained. The overall procedure of SAW method is shown in the figure 3.8.

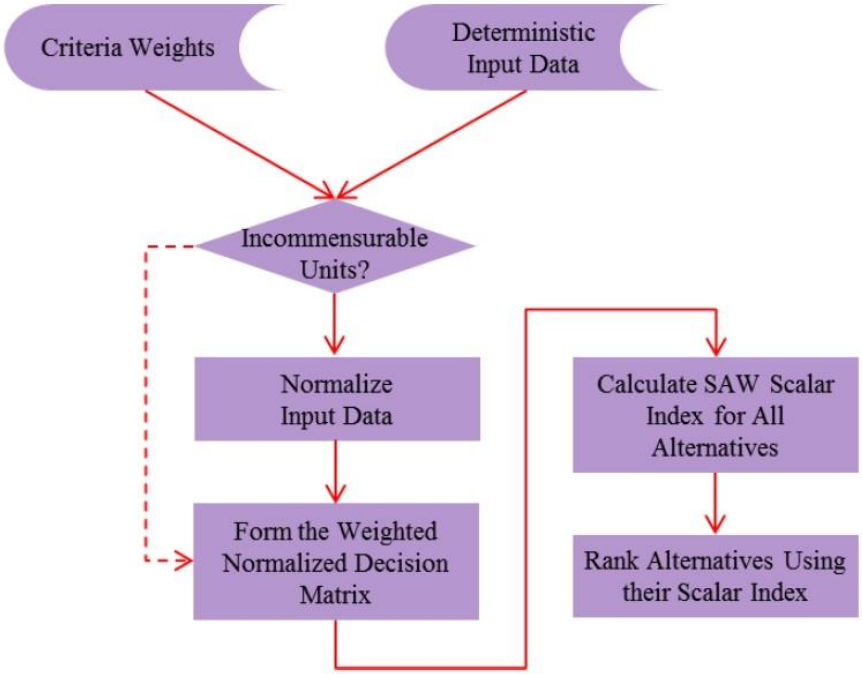

Figure 3.8: Flow of steps in the SAW method (Mokhtari 2012)

This method forms as the basis for other MCDM methods like TOPSIS, AHP and ELECTRE which uses additive aggregation for evaluation of the best alternative. In single dimensional cases where the units of all the criteria are the same, the SAW method can be used without any difficulty. There is a variation to this model available which is known as weighted product model (WPM). The main difference between SAW and WPM method is that instead of addition, there is multiplication in the WPM model.

3.5.6 TOPSIS:

The technique for order preference by similarity to an ideal solution (TOPSIS) method was first developed by Yoon and Hwang (1980). The main concept of the TOPSIS method is that the alternatives are assumed as points in a geometric space and criteria are considered as different dimensions. In the TOPSIS method, we select the alternative with the shortest distance from the ideal performance as the best alternative. The selected best alternative must also be farthest from the negative ideal performance in the assumed geometric space (Darsow 2014). The flow of steps involved in the evaluation of the TOPSIS method is shown in the figure 3.9.

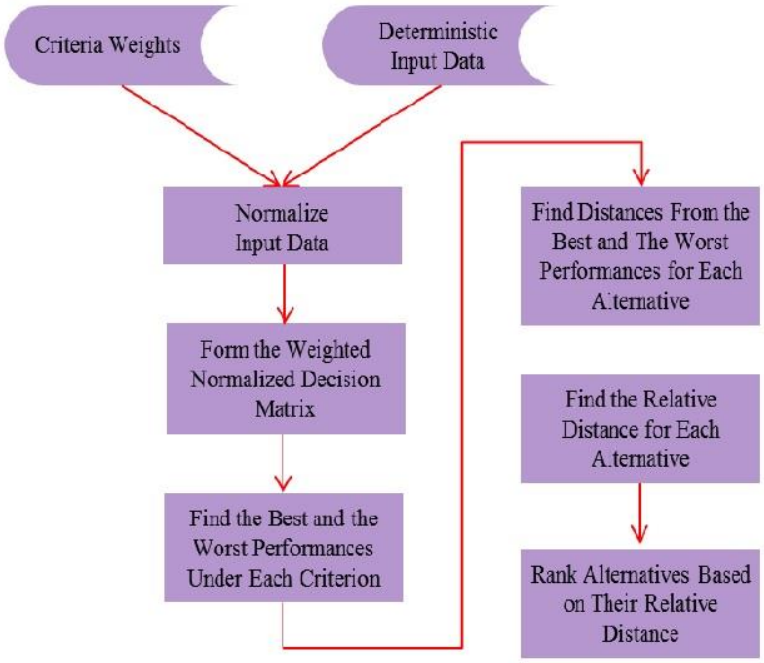

Figure 3.9: Flow of steps in the TOPSIS method (Mokhtari 2012)

3.5.7 ELECTRE:

The ELECTRE (for elimination and choice translating reality; translated from French) was introduced by Benayoun et al. (1966). The basic concept of the ELECTRE method is to deal with the outranking relations by using the pairwise comparisons among alternatives

under each one of the criteria separately. There are two approaches available in this method (ELECTRE I and ELECTRE II). Using performance values of alternatives, decision criteria can be divided into two groups, namely concordance sets and discordance sets. Concordance sets refers to all criteria under which one alternative outranks one another and discordance set refers to reverse of concordance sets. The next step is to determine the power of each through which concordance and discordance index can be obtained. The overall ranking of all the alternatives can be identified by evaluating the dominance relation between the indices (Darsow 2014).

ELECTRE method is used in many water management studies, finance and transportation research studies. Compared to other MCDM methods, the evaluation of the ELECTRE can be challenging. ELECTRE method forms the basis for other MCDM methods which adopts outranking relations.

3.5.8 Analytical Hierarchy Process (AHP):

Analytical Hierarchy Process (AHP) is one of the MCDM methods used to support decision making in various fields (Skoric, Pein and Orehovacki 2016) (Wilson, Khazaei and Hirsch 2016). AHP organises the basic rationality by decomposing the problem into smaller constituent parts. By breaking the decision problem, AHP enables the decision maker to focus on limited number of criteria at a time (Wilson, Khazaei and Hirsch 2016). AHP is a hierarchical model introduced by Professor Thomas L. Saaty in 1980. The decision analysis process of AHP consists of three steps: defining the decision problem, constructing the hierarchy and finally evaluating the components in the hierarchy to identify the best alternative (Wilson, Khazaei and Hirsch 2015). The AHP hierarchy according to (Saaty 2008) is shown in the figure 3.10.

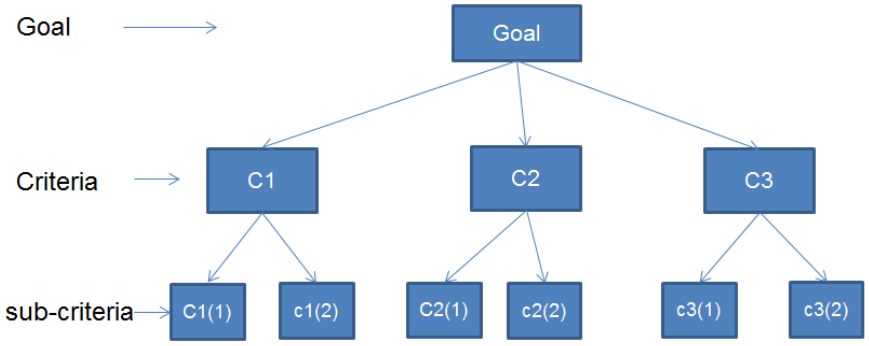

Figure 3.10: AHP hierarchy (Saaty 1980)

The evaluation process of AHP involves pairwise comparison of each criteria against each other. The decision maker rates each criteria based on its importance using the scale of relative importance defined by (Saaty 2008) shown in table 3.2 (Wilson, Khazaei and Hirsch 2016).

Scale of importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	weak importance of one over another	Experience and judgement favor one activity over the other
5	Essential or strong importance	Experience and judgement favor one activity over the other
7	Demonstrated importance	An activity is strongly favoring one activity over another of the highest possible order of affirmation
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the adjacent judgements	When compromise is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

Table 3.2: Scale of relative importance used in AHP (Saaty 2008)

The result of the pairwise comparison is then constructed into an n x n matrix. In pairwise comparison matrix, a relative importance score of 9 indicates that the criteria is extremely important compared to the other criteria. Similarly, the reciprocal of 9 (1/9) will indicate that the criteria is extremely less important than the other (Wilson, Khazaei and Hirsch 2016). Once the pairwise comparison matrix is constructed, the next step is to identify the priority vector (Skoric, Pein and Orehovacki 2016). Eigenvalue method is the most widely used method to identify the priority vector.

Consider a pairwise comparison matrix A. According to the Eigenvalue method, the priority vector w is calculated as the eigenvector of A and λ_{max} the maximum eigenvalue of A. λ_{max} is calculated by solving the system $Aw = \lambda_{max}w$, $\sum w_i = 1$ (Wilson, Khazaei and Hirsch 2016). 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 the formula (Saaty 2008).

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

where n represents the number of elements compared. Once CI(A) is calculated, Consistency ratio (CR) can be calculated by using the formula,

$$CR = CI/RI$$

where RI is the random index which can be obtained from the following table 3.3.Random Consistency Index (RI) for different values of n (Saaty 2008).

Matrix size (n)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Table 3.3: Random consistency index (RI) used in AHP (Saaty 2008)

The pairwise comparisons are considered consistent only if CR is less than 0.1. If CR is higher than 0.1, re-evaluation is required and decision makers will have to perform the pairwise comparisons again.

3.5.8.1 Appropriateness of using AHP for cloud adoption decision support:

The methods discussed in the previous section are some of the decision analysis methods that are grouped under MCDM in the decision science literature. According to sun and li (2008), since 1950's more than 70 MCDM methods have been developed. We have only considered most widely used single decision maker decision analysis methods. The methods Dominance, Maximin and Lexicographic cannot be implemented to support cloud adoption decision support as they are suitable mainly for structured decision problems.

The second set of methods explained in the previous section SAW, WSM, TOPSIS, ELECTRE and AHP are methods which can support semi-structured and unstructured decision problems. SAM, WSM and AHP focus on decomposing the decision problem into sub problems. These models focus on a model from which a vector of performance scores of attributes are obtained by completing pairwise comparisons. ELECTRE uses concordance sets and discordance sets using which concordance and discordance vertices are obtained. This is then used to provide a preference ranking of the alternatives. TOPSIS can be grouped

under compromising MCMD methods as the method assumes that no ideal solution exists and aims to identify the optimal solution for a decision problem.

Of all these methods, AHP provides consistency in judgement as the CI is calculated before creating pairwise comparison matrices. Consistency of comparison is an importance factor and other methods do not provide consistency. TOPSIS and SAW methods are very simple to adopt. However, due to simple mathematical calculations the process provides numerous alternatives. ELECTRE method is based on fuzzy logic and using this method only partial raking can be obtained. The comparison between the different MCDM methods are shown in the figure 3.11.

	AHP	ELECTREE	SAW	TOPSIS
Consistency	Yes	Yes	No	No
Core process	Hierarchy principle	Pairwise comparison principle	Weighted average principle	Distance principle
Problem structure	Few criteria and alternatives	Many criteria	Many criteria and alternatives	Many criteria and alternatives
Concept	Scoring model	Concordance model	Scoring model	Compromising model
Final results	Global, net ordering	Partial pre-order	Global, net ordering	Global, net ordering

Figure 3.11: Comparison of the different MCDM methods (Thor, Ding and Kamruddin 2013)

Therefore for a decision problem with well-defined alternatives and criteria, the AHP method can be adopted to provide decision support. Since introduced by Thomas L.Saaty in 1980, AHP has been used by decision makers and researchers to aid decision making in many different activities. Some of the common activities where AHP is implemented are planning, selecting best alternative (product, service, vendor etc.) evaluation of a product and cost benefit analysis. The above method activities take place in almost all fields. Many well cites works have been published when AHP is used as a decision support tool. Some of the practical examples are in the fields of construction, production, manufacturing, defence, computer science and management.

Researchers in the field of computer science and information technology have used AHP to support decision making mostly for selecting the best alternative. The main reason behind AHP being used as the decision analysis method is its simplicity and ability to integrate with operational research methods like linear programming and network programing. AHP can also be used with fuzzy logic. The usage of AHP has been attempted to support decision making for migrating data and application to cloud environment. (Alhammadi 2016) has implemented AHP in his decision framework. (Abubaker 2016) has implemented AHP to identify the determinants of cloud adoption for SMEs in the sub Saharan Africa. As part of this thesis, we have completed a case study with two SME decision makers to test the usefulness of AHP for cloud adoption support in Tamil Nadu which is explained in detail in next chapter.

3.5.8.2 Limitations of Analytical Hierarchy Process:

Though AHP is popularly used for decision making, many experts (Thor, Ding and Kamruddin 2013) (Triantaphyllou 2000) have highlighted the weakness of the AHP methodology. They are listed below,

- Rank reversal is the major issue identified by few of the authors. According to (Triantaphyllou 2000) when an irrelevant alternative is introduced, changes in the final ranking have been observed.
- As AHP decomposes the decision problem into a number of sub systems. These sub systems are constructed into a hierarchy and number of pairwise comparisons is performed. For a complex problem with more alternatives and criteria, the number of pairwise comparisons needs to be done is usually large ((n (n-1)/2) comparisons) (Skoric, Pein and Orehovacki 2016). This makes the whole process lengthy and complex.

- Another important weakness of AHP is its limited scale of relative importance (1-9). For example if alternative A is 25 times important than alternative B, it cannot be expressed in AHP as the scale of relative importance used in AHP is only between 1 and 9.

These are the perceived weaknesses of the AHP methodology. If these limitations are addressed, AHP can be effectively used as a decision support methodology. To implement AHP for cloud adoption decision support, the alternatives and criteria (factors) that affect cloud adoption need to be identified. To address uncertainty in decision making, decision makers must also be made aware of the risks involved in cloud migration. To reduce the number of comparison and to facilitate decision maker cognition for making correct judgement, the number of alternatives and criteria can be limited to a maximum of 7 (Saripplli and Pingali 2011). To understand the determinants of cloud adoption among SMEs in Tamil Nadu, we have utilised the technology adoption theories. The next part of this chapter discusses the theoretical background of the technology adoption theories.

3.6 Diffusion and adoption of Technology innovation:

The decision of whether a new technology can be adopted, the time it takes for a new technology innovation to be available for mainstream adoption is a source of research across many different fields (Alhammadi 2016). In computer science and information systems research, this is one of the main research area and many researchers have developed theories to study the diffusion and adoption of technology (Sharma and Mishra 2015). Diffusion and adoption of a new technology is multi-disciplinary and it influences businesses, researchers and all everyday activities related to that innovation. Innovation as defined in previous chapter is an idea, practice or object that is perceived as new by individual or other units of adoption. A new technology innovation does not mean it will be definitely be beneficial to an

individual or an organisation. It simply refers that the idea of the practice (or piece of technology) is objectively new. Businesses make huge investments to study the adoption and diffusion of a new technology innovation to understand the perception and potential of the innovation amongst its target users. In general, Technology adoption can be defined as "the stage of selecting a technology for use by an individual or an organisation". From an organisations point of view, technology adoption can be defined (Carr 1999) as *"the stage at which a technology is selected for use by an individual or an organisation"*. The term diffusion of technology (Carr 1999) refers to *"the stage at which the technology spreads to general use and application"*. Though technology adoption and diffusion of technology appear together, they both have different definitions. While technology adoption can be considered as the decision made by an individual at organisational level, diffusion can be considered as the adoption of technology by the entire target population.

The process of technology innovation in an organisation takes place in stages. Different researchers refer to these stages differently. According to (Alshamaileh 2013), all the different activities that take places during technology innovation can be grouped in two stages; Initiation and Implementation. The initiation stage covers all the activities that lead the decision to adopt the technology including gathering information, checking suitability and risk analysis. The implementation stage covers all activities that are involved in putting the innovation in place (Alshamaileh 2013). For a technology innovation like cloud computing, it is very essential to study the adoption and diffusion as its adoption is not dependant of the technical aspects alone. Cloud computing is a technology that can be affected by both social and environmental factors (Alshamaileh 2013, Alhammadi 2016, Senarathna 2016). For example, cost and availability of certain cloud service vary between developed and a developing country as it is subjected to the availability of relevant technologies. As this research study is focused on developing a framework to support cloud adoption decision

making process by SMEs in Tamil Nadu, it will only serve the purpose if the factors that affect the adoption and diffusion of cloud adoption are included in the framework. There are different theories available to study the adoption and diffusion of technology focusing on computer science research. Through applying established theories of technology adoption, we can also create empirical evidence of the determinants of cloud adoption for SMEs in Tamil Nadu. The different theories of technology adoption and the hypothesis derived as part of the main study in explained in the remainder of this chapter.

3.7 Theories of technology adoption:

There are many theories of technology adoption used in IS research. Ontologically, these theories can be classified based on their focus of analysis. Some theories focus their analysis on the user (individual level) and some focus on the business (Organisation level) or market (market where innovation is studied) (Oliveira and Martins 2011). In this section, we review all the theories with importance to theories at organisation level as our research is focused on studying cloud computing adoption at organisation level.

3.7.1 Technology acceptance model (TAM):

TAM is one of the widely used Technology adoption theories introduced by Davis in 1989. The major advantage of the TAM model is its simplicity and has only two main constructs. According to TAM model (Davis 1989), two main factors affect user's decision when they are presented with a new technology, namely; perceived usefulness and perceived ease of use. Perceived usefulness refers (Davis 1989) to the "*degree to which a person believes that a particular system would enhance his/her job performance*". Perceived ease of use refers (Davis 1989) to the "*degree to which a person believes that using a particular system would be free from effort"*. The TAM model according to Davis is shown in figure 3.12.

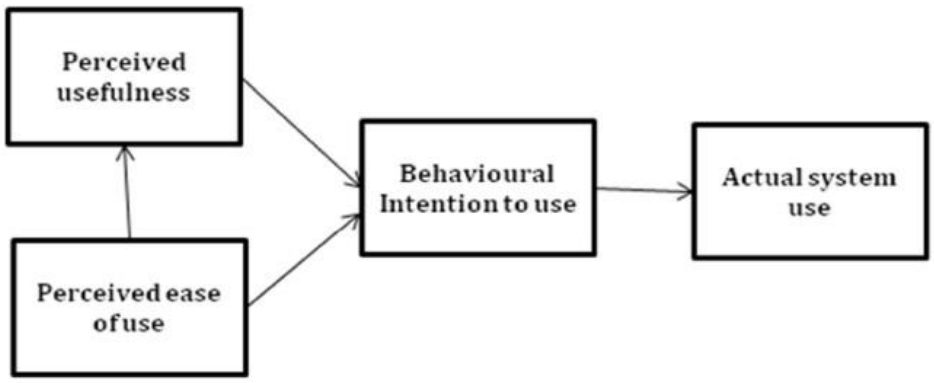

Figure 3.12: Technology Acceptance Model (TAM) (Davis 1989)

The major application of the TAM is to understand the technology acceptance by users. The TAM model was first tested and implemented to study the acceptance of email service and file editor at IBM, Canada. Many researchers have criticised the TAM model for its assumption that only perceived usefulness and perceived ease of use as the major determinants in ever changing IT environment. Many researchers conclude that additional factors should be included in the TAM model to better understand the behavioural intention to accept technology. As TAM model focuses on the user acceptance rather than the business and does not include environmental factors, it can be considered as not suitable for our research study (Sharma and Mishra 2015).

3.7.2 Theory of reasoned action (TRA):

Theory of reasoned action was first introduced by Fishbein and Ajzen in 1975. Similar to TAM, TRA also focuses on technology adoption at the individual level. The concept of TRA is based on the assumption that individuals make rational decisions based on the information available to them. Fishbein and Ajzen (1980) argue that an individual will consider the consequence of their action before deciding a particular solution. TRA model uses three main constructs, namely; Behavioural intention (BI), attitude (A) and subjective

norm (SN). The TRA model according to Fishbein and Ajzen (1980) is shown is in figure 3.13.

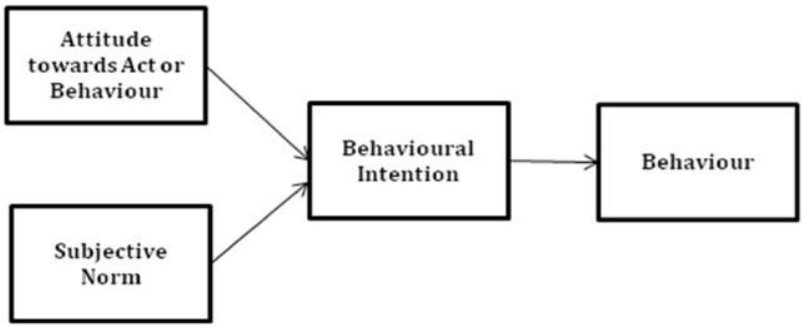

Figure 3.13: Theory of reasoned action (Fishburne and Azjen 1975)

According to TRA, behavioural intention of a user depends on their attitude and subjective norms. Subjective norm refers to the influence of social environment on behaviour. The major limitation of TRA model is the effect of subjective norms on behavioural intention. Many researchers have reported mixed results using TRA model. In order to improve the model, Ajzen (2002) proposed the theory of planned behaviour which contains perceived behavioural control as an additional construct.

3.7.3 Theory of planned behaviour (TPB):

Icek Ajzen proposed the theory of planned behaviour (TPB) in 1991 to address the limitation of TRA. The major criticism faced by TRA is that it deals solely with behaviour under volitional control. Ajzen introduced the concept of perceived behavioural control (PBC) to the constructs subjective norms (SN) and attitude (A). PBC refers to "the individual's perception of the difficulty or ease of performing behaviour". The TPB according to Ajzen is shown in figure 3.14.

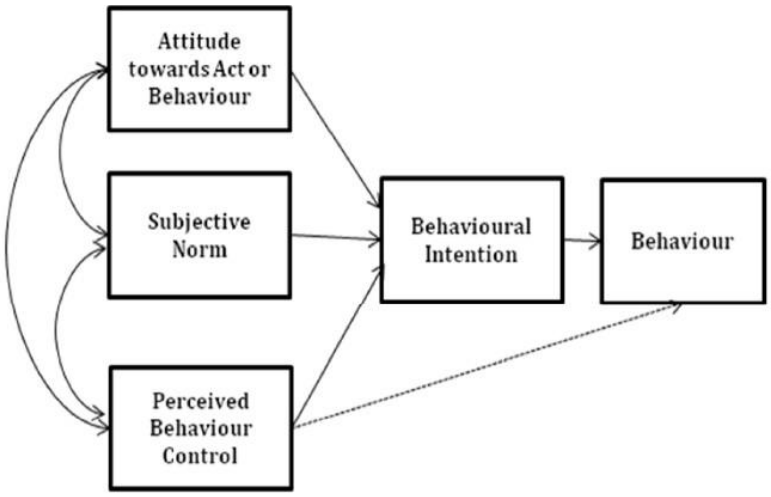

Figure 3.14: Theory of planned behaviour (Azjen 1991)

The major limitation of both TRA and TPA is that these these theories do not consider personality related factors, social and cultural factors that shape an individual's behaviour. These two theories are most suitable for investigating the acceptance of a particular technology by an individual (Sharma and Mishra 2015).

3.7.4 Unified theory of acceptance and Use of Technology:

Unified theory of acceptance and Use of technology referred to as UTAUT was formulated by Venkatesh (2003). The main aim of this model is to produce a unified model to study user's technology acceptance. Venkatesh (2003) proposed this model by considering the constructs of TAM, TRA and TPA to serve as a comprehensive model to study to technology acceptance by users. The four main constructs of the UTAUT model are performance expectancy, effort expectancy, social influence and facilitating conditions.

Venkatesh et. al (2003) claimed that the UTAUT model is superior to other theories and it is able to explain 70% of the variance in users intention to adopt a technology. The major limitation of the UTAUT model is its very complex when compared to other theories and therefore used mainly for theory building rather than actual studies (Sharma and Mishra 2015).

3.7.5 Institutional theory:

Institutional theory was first introduced by Richard W Scott in 2001. Institutional theory aims to inquire how elements are created, diffused, adopted and adapted over space and time; and how they fall into decline and diffuse. Elements refer to the processes by which structures, schemas, a rule, norms and routes becomes established as an accepted standard for social behaviour (Scott 2001). According to Scott (2001), "*Institutions consist of cognitive, normative, and regulative structures and activities that provide stability and meaning to social behaviour Institutions are transported by various carriers—cultures, structures, and routines—and they operate at multiple levels of jurisdiction".* Cognitive, normative and regulative structure can be considered as three pillars of the institutional theory. Many studies in social sciences have used the institutional theory to investigate the structure and behaviour of organisations.

3.7.6 Resource based View (RBV) theory:

The Resource Based View (RBV) analyses internal resources of an organisation to formulate a strategy to achieve retainable competitive advantage. In RBV, the emphasis is on the internal resources and the capabilities of the internal resources to achieve competitive advantage. RBV follows an "inside out" view to analyse why an organisation fail in the market place (Madhani 2010). According to RBV, organisation can be considered as a collection of resources (physical, human and organisational) which enables the individual organisation to achieve competitive advantage. If the competitive advantage is sustained over a period of time, it leads to superior long term performance. According to RBV, the resources should fulfil the VRIN criteria. The VRIN criterion is explained below (Jurevicius 2013).

Valuable (V): Resources of the organisation can be considered valuable if it adds specific value to the organisation like profit or asset. There is no competitive advantage in possessing a resource which does not add any value to the organisation.

Rare (R): To provide competitive advantage, resources must be difficult to find among the competitors. A unique business strategy cannot be created if the resources are not rare.

Imperfect Imitability (I): In addition to being rare, the resource should be hard to copy or imitated by a rival organisation.

Non-substitutable: Resources should be substitutable by another resource by competitors. If resources satisfy the previous three criterions, even if it is replaced by a substitute it may not achieve same performance.

Though the RBV considers the tangible and intangible resources to achieve competitive advantage, the concept of RBV has been criticised by many authors. According to (Madhani 2010), it may be hard to locate a resource which satisfies the VRIN and some have criticised the vagueness of the VRIN. The other limitation of RBV is that it follows an "inside out" approach and it does not consider outside factors that affect competitive advantage. This is one of the major limitations of the RBV theory. As the RBV theory does not include external factors it is not suitable for our investigation.

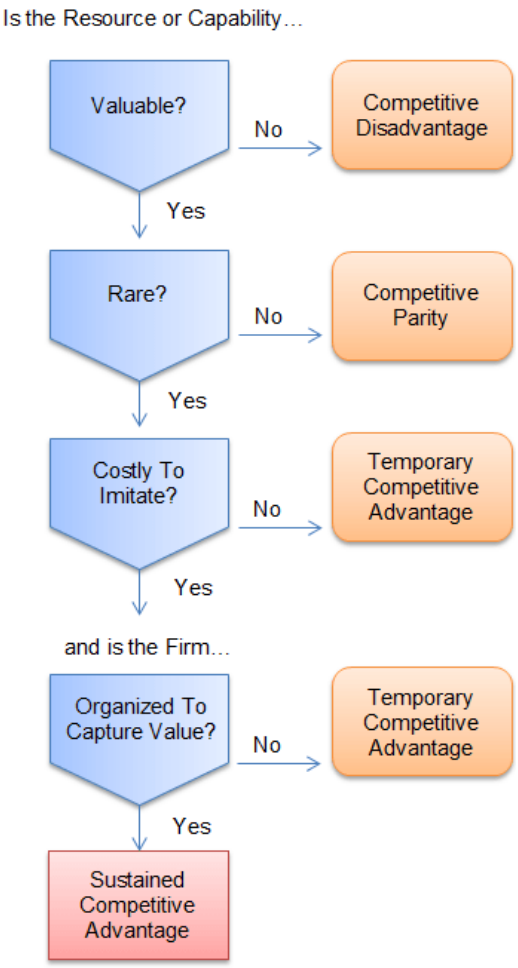

Figure 3.15: VRIN criteria (Jurevicius 2013)

3.7.7 Diffusion of Innovation:

The theories discussed so far either analyses adoption and diffusion of innovation at individual level or at the organisation level. Diffusion of innovation is a market level theory which can be used to investigate the determining factors that affect or influence the decision to adopt a new technology. DOI was first introduced by Everett Rogers in 1995. DOI is a theory which aims at identifying how, why and at what rate a particular innovation spread through the market, at individual and at organisation level (Oliveira and Martins 2011). According to DOI theory, organisations are considered to possess different levels of willingness to adopt technology and the level of adoption is normally associated with time (Oliveira and Martins 2011). The process of innovation in organisation is complex as it

involves individuals with different opinions (supporters, sceptics and opponents) of the new idea, playing important role in the idea becoming ready for mainstream adoption (Straub 2009). Figure 3.16 shows how individual decision contributes the diffusion of the technology.

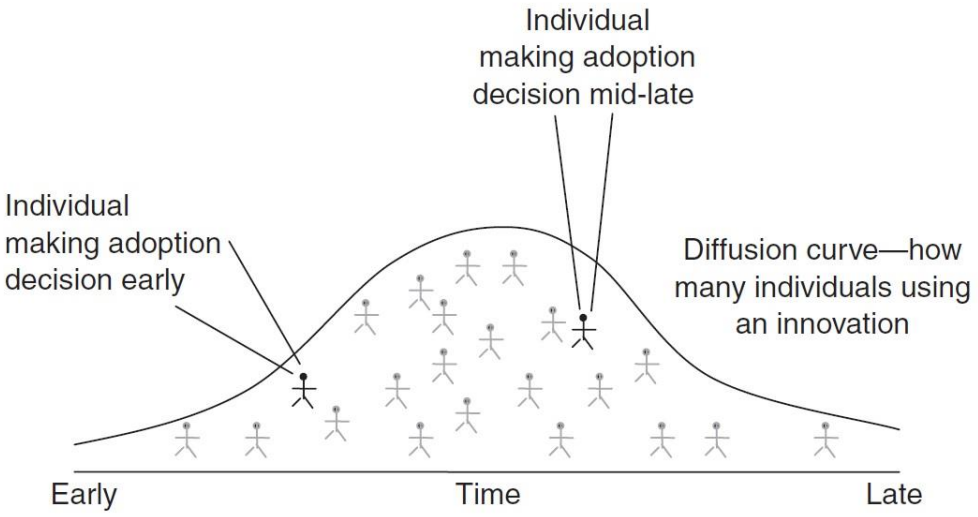

Figure 3.16: How individual adoption decision influence diffusion (Straub 2009)

Based on the level of innovativeness of the individual organisation, Rogers (2003) classified innovators into five categories; Innovators, early adopter, early majority, late majority and laggards.

Innovators: Innovators are usually the first adopters of a new technology innovation and they are considered as gatekeepers. Innovators have high capital which lets them invest in a new technology and they can recover even if the implementation results in a loss to the organisation. Additionally, innovators will have high level of expertise to deal with the uncertainty and complexity of the innovation process (Oliveira and Martins 2011, Alshamaila 2013).

Early adopters: Early adopters holds important leadership role in the social system. Other organisations go to them for advice or information about the innovation. Early adopters are

very important as they are the first adopters of the technology and the success of the innovation depends on their approval. (Oliveira and Martins 2011, Alshamaila 2013).

Early majority: This group of innovators constitute one third of the total members of the system. According to Rogers, early majority have good interaction with the other members in the system and their innovation decision usually takes longer time duration when compared with the innovators and early adopters (Oliveira and Martins 2011, Alshamaila 2013).

Late majority: This group of innovators usually constitute about the same numbers as the previous type. Late majority group of innovators are usually sceptical about the innovation and the outcomes of the innovation. Usually economic necessity and competitive pressure contribute to the adoption decision.

Laggards: They are the last group of organisation to adopt a new technology innovation. Management's resistance to change, lack of awareness, lack of capital and lack of expertise are some of the reasons for organisation being laggards. This group of innovators will want to make sure the innovation works before making the decision. (Oliveira and Martins 2011, Alshamaila 2013).

According to Rogers (2003), DOI is an uncertainty reduction process and he has proposed attributes to help in reducing the uncertainty about a technology innovation. They are Relative advantage, Compatibility, Complexity, Trialability and observability. The definitions of the attributes according to Rogers are shown in the table. Rogers (2003) argues that an innovation which satisfies all the five attributes will be adopted much faster than other innovations. DOI is widely used to investigate technology adoption than the previous mentioned theories. The major criticism of DOI is the exclusion of the social context in the definition of attributes. As innovation has been proved to be affected by social and

environmental factors, this theory can be better employed by integrating with other studies which include social and environmental factors.

3.7.8 Technology, Organisation and Environment (TOE) Framework:

The TOE framework was first introduced by Tornatzky and Fleischer in their book, the process of technological innovation in 1990. They have explained how TOE framework can be implemented to determine the factors that influence technology adoption decision. Though some authors have referred to TOE as a market level theory, it is mostly employed to investigate technology adoption decisions at organisation level. TOE uses three different elements from the firms view to evaluate the factors that influence innovation adoption decision. The three elements are Technology context, Organisational context, Environmental context. (Oliveira and Martins 2011, Alshamaila 2013).

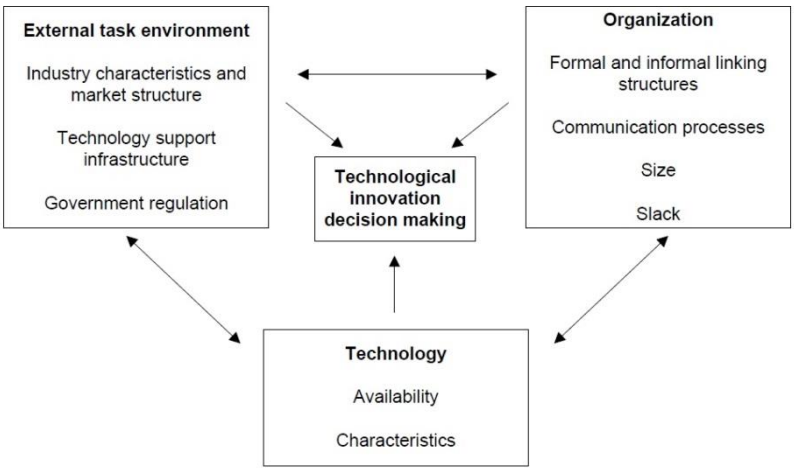

Figure 3.17: Technology, Organisation, Environment Framework (TOE) (Tornatzky and Fleischer (1990)

The TOE framework as described by (Tornatzky and Fleischer 1990) is shown in the figure 3.17. The technology context refers to the internal and external technological requirements to implement to the new technology innovation. It also includes existing infrastructure, practices, equipment available both internal and external to the organisation.

The organisation context refers to the organisational measures such as size of organisation, management structure and support to implement the technology innovation. Lastly, environment context refers to the social environment where the organisation runs its business. Environmental context also includes competitors, compliance, and legal and government regulations. The TOE framework is consistent with DOI as both the theories focuses on individual organisations internal and external characteristics to implement the innovation (Alhammadi 2016). The main difference in TOE framework is that it includes the very important element, environmental context. Through TOE framework, the attributes of innovation explained by Rogers can be better implemented. We choose to employ TOE framework for our study as the framework is simple and can be used to determine the factors that can affect cloud migration adoption among SMEs in Tamil Nadu.

3.8 Integrating DOI and TOE:

There are many instances where researchers have used the combined TOE and DOI framework to study technology adoption. Table shows some of the most well cited studies which employed combined DOI and TOE framework. To study the influence of CEO's innovativeness in technology (Thong 1999) used a conceptual model which is a combination of DOI and TOE framework. In another study, (Chong et al. 2006) used a conceptual framework combing the DOI and TOE framework to investigate the impact of e-business on organisations. In recent years, to study diffusion and adoption of cloud computing many researchers have combined DOI and TOE and used in their (Senarathna 2016, Alhammadi 2016, Alkhalil, Reza and David 2014, Alshamaila 2013) research studies. It is to be noted that all these studies have used the innovativeness characteristic defined by Rogers (2003). As mentioned earlier, the only difference between the two studies is the introduction of environmental context in the TOE framework.

3.9 Applying DOI and TOE to investigate SME cloud adoption in Tamil Nadu:

Cloud adoption can be considered as a new technology innovation to support business operations and therefore TOE framework can be used as a theoretical foundation to understand the conceptual factors that influence cloud adoption decision and outcomes. The benefits of cloud computing and its adoption has already been realised in some markets and in a developing country like India, determinants for cloud adoption for the SME sector is under researched. The theories of technology adoption discussed in the previous section including the TOE framework were not developed specifically for SMEs. Therefore, theories developed for larger firms cannot be applied directly for SMEs. Moreover, the innovativeness of the SME decision makers vary based on the type of industry, their objectives and geographical location of the business. Therefore it is very essential to review previous research studies employing TOE/DOI to identify the variables and research factors relevant to cloud adoption for SMEs in Tamil Nadu.

Many studies focussing on determining the factors affecting cloud adoption in different countries have adopted the integrated TOE and DOI approach. A conceptual framework designed based on factors identified from previous IS research relevant to our study is shown in figure 3.18.

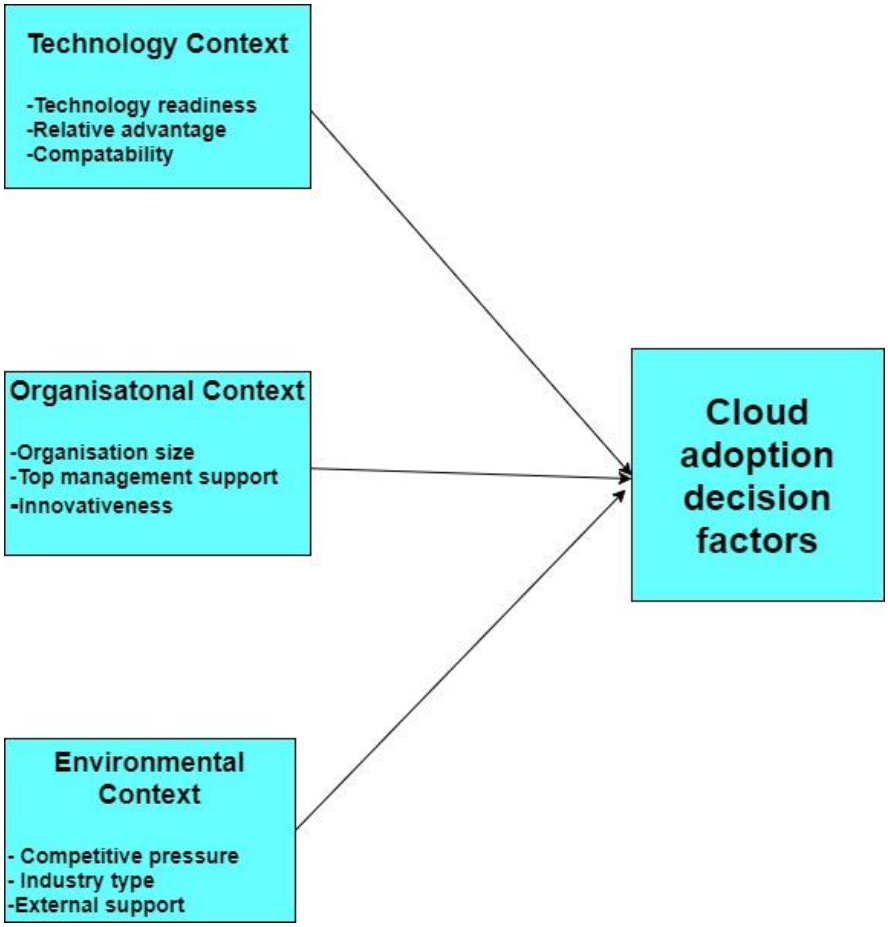

Figure 3.18: TOE Conceptual Framework

By choosing an appropriate research methodology and research method, the determinants of cloud adoption for SMEs in Tamil Nadu can be investigated. The research strategy and research methods are explained in the next chapter.

3.9.1 Hypothesis development:

This section presents the hypothesis developed based on the TOE framework to address the research question. Justification for choosing each research factor is also explained in this section.

3.9.1.1 Technology Context:

Cloud computing offers a new model to deliver IT services over the internet. Therefore, the technology context is very important when making cloud adoption decision. In the original TOE framework, the technology context includes both the internal and external

technology requirements relevant to the organisation to adopt the new technology. The research factors that are to be investigated on technology context are technology readiness, relative advantage, compatibility and complexity.

According to (Zhu et al. 2004) technology readiness is an important factor that will influence the adoption of new technology. (Zhu et al. 2004) used technology readiness as a research factor in their investigation of the factors influencing e-business. Like e-business, cloud computing is also a technology dependant on internet connectivity. Therefore, technology readiness can be considered as a research factor for the technology context. In the context of cloud computing, technology readiness refers the availability of human and physical resources to adopt and manage cloud computing services.

Hypothesis 1 (H1): *The technology readiness of an SMEs in Tamil Nadu will positively influence cloud computing adoption.*

Relative advantage refers to the degree to which a technological factor is perceived to provide greater benefit for the organisation (Rogers, 2006). Relative advantage has been considered as a central indicator for a number of new technology adoption studies (Senarathna 2016). According to Al Jhabri and Sohail (2012), relative advantage considers the economic benefits, increased efficiency and improvements in the status of the IT system. There are a number of perceived benefits of a successful cloud adoption. Most important benefits are lower capital, high scalability, reliability and flexible payment options. It has been proven from previous studies that if the perceived benefits are higher, the probability of the adoption will increase. Therefore, this research factor will be examined through the following hypothesis:

Hypothesis 2 (H2): *Relative advantages of cloud computing will positively influence the SMEs decision to adopt cloud computing in Tamil Nadu.*

Compatibility refers to the degree to which an innovation is considered as similar to the existing values, past experiences and needs of potential adopters (Rogers, 2006). For a new technology adoption, it is essential for the new innovation to be compatible with the existing infrastructure as integration can prove to be very complex if the existing system is incompatible to the new technology innovation. Similar to relative advantage, many research studies have extensively described the compatibility in technology adoption (Alkhalil, Reza and David 2014). It has been shown in many studies that increased compatibility has a positive influence on the adoption of the technology.

Hypothesis 3 (H3): *Increase in compatibility of cloud computing services will have a positive influence on the SMEs decision to adopt cloud computing.*

3.9.1.2 Organisational Context:

The organisational context refers to the characteristics of the organisation and its resources to support the new innovation. In the context of cloud computing, a successful cloud adoption will bring both technical and organisational change to the organisation. Therefore, organisation context is very important factor that will affect cloud adoption decisions. The research factors that are identified as relevant to our research study are size, top management support and organisational readiness.

The size of the organisation is an important factor that affects the adoption of a technology innovation. Many studies have shown that the size of the organisation can have a positive impact on the adoption of the technology (Alshamaila 2013). However, some studies have shown that the size of the organisation has negatively impacted the adoption of technology as well. It has been argued that larger enterprises will have more resources, capital and expertise to adopt the innovation and recover if it may fail (Senarathna 2016). In the context of cloud computing, it is not true as cloud services can be implemented with less capital investment on IT. The hypothesis to investigate this factor is,

Hypothesis 4 (H4): *The size of the organisation either positively or negatively impacts the adoption of cloud computing by SMEs in Tamil Nadu.*

Top management support refers to the support of the decision makers who influence the adoption of innovation. Top management support has been discussed as one of the crucial factor in many IS adoption studies as top level managers are responsible for all strategic decisions in an organisation. The adoption of the new innovation depends on the innovativeness of the top level managers. According to Baker (2012), top management can support is essential to create a vision for the organisation, that supports innovation and change. In the context of cloud adoption among SMEs in India, top management's resistance to change has been identified as one of the major hindrance for the use of any type of technology among SMEs.

Hypothesis 5 (H5): *Top management support will have a positive influence on the adoption of cloud computing by SMEs in Tamil Nadu.*

As discussed in previous chapter, innovation in ICT has proved to improve the competitiveness and productivity of an individual business (Alshamaila 2013). In the context of cloud computing, if an SME is innovative it will have a very good impact in the adoption of cloud based services. The hypothesis developed for this factor is,

Hypothesis 6 (H6): *Innovativeness of an organisation will have a positive influence on the adoption of cloud computing by SMEs.*

3.9.1.3 Environmental context:

The environmental context refers to the current operating environment of SMEs in Tamil Nadu. We have identified factors like Industry type, competitor pressure and external support will have an influence on the organisation while making decision for cloud migration.

The industry sector to which the organisation belongs plays an important role in

influencing the decision to adopt a new technology. As businesses in different sectors have different business needs, businesses which rely on IT are more likely to adopt a technology innovation like cloud adoption. Many recent studies have used this as an indicator for investigating the determinants of cloud adoption.

Hypothesis 7 (H7): *The industry sector which the organisation belong can influence the adoption of cloud computing by SMEs in Tamil Nadu.*

Competitor pressure refers to the "level of pressure felt by the firm from competitors within the industry". Organisations may lose business to their competitors if they fail to adopt new innovations in IT. Some studies have indicated that competitive pressure have a positive influence on the adoption of innovation and some empirical studies have shown there is no relation between competitive pressure and adoption of technology. As cloud computing is used by business that relies on IT and IT related services, competitive pressure may impact cloud adoption.

Hypothesis 8 (H8): *Competitive pressure will impact the adoption of cloud computing by SMEs.*

External support is the availability of support for implementing and using an information system. In the context of cloud computing, external support refers to the support provided through CSPs, government policies and legal safeguards to help SME decision makers adopt cloud computing. According to Premkumar and Roberts (1999), organisations will more likely adopt a new technology if there is sufficient external support.

Hypothesis 9 (H9): *External support will have a positive impact on cloud adoption by SMEs in Tamil Nadu.*

3.10 Conclusion:

In this chapter, we have reviewed the decision science literature and explained in detail the theoretical foundation of this research. We discussed the different MCDM methods and have shown how AHP can be used to provide cloud adoption decision support. We also discussed the different theories of technology and the reasons for choosing a TOE/DOI framework. Based on TOE and DOI, we have postulated a number of hypotheses to determine the factors that affect cloud adoption among SMEs in Tamil Nadu. The research strategy and the methods adopted to achieve the research objective will be discussed in the next chapter.

Chapter 4: Research Methodology

4.1 Introduction:

The term research is defined as the "*systematic investigation into and study of materials and sources in order to establish facts and reach conclusion*" (Oxford Dictionaries 2015). According to (Mcgregor and Murname 2010),

"*Methodology is a branch of knowledge that deals with the general principles or axioms of the generation of new knowledge*".

In general, research methodology can be considered as a study of how a research is done systematically to solve the research problem. A researcher can use different tools, techniques and processes in a study and they are referred to as the research methods. This chapter introduces the research methodology used in this research study. The way in which a research study is conducted is based on the aim and objectives of the research. The main aims, objectives and the research questions were discussed in Chapter 1. In this chapter, we have discussed

- The different research philosophies and the research philosophy adopted for this research;
- The research strategy adopted to answer the research question, including the research methodologies adopted; and
- The data collection and data analysis methods that will be used in the study.

4.2 Research Philosophy:

The term research philosophy refers to the system of beliefs and assumptions about the development of knowledge (Saunders, Lewis and Thornhill 2016). Adopting an appropriate research philosophy is very important for any research as the main objective of a

research would be is to answer a specific research question, which is developed as a new piece of knowledge in that field (Saunders, Lewis and Thornhill 2016). Research is a cyclic process (Rudestam and Newton 2014) and at every stage, we make a number of assumptions. These assumptions will determine the research strategy and the methods we use in the research. According to Saunders, Lewis and Thornhill (2016, p124)

"A well-thought out and consistent set of assumptions will constitute a credible research philosophy, which will underpin your methodological choice, research strategy and data collection techniques and analysis procedures"

There are different research philosophies and each of them can be differentiated based on the assumptions made. According to many authors (Saunders, Lewis and Thornhill 2016), (Bryman and Bell 2015), (Oakshott 2016), (Ihuah and Eaton 2013) Ontology, Epistemology and Axiology are the three main assumptions used to distinguish each of the research philosophies.

Ontology *refers to the assumptions about nature of reality* (Saunders, Lewis and Thornhill 2016, p127). It refers to how we view ourselves and study objects. ***Epistemology*** *is concerned with the assumptions about knowledge, what is constituted as acceptable, valid and legitimate knowledge and how we communicate knowledge* (Saunders, Lewis and Thornhill 2016, p127). ***Axiology*** refers to the role of values and ethics involved in the research process (Saunders, Lewis and Thornhill 2016).

There are five main research philosophies discussed by various authors (Jarvinen 2000), (Galliers 1991), (Ihuah and Eaton 2013) as suitable for research in social sciences, business, IS and computer science research projects. They are **Positivism, Interpretivism**, Critical realism, Postmodernism and **Pragmatism**. We have discussed the philosophies which are considered relevant for this research (in bold) in the next sections.

4.2.1 Positivism:

Positivism is an epistemological position that advocates the application of the methods of the natural sciences to study social reality. A positivist research uses existing theory to generate hypothesis. These hypotheses are then tested using suitable research methods and confirmed, or refuted leading to the generation of new theory (Bryman and Bell 2015). Thus developed new theory may be tested in future research activities. Epistemologically positivist research focusses on discovering observable and measurable facts and regularities (Saunders, Lewis and Thornhill 2016). Therefore, a positivist researcher only plays the role of an explainer of the social reality and does not participate in the research (Galliers 1991). Positivist research usually follows deductive approach. Deductive approach is considered as a Top-down approach where the research moves from a general idea to the specific observations. As quantifiable data is collected during positivist research, surveys and structured interviews are typical data collection methods used (Bryman and Bell 2015).

4.2.2 Interpretivism:

Interpretivism emerged as a research philosopy in the early 20th century and in practice, it consists of two variations; Phenomenologists and Hermeneutists. Epistemologically Interpretivist believes that people cannot be separated from the research and that there is a relationship between the researcher and the research. Interpretivism developed as a research philosophy as a criticism for positivism. The main aim of interpretivist research is to create new, in-depth understanding and interpretation of social reality. Therefore, interpretivist research is value bound and typically follows inductive approach. Inductive approach is considered as a bottom-up approach where the research moves from the specific observations to the general ideas. Common research methods used in this type of research are structured and semi-structure interviews (Bryman and Bell 2015).

4.2.3 Pragmatism:

Pragmatism asserts that concepts are only relevant when they support action (Saunders, Lewis and Thornhill 2016). This research philosophy concerns thinking that taking one position (positivist or interpretivist) may be unrealistic for some research problems. When the research question is not clear and does not suggest either a positivist or interpretivist philosophy, multiple methods are often used within the same study (Ihuah and Eaton 2013). In a pragmatic research concepts, theories, hypotheses and research findings plays an important role as instruments of though and action. For a pragmatist research, research starts with a problem and the researcher aims to obtain practical solution to the problem by using methods which works (Saunders, Lewis and Thornhill 2016). A pragmatist approach suit IS and computer science research as the research will be focused on creating practical outcomes (Mkansi and Acheampong 2012). Mixed methods are used and the research follows either inductive or deductive or both the approaches within the same study.

4.2.4 Qualitative-Quantitative-Mixed methods:

Research methods can be classified into two categories; Qualitative and Quantitative. The term qualitative and quantitative are used in research studies to differentiate the data collection and data analysis techniques adopted in the research (Alshamaila 2013). Qualitative is inductive and interpretive. In Qualitative research, data collection and data analysis procedures do not involve numbers. Qualitative research method is used for a broader research question where the data collection is usually unstructured or semi structured. The research methods associated with qualitative method are ethnography, participant observation, interviews and focus groups. The researcher plays the role of an observer and collects data in the form of interviews transcripts and recordings, photographs and written notes by the participants. On the other hand, quantitative methods as the name suggests involves collecting and analysing numbers. It is one of the dominant research strategy used in social sciences and business related research. Quantitative research can be experimental or

non-experimental. Quantitative research starts with the development of a hypothesis from a theory. Hypothesis is then tested, confirmed or refuted by testing the research variable. The research “variable” is an important entity in such kinds of research and the results are often summarised numerically or expressed by graphs, charts and statistics. A research variable can be defined as the character or attribute that varies during the research. Surveys, questionnaires and structured interviews are some of the common quantitative research methods. A third category of research called "Mixed method" is also used. There are different definitions available for mixed methods. In general, a mixed method is a research strategy that uses both quantitative and qualitative research methods to solve the research problem (Bryman and Bell 2015).

4.3 Research strategy:

As discussed in the previous section, there are large numbers of research methods that can be used in a research. As research is interdisciplinary, there is much debate on where a particular method is rooted with respect to philosophies. According to (Galliers 1990), classification of research methods indicating whether they confirm to positivist or interpretivist philosophy is shown in table 4.1.

Positivist	***Interpretivist***
Laboratory Experiments	*Subjective/Argumentative*
Field Studies/Experiments	*Reviews*
Surveys	*Action Research*
Case Studies	*Descriptive/Interpretive*
Theorem Proof	*Futures Research*

Positivist	***Interpretivist***
Forecasting *Simulation*	*Role/Game playing*

Table 4.1: Research methods in the context of positivist and interpretivist philosophies (Galliers 1990)

As discussed in the previous section, if a research uses both positivist and interprevist paradigms it can be classed as pragmatist. Before discussing the methodologies used in this research and the rationale behind choosing the particular method, we discuss the different methods suitable or relevant for IS research projects.

4.3.1 Laboratory experiments:

Laboratory experiments allow the researcher to establish precise relationship between variables in a designed and controlled environment using quantitative analytical techniques. The major advantage of this research method is the ability of the research to isolate small number of variables which can be studied extensively. The major weakness of this approach is the limited extent to which identified relationship exist in the real world due to oversimplification of the experimental situation and the isolation of such situations from most of the variables that are found in the real world (Galliers 1990).

4.3.2 Field experiments:

The main aim of field experiments is to conduct the research as realistic as possible in its natural setting. In other words, field experiments can be considered as an extension of laboratory experiments in real life setting. The limitation of laboratory experiments applies to field experiments as well. Additionally, it is very difficult to find organisations that are prepared to spend time and resources on field experiments and field studies. We faced the

same issue in our research and it is the main reason for excluding field studies from the main study (Galliers 1990).

4.3.3 Surveys:

Surveys are one of the most widely research method which are like snapshots of practice, situations or view at a particular point in time. Data collection for this method is usually done using questionnaires or structured interviews. Quantitative techniques are used to analyse the data and interpret relationship between variables. Unlike laboratory experiments or field experiments, surveys can be used to study a large number of variables and can provide an acceptable description of a real world problem from a variety of viewpoints. Sampling errors, research and participant bias are some of the limitations of the survey method (Galliers 1990).

4.3.4 Simulations:

Simulation research follows an interpretivst approach and is most used for theory or hypothesis testing rather than in the main study. Similar to laboratory experiments, difficulty in devising a simulating strategy that accurately reflects the real world setting is the major weakness of this research method (Galliers 1990).

4.3.5 Forecasting and futures research:

Forecasting research is used in business research by using the regression analysis and time series analysis techniques to predict about likely future events by considering the existing data on the particular research problem. With advanced IT tools, predication can be made on changes that take place in an individual, organisation or society. The major limitation of this research method is that we can only build scenarios of possible outcomes and not true reality of future (Galliers 1990).

4.4 Discussion and rationale for the choice of approach: Pragmatism-Mixed methods:

The choice of approach used in this study is shown in figure 4.2 as per (Saunders, Lewis and Thornhill 2016) research onion.

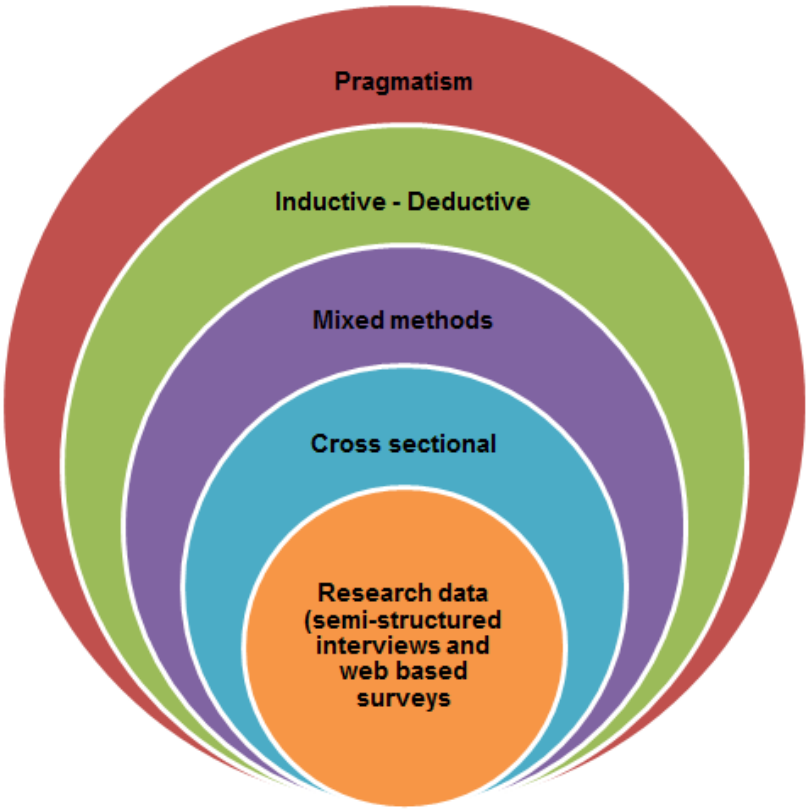

Figure 4.2: Research onion to represent the adopted research strategy

We have adopted mixed methods with a pragmatic research viewpoint to approach the research objective. It is necessary to adopt an inductive approach with a deductive thinking to enable it to approach a real world problem (Ihuah and Eaton 2013) like cloud computing adoption. The research objectives as mentioned in Chapter 1 dictate the use of mixed methods as the use of either qualitative or quantitative method does not fully answer the research objective. This research study can be divided into two parts:

- The first part aims to identify the factors that affect or influence cloud adoption among SMEs in Tamil Nadu.
- The second part of the study aims to develop a CADSF for SMEs in Tamil Nadu.

To answer the research objective, we have to use both qualitative and quantitative research methods. We have adopted the pragmatic research viewpoint as pragmatism provides the justification and rationale for combining methods and the knowledge for providing tentative answers to research question for mixing approaches and methods in a research study.

4.4.1 Research stages:

The research project has progressed in several stages as shown in figure 4.3. The different research philosophies, research designs and methods were considered at each stages and the research strategy adopted has guided the progress of this research. Some of the activities carried out as part of the research were one-off, some of the activities had to be repeated and tasks like literature review was carried out at every stage of the research.

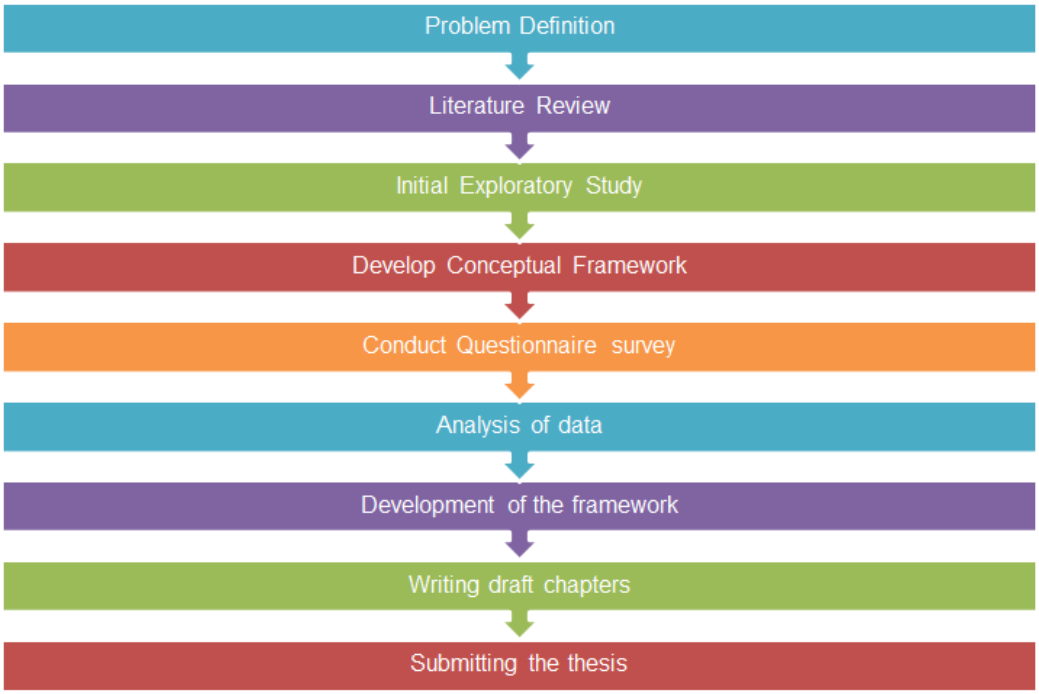

Figure 4.3: Research Stages

4.4.1.1 Stage one (Exploratory phase):

The main objective of this research is to design and develop a framework to support cloud adoption decision making process for SME cloud adoption in Tamil Nadu. To design and develop a framework to support SME cloud adoption, it is essential to understand the cloud adoption process, and examine the factors that affect or influence cloud adoption. Cloud computing is a new phenomenon in its formative stage. The context (SME sector) and location (Tamil Nadu) of cloud computing adoption that is investigated in this study is not investigated in any previous studies to the best of our knowledge. The initial phase of our study was exploratory in nature, during which we aimed to understand the issues faced by organisation which affect cloud adoption. During this exploratory stage, we have adopted a positivist approach where the research is influenced by deductive reasoning. As we aim to study the phenomenon of cloud adoption and answer "what" "why" and "how" type of

research of research question, we used case studies as the research method during this stage. Case studies have been used in previous similar research studies (Khajeh-Hosseini 2013). Methods like participant observation, field experiments, ethnography, structured and semi-structured interviews are commonly used methods to collect data in case studies. We adopted semi-structure interviews to collect data from SME decision makers. Through the data collected and with the help of secondary data collected in the form of reviewing literature, we were able to understand the issues and factors that affect or influence cloud adoption among SMEs in Tamil Nadu.

4.4.1.2 Stage two (Survey):

In the second stage of the study, we have used the TOE framework to frame the research hypotheses. The hypotheses framed for data collection and data analysis was discussed in the previous chapter. As part of the data collection for the main study, survey method was adopted and on-line questionnaire through google forms was used as a data collection method to test the hypotheses. There are two main types of descriptive survey research design; cross-sectional and longitudinal surveys (Oakshott 2016). Both cross-sectional and longitudinal survey designs are observational research designs. Researcher plays the role of an observer and records the information about the participant without manipulating the study environment. Cross-sectional surveys are the most commonly used descriptive research design. In cross-sectional surveys, the researcher collects information from a given sample only once. Cross-sectional surveys allow researcher to compare a number of research variables at the same time. In the case of longitudinal surveys, data are collected from the same population at different times with an intention to study the phenomenon over time. This type of research design is time consuming and usually last for a few months to a few years (Bryman and Bell 2015), (Oakshott 2016). Though longitudinal survey design can be adopted to study the diffusion of cloud adoption in Tamil Nadu, this

method was not adopted due to issues like limitation in time and the huge task of managing participant contacts for a follow up survey. We have identified cross-sectional survey with participant completed questionnaire administered through google forms as the appropriate method to collect data. Other methods like participant observation and field experiments also suit the requirements of this research and can answer the research question. However, due to various issues (limitation in time and funding) we were not able to adopt those methods.

4.4.1.3 Stage three:

The final stage of the research is to design and develop a prototype DSS for SME cloud adoption in Tamil Nadu. During this stage, we have adopted an an interpretivist approach where the research is influenced by inductive reasoning. The principles of evolutionary prototyping from software engineering were used as the design methodology for the prototype. A conceptual framework for the cloud adoption process was developed after stage one. We have employed Analytical Hierarchy Process (AHP) to support cloud adoption decision making and we have studies the usefulness of AHP for a cloud adoption decision support through two case studies. A prototype of the DSS is then developed by considering the different models available to support human decision making. The choice of research methods used at this stage is online questionnaire with decision makers who have participated in the previous stage of the study.

4.5 Data collection:

Research data can be defined as *"recorded factual material commonly retained by and accepted in the scientific community as necessary to validate research findings; Research data is collected, observed; or created for the purpose of analysis to produce original research results"* (Brown and Kernohan 2015). Two types of research data are collected in a research study; Primary data and secondary data. Primary data is collected to support the research problem and answer the research question in hand. Secondary data are data that

already exist from secondary sources. Unlike primary data, secondary data is not created by the researcher. Secondary data is usually collected to support the methodology and techniques adopted to answer the research. Any assumptions made by the researcher will also be based on the secondary data. Secondary data collected by the researcher can be in the form of text or statistical information from previous research studies like books, white papers, journals and conference publications (Brown and Kernohan 2015).

In this research, primary data is collected using semi-structured interviews and surveys. Secondary data collected during this research are white papers, journal articles, conference papers and text books relevant to cloud adoption. In this research study, qualitative research in the form of semi-structured interviews is employed to investigate the cloud adoption factors among SME in Tamil Nadu, and a quantitative questionarrie was then developed based on the insights gained from the analysis of the qualitative data. The data collection methods and other considerations are discussed in this section.

4.5.1 Interviews:

Interviews are the most commonly used qualitative method for research studies in various fields. There are three types of Interviews; structured, un-structured and semi-structured. Structured interviews are used to collect quantitative data and the other two types are used to collect qualitative data. In unstructured interviews, the researcher uses a set of prompts and discusses a range of topics with the interviewee. The interview may start with a single question and based on the response, interviewer asks the follow-up question. In sem-structured interviews, the interviewer has a list of questions or concepts that needs to be covered usually referred to as interview guide. The interviewee is questioned based on the interview guide. The order of the questions can vary for each participants of the interview. Therefore, both these types of interview are flexible in their process (Bryman and Bell 2015), (Saunders, Lewis and Thornhill 2016).

We have chosen the use of semi-structured interviews to conduct our interviews. This specific type of interview method was selected because of its suitability for the research problem. In this research study, we investigate the status of cloud computing in Tamil Nadu, how SMEs consider innovation and the scope of cloud computing adoption for SME sector in Tamil Nadu. We also considered field experiments/studies to explore the research problem. However the SME contacts we had were very reluctant to spend time for the research. Survey method was also considered for the initial exploratory study. As cloud computing was new, decision makers may be unfamiliar with the terminologies used in cloud computing which can make survey data inaccurate. Therefore semi-structured interviews are considered as the most suitable method for the initial exploratory study.

The interviews were conducted with an intention to gain in-depth knowledge about the emerging technology innovation (i.e.) cloud computing from the end users perspective. In particular, the interviews were focussed on,

- Major enablers and barriers of cloud adoption.
- Challenges for technology adoption in the organisation.
- Challenges and issues in cloud adoption and migration.
- Security and privacy issues in cloud adoption.
- Benefits of cloud adoption.
- Future of cloud adoption for SMEs in Tamil Nadu.

A single case case-study strategy was used to collect data from the participants. The interviewee's were decision makers from three different types of SMEs operating from Chennai, Tamil Nadu. The sample identified for the exploratory study is based on the INTUIT classification of SMEs in India based on the innovativeness of the organisation. According to study conducted by INTUIT on the Indian SME sector, based on the technology

innovativeness, SMEs can be classified into three types. They are Tech non-adopters, Tech aspirers, and moderate tech-adapters.

Type	***Sector***	***Description***
Tech non-adopters	*Old manufacturing companies*	*These organisation do not employ any type of IT in their business and they usually are old manufacturing companies practicing old business and process models.*
Tech aspirers	*Service and Manufacturing*	*This represents new SMEs who employ some IT in their business. They are aware of the business benefits of technology. However very cautious and implement only after its tried and tested by other enterprises.*
Moderate Tech adopters	*Mostly Service sector*	*Most advanced of the three and actively engage technology in their business.*

Table 4.2: SME classification according to INTUIT based on innovativeness

One SME is identified on each category for the purpose of the pilot study and prior to the interview, the decision makers from the SMEs were briefed about the aims and objectives of the study and general definition and benefits were explained to them. Both Tamil and English language was used for communication during the interview as the participants were not comfortable with speaking only using English. Only notes were taken during the interview as participants were not happy to be recorded during the interview.

4.5.2 The use of the questionnaire:

Research studies which uses survey strategy uses questionnaire method as the common research method. Questionnaire is used in experiments and also in case studies. Based on the design of questions, how it is delivered and returned back to the researcher, questionnaires are divided into two types; self-completed and interviewer completed. Self-completed questionnaires are completed by the respondents and administered either through internet or post. Interviewer completed questionnaires are completed by the interviewer based on the response of the participant. Data collected for this type is made either face to face or by telephone (Oakshott 2016).

4.5.2.1 Web survey method:

We have adopted self-completed questionnaire method administered through electronic means by send emails with URL link for the survey directly to the respondent. As the researcher is based in UK and the target population is based in Tamil Nadu (India), this method is identified as the suitable method for primary data collection. The advantages of self-completed questionnaire over other forms of quantitative data collection methods are listed below (Bryman and Bell 2015):

- Cheaper to administer,
- Quicker to administer,
- Absence of interviewer effects,
- No interviewer variability, and
- Convenient for respondents

We considered survey monkey, zoho survey and google forms as possible tools to conduct the web based survey. All of the three above mentioned tools are web based and offers tools to design, deploy and analyse surveys in an easy and convenient way. Survey monkey offers up to 10 free questions and requires a subscription for more questions. Zoho

survey offers a free one year subscription for academic students and allow to use allows usage of all analysis tools. Google forms are free to use and directly linked to the google drive provided by Sheffield Hallam University. All of the above tools allow creating a variety of question with the use of tools like dropdowns, menus, rating and text boxes.

We have used google forms to deploy our questionnaire as it is free to use and data collected is directly linked to the google drive provided by the university. Data collected can then be downloaded in the form of Microsoft excel sheets for further analysis. Invitations will be sent by email to the target sample in the form for a link to participate in the survey. To increase response rate, reminder notifications were also sent to the respondents. To validate the responses, a valid email address is collected as part of the survey.

4.5.2.2 Questionnaire design:

The questionnaire was designed with an aim to explore the TOE factors on SME adoption of cloud computing in Tamil Nadu. There are no standard designs in creating questionnaire. Though there is no standard defined structure to questionnaire design, there are guidelines by different authors on how to frame a questionnaire. According to (Oakshott 2016), the questionnaire design will depend on three main factors. They are,

- Type of respondents (For example businesses, consumers and children),
- Method of data collection (face-to-face, telephone or web based), and
- The resources available.

Closed-end questions are the most common type of question used. On web surveys, closed-end questions can be one of the following types; dichotomous questions, numberic questions, multiple choice questions, likert scale questions, semantic differential and raking order questions (Oakshott 2016). We have considered all the different types of closed-ended questions and have used them in our survey. The use of open-ended question can make the

data inconsistent. Therefore, we have avoided the use of open-ended as much as possible. There are two open-ended questions where respondents are asked to type their opinion in a text box. These two questions were made optional to improve the quality of the data.

4.5.2.3 Development of the questionnaire:

The questionnaire was developed based on the secondary data collected from the literature review and also from the qualitative data collected from the preliminary exploratory study. According to Burgess (2001), there are three steps in the development of a questionnaire. They are as follows:

- Determine the question to be asked,
- Select the question type for each question and specify the working, and
- Design the question sequence and overall questionnaire layout.

The first part of the second step and the third step can be facilitated by the software tool used to develop the questionnaire. Several researchers and authors have provided guidelines regarding wording the questions in the survey. Some of the important guidelines are mentioned below (Oakshott 2016):

- Avoid asking hypothetical questions.
- Avoid asking two questions in the same question.
- Avoiding the use of technical jargons and keeping the questions short and simple.
- Avoid leading questions.
- Avoiding questions that rely on memory.
- Having a logical sequence to the questions and starting the questionnaire with simple questions like age, gender and then leading to more complicated questions.

We have considered all of the above guidelines and have used close-ended questions as much as possible in the questionnaire. The question types used in the questionnaire are

multiple choice questions, ranking order, dichotomous and likert scale questions. We have used a 5 point likert scale which has been used in similar cloud adoption empirical studies. The questionnaire can be divided into three parts. The first part of the questionnaire relates to the participant information sheets and is aimed to serve the purpose of a participant consent form. There are 5 questions in this section and all of the questions are dichotomous (Yes or No) type of questions. The second part of the questionnaire captures the SME profile (demographic location, industry type and number of employees). The third part of the questionnaire contains questions relating to cloud adoption. The questionnaire is related to the TOE factors discussed in Chapter 3. Table 4.3 shows the number of questions relating to each research factor.

TOE hypothesis	Questions
Technical Context	
Technology readiness	6
Relative advantage	9
Compatibility	6
Organisational Context	
SME profile	5
Top management support	5
Environmental Context	
Competitor pressure	3
External issues (Government/legal)	6
Total	34

Table 4.3: Questionnaire format

4.5.3 Sampling design:

Sampling is one of the most important tasks carried out in most of the survey based research. For a survey based research study, due to issues like limited funding and time to complete the research, it is nearly impossible to gather data from all the representatives of the target population. In such situations, sampling methods and sampling techniques are used to

improve the quality of the data. Sample population and sampling method adopted in this research is discussed in this section.

4.5.3.1 Sample population:

If a research study is conducted without representatives of the target population, the result of such study is described as biased. One of the main aims when identifying the sample is to minimise the bias in the sample. According to Bryman and Bell (2015), a research sample can be defined as the segment of the population that is selected for investigation. It is also referred to as target population. The target population is usually selected from the sampling frame. Sampling frame is the listing of all units in the population form which the sample will be selected.

The unit of analysis for this research study is the SME sector of Tamil Nadu. The SME sector of Tamil Nadu is grouped into different clusters with each cluster representing SMEs from a particular field like textiles, leather processing and manufacturing. We aim to study the cloud adoption decision factors through a quantitative study using the survey method. Therefore, the target population for this research study is the decision makers, CEOs, CIOs, IT managers and personals at SMEs from these different clusters. A sampling frame was obtained from an online market research company, which included the contact list of all the registered SMEs in Tamil Nadu.

4.5.3.2 Sample size and Sampling method:

The sample size requirements can be calculated using the formula $N > 50m$, where m is the total number of independent variable in the study (Oakshott 2016). When conducting our preliminary exploratory study, we conducted our initial survey among decision makers from SMEs from Tamil Nadu. One of the main issues we faced was in getting the responses from the respondents. As the target population can include both adopters and non-adopters of cloud computing, a simple random sampling method was used. In simple random sampling,

every member of the target population will have equal chance of being selected (Oakshott 2016).

4.5.4 Piloting the study:

A pilot study also called as feasibility study refers to "small scale version or trial run in preparation for a major study". As sample size chosen for pilot studies are usually smaller than the main study. (Peat et al. 2002) suggests that data collected during pilot study should not be used to test the hypothesis. However, they insist that the data collected can be used to verify the chosen research tool and to check if a full scale study is feasible. A suitable sample size for pilot can be 10-20% of the sample size planned for the actual study (Baker 1994).

Before conducting the pilot study, the survey questionnaire was pre-tested by the Supervisors and two colleagues from the Cultural, Communication and Computing Research Institute (C3RI) at Sheffield Hallam University. Questionnaire was improved based on their comments and the final questionnaire was framed. For the pilot study, the questionnaire for e-mailed to 7 SME decision makers. The purpose of the pilot study was explained to the participants and feedback on the questions of the survey was gathered. In order to increase the response rate, reliability and validity of the responses, changes were made to some of the questions and some items were removed based on the feedback from the respondents.

4.6 Data Analysis:

IBM SPSS will be used to analyse the survey results. The results of the survey will be imported to Microsoft Excel sheet and IBM SPSS will be used to perform all statistical analysis.

4.7 Ethical considerations in the research:

Ethics can be thought of as the study of good conduct and of the grounds for making judgements about what is good conduct (Rudestam and Newton 2014). According to Burton

(2000), ethical concerns go beyond data collection and is present is analysis and publication stages of the research. Therefore, it is the researcher's responsibility to ensure proper ethical code of conduct is followed and confidentiality and integrity of the data collected is maintained throughout the research. In order to ensure the research is planned in accordance to the ethical principles of the Sheffield Hallam University, a research ethics form was submitted to the ethics committee before conducting the main study. A participant information sheet describing the aims and objectives of the study, which contact information of the researcher was provided to the participants of the research study. The voluntary nature of the study and the right to withdraw from the research study was clearly explained in the information sheet. A participant consent form is collected for both interviews and surveys. The data collected was stored in a password protected google drive provided by the University to ensure confidentiality. During the compilation of this report, data sources used were clearly acknowledged by using the appropriate referencing system to avoid plagiarism.

4.8 Conclusion:

In this chapter, we have discussed in details the methodological issues involved in this research. We have adopted mixed methods with a pragmatic research viewpoint in our research. The rationale for the adoption of this particular approach is also discussed. For data collection, we have used semi-structured interviews and web-based survey. The initial qualitative research facilitates the quantitative approach for the second part of the study. The findings of the research are discussed in the following chapters.

Chapter 5: Data Analysis

5.1 Introduction:

In Chapter 4, we provided the methodological considerations of this research study. As discussed in the previous chapter, this research study has three stages. This chapter presents the results of the data analysis from the first two stages of this research. In stage 1, semi-structured interviews were used to collect the data. In stage 2, web based questionnaire method was used to collect data. The aim of this chapter is to report the findings of the exploratory study which served as the basis for the quantitative study conducted using the questionnaire method. The second part of this chapter presents the quantitative data analysis of the questionnaire survey which is aimed to identify the determinants of cloud adoption for SMEs in Tamil Nadu.

5.2 Interview Analysis:

The semi-structured interviews was designed to gain in-depth knowledge about cloud computing and issues related to cloud adoption for SMEs in Tamil Nadu. We have adopted a Single-Case study method for the exploratory stage of this research study. As part of the exploratory study, semi-structured interviews were conducted with decision makers from different SMEs in Tamil Nadu. To eliminate any pro-adoption bias, we have used the classification of SMEs by INTUIT based on innovativeness to identify the participating SMEs. Therefore both adopters and non-adopters of cloud computing were interviewed. As we have employed single-case study method, each participant is considered as a representation of the target sample. This exploratory study only serves as preliminary step towards the development of hypothesis for the second stage of the study. No conclusions

were drawn based on this exploratory study. To ensure confidentiality, data is anonymised so that the personal details or company details cannot be identified.

5.2.1 A Case of Small Manufacturing Company:

The interviewed participant belongs to a small manufacturing company located at Chennai (Tamil Nadu) in one of the SME clusters including other small businesses involved in Engineering, Auto-ancillary and fabrication works. We refer to the SME as simply P1 in this report for the purpose of confidentiality. P1 is a family run business established 20 years ago, and mostly depends on the local industrial association for introduction and implementation of any form of technology innovation in their business. This is a typical representation of "tech non-adopters" as they use very minimal IT to support their business. P1 still uses old business practices and processes for payroll and human resource management. At the time of the interview, they were using an old version of ERP software for Sales and Invoicing. The interview was conducted with the Director of the company with the aim to explore the perception, benefits and issues of adopting a cloud infrastructure in their business. The aims and objectives of the research were clearly explained to the participant before the interview. This case study investigated the potential benefits and risks associated with the adoption of cloud infrastructure in similar SMEs. The results of the interview are discussed in three sections with respect to the TOE framework.

5.2.1.1 Technical issues:

The main issue faced by P1 is the lack of awareness of the potential benefits of cloud adoption for their business. As P1 does not have an established IT infrastructure, they were also not sure about the technological requirements (reliable internet connectivity) and potential benefits of adopting cloud infrastructure. At the time of the interview, P1 was completely unaware of the benefits of cloud computing like scalability, increased accessibility and pay per use model. We also identified they lacked expertise to adopt a

technology innovation like cloud computing. Even though internet availability wasn't an issue, P1 identified cost of bandwidth will be a major factor if they were to use cloud infrastructure.

5.2.1.2 Organisational Issues:

From P1's perspective, they agreed that their productivity and customer base will increase if they have an online presence. P1 was planning to spend nearly 95 lakh Indian rupees (approximately £100,000) to upgrade the machinery in two phases starting January 2015. However, they were not ready to spend the money for upgrading the existing IT department (recruiting new staff and upgrading equipment), citing lack of experience and being happy with the current business model they follow. P1 was of the view that spending on something they are not completely sure of can result in an unrecoverable loss.

5.2.1.3 Environmental Issues:

P1 was aware that there are potential benefits in upgrading IT and adopting a new technological innovation like cloud computing. They were not ready to take risks and suggested that there is no requirement for them to spend on IT which is mainly due to the fact that their competitors also use only very little IT to run their business. P1 pointed out that it was only in 2006 they first started using IT for their business for invoicing due to external pressure from clients.

5.2.2 A case of two Tech-Aspiring SMEs:

Tech-aspirers represent the group of SMEs which employ some IT in their business. They are usually aware of the business benefits of technology. However, they are very cautious and implement only after its tried and tested by large enterprises. We refer to the two companies interviewed as P2 and P3 in this report. P2 belongs to the IT industry with operations in two southern states of the Indian Union. The company was founded in 2007 and provide services IT consulting and business process outsourcing. P3 is a service industry

based in Chennai involved in retail and transport services. P2 has an established IT department with designated associates managing the IT infrastructure. We interviewed the Managing Director of P2. P3 does not have an established IT department, but the participant who we interviewed manages the IT requirement and operation in the business. The results of the interview are discussed in the following sections.

5.2.2.1 Technical Issues:

Both P2 and P3 agreed that the perceived benefits of a particular technology are very essential while adopting any new technology innovation in their business. It was clear from the discussion that both the participants were aware of the technical requirements and benefits of cloud computing. P2 considered them as adopters as they already have a cloud based service in their business. P2 considered cloud computing to be compatible with their existing IT and highlighted apart from scalability and agility of cloud services, potential savings on software licensing, support and maintenance are some of the drivers of cloud adoption for their business. Both P2 and P3 were uncertain about the exact financial and technological benefits a cloud migration can bring to their business. We identified that security of data, high bandwidth cost and vendor lock-in are considered as the barriers of cloud adoption. P2 and P3 cited security concerns for not moving data to a third party data center.

5.2.2.2 Organisational Issues:

We could clearly understand that the perception of the decision maker on the innovation (cloud computing) is very critical for its adoption from the interviews. The interviewed person from P2 was the sole decision maker. In the case of P3, we interviewed the employee who manages the IT for the business. From P2's perspective, he felt that his organisation was not ready yet to move business critical data and application to cloud. The major issues are the lack of trained professional in their organisation. According to P2,

"My data is my asset. I run my business based on my data. Moving to cloud will mean data can be made accessible from outside my business space. I trust the technology but not the people".

It was the lack of trust with their employees P2 were worried more than the trust in cloud computing service providers. P3 suggested their top management has a positive attitude towards cloud computing and are currently exploring ways to implement cloud computing.

5.2.2.3 Environmental Issues:

As P3 falls under the service sector, they felt they are compelled to use innovation in IT more due to the pressure in the market. As a retail company, they are forced to use technology innovation to stay on par with big market players. However, P3 insisted they were ready to invest in Technology as and when it is required for the business. P2 was worried more about the legal guarantee their company will get from the government in case of breach of security. The decision maker from P2 quoted the example of Zeneith Infotech who ceased their operation in 2014 and its users were forced to take their data back. He felt that such an instance can put his business to untenable loss. P2 and P3 agreed they would prefer cloud services from providers within India.

5.3 Findings and Discussion:

During the interview, the discussions were around the topics of perception of cloud computing, enablers and barriers of cloud adoption specifically for SMEs in Tamil Nadu. Table 5.1 shows the findings of the study with regards to each category that was discussed during the interview in the context of cloud adoption for SMEs in Tamil Nadu. Table 5.2 shows the issues faced by each SME for different Technological, Organisation and Environmental factors.

Theme	***category***	***Description***
Lack of Awareness/ prior knowledge of cloud adoption	*Need assistance/knowledge on aspects of cloud computing*	*-Pricing models* *-Payment methods* *-Support from CSPs* *-standards* *-Product suitability* *-Compliance requirements* *-Security policies* *-Different types of datacenters.*
	Need more awareness on these issues	*-Migration strategies* *-Cost of migration (Hidden costs)* *-Legal issues* *-Interoperability issues* *-Integration requirements* *-Issues in moving back to original legacy system (vendor lock-in)*
Factors that affect cloud adoption decision for SMEs in Tamil Nadu	*Enablers of cloud adoption*	*-Cost benefits* *-Scalability* *-Reliability* *-Back up and disaster recovery* *-Agility*
	Barriers of cloud adoption	*-Security issues* *-Loss of control over data* *-Lack of knowledge and expertise in cloud adoption* *-Complex migration process* *-Legal issues*

Category	*Technological*				*Organisational*				*Environmental*		
	Cost of bandwidth/availability	Complex migration process	Compatibility with existing IT	Security issues	Top management Support	Lack of Expertise/awareness	Costs	Loss of control	Lack of regulation	Legal issues	Competitor/client Pressure
P1	✓	✓	×	×	×	✓	✓	×	×	×	✓
P2	✓		✓	✓	×	×	×	✓	✓	✓	×

		-Cost of bandwidth and availability of reliable broadband

Table 5.1: Summary of topics discussed during interviews

P3	✓	✓	✓	✓	✓	✓	×	×	×	×	✓

Table 5.2: Issues that affect cloud adoption for each organisation

The analysis of stage 1 of the qualitative interviews provided a foundation for the next stage of the research. Cloud computing is rapidly changing the way computing services are purchased, used and maintained by businesses around the world. The Indian SME sector has one of the lowest levels of IT adoption when compared with other developed countries. Cloud computing offers highly scalable and reliable computing technologies over the internet, without the need to spend on expensive IT infrastructure. The availability of broadband and cost of a reliable internet connection is identified as one of the major barrier for adoption of cloud based services. As discussed in chapter 2, penetration of fixed line broadband in rural areas is very limited (2%). Internet through mobile technologies like 2G and 3G is also considered a failure as telecommunication companies did not invest on 3G. Due to the alleged irregulation in the 2G spectrum, the 2G and 3G sold to telecommunication

companies were cancelled in 2010. When the spectrum was auctioned again, telecommunication companies had to spend a lot for the spectrum. Due to advances in technology and the launch of 4G globally, telecom companies in India did not invest in 3G. Even though, 4G was launched by Bharti Airtel in 2012, the usage level was very less due to high costs and non-availability in majority of the areas. In September 2016, Reliance Jio a telecommunication company based in India launched their 4G across. Due to effective marketing and very competitive pricing, they have a customer base of over 100 million in less than two quarter since the launch of their operations. Other telecommunication providers were forced to make their price cheaper to remain competent in the market. Today, India has one of the fastest growth rates with consumers using 4G network infrastructure. According to Rohm (Japanese Semiconductor Industry), 4G is the best option for India towards the goal of digitally connected nation. As the interviews were conducted between 2014 and 2015, the broadband availability and cost of bandwidth factor needs to be reinvestigated in the second stage of the research.

This qualitative study is our first step towards exploring and developing a model for cloud adoption decision support for SMEs in Tamil Nadu. TOE framework by (Tornadzky 1990) provided the theoretical foundations of this study. The analysis of stage 1 provided us with a TOE framework to examine in detail with a large group of SME users through a subsequent quantitative study. It is clear from these interviews that external factors like legal issues and competitor pressure can affect cloud adoption decisions. Therefore, Environmental context is as important as other two contexts (Technological and Organisational) of the TOE framework. The main factors identified as playing a significant role in SME cloud adoption decision making are: relative advantage, complexity, compatibility, technology readiness, top management support, level of expertise/prior experience, organisation size, external pressure,

legal issues and market scope. The TOE framework developed based on the findings of the preliminary research was discussed in detail in Chapter 3.

5.4 Questionnaire survey findings:

The remainder of this chapter discusses the findings of the questionnaire surveys conducted during stage 2 of the research. We conducted a preliminary survey with a smaller sample size in June 2015 and the main survey was conducted in January 2017 with a larger sample size. We have presented the findings of the survey and it relevance with regards to existing literature and the testing of the hypotheses discussed in previous chapters in the following sections.

5.4.1 Preliminary survey:

The preliminary survey was conducted with an aim to test the usefulness of the TOE framework and also to identify the factors that influence cloud adoption decisions among SME decision makers in Tamil Nadu. We used 9 TOE factors and for the purpose of exploring these factors, a questionnaire of 36 questions was designed. The questionnaire was designed to capture SME profile, enablers and barriers of cloud adoption and the factors that influence cloud adoption (Technological, Organisational and Environmental). The survey questionnaire was sent to 70 decision makers from different SMEs in Tamil Nadu. We received 16 responses and 14 were deemed valid. 6 respondents were decision makers belonging to the IT industry, 2 each from retail and education section and 1 from manufacturing sector. 4 respondents did not specify the sector and selected other as the option. We used IBM SPSS for analysis of the quantitative data. The results of the preliminary survey have been published in (Wilson, Khazaei and Hirsch 2015). To identify the importance of each decision factor, we calculated the relative importance of each of the factors.

5.4.1.1 Enablers and barriers of cloud adoption:

From the preliminary study, we identified 5 drivers and 4 barriers for cloud computing adoption for SMEs in Tamil Nadu shown in table 5.3 and table 4. Cost benefits of using the cloud infrastructure was identifed as the major driver for cloud adoption for SMEs in Tamil Nadu (Wilson, Khazaei and Hirsch 2015). Scalability and agility of cloud applications was identified by decision makers as the second major driver for cloud adoption in Tamil Nadu. One decision maker stated,

"Definitely cloud computing is going to hit the markets well and even the SME's too, but it may take some time. The main challenge is internet cost and the next is lack of knowledge with the business owners. Most SME business owners use small time software applications even pirated copies to run their business with / without knowledge of compliance requirements. ".

Enabler	***Relative Importance Index***	***Rank***
Cost benefits of using cloud infrastructure	0.85	1
Scalability and flexibility of cloud	0.81	2
Increased productivity	0.78	3
Minimises software licensing costs	0.71	4
Reduces system downtimes	0.68	5

Table 5.3: Enablers of cloud adoption (Wilson, Khazaei and Hirsch 2015)

The preliminary study revealed among technical issues, decision makers considered vendor lock-in as the major barrier for cloud adoption in Tamil Nadu. Security of cloud service and privacy was identified as the second major barrier for cloud adoption which is

consistent to the literature review and results of similar studies (Rath et al. 2012). One decision maker had mentioned

"We are Not sure business critical / sensitive documents like designs / patents / or crucial information like this can be shared on cloud. Don't see this can be possible in India in near future. We still believe in securing it ourselves even if costs little more".

Barrier	***Relative Importance Index***	***Rank***
Vendor lock-in	0.85	1
Security of cloud services and Data privacy	0.72	2
Dependence on internet	0.71	3
Cost of bandwidth	0.68	4

Table 5.4: Barriers of cloud adoption (Wilson, Khazaei and Hirsch 2015)

5.4.1.2 Factors that influence cloud adoption:

From the small sample that was surveyed, we identified 12 organisational level factors with relative importance index more than 0.71 to have an influence cloud adoption among SMEs in Tamil Nadu. These factors are categorised according to TOE under technological (4), organisational (4) and environmental context (4) (Wilson, Khazaei and Hirsch 2015). The organisational factors that were identified are shown in the table 5.5. This preliminary study was conducted with an aim to identify the factors that affect cloud adoption

Technology Factors	Compatibility with existing systems Complexity of the migration process Addressing interoperability and portability Required technical expertise in cloud computing
Organisational factors	Top management support Top management's intention to adopt cloud computing Size of the organisation Organisation's trust in the cloud
Environmental factors	Competitive pressure Government policies Data center location Business requirement

Table 5.5 Organisational factors that affect adoption of cloud computing by SMEs in Tamil Nadu (Wilson, Khazaei and Hirsch 2015)

The major drawback of this preliminary survey is the small number of samples examined. Therefore, the results of the survey have less importance. However, we were able to validate the usage of the TOE framework for the main study. Due to the evolving nature of cloud computing, these factors were examined with a larger sample to create an empirical evidence of the determination of cloud adoption among SMEs in Tamil Nadu (Wilson, Khazaei and Hirsch 2015).

5.5 Results and findings of the main study:

The preliminary survey conducted helped us to verify the chosen research method and also test the suitability of TOE framework for the research problem. This section discusses the results and findings of the survey from the main study. The results are used to test the hypotheses discussed in Chapter 3. Although there are some empirical studies done to investigate the determinants of cloud adoption among organisation in India, during literature review we did not identify any study focussed on SMEs for a specific region in India. The results of the main study will create empirical evidence of determinants of cloud adoption for

SMEs in Tamil Nadu. As mentioned in Chapter 4, IBM SPSS 24 was used for data analysis. The factor analysis statistics generated through SPSS is shown in Appendix.

5.5.1 Response rate and data screening:

Participants were invited to take part in the survey through questionnaire links distributed to them by email. We used a SME database obtained from a market research company in Tamil Nadu to select the participants of the survey. SMEs that use some form of IT for their business are only considered for the survey. The survey was conducted over a period of 3 months between January 2017 and March 2017. In total, 630 invites were sent through email. The total response received at the end of the study was 98 which give a total response rate of 15.5. The data set was screened to identify questionnaires that were not completed in full. Some questionnaires were excluded from analysis as same answer was selected for all the questions. Some (2) were excluded as the respondent had mentioned they don't have operation in Tamil Nadu anymore. After data screening, 83 responses were identified as valid responses.

5.5.2 Participant Information:

The descriptive statistics of the participants of the survey are shown and discussed in this section.

5.5.2.1 Job role of the participant:

Table 5.6 shows the job role of the participants of the survey. Majority of the participants (54.2%) were IT executives (Senior IT executives and Team Leads), 22.9% were managing directors of the firm and 9.6% were project managers, and the rest of the population of the sample included CEOs, director, IT administrator and other sales and marketing roles in the organisation.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. Managing Director	19	22.9	22.9	22.9
	2. Chief executive officer (CEO)	2	2.4	2.4	25.3
	Business Development Manager	1	1.2	1.2	26.5
	Creative Analyst	1	1.2	1.2	27.7
	Director	1	1.2	1.2	28.9
	Executive	1	1.2	1.2	30.1
	IT Administrator	1	1.2	1.2	31.3
	Manager -operations	1	1.2	1.2	32.5
	Project Manager	8	9.6	9.6	42.2
	Sales	1	1.2	1.2	43.4
	Sales executive	1	1.2	1.2	44.6
	Senior IT Executive	18	21.7	21.7	66.3
	System engineer	1	1.2	1.2	67.5
	Team Leader (IT)	27	32.5	32.5	100.0
	Total	83	100.0	100.0	

Table 5.6: Job role of the participants

5.5.2.2 Duration of the organisation:

Table 5.7 shows the number of years the organisation has been doing business in Tamil Nadu. The first category mentioned represents the start-up SMEs which are in operation in the last 3 years. Majority of the participating organisations (73.5) are in business for more than 5 years and 20.5% of the respondents had indicated their business is in operation between 3-5 years.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. less than 3 years	5	6.0	6.0	6.0
	2. between 3-5 years	17	20.5	20.5	26.5
	3. 5-10 years	24	28.9	28.9	55.4
	4. more than 10 years	37	44.6	44.6	100.0
	Total	83	100.0	100.0	

Table 5.7: Duration of the business

5.5.2.3 Size of the Organisation:

The SME definition based on ministry of MSME in India categorise the SMEs only based on the total asset and turnover of the organisation. As discussed in Chapter 2, several countries categorises SMEs into Micro, Small, Medium and Large enterprises based on the number of employees in the organisation. Therefore, we have used the definition by to capture the number of employees in the organisation which represents the four types of SMEs (Micro, Small, Medium and Large enterprises) shown in table 5.8. The highest percentage of the responding businesses belonged medium and large enterprise (51.8%) category. 22.99% were micro businesses and 25.3% were small enterprises.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. less than 50	19	22.9	22.9	22.9
	2. 51- 100	21	25.3	25.3	48.2
	3. 101-250	28	33.7	33.7	81.9
	4. more than 250	15	18.1	18.1	100.0
	Total	83	100.0	100.0	

Table 5.8: Size of the organisation

5.5.2.4 Industry sector:

As shown in table 5.9, majority of the participants (50.6%) belonged to the IT, Telecommunication and IT enabled services sector. SMEs from the manufacturing sector had the second highest percentage (10.8%) followed by SMEs related to education (8.4%) and retail industry (6.0). Responses were received from a variety of organisation including Pharma sector, Textile industry Transport and Exports.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. Retail	5	6.0	6.0	6.0
	3. Healthcare	1	1.2	1.2	7.2
	4. Education	7	8.4	8.4	15.7
	5. Information Technology (IT), Telecommunications and IT enabled services	42	50.6	50.6	66.3
	6. Manufacturing	9	10.8	10.8	77.1
	7. Media and Publishing Sector	2	2.4	2.4	79.5
	8. Building & Construction Sector	2	2.4	2.4	81.9
	BPO	2	2.4	2.4	84.3
	Clothing Company (Exports)	1	1.2	1.2	85.5
	EMS	1	1.2	1.2	86.7
	Exports	1	1.2	1.2	88.0
	IT Distribution and service provider.	1	1.2	1.2	89.2
	Pharma sector	1	1.2	1.2	90.4
	Service	1	1.2	1.2	91.6
	Service industry	1	1.2	1.2	92.8
	Service sector	1	1.2	1.2	94.0
	Textile	1	1.2	1.2	95.2
	Textile industry	1	1.2	1.2	96.4
	Textiles	1	1.2	1.2	97.6
	Transport and Logistics	1	1.2	1.2	98.8
	Travel and tourism	1	1.2	1.2	100.0
	Total	83	100.0	100.0	

Table 5.9: Organisation sector

5.5.3 Adopters and non-adopters of cloud computing:

After collecting the information about the participating SME, the next section of the questionnaire started with a dichotomous question asking the participant to indicate if they are adopters or non-adopters of cloud computing. To understand to participant's intention to adopt cloud computing, three conditions were given as help hints to choose the answer. Participants were advised to choose "Yes" if, (1) the company has conducted any market study or any business research activity in cloud computing (2) if the company is planning on

cloud adoption and (3) if the company has made commitment to implement cloud adoption in immediate future. Out of the valid 83 responses, 55 cases (66.3%) considered themselves as adopters and the remaining 28 cases (33.7) were non-adopters of cloud computing. Out of the 55 cases, only 37 responses had indicated they already use cloud for at least one service in their organisation.

Therefore, only 44.6% of the organisations are current adopters of cloud computing in Tamil Nadu (Shown in table 5.10). 42.1% of the organisation either had no plans to adopt cloud (31.3%) or has indicated it will take more than 18 months to implement cloud at their business (10.8%).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1. Less than 6 months	4	4.8	4.8	4.8
	2. 6-12 months	7	8.4	8.4	13.3
	4. more than 18 months	9	10.8	10.8	24.1
	5. no plans as yet to adopt	26	31.3	31.3	55.4
	6. Already use at least one cloud service	37	44.6	44.6	100.0
	Total	83	100.0	100.0	

Table 5.10: Adopters vs Non adopters

Table 5.10 presents the results of the cloud adoption statistics with regards to size of the organisation, number of years in business and the main 4 industry types of the sample surveyed. SMEs that are in business for less than 3 years have a very high adopted percentage (60%) which is higher when compared to SME in business longer than 3 years (SMEs between 3-5 years = 29.4%, 5-10 years = 33.4%). This piece of information is consistent with the literature review findings as similar studies investigation cloud computing adoption have recorded highest adoption rates among start-up's and new businesses. In the case of start-up's,

cloud computing is an attractive and suitable option as they will have no legacy infrastructure and can make cloud adoption decisions with having to worry about capital investments.

Category	**Frequency (n)**	**Non adopter**		**Already use at least one cloud service**		**Plans to adopt in less than 6 months**		**Plans to adopt between 6-12 months**		**More than 18 months**	
		n	%	n	%	n	%	n	%	n	%
Firm Size:											
1-50 employees:	19	8	42.1	8	42.1	-		2	10.5	1	5
50-100 employees:	21	13	61.9	5	23.8	-		1	4.7	2	9.5
101-250 employees:	28	5	17.8	13	46.4	5	17.8	3	10.7	2	7.14
more than 250 employees:	15	-		14	93.3	-		-		1	6.7
Less than 3 years:	5	1	20	3	60	1	20	-		-	
3-5 years:	17	5	29.4	8	47.05	-		3	17.6	1	5.8
5-10 years:	24	9	37.5	8	33.3	1	4.1	1	4.1	5	20.8
more than 10 years:	37	11	29.7	18	48.6	3	8.1	2	5.4	3	8.1
Organisation Sector:											
Information technology (IT) and IT enabled services (ITES):	42	7	16.6	21	50	3	7.1	5	11.9	6	14.2
Manufacturing:	9	5	55.5	3	33.3	1	11.1	-		-	

Category	Frequency (n)	Non adopter		Already use at least one cloud service		Plans to adopt in less than 6 months		Plans to adopt between 6-12 months		More than 18 months	
		n	%	n	%	n	%	n	%	n	%
Education:	7	-		6	85.7	1	14.2	-		-	
Retail:	5	5	100.0	-		-		-		-	

Table 5.11: Relationship between cloud adoption vs (size, duration of business and organisation sector)

However, the findings were not consistent with other empirical studies in the case of industry type as cloud adoption is not linked to any particular industry. Similar research studies by (Alkhater, Wills and Walters 2014, Alhammadi 2016 and Senarathna 2016) focussed in different regions has identified significantly higher adopted levels among businesses in the technology sector. Only 50% of the SMEs in the IT sector use at least one cloud service and more than 30% have no plans to adopt cloud computing in the next 12 months. Irrespective of the type of business, the level of cloud adoption increases as the size of the organisation increases. A chi-square test was performed for all the three categories and the results of the chi-square test are shown in table 5.12. We identified from the chi-square test that the size of the organisation and industry sector has a significant influence of cloud computing adoption.

Relationship between cloud adoption and organisation size			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	37.491[a]	12	.000
Likelihood Ratio	37.911	12	.000
N of Valid Cases	83		
a. 13 cells (65.0%) have expected count less than 5. The minimum expected count is .72.			

Table 5.12: Chi-square test

5.5.4 Perception of cloud computing:

After the demographic question, the survey sought to identify the key motivators and barriers for migrating to a cloud environment. We included a list of 7 key enablers identified from the preliminary survey and the interviews. Participants were asked to indicate the major drivers of cloud adoption for their organisation. Figure 5.1 shows the column chart of the major driver of cloud adoption for SMEs in Tamil Nadu. Reduced hardware costs seem to be the major driver for migrating to cloud environment for SMEs in Tamil Nadu as 63 of the 83 respondents identified reduced hardware costs as a major motivating factor. In our preliminary survey, reduced software costs were identified as one of the driver for adoption. However with a larger sample, only 21% of the respondents considered reduced software costs as an enabler for cloud adoption. Many empirical studies have identified flexibility of cloud services and the pay per use model as one of the major motivation for adoption of cloud computing. The findings of the survey is not consistent with the literature as only 40% of the respondents identified pay as you use model as a major driver for cloud adoption.

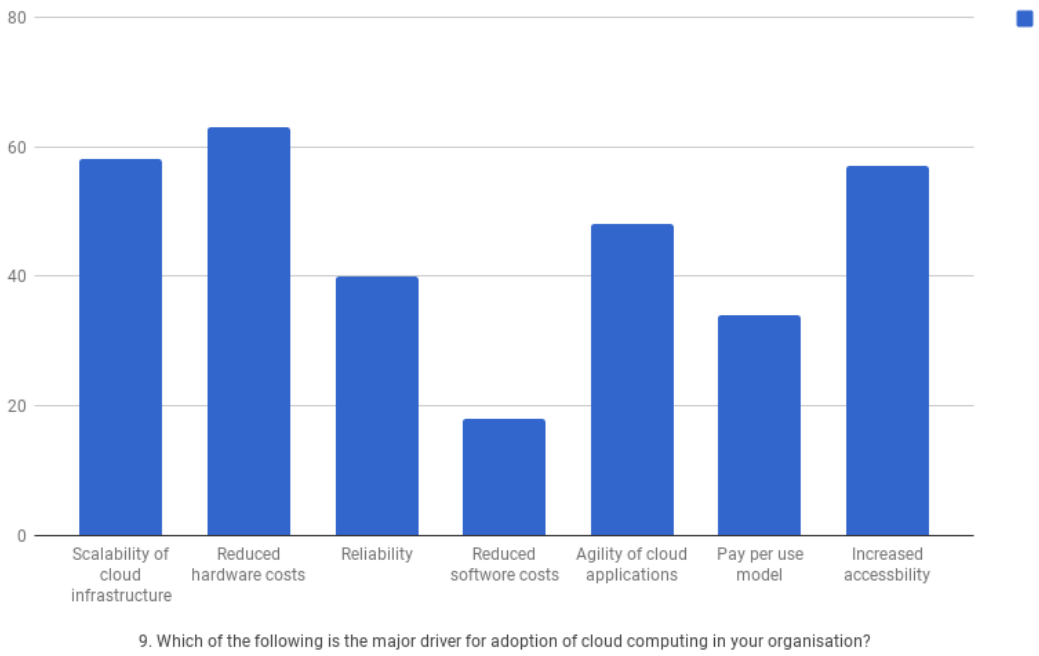

Figure 5.1: driver of adoption of cloud computing

The factors that affect cloud adoption were investigated in this study through a 5 point likert scale question. The result of the data analysis is shown in table 5.13. The findings show that broadband availability and high cost of bandwidth followed by lack of awareness/expertise and managements resistance to change as the factor that most affects cloud adoption decision in organisations. This finding is consistent with the study by (Alhammadi 2016) conducted in a technological developing country like India.

On a scale of 1-5, please rate the following factors which can affect cloud adoption among SMEs in Tamil Nadu.								
	Very Unlikely (%)	Unlikely (%)	Neither (%)	Likely (%)	Very Likely (%)	Don't Know (%)	Mean	Rank
Broadband availability and bandwidth costs	3.6%	1.2%	6.0%	20.5%	**65.1%**	3.6%	4.53	1
Security issues	1.2%	3.6%	16.9%	**56.6%**	15.7%	6.0%	4.00	6
Privacy Concerns	1.2%	4.8%	36.1%	**37.3%**	9.6%	10.8%	3.82	7
Interoperability/Portability issues	1.2%	2.4%	36.1%	**41.0%**	4.8%	14.5%	3.89	
Vendor Lock-in	3.6%	1.2%	25.3%	**37.3%**	20.5%	12.0%	4.06	5
Lack of awareness and expertise	3.6%	0%	4.8%	**28.9%**	59.0%	3.6%	4.51	2
Complex migration process	3.6%	2.4%	14.5%	**42.2%**	31.3%	6.0%	4.13	4
Management Resistance to Change	4.8%	0%	15.7%	**34.9%**	39.8%	4.8%	4.19	3

Table 5.13: Barriers of cloud adoption for SMEs in Tamil Nadu

5.5.5 Expertise in Cloud computing:

Participants were asked if they have experts in cloud computing within their organisation. Nearly half of the respondents (42.2%) indicated they don't have experts in cloud computing in their organisation. It can also be seen that majority of the organisation (87.1%) which has the required expertise have either already adopted cloud computing or they are planning to adopt cloud within the next 12 months. 10.8% of the respondent

highlighted that they were either using/planning to use a third party to support cloud adoption.

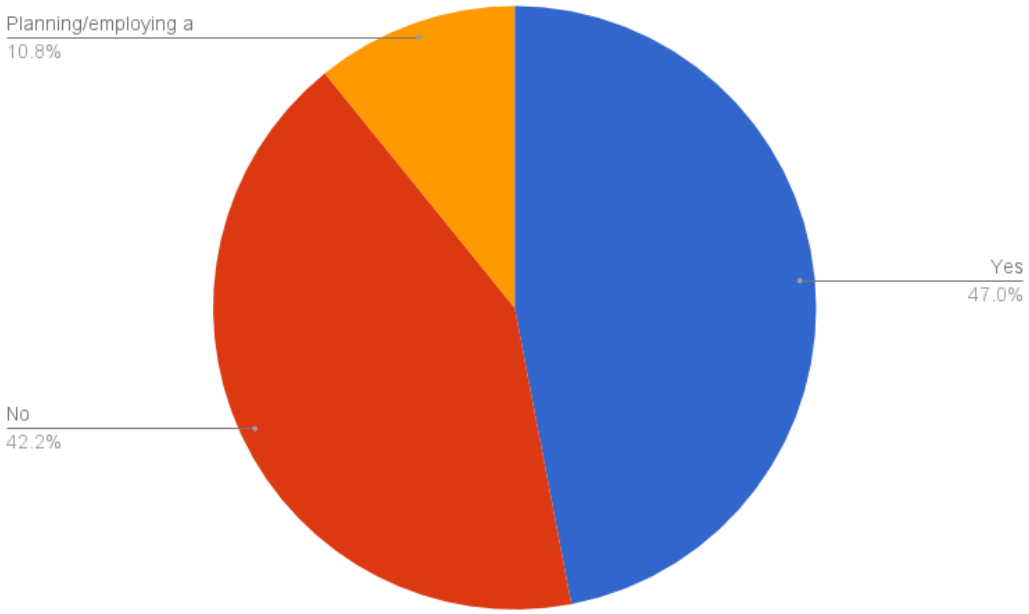

Figure 5.2: Expertise in cloud computing

5.5.6 Post migration benefits and challenges:

The following questions were included to explore the impact of implementing cloud based services. These sets of questions were only presented to participants who have already adopted cloud computing in their business. A total of 37 responses were received for this section and SMEs identified Lack of past experience in using cloud infrastructure (64%) and managing multiple cloud providers (62%) as major challenges they faced while implementing cloud based services in their businesses. Figure 5.3 shows the challenges faced by SMEs while adoption cloud computing in their business.

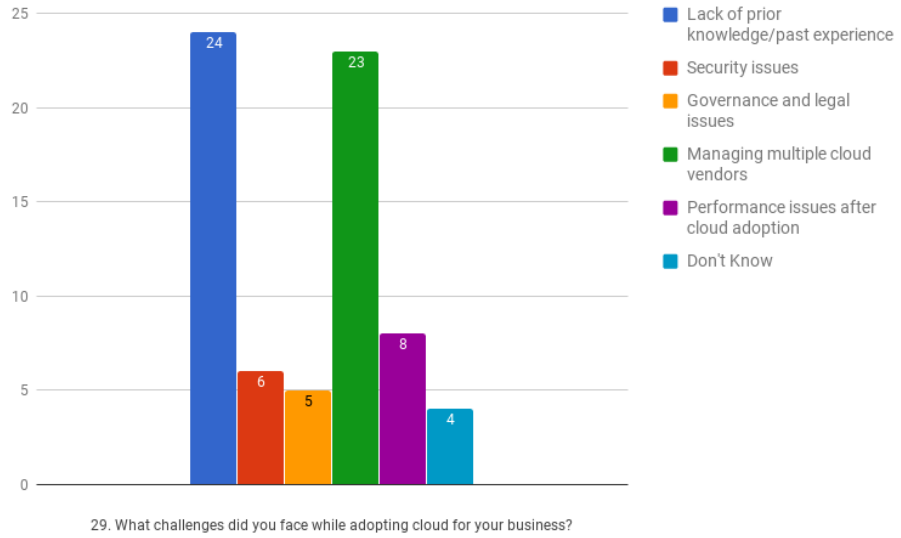

Figure 5.3: Post migration challenges

The analysis shows that the majority of respondents can already see benefits of cloud computing like agility (81.7%) and scalability (59.4%). Only 16.2% of the respondents feel they can see reduction in costs spent on IT after cloud adoption.

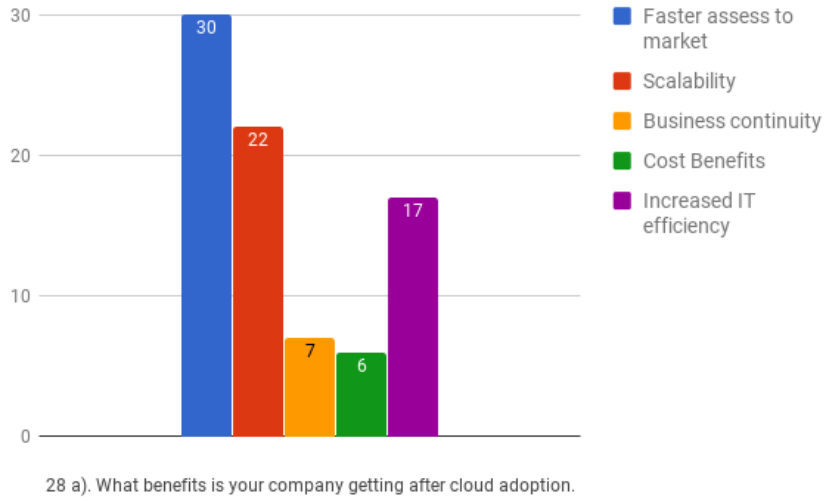

Figure 5.4: Post migration benefits 1

It is also clear from the analysis (Figure 5.5) that a majority of respondents are expecting to get reduction in costs on IT (infrastructure, maintenance and upgrade) because of adopting a cloud infrastructure. Therefore, economic benefits of using cloud infrastructure remain one of the major drivers for cloud adoption.

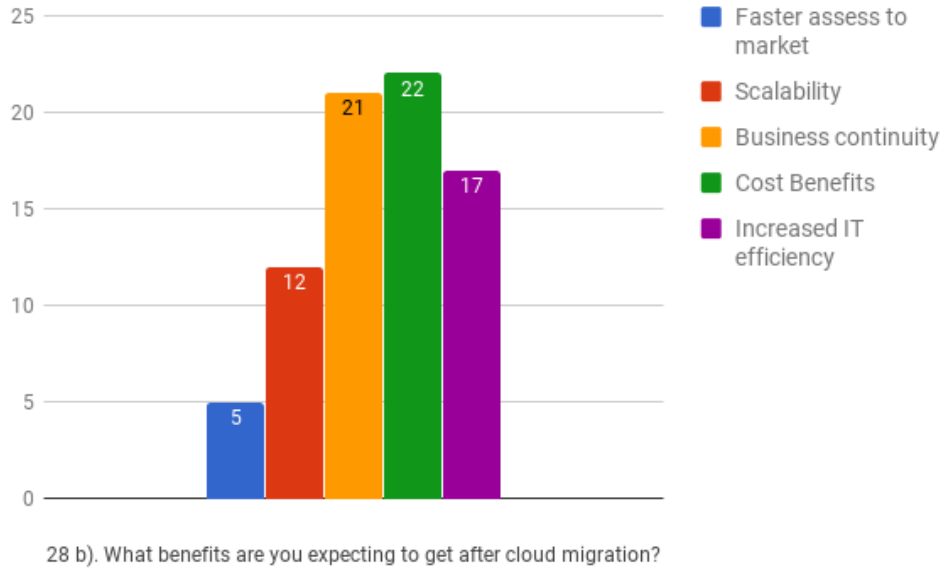

Figure 5.5: Post migration benefits 2

5.5.7 Analysis of the cloud adoption factors:

The next section of the questionnaire included 5-point likert scale questions to explore the cloud adoption decision factors. The design of this section of the questionnaire is based on the theoretical frameworks discussed in Chapter 3. 24 statements were divided into 2 two questions and participant were asked to indicate if they agree or disagree to the statement. To identify the statistical importance of each of the factors, standard deviation, mean and standard error were calculated for all the adoption factors. The statements under the Competitive pressure factor were the least agreed by majority of the participants. The statements "*Cloud infrastructure is dependent on internet and the performance of our system can be affected because of this factor*" and *"Cost of high bandwidth and availability of internet will be an issue for my organisations decision to adopt to cloud"* were strongly

agreed by majority of the participants. Unlike preliminary survey, the statement "*I am satisfied with the security features provided by the cloud provider"* and the statement *"We are unsure of the technology yet and our employees might need to be trained to make use of the services offered by cloud providers"* was agreed by most of the respondents.

5.5.8 Reliability and validity of the measures:

Reliability is the ability of a measurement instrument to provide the same error-free result consistently (Senarathna 2016). In quantitative studies, reliability of the measures is tested to identify the random-error that may exist in the measurement. Cronbach's alpha (α) coefficient is a common statistical analysis measure used in quantitative research studies to test the reliability of the measures. Cronbach's alpha measures how the consistency between two items of the same research factor. According to Hinton (2004), there are four cut off points for reliability that can be established from Cronbach's alpha (α). They are,

- 0.90 and above - reliability is excellent;
- 0.70 to 0.89 - reliability is high;
- 0.50 to 0.69 - reliability is moderate; and
- below 0.50 - very less reliability.

Cronbach's alpha value of more than 0.70 is usually an accepted measure in survey based research projects. The Cronbach's alpha (α) is identified for the 24 items and is shown in table 5.14. All of the research items were found to be reliable and therefore no research items were deleted.

Item-Total Statistics					
	No of Items	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Innovativeness	3	88.11	109.147	.144	.774
		88.10	109.503	.106	.774
		87.77	104.301	.312	.767
Compatibility	4	89.66	111.324	-.081	.785
		88.20	99.555	.361	.763
		88.73	100.441	.301	.768
		87.94	100.789	.497	.758
Top Management Support	4	88.02	102.170	.322	.766
		87.89	106.147	.123	.778
		88.07	102.800	.388	.763
		87.34	105.251	.293	.768
Relative Advantage	4	87.64	102.917	.430	.762
		87.72	104.422	.372	.765
		87.99	100.646	.460	.759
		88.40	97.413	.470	.756
Competitive Pressure	3	87.63	99.920	.305	.768
		87.80	96.677	.393	.761
		87.95	97.193	.332	.767
External issue	1	88.07	100.604	.291	.768
Technology readiness	5	88.46	96.398	.547	.751
		87.84	102.329	.368	.763
		88.25	104.996	.268	.769
		87.92	103.395	.261	.769
		87.72	103.325	.275	.768

Table 5.14: Reliability of the measures

The validity of the research model can sometimes be affected by Multicollinearity. Multicollinearity is common in observational or survey based studies where there are high correlations between two or more variables. In other words, one predictor variable can be used to predict the other. This creates redundant information, skewing the results in a regression model. Similarly to test for multicollinearity, Variance Inflation factor (VIF) and tolerance statistics were examined. It was identified that all of the research items had a tolerance values above the accepted 0.1 and the VIF was below 10. This shows that there are

no issues of multicollinearity in the research model. The collinearity statistics are shown in table 5.15.

Coefficients[a]			
		Collinearity Statistics	
Model		Tolerance	VIF
1	@6.TopManagementSupport	.474	2.108
	@7a.Innovativeness	.474	2.108
	@7b.Innovativeness	.535	1.871
	@22a.Compatibility	.371	2.692
	@22b.TopManagementSupport	.409	2.445
	@22c.TopManagementSupport	.245	4.085
	@22d.Compatibility	.235	4.255
	@22e.Compatibility	.441	2.265
	@22f.TopManagementSupport	.295	3.386
	@22g.CompetitvePressure	.433	2.308
	@22h.CompetivePressure	.383	2.612
	@22i.CompetitivePressure	.416	2.405
	@22j.Externalissue	.557	1.794
	@22k.Industrytype	.464	2.153
	@20a.RelativeAdvantage	.500	2.002
	@20b.RelativeAdvantage	.448	2.234
	@20c.RelativeAdvantage	.354	2.821
	@20d.RelativeAdvantage	.454	2.202
	@20e.Technologyreadiness	.328	3.047
	@20f.Technologyreadiness	.391	2.557
	@20g.Technologyreadiness	.425	2.351
	@20h.TopManagementSupport	.396	2.528
	@20i.Technologyreadiness	.398	2.514
	@20j.Technologyreadiness	.473	2.113
a. Dependent Variable: time			

Table 5.15: Tolerance and VIF of the research factors

5.6 Testing the Hypotheses:

We have used regression analysis (logistic regression) to test the hypotheses discussed in Chapter 4. We have used the cloud adoption research factors as the independent variable and the dichotomous question to understand whether the SME has adopted cloud or not as the

dependant variable. The logistic regression done through SPSS is shown in table 5.16. The Sig value in the table provides the p value which represents the statistical significance of the independent variable. The independent variable is statistically significant if the p value is less than 0.05. All independent variables with p value higher than 0.05 will have no statistical significance and have no impact on cloud adoption.

Logistic Regression							
		B	S.E.	Wald	df	Sig.	Exp(B)
	Innovativeness	-5.023	2.529	3.946	1	**.047**	.007
	Relative Advantage	-3.379	1.429	5.590	1	**.018**	.034
	Technology readiness	.879	.817	1.158	1	.282	2.409
	Top Management Support	2.197	1.198	3.363	1	.067	8.997
	.Compatibility	3.013	1.300	5.376	1	**.020**	20.349
	Competitive Pressure	-1.362	1.181	1.329	1	.249	.256
	External issue	-5.088	1.822	7.799	1	**.005**	.006
	Constant	-15.746	10.806	2.123	1	.145	.000

Table 5.16: Logistic Regression

From the results of logistic regression, 4 research factors were found to be statistically significant. We have already shown in section 5.5.3 through chi-square tests that both organisation size and industry sector has a positive influence on the adoption of cloud computing. Overall, six research factors are found to have statistically positive impact on cloud computing. The hypotheses that were accepted or rejected is shown in Table 5.17.

Summary of Hypotheses		
Hypothesis	**Sig value (p)**	**Accepted or Rejected**
H1: Relative Advantage	0.18	Accepted
H2:Technology readiness	0.282	Rejected
H3:Compatibility	0.20	Accepted
H4:Top Management Support	0.067	Rejected
H5: Innovativeness	0.018	Accepted
H6: Organisation Size	Categorical	Accepted
H7:Competitive Pressure	0.249	Rejected
H8:External Issues	0.005	Accepted
H9: Industry Type	Categorical	Accepted

Table 5.17: Hypothesis testing

5.7 Discussion:

5.7. 1 Technology Context:

The three research factor of the technology context that was tested is relative advantage, technology readiness and compatibility. Out of the three, relative advantage and compatibility were identified as having significant positive impact on the adoption of cloud computing among SMEs in Tamil Nadu. During the interview stage, technology readiness was identified as an influencing factor for migration data and application to a cloud environment. Based on the analysis of survey data, technology readiness was found to have no statistical significance in the decision to adopt cloud computing. This finding is consistent with other research studies which used technology readiness as an influencing factor in the decision to adopt cloud computing. Similarly, data security and privacy concerns were found to have no impact on adoption of cloud computing. The compatibility of the technological requirements to implement cloud to existing infrastructure is found to have a positive influence on decision to adopt cloud computing. If the organisation has the required infrastructure and the relevant expertise to support cloud adoption, the level adoption will be higher. Though technology readiness is not identified as a significant determinant of cloud adoption, it should be considered by decision makers to understand the suitability of cloud environment for their IT infrastructure. One decision had answered,

*"cost of cloud services, broadband availability, standardisation, availability of business applications (apart from standard productivity tools)"*as some of the issues that affect the adoption of cloud based services for SMEs in Tamil Nadu.

5.7.2 Organisational Context:

In the organisational dimension, size of the organisation and the innovativeness of an individual business were identified as having a positive influence on the adoption of cloud computing. It is identified from the survey that, if the decision makers have a positive attitude towards an innovation, it has a positive influence on the adoption of that innovation. From the descriptive analysis of the survey data, we identified that the level of adoption increases as the size of the organisation increases. It can be argued that SMEs which have more employees may have an established IT department. Therefore, the IT department staffs can be trained or new staff can be recruited to implement cloud in the business. Lack of awareness of the requirements to adopt cloud is identified as one of the major barrier for cloud computing. One decision maker had responded in one of the question that

"Lack of awareness is one of the major issues. The major issue is that payment method. Most of the SMEs financial team don't allow the credit cards for company payment system. Another one is the EMI option. There are no quarterly or yearly payments in some of the providers due to the online payment system and credit cards payments."

A decision maker of another SME answered for the same question as,*"I have heard about the benefits of cloud, but for a small manufacturing company like us, we don't have the expertise to run those systems. We have to get third party to consult to know what's best.....At the moment cloud is not a business requirement".* Issues with payment options were mentioned by another decision maker, *"Lack of previous experience, negotiation, issues with setting payment plans are some of the issues we faced. Broadband is another issue, but that should improve in the next few years".*

It is clear from the findings that both the technological and organisational dimension of the TOE framework has equal significance in the adoption of cloud for SMEs in Tamil Nadu.

5.7.3 Environmental Context:

Competitive pressure was rejected as a decision factor in the adoption of cloud computing for SMEs in Tamil Nadu. Majority of the respondents had indicated they don't know if their main competitors have adopted cloud based services and had said adoption of cloud computing by their competitors hasn't affected their business. The type of the business is found one of the determinants of cloud adoption. The levels of adoptions were found to be significant higher for businesses which rely on IT when compared to other businesses.

5.8 Conclusion:

In this chapter, we have presented the statistical analysis of our investigation. We conducted two web based surveys to investigate and identify the factors that affect cloud adoption decisions among SMEs in Tamil Nadu. We used logistic regression to test the hypotheses that were framed based on the TOE framework. Out of the nine hypotheses defined, only 6 factors (2 technological, 2 organisational and 2 environmental) were found to be statistically significant. Lack of awareness, lack of expertise, broadband cost and availability are some of the issue identified as major barriers of cloud adoption. Through the survey results, we were also able to identify lack of understanding of the payment options (pay per use model of cloud computing), lack of products specific for the Tamil Nadu market, managing multiple cloud provider as some of the challenges that were faced by SMEs who have already adopted the use of cloud computing for their business. In the following chapter, we have discussed the development and prototypical implementation of the framework based on the findings from the survey and interviews.

Chapter 6: The proposed framework to support cloud adoption decision making (CADM)

6.1 Introduction:

In this chapter, we have discussed the knowledge driven cloud adoption decision making framework developed to support cloud adoption by SMEs in Tamil Nadu. We have considered all the different tasks and stages of cloud adoption process while developing this decision framework. In Chapter 2, we have discussed several decision support models, tools and frameworks that cover different stages of the cloud migration process. However, there is only limited literature available which focuses on the whole migration process. In this chapter, we attempt to fill the gap by proposing a framework to support cloud adoption decision making by SMEs in Tamil Nadu which covers the whole cloud migration process. We have also discussed how the data collected through interviews and questionnaire surveys have helped in the development of the framework.

6.2 Cloud adoption decision making:

The benefits of cloud computing are very appealing due to the highly marketed benefits of the cloud infrastructure like reduced hardware costs and access to highly scalable technologies. This fact was confirmed by our primary research as majority of the respondents of the survey agreed reduced costs and scalability of the cloud infrastructure as the major driver for cloud adoption by SMEs in Tamil Nadu. It can be understood from these statistics that cloud computing is a suitable model for start-ups and enterprises with no IT infrastructure or legacy applications. In the case of large enterprises that are planning to migration their legacy IT application to a cloud infrastructure, it may not be straightforward as they have to recode the application if cloud services are not interoperable with the existing

IT system. The decision makers need to identify the integration requirements of the application before planning a migration. Poor planning can result in the failure of the migration project.

Many previous empirical studies have explored the benefits and barriers of cloud adoption for different target populations. The most notable publications of these empirical studies were carried between 2010 and 2013. Cloud computing as a IT model has evolved in the last few years and most of the findings of these studies are not consistent with the current status of cloud computing in India specially Tamil Nadu. Literature review also revealed several models and frameworks available to support different stages of the cloud migration process. There are only a few attempts (Alhammadi 2016), (Alkhalil 2016) made to develop a model or framework to cover the whole migration process. There are no models focussed on the SME population in Tamil Nadu. To leverage the benefits of cloud computing and to complete a successful migration a framework to support cloud adoption decision making process will be very useful.

6.3 A proposed framework to support cloud adoption decision making by SMEs in Tamil Nadu:

The research of current state of cloud computing among SMEs in Tamil Nadu revealed lack of awareness and lack of expertise of the cloud computing model as major organisational barrier for adoption of cloud based services. Through the findings of both the primary and secondary research, we have proposed cloud adoption decision support framework (CADSF) for SMEs in Tamil Nadu. The findings of the quantitative survey helped us define 7 decision factors that will form the basis of the cloud suitability assessment of the CADSF.

A successful cloud adoption brings both technological and organisational changes to an organisation (Khajeh-Hosseini 2011). The technological requirements of a cloud infrastructure and the technical issues that SMEs will face during cloud migration process will be very much similar irrespective of the location of the individual business. It has been proved by other research studies and by our primary research that organisational factors and environmental factors also plays role in cloud adoption decision making process (Alkhalil 2016). For instance, pay-per-use model of cloud computing is considered as one of the driver for cloud adoption. However among decision makers in Tamil Nadu, payment modes and payment methods were considered a barrier for cloud adoption. Additionally, majority of the participants were worried about the legal implications of cloud implementation. Therefore, organisational and environmental factors that affect cloud adoption must be included in the framework to make the framework relevant for SMEs in Tamil Nadu.

To develop the CADSF, we have identified the different stages in a cloud migration process and the different tasks that must be carried at each stage of the process by completing a thorough literature review and primary research. The findings of the research are structured into a framework according to the scientific decision making method discussed in Chapter 3. The reason behind choosing the scientific method is that it covers all the steps involved in human decision making. As the cloud computing model is still in its formative stage, a successful cloud migration or adoption should be managed to leverage the benefits of the cloud infrastructure. The last step of scientific method supports managing or reviewing the decision. This is one of the reasons for choosing this method of decision making. The proposed framework is discussed in detail in the next section. The conceptual view of the framework according to the scientific method of decision making is shown in figure 6.1.

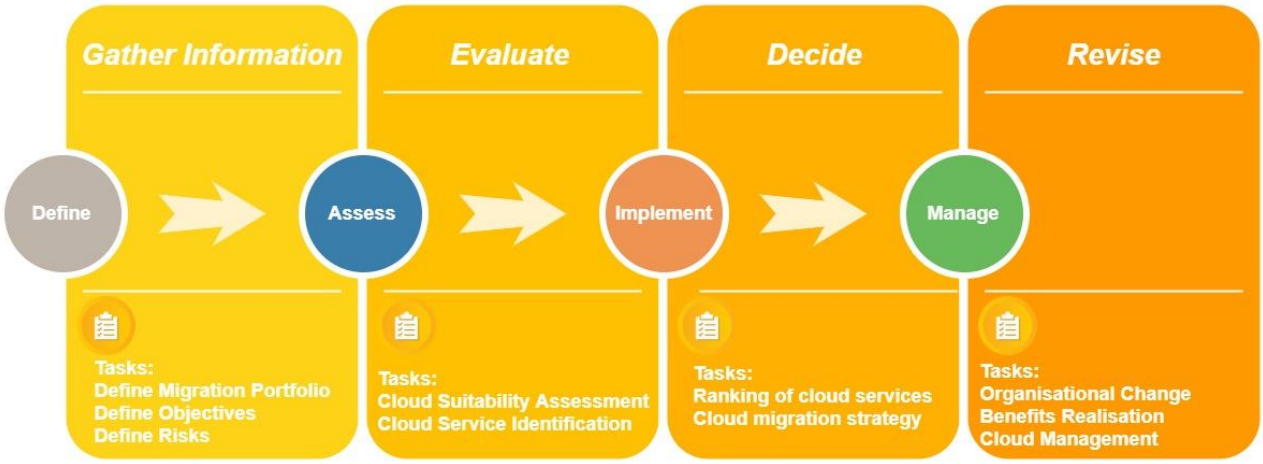

Figure 6.1: Conceptual view of the CADS framework

6.4 Cloud adoption decision support (CADS) framework:

The proposed CADS framework consists of four stages, namely; *Define, Assess, Implement and Manage.* Through these 4 stages, a decision maker is guided through the different tasks that is involved in the cloud adoption process starting from planning a cloud adoption to completing and managing the migration. To provide decision support, we have used the principles of MCDM discussed in Chapter 3. The different stages of the CADS framework are shown in the figure 6.2.

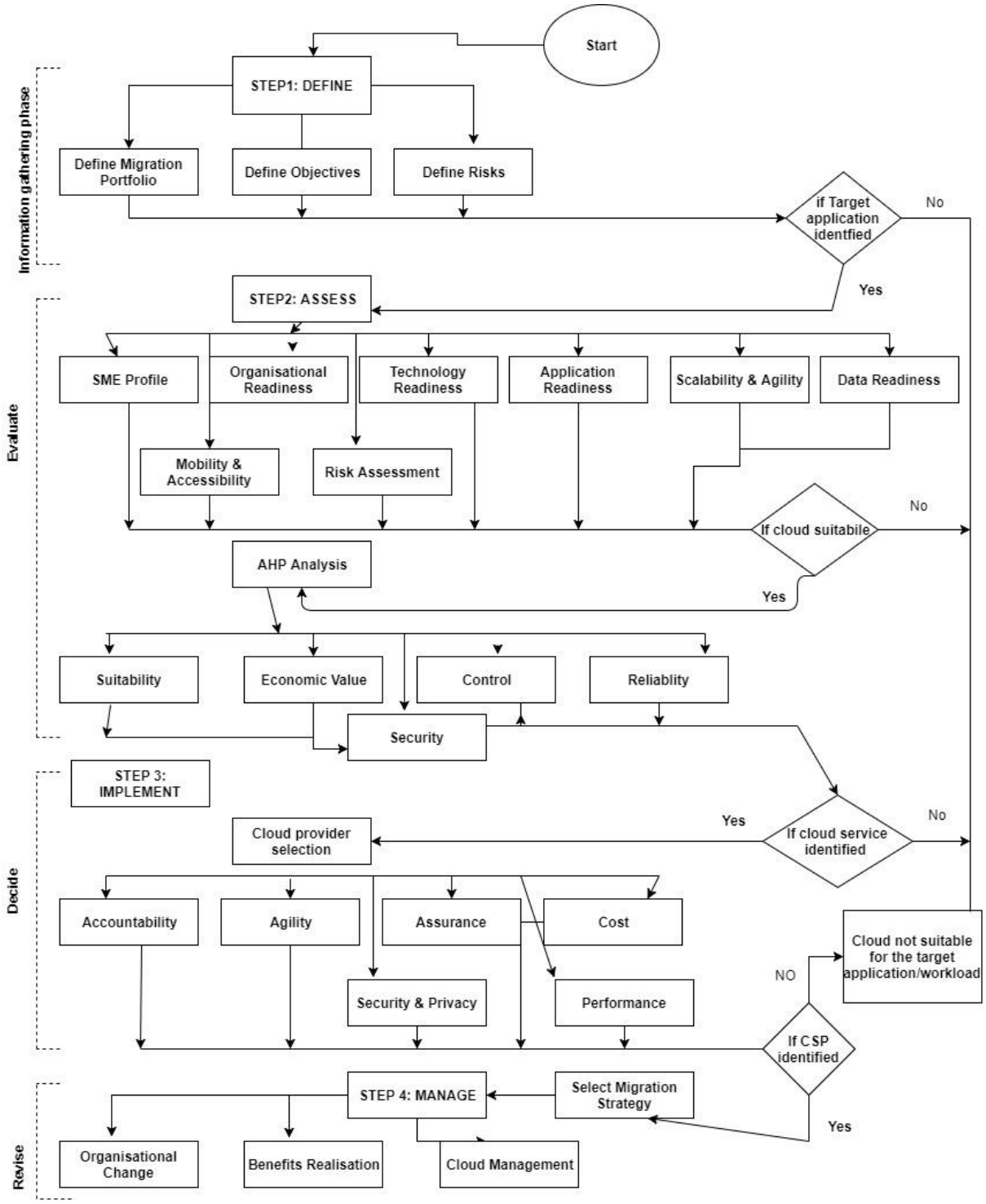

Figure 6.2: Cloud adoption decision making process (step by step with tasks)

The process starts by defining the problem. In our case, the goal of the framework is cloud adoption. The decision analysis using MCDM methods is centred on the second stage. We

have proposed two main tools in this stage; cloud suitability assessment and cloud service identification. The first tool incorporates the 7 decision factors along with risk assessment tool to determine the suitability of the cloud infrastructure for the organisation. Through this assessment, the best alternative for the deployment model (Public, private or hybrid) is also suggested for the decision maker. The next step of the Assess phase involves identification of a suitable cloud service. The proposed cloud service identification tool aims to provide decision support through Analytical Hierarchy Process (AHP) analysis to identify a suitable cloud service. The next two phases of the cloud migration process involves implementing and managing the cloud adoption decision.

6.4.1 Stage1 - Define:

The Define phase of the cloud adoption process includes gathering information about the SMEs cloud adoption project. Three types of information are collected under *Define migration portfolio, Define objectives and Define risk*. By gathering information from the decision maker, we can analyse the existing cloud computing needs of the organisation. This stage will enable decision makers to list out the benefits, weaknesses and potential risk of a cloud computing adoption before assessing the suitable of a particular cloud based service. This phase will be very helpful in generating a roadmap to cloud adoption and also to evaluate if the benefits listed during this stage are realised after cloud migration. The design of this step is based on the initiation stage of the software development lifecycle which aims to identify the aim, scope and deliverables of a software project.

6.4.1.1 Define migration portfolio:

This step comprises of a checklist which collects information regarding the existing workload(s) that the organisation is planning to migration to a cloud environment. In the case of start-ups with no legacy application, information regarding the target application that is planned to be deployed on cloud environment is collected.

6.4.1.2 Define Objectives:

The second activity involves decision maker specifying the objectives of the migration. Identification of key objectives plays an important role in the identification of risks involved in that particular type of cloud adoption. This step also captures the major motivations of cloud adoption for the business. The cloud adoption objectives checklist collects information under the following four sub-sections; business objectives, technical objectives, security objectives and management objectives.

6.4.1.3 Define risk:

The type and the level of risk that an organisation will face vary for every cloud adoption projects. As discussed in Chapter 2, the degree of risk associated with the cloud adoption depends on the type of deployment and service delivery model. (Khajeh-Hosseini 2011) has developed a excel worksheet based benefits and risks assessment tool which decision makers can use to review the risks involved in a cloud migration. In their tool, (Khajeh-Hosseini 2011) have included the mitigated approaches for each of the risks. As part of the literature review, a total of 103 published journal articles and conference papers were identified as relevant to SME cloud adoption and the risks mentioned in these papers were categorised under similar sub-sections as objectives; Business risks, technical risks, security risks and management risks. The actions required to minimise, eliminate or transfer the risk is provided along with the level of risk in the form of an excel worksheet. This step involves decision makers selecting potential risks that are relevant to each objective which will be assessed in the subsequent 'access' section.

The process only moves to the next stage if the target application or workload is identified by the decision maker for cloud assessment.

6.4.2 Stage 2 - Assess:

6.4.2.1 Cloud suitability assessment:

The first step of the assess phase is to conduct a cloud suitability assessment for the SME to identify if the organisation is cloud ready. The proposed tool will include a questionnaire based cloud suitability assessment and based on the assessment result, DMs can identify if cloud environment is technologically suitable (Wilson, Khazaei and Hirsch 2016). Based on the result and the migration portfolio gathered in the previous, a suitable deployment model can be suggested. The analysis of the data collected through the questionnaire survey resulted in the definition of 7 question categories for this assessment. The categories represent the suitability criteria that have to be evaluated in the assessment of an organisation that is considering adopting cloud services and these criteria are similar to question categories used in similar suitability assessment on the models by (Khajeh-Hosseini, 2013), (Garg, Versteeg and Buyya 2013), (Iñaki Bildosola, 2015), (Colicchio, Giovanoli and Stella, 2015), (Oracle, 2015). Every category is covered by a set of specific questions that an organisation has to answer in order to assess its suitability in this category. The questions for each criterion are designed to address the (technical, organisational and environmental) requirement of SMEs in Tamil Nadu.

The format of the assessment question and a sample question is shown in table 6.1. A format has been used by (Colicchio, Giovanoli and Stella, 2015) and (Iñaki Bildosola, 2015) in their decision support tool and a slightly modified version was used by (Garg, Versteeg and Buyya 2013). We have used a scale of 1-9 as criteria weight to simplify the calculation of the cloud suitability scores. Criteria weight will not be visible for the decision maker as it may influence their decision. The overall cloud suitability scores will depend on the criteria weight. For example, for the sample question shown in Table 6.1: If the decision maker

chooses the fourth option with a criteria weight 1, it will have a negative impact on the overall suitability score.

Have you evaluated the type of application(s) or workload(s) to move to the cloud?	**Criteria weight (CR)**
Answer 1: We have identified application(s) / workload(s) and our internal IT team have prioritised the application that needs to be moved to the cloud first based on a risk analysis performed for cloud infrastructure. We have developed a business model for the cloud.	9
Answer 2: We have identified a few application(s)/workload(s) that may be ready for cloud. We are still not sure about the risks that are involved in migrating these applications to the cloud.	7
Answer 3: We are aware of the benefits of a potential cloud adoption. But we lack the expertise to formulate a cloud strategy to adopt cloud services for our applications	5
Answer 4: No, we haven't evaluated the type of applications that we want to move to the cloud	1
Recommendation: 1. Having a clear strategy helps identifying risks and helps to negotiate the terms in provider SLA	
Recommendation: 2. Identifying the type of application is very important to evaluate the risks in cloud adoption. Your CIO must test a non-critical application's migration to cloud before committing to a total cloud transformation to identify the potential risks it may be bring to your organisation	
Recommendation: 3. External experts/third party cloud consultants can be hired to help in formulating a cloud strategy and generate a roadmap for cloud adoption	
Recommendation: 4. Having a clear cloud strategy is very important and if your internal IT lacks the expertise, you can take advice from external experts or third party consultants	
Reference: (Colicchio, Giovanoli and Stella, 2015)	

Table 6.1: Sample assessment question

A set of recommendation corresponding to each answer will be store on the knowledge base and will be provided as a recommendation to improve the cloud suitability score. The question categories are discussed below,

SME profile: This was identified as a determinant of cloud adoption, as organisation size and type of industry were found to be statistically significant in our primary research. The findings were consistent with other similar researches (Alhammadi 2016) (Alkhalil 2016). This section of the cloud suitability assessment contains questions about the organisation (number of employees, organisation type, and years in business). The other reason for including these criteria is to help decision makers check previous cases of cloud suitability assessment according to the SME profile.

Organisational readiness: This section of the assessment contains questions relating to the innovativeness of the organisation. It was identified from our primary research that innovativeness had a positive impact on the adoption of cloud computing. This section also contains questions relating to the IT budget, expertise and prior experience in technology innovation within the organisation.

Technology readiness: In addition to organisational readiness, the existing IT infrastructure should be compatible to use cloud computing services. This section contains questions regarding internet connection, hardware, security and integration requirements of the target application.

Application/Workload readiness: This section of the assessment question is very important as cloud adoption is driven by workloads. The cloud adoption process can only move to the next step if the workload is identified to be cloud ready. Cloud based services are suited for applications with less integration requirements. Therefore, business critical applications or applications which require high level of customisation may not be suitable for cloud infrastructure. The assessment question on this section is very important as it helps determine if the intended target application/workload is suitable for the cloud.

Data readiness: Regulatory and legal requirements might restrict migration of data from an on-premise data center to external data center. In such instances, private cloud or hybrid cloud may be the suitable deployment model. Additionally, amount of data transfer (size in GB) may also determine the suitability of cloud environment. The results for the assessment questions for the above two criteria can help us in determining a suitable cloud deployment model.

Risk assessment: The risks that were defined in Step 1 will be assessed in the questions from this section. Based on the answers for the questions from this section, recommendation to mitigate the risks will be provided. If the risks involved in cloud adoption outweigh the benefits of the cloud infrastructure, the assessment scores will be low in this section. In such instances, cloud adoption can be deemed less beneficial and the choice of retaining or continuing with the existing infrastructure will be suggested.

Scalability & Agility: This section analyses the expected growth of the organisation and its implication on the IT infrastructure. If workloads are expected to change unpredictably, it increases the suitability of such application for the cloud infrastructure. In addition to faster access to resources, applications can be tested and deployed faster through cloud infrastructure. These requirements will also be evaluated in this section.

Mobility & Accessibility: It has been proved that cloud infrastructure can improve the competitiveness of an organisation. SMEs with limited IT budget can get access to highly scalable technologies through the use of cloud infrastructure. Cloud can serve as an ideal platform for virtual organisation which completely relies on IT. The assessment questions of this section will analyse the accessibility requirements of the individual organisation.

6.4.2.2 Calculation of the cloud suitability assessment scores:

The cloud suitability assessment scores will determine the extent to which the cloud environment is suitable for the organisation based on the answers to the assessment questions. As discussed in previous section, the criteria weight values are in the range of 1 to 9. If the CW values are higher, it indicates the organisation is cloud ready for the particular criteria. In order to simplify the decision analysis process, a simple decision matrix will be constructed for each of the question criteria. The average score of CW will indicate the cloud suitability of each of the question criteria.

6.4.2.3 Cloud service Identification:

The next step in the CADS framework is to identify the type of cloud service delivery model to deploy the target application. The cloud service models available are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). All 3 service delivery models require users to either design, develop, build and deploy applications to cloud (Wilson, Khazaei and Hirsch 2016).

SaaS offers user to buy an "off the shelf product" and configure it to their requirements. Therefore, the decision maker needs to make a decision whether to "build" or "buy" while decision on the type of service delivery model for the target application. It makes more sense for SMEs to choose SaaS as the preferred service delivery model, if a suitable SaaS product is available as it does not require technical expertise to configure and implement a SaaS product (Weston and Kaviani 2013) (Wilson, Khazaei and Hirsch 2016). However, if the user already has a legacy system or does not find a suitable SaaS service, PaaS or IaaS would be best alternative. To identify the most suitable cloud based service, the first step is identifying the number of alternatives. After reviewing the literature and feedback from the case analysis of AHP with two SME decision makers (Explained in section 6.4.2.4), we have defined 5 possible alternatives. The working of AHP and suitability of AHP for cloud adoption is

discussed in the next section. The possible alternatives that organisation have are, ***Replace, Reuse, Re-host and Retain.*** Table 6.2 shows the different alternatives defined for cloud adoption.

Possible Alternatives available for cloud migration	**Possible actions**
Replace/ Add	- Replace or add application with SaaS service. - Build cloud based application from scratch with similar or improved features
Reuse	- consolidate similar application and services by cloud based technologies (server consolidation and virtualisation).
Re-host	- Migrating from one platform to another (Virtual to cloud, physical to virtual to cloud). - server colocation, lift and shift and virtualisation replatforming
Retain	- Leave the application as it is.

Table 6.2: Alternatives for Cloud adoption/migration

Decision makers can choose the relevant alternatives that are suitable for their application and perform the AHP analysis to identify the best alternative.

6.4.2.4 AHP analysis:

To identify the best alternative the problem can be approached using Analytical Hierarchy Process (AHP). Analytical Hierarchy Process (AHP) is one of the most widely used MCDM methods and we have used AHP to provide decision support in identifying the suitable cloud service. In AHP, Level 1 represents the goal of the system. Level 2 represents the different criteria for cloud adoption and Level 3 represents the five alternatives (Wilson, Khazaei and Hirsch 2016). In our case, the goal of the system (Level 1) is identifying the best cloud based service for the target application. The AHP hierarchy for cloud adoption is shown in Figure 6.3.

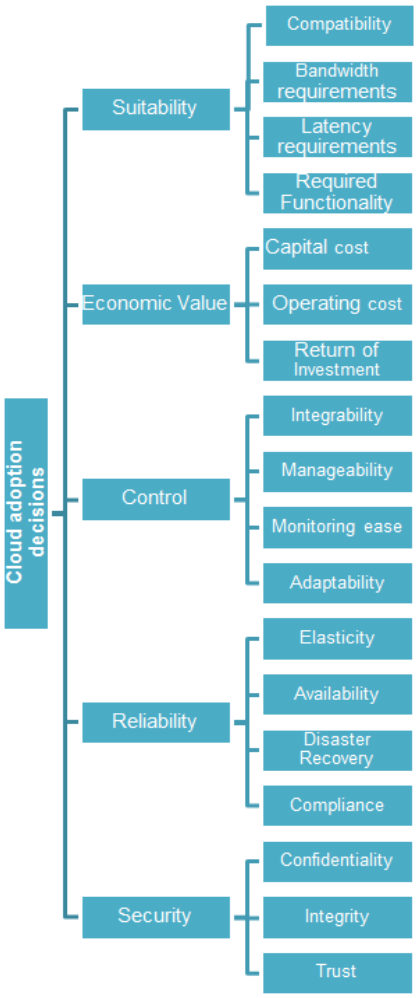

Figure 6.3: AHP hierarchy for cloud adoption

The chosen AHP hierarchy is based on the MADM framework by (Saripalli and Pingali 2011). Five factors based on MADM framework (Saripalli and Pingali 2011) forms the middle layer of the hierarchy. They are Suitability (C1), Economic Value (C2), Control (C3), Reliability (C4) and Security (C5) (Wilson, Khazaei and Hirsch 2016). To test the usefulness of using AHP to support cloud adoption decisions, we have completed two case scenarios with decision makers from two different SMEs operating from Tamil Nadu. The findings of the two case scenarios are published in (Wilson, Khazaei and Hirsch 2016). The participating SMEs belonged to the SME sector operation from Tamil Nadu. The DMs were informed about the aims and objectives of the study and was advised to complete the pairwise comparisons considering a specific workload according to the requirement of their business. Participant 1 wanted to determine the best alternative for a Legacy web application not built for cloud (W1). Participant 2 wanted to identify the best development and testing environment for building applications (W2). Pairwise comparisons made by the decision makers were captured using a quantitative questionnaire. We used a 5 point Likert scale (1, 3, 5, 7, and 9) to capture the scale of relative importance. The decision matrix constructed using the likert scale measures was then used to identify the priority vector (Saripalli and Pingali 2011). The alternatives used during this case study are shown in table 6.3.

Alternative	**Description**
Virtualisation/ Server consolidation (**A1)**	Virtualise to consolidate servers or server consolidation on blades/racks
SaaS implementation **(A2)**	Adapt a Software as a Service (SaaS) implementation

Alternative	Description
PaaS implementation **(A3)**	Adapt a Platform as a service (PaaS) implementation. Development and testing platforms on demand on a public or private cloud
IaaS implementation **(A4)**	Virtual machines and storage hosted on cloud environment. Infrastructure as a Service (IaaS)
Server colocation **(A5)**	Outsourcing server hosting to a third party provider

Table 6.3: Alternatives used in the case study

Table 6.4 shows a sample comparison matrix constructed for the main criteria for W1 based on pairwise comparisons made by the DM. The rows of the comparison matrix are then summed and the sum is used to normalise the eigenvector elements to add to 1 (Wilson, Khazaei and Hirsch 2016).

	C1	C2	C3	C4	C5
C1	**1**	1/5	3	3	3
C2	5	**1**	5	5	5
C3	1/3	1/5	**1**	1/3	1
C4	1/3	1/5	3	**1**	1
C5	1/3	1/3	1	1	**1**

Table 6.4: Pairwise comparison matrix

Similarly, criteria weight is calculated for W2. The criteria weight for W1, W2 and CR are shown in Table 6.5. Using the same method, the weights for each of the sub criteria is also calculated (Wilson, Khazaei and Hirsch 2016).

	C1	C2	C3	C4	C5	CR
W1	0.219	0.486	0.073	0.117	0.100	0.03
W2	0.268	0.311	0.119	0.119	0.181	0.06

Table 6.5: Criteria weights (W1, W2)

Table 6.6 shows the comparison matrix and the priorities when comparing the alternatives against C1 for W1. The same process is repeated to identify the priorities for C2, C3, C4 and C5. A final rating matrix is constructed using the priorities obtained for C1, C2, C3, C4 and C5. The overall priority vector is identified by transposing the final rating matrix and multiplying it with the criteria weight (Wilson, Khazaei and Hirsch 2016). The alternative with the best performance score is identified as the best alternative. Table 6.7 shows the summed-up final result for W1 and W2.

	A1	A2	A3	A4	A5	PRIORITIES
A1	1	1/7	1/5	1/3	1	0.050
A2	7	1	5	7	9	0.562
A3	5	1/5	1	3	7	0.231
A4	3	1/7	1/3	1	3	0.108
A5	1	1/9	1/7	1/3	1	0.0446
CONSISTENCY RATIO (CR**)** = 0.05 < 0.1						

Table 6.6: Pairwise comparison matrix

Through AHP analysis, criteria weights and priorities of each element in the AHP hierarchy (goal, criteria and sub-criteria) has been determined.

	A1	A2	A3	A4	A5
W1	0.083	**0.492**	0.213	0.121	0.089
W2	0.184	0.085	**0.472**	0.225	0.031

Table 6.7: Final priority ranking

As presented in Table 6.7, A2 with highest priority is suggested as the best alternative for W1 and A3 with the highest priority is suggested as the best alternative for W2. For participant 1, SaaS implementation is identified as the best alternative and for participant 2, PaaS implementation is identified as the best alternative based on the pairwise comparisons made by the decision makers. For both the case scenarios, economic value, suitability and reliability were the importance criteria as they had gained the highest criteria weight (Wilson, Khazaei and Hirsch 2016).

6.4.3 Step 3- Implement:

If a cloud infrastucture is identified as suitable for the target application/workload and if a suitable cloud service is identified, the next step in the cloud adoption process is the identification of a cloud service provider. As CADSF focusses mainly on SMEs in Tamil Nadu, the vendor suggestion should include local cloud providers from Tamil Nadu (Wilson, Khazaei and Hirsch 2016). The ranking of the services offered by the cloud will be based on 6 criteria according to SMI cloud (Garg, Versteeg and Buyya 2013) namely; suitability, reputation, performance and accountability, cost, agility and security.

6.4.4 Step 4- Manage:

The final stage of the cloud migration process involves managing the cloud migration project. It is the responsibility of the management to address the organisational changes due to cloud adoption and provide any training needed by the staffs. Effective usage of cloud management tools can help leverage the benefits of cloud computing infrastructure.

6.5 Prototypical implementation of the CADS framework:

A prototype can be defined as a working model of software with limited functionality. A software prototype does not hold the exact logic used in the final version of the software application. However, prototyping allows the end user to evaluate the proposal system before its actual implementation. The proposed CADSF is knowledge driven and can be developed into a working model or system by adopting the system architecture shown in the figure 6.4. The three main components are database, knowledge base and user interface.

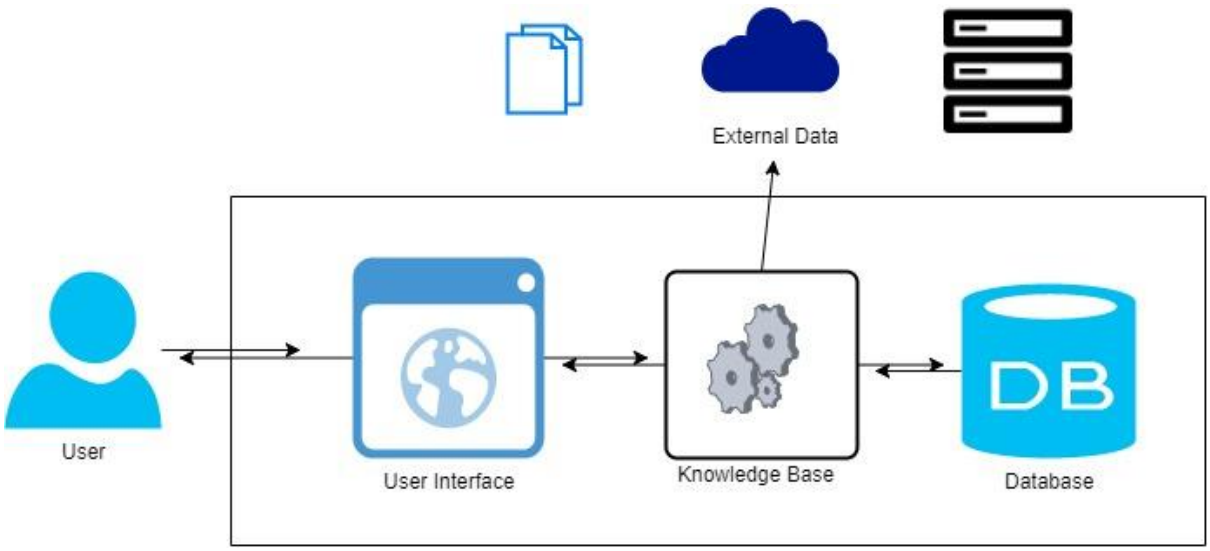

Figure 6.4: System architecture of a CADS system

Database: The database will contain all the information and data required to perform the decision analysis.

Knowledge base: The knowledge base will consist of methods and models required for performing decision analysis. This will also include documents and access to external data through internet.

User interface: The user interface will handle all input and output communication between the decision maker and the DSS. A prototypical implementation of a DSS based on CMDSF

is discussed in this section. A home page of the prototypical implementation is shown in the figure 5.

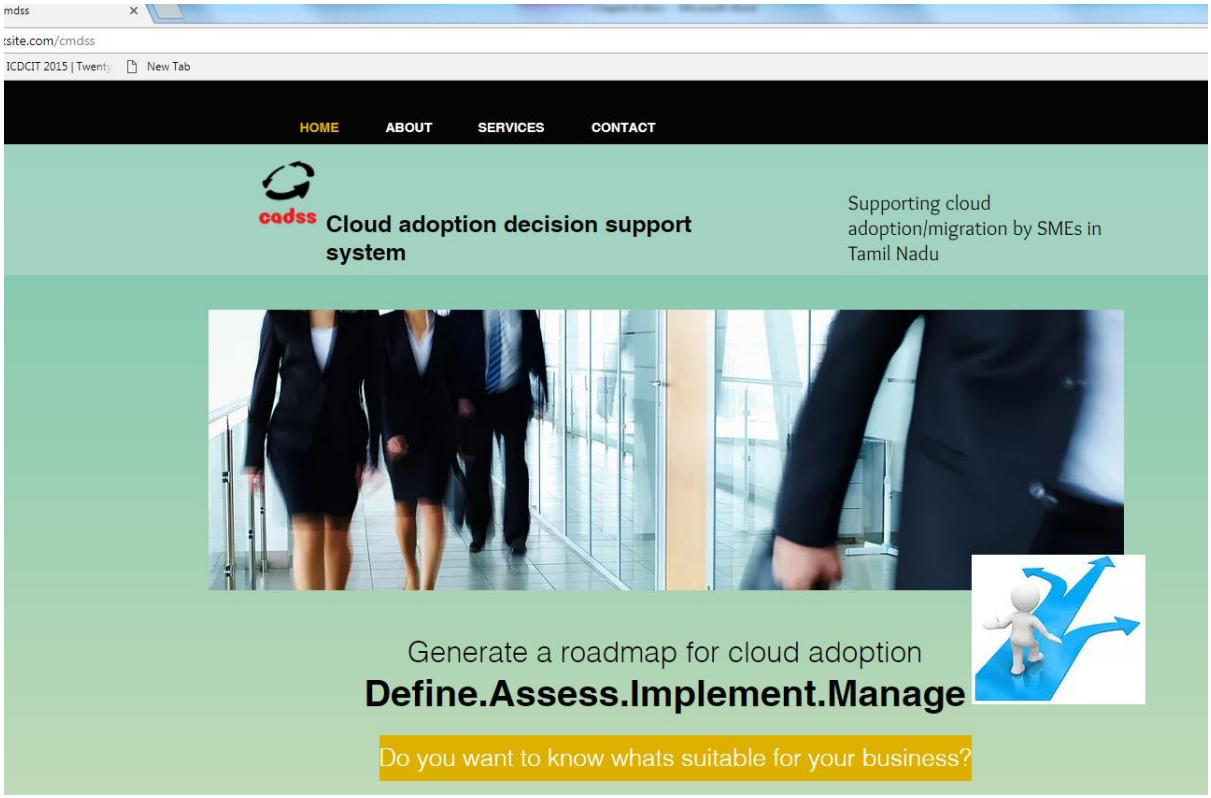

Figure 6.5: Home page of the cloud adoption decision support system (CADSS)

6.5.1 What does the decision maker need to know?

Figure 6.5 shows the home page of the proposed CADSS. The first stage of cloud adoption process is the Define stage (Figure 6.6). To plan a successful migration, decision maker needs to know information about the business requirements and have basic knowledge cloud computing infrastructure (Radich et.al 2012). The following are some of the information which a decision maker needs to know to plan a migration,

- Cloud deployment models - (Public, Private and Hybrid cloud).
- Service delivery models - (SaaS, PaaS and IaaS).
- Current System Architecture (Distributed, centeralised or localised etc.).
- Workload requirements (CPU, memory, storage etc.).

- Bandwidth and Latency.
- Organisation size (Number of users, servers, sites or units involved etc.).
- Operational Cost (Annual budget spent on Software maintenance, implementation, upgradation).
- End-user or business- user requirements.
- Security, Privacy and Compliance requirements in India (compliance to regulatory bodies like TRAI, FSSAI, IRDA etc.).

The home page gives a general overview of the cloud adoption decision support framework. Figure 6.6, shows the checklist presented to the decision maker as part of the define phase. As discussed in the previous section, no evaluation is carried out in this phase.

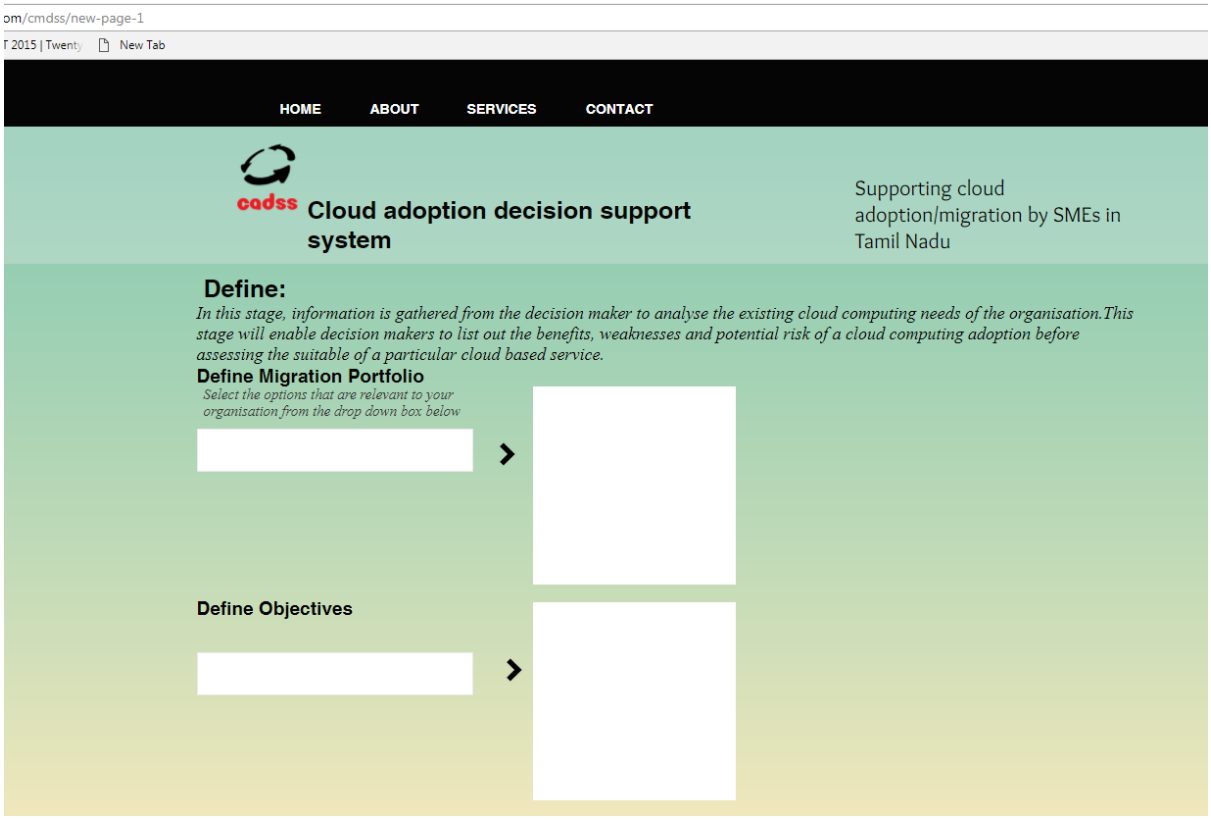

Figure 6.6: Representation of the design phase

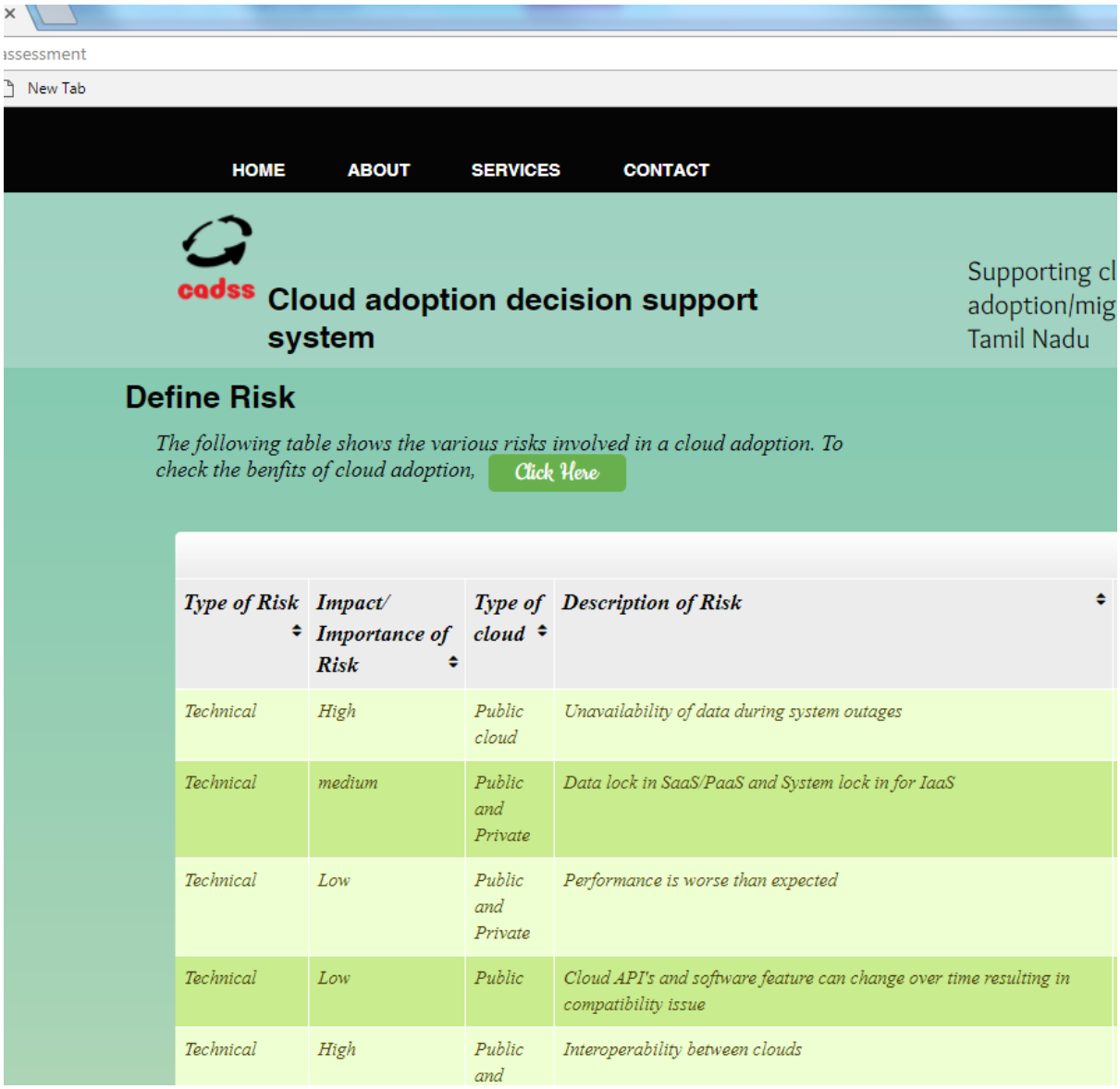

Figure 6.7: Risk identification (define phase)

6.5.2 Whether cloud is suitable for the business?

The first tool is the cloud suitability assessment tool which can be used to determine the suitability of cloud infrastructure for the identified target application. The proposed cloud suitability assessment is a questionnaire based tool and uses simple additive weighting (SAW) to calculate the suitability of a particular application or workload for a cloud infrastructure. Figure 6.8 shows the tools proposed in the second phase of the cloud migration

process. Figure 6.9 shows the cloud suitability assessment with assessment questions for the organisational readiness category.

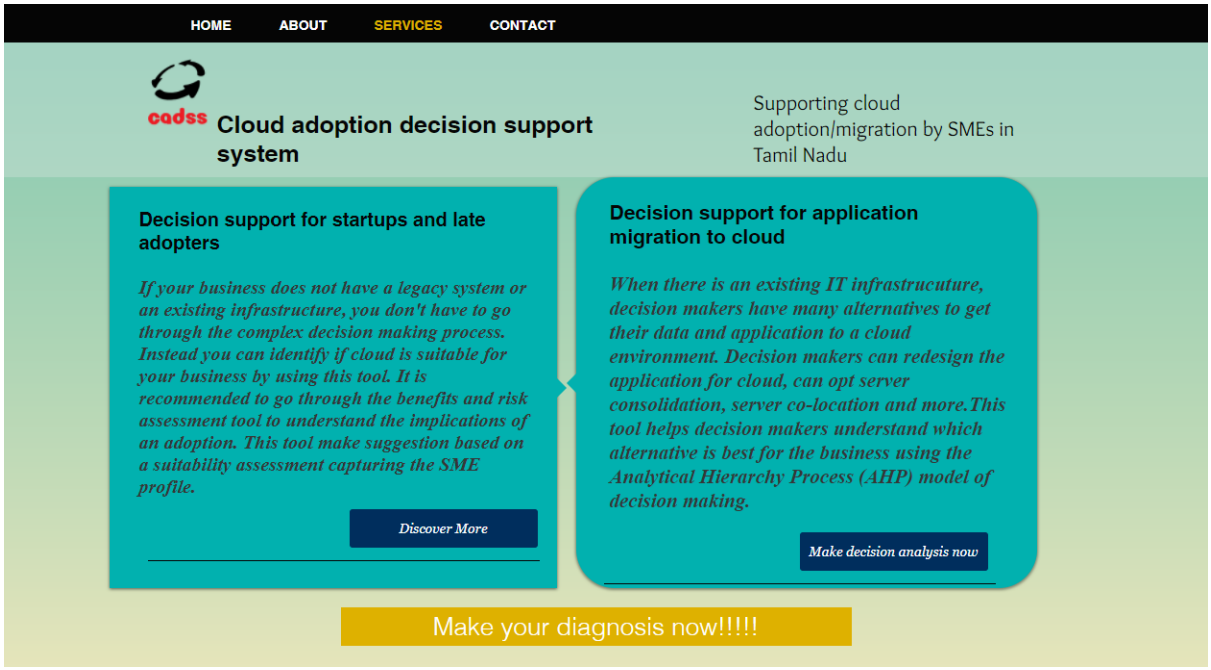

Figure 6.8: Page showing the two tools to support cloud adoption decision making

Once the decision maker completes the questionnaire, the cloud suitability report is presented to the decision maker. Figure 6.10 shows a sample cloud suitability report. Recommendations will be provided for each assessment criterion to improve the cloud suitability scores (figure 6.11). User has the option to view the cloud suitability scores in the form of graph and charts. Once a case is completed, it is added to the database to provide comparison of similar cases.

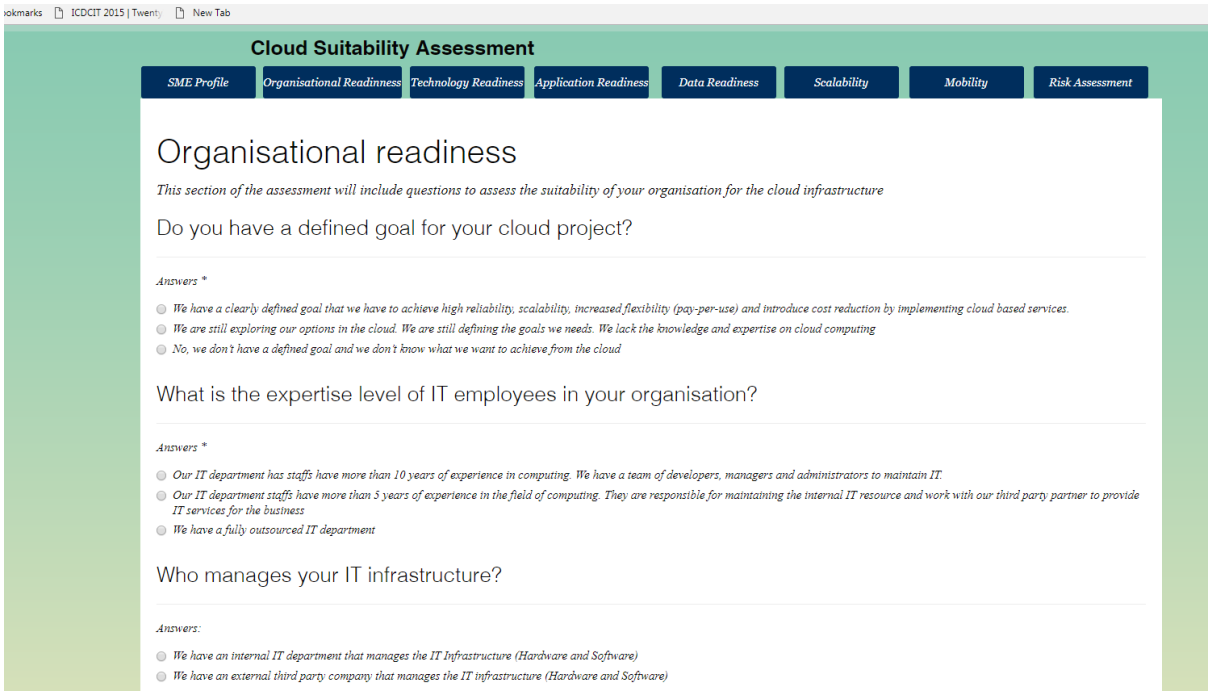

Figure 6.9: Cloud suitability assessment page 1

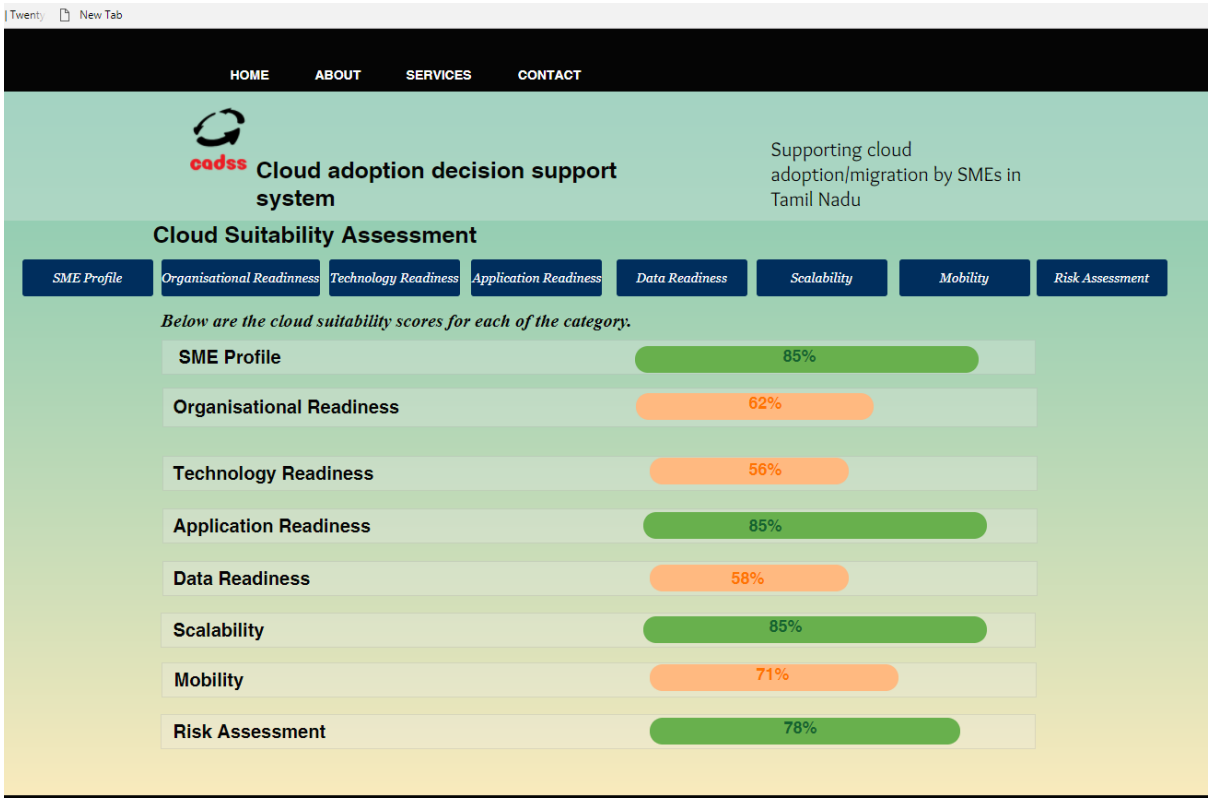

Figure 6.10: Cloud suitability assessment page 2

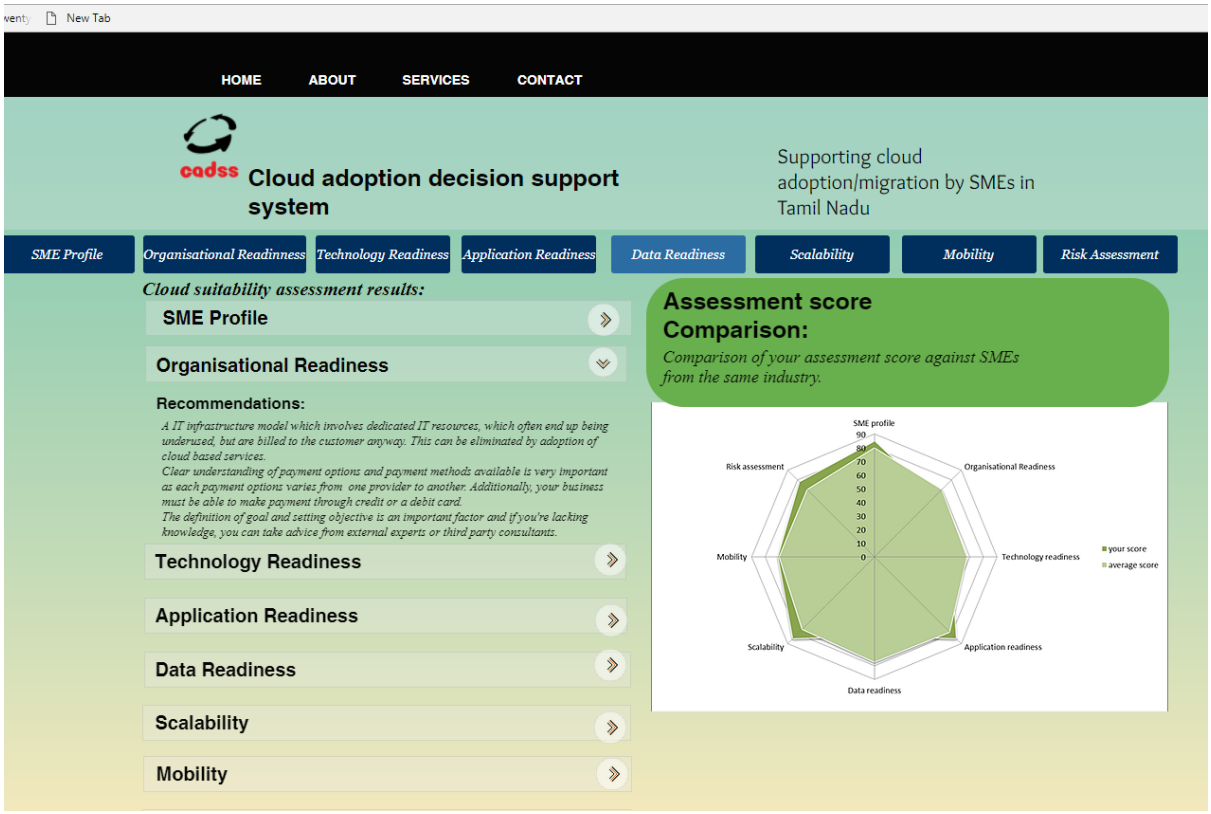

Figure 6.11: Cloud suitability assessment report

6.5.3 Where does the application belong? Public, Private or Hybrid cloud

The cloud deployment model (Public, Private or Hybrid) can be determined through the data sensitivity, regulatory requirement, data center and colocation preferences indicated by the user in the cloud suitability assessment. If the data is not sensitive and not regulated by any government bodies then Public cloud can be suggested. If data handled is sensitive, a Private cloud deployment would be the suitable model for the user. In instances where the amount of data handled is very high, a hybrid model can be suggested based on the sensitivity of the data.

6.5.4 What type of cloud based service to use?

The next stage of cloud adoption process involves pairwise comparison of the criterion to identify the best alternative. To simplify the process, decision maker is allowed to choose only the alternatives they want to compare. Figure 6.12 shows a sample comparison.

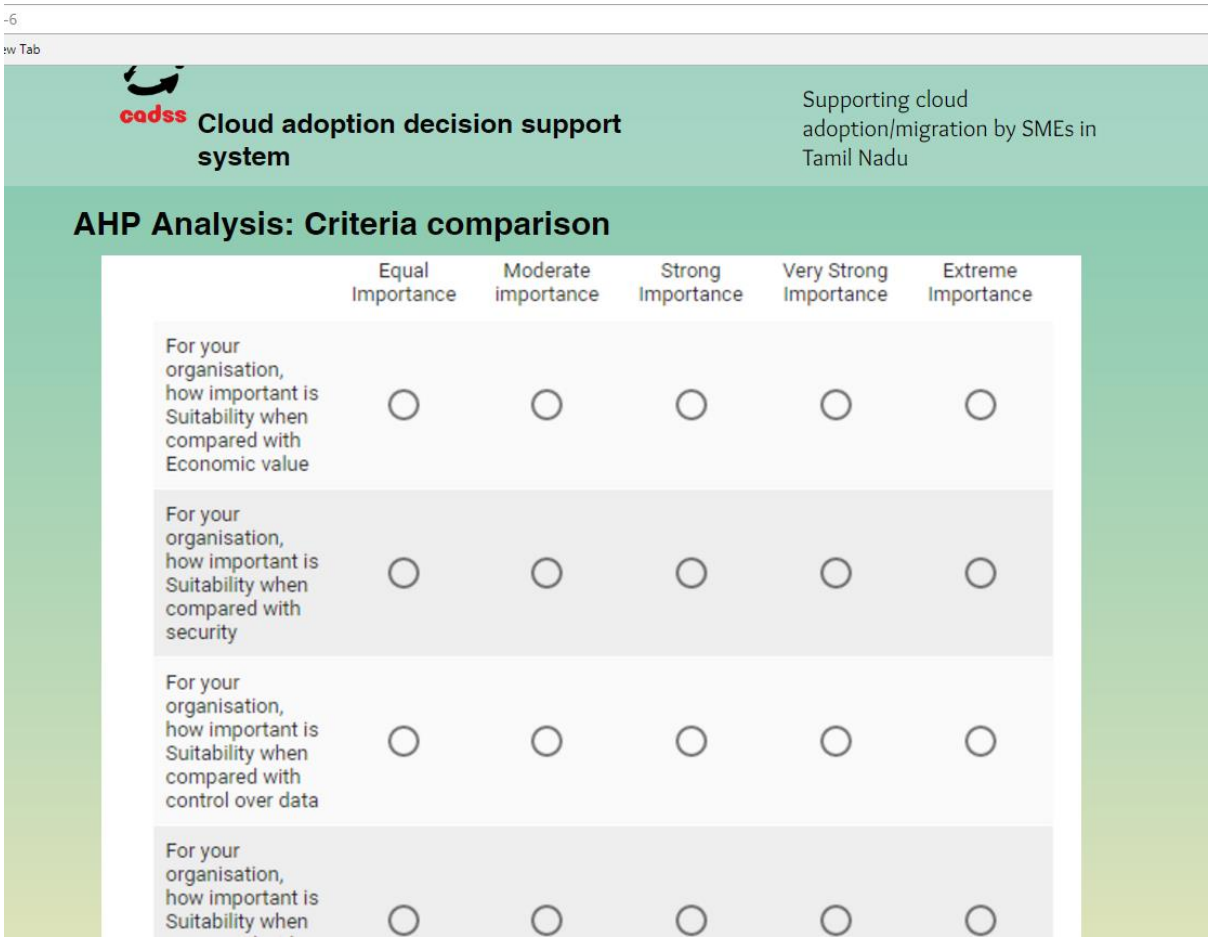

Figure 6.12: AHP analysis

6.5.5 Ranking of Cloud vendors: (Buyya et.al 2013)

Suggesting a suitable cloud vendor should be based on the vendor selection criteria (SMI cloud) by (Buyya et.al 2013):

Suitability: According to (Buyya et.al 2013) suitability of a cloud service can be defined as the degree to which a customer's requirements are met by the cloud provider. In the context of SaaS applications, suitability can be identified by the following formula.

Suitability = (No of services required by the cloud customer)/(No of services offered by the vendor).

The ranking can be based on the provider with the maximum suitability score. Some cloud vendor's offers wide variety of software applications. Instead of using different vendors for each department, using the same vendor will reduce portability and integration issues.

Reputation: Reputation in general can be defined as "the beliefs or opinions that are generally held about someone or something". Reputation of a particular cloud provider can be identified by the number of years in business and the number of paying customer the organisation has.

Performance: While suggesting a SaaS provider, performance can be measured based on the availability of services guaranteed by the vendor on their SLA.

Cost: For SaaS providers, subscription costs are paid either monthly, quarterly or annually. Some user may not want to enter into a long term commitment with the cloud vendor. Therefore payment options and contractual obligations will also be key ranking criteria while ranking cloud providers.

Agility: Decision makers will need to know how long it will take to get the application deployed and ready to use. Free trial options, customisation tools and support tools will be the factors for this criterion.

Figure 13 shows a sample vendor selection page. User rating is added as criteria in addition to the above mentioned criteria.

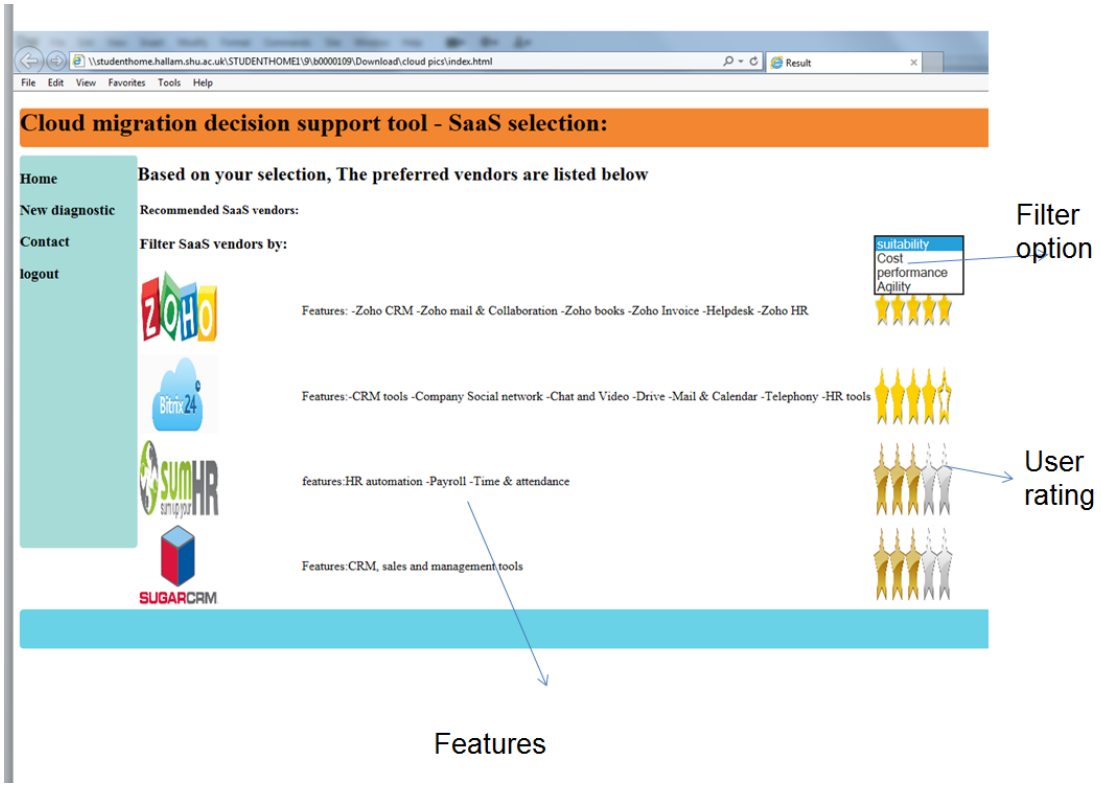

Figure 6.13: Results page

6.8 Conclusion:

In this chapter, we have presented our proposed framework to support cloud adoption decision making by SMEs in Tamil Nadu. We have discussed the existing research and frameworks on cloud adoption and have identified the research gap. To fill the gap, we have proposed the CADS framework through the findings of the primary and secondary research. The proposed CADS framework is based on the SDM method (Pearce and Bull 2016). The four steps of the CADSF are Define, Assess, Implement and Manage. We have used AHP to provide decision in identifying a suitable cloud service for implementation. The following chapter provides conclusion for the thesis highlighting the contribution of the research and identifying future areas of research in cloud adoption.

Chapter 7: Conclusion and Future work

7.1 Introduction:

The main aim of this research was to explore, investigate and develop a framework to support cloud adoption decision making for SMEs in Tamil Nadu. The findings of the research study validate the research strategy adopted to answer the research objective. This chapter starts with an overall summary of research, highlighting research question and objectives that were set in Chapter 1. This chapter also discusses the theoretical and practical contribution of the research to the growing body of knowledge on cloud computing adoption focusing on the SME sector. Finally, this chapter concludes by discussing the limitations of the research and identifying areas for future research in this field.

7.2 Research Summary:

As discussed in chapter 1, cloud computing represents a paradigm shift in the way computing resources like hardware, storage and servers are purchased and maintained. Cloud computing is considered as a technology innovation which has all the features and facilities to transform computing into a utility like gas, electricity and water. Due to the benefits of cloud computing infrastructure like less capital investment on the IT infrastructure and access to highly scalable technologies, cloud computing can improve the level of IT adoption among SMEs in developing countries. Despite the potential technical and economic benefits of adopting cloud infrastructure, the level of adoption is less when compared to developed countries. SME sector is considered as the backbone of a country's economy. In India, 40% of the total workforce is employed by the SME sector (Devika 2015). Traditionally, the level of IT adoption among Indian SME sector is very low when compared to other developed countries. Issues like lack of capital, lack of expertise, lack of skilled labor are some of the issues that are cited as main issues for less adoption level of IT in any business (Intuit 2013).

Innovations in IT among SMEs have proved to improve their productivity and competitiveness and enable SMEs to compete with larger enterprises (Alshamaila 2013). This makes cloud computing as a perfect candidate for SMEs in India. To leverage the full potential of cloud computing, it is essential to investigate the issues, challenges and other critical factors that affect cloud adoption. This remains the major motivation of this research study. This research is focused on SMEs in Tamil Nadu, a southern state of the Indian Union.

Literature review in Chapter 2 revealed that there are several empirical studies and practical research carried in the specific field of cloud computing adoption. Empirical studies like have investigated factor that influence cloud adoption for different geographical location. There are also several frameworks available to support different stages of cloud adoption process. We identified a total of 103 journal articles and conference papers on cloud adoption focused on the SME sector. Only a few attempts have been made to develop a framework to support the whole cloud adoption process. We also identified that there are no empirical studies previously done to investigate a technology adoption focusing on the SME sector in Tamil Nadu. Therefore, to achieve the research objective it became important to theoretically investigate the cloud computing adoption by SMEs in Tamil Nadu.

In order to investigate the factors that influence cloud adoption and to develop a framework to support cloud adoption decision making, the research was divided into two parts. The first part of the study aimed to identify the determinants of cloud adoption for SMEs in Tamil Nadu. The second part of the study aimed to incorporate the findings of the first part of the study and develop a framework to support cloud adoption decision making process. The theoretical foundations of this research are discussed in Chapter 3. TAM, UTAUT, DOI and TOE are some of the theories to study diffusion and adoption of a technology at individual and organisation level. Though there are no theories developed

specifically for SMEs, through literature review we were able to identify that several empirical studies investigating cloud adoption have employed TOE and DOI. Therefore, a conceptual framework integrating TOE and DOI was developed. The framework included 9 decision factors that are relevant for SMEs in Tamil Nadu. The hypotheses developed based on TOE-DOI were tested to identify the relationship of factors to cloud adoption. For the second part of the study, we have used the scientific method of decision making to develop the framework. The theoretical background of human decision making is discussed in Chapter 3. We have discussed the various MCDM methods and appropriate justification is given for choosing AHP to support cloud adoption decision support.

To conduct this research, a mixed methods approach with a pragmatic research viewpoint was used to approach the research problem. The research methodology adopted is discussed in Chapter 4. The research progressed in three stages. During the first stage (Exploratory phase), semi-structured interviews and a preliminary survey was conducted to identify the perception, enablers and barriers of cloud computing by decision makers from SMEs in Tamil Nadu. To test the TOE-DOI model developed in Chapter 3, empirical data was planned to be collected using a web based questionnaire through google forms. The questionnaire was sent to decision makers from SMEs in Tamil Nadu. IBM's SPSS was used to analyse the quantitative data.

The link to the questionnaire was sent to 630 SME contacts and a total of 98 responses were received. Out of the 98 responses, 83 were identified as valid after screening for valid responses. The Cronbach's alpha was identified for each item of the research factors to understand the reliability of the statistics. All of the research factors had good reliability measures. Multicollinearity and VIF were examined to identify the validity of the measures. The hypotheses developed in Chapter 3 were tested using logistic regression. 6 cloud

adoption decision factors were found to have statistically positive impact on cloud adoption. 3 hypotheses were rejected as they were not statistically significant.

The factors identified were incorporated and a framework was developed based on the scientific method to support cloud adoption decision making process. The steps and tasks involved in cloud adoption were identified from literature review and issues specific to Tamil Nadu were identified from our primary research. A case study was employed to test the usefulness of AHP to support cloud adoption problem.

7.3 Research contributions:

To the best of our knowledge, this study is the first attempt to explore and investigate the adoption of cloud computing among SME decision makers from Tamil Nadu. The contribution of this research to the growing body of knowledge on cloud adoption is discussed in this section,

7.3.1 Methodological contributions:

This research makes important methodological contribution to existing knowledge on cloud adoption. The major methodological contribution is the three-stage research approach designed to approach the research objectives. Even though, this research methodology was developed specifically for SMEs in Tamil Nadu, this model can be modified according to the geographical location and can be used to investigate technology innovation for any developing economies.

7.3.2 Theoretical contributions:

The research makes two important theoretical contributions. Firstly, this research makes theoretical contribution by extending the current understanding of cloud computing adoption among SMEs in Tamil Nadu. The TOE-DOI conceptual framework build based on the existing literature was applied to the SME sector in Tamil Nadu to identify the factors that

influence the adoption of cloud computing infrastructure. During the initial exploratory phase, participants were considered as case representative of the type of SME. The main survey did not have any special cases and SMEs from all types of industry were invited to take part in the survey. The empirical investigation identified 6 independent variables that were statistically significant and having a positive impact on cloud adoption.

The second important contribution is the framework developed to support cloud adoption decision making by SMEs in Tamil Nadu. The literature review revealed a comprehensive framework covering whole migration process was not available. The framework developed was based on the scientific model of decision making process by. We adopted this model due to the suitability of the scientific model to the steps involved in cloud migration. The framework has four phases; Define, Assess, Implement and Revise. The two tools developed for the Assess phase (cloud suitability assessment and cloud service identification) are unique contributions built specifically for SMEs in Tamil Nadu based on the existing frameworks identified from our literature review.

7.3.3 Practical contributions:

This research also has important practical implications for decision makers and cloud service providers. From a cloud service provider's perspective, the empirical investigation will provide a clear understanding of the issues related to cloud adoption for SMEs in Tamil Nadu. The results of the study indicated that lack of awareness of the benefits of cloud adoption, lack of understanding of the payment models, lack of expertise as some of the major barrier for cloud adoption in Tamil Nadu. SME decision makers also highlighted that the products and services available are not designed specifically, for the Indian market. Cloud service providers can choose an effective marketing strategy to create awareness of the benefits of cloud adoption and cloud infrastructure. If these issues are addressed by cloud

service providers, it will have a positive impact on the level of cloud adoption among SMEs in Tamil Nadu.

The study also identified lack of clarity or understanding on the legal implication of cloud adoption. The state government can address this issue by creating awareness, policies and legal framework to support cloud adoption for SMEs in Tamil Nadu through the SISI (small industries services institute).

From a decision makers perspective, the framework developed can help decision makers make decisions regarding cloud adoption effectively. This research also has practical implications for researchers in the field of cloud computing. As discussed in the previous two sections, the methodological and theoretical contribution can be modified to extend the current understanding of cloud adoption. The future avenues of research in cloud adoption are discussed in section 7.5.

7.4 Personal Reflection:

The initial stage of the PhD journey was very exciting. The most important challenge during the initial preliminary stage was to narrow the domain of the research and focus its aims and objectives. The original aim of the research was focused on developing a DSS for SMEs in India. This became less of a focus as the project progressed. During the literature review, it became apparent that cloud migration cannot be completed based on considering the technical aspects alone. Cloud adoption brings both technological and organisational changes to SMEs. Along with technical issues like infrastructure availability (reliable and affordable internet availability), security issues and vendor lock-in, the findings also identified specific organisational factors related to SMEs in Tamil Nadu. For example: innovativeness, competitiveness and positive attitude towards technology adoption were identified as major factors that influenced cloud adoption. The organisational factors are very

influential and need to be included in any framework for cloud adoption. As a result, the original domain of the research was further focused to SMEs in a specific region i.e. Tamil Nadu instead of the whole of the Indian Union so these organisational factors could be effectively investigated.

The evolving nature of cloud environment was another challenge as the researcher had to constantly update the literature review for the work to include recent trends in the field. Lack of experience in conducting qualitative interviews was a further challenge that needed to be overcome. One of the limitations of findings of this research is the smaller sample employed for the semi-structured interviews in comparison to the main survey. In terms of methodology, a larger sample would have helped us to be more confident with the findings about the status of cloud adoption among SMEs in Tamil Nadu. On reflections and given more time, more interviews with the SME decision makers and cloud service providers would have been useful and would have consolidated the findings especially on the organisational issues.

The literature review and the data collection stages were successful, and two IEEE conference papers were written and then published based on the findings. This helped to focus the work and gain confidence to move to the later stages of the research. From the beginning, the supervisory team and the researcher had a plan regarding facilitating the writing up stage of the PhD. This was through writing papers and attending conferences. This proved as a very useful strategy as the five conferences attended during the PhD has to a great extent influenced the writing of the thesis in a major way.

7.5 Future Research:

There are several avenues of research that can be pursued based on the findings presented in this thesis:

The framework developed in this thesis can serve as a starting point for the development of a cloud adoption decision support system. A technical implementation of the framework will automate the cloud adoption decision making process and reduce the workload of the decision makers while making decision regarding cloud adoption.

A second line of research, arise from the findings of the web-based survey. The survey identified the determinant factors of cloud adoption for SME in Tamil Nadu. The determinants are relevant for studies focusing on developing DSS/tools/frameworks for each of the cloud service delivery models (IaaS, PaaS or SaaS). With recent developments in internet infrastructure, SMEs have begun to increasingly use SaaS application offered by various cloud providers. This is evident based on the success of cloud computing-based companies like Zoho in India (Chandrasekhar 2018). The innovative SMEs are adopting different types of SaaS products to support various areas of their businesses. The findings of the survey can serve as a starting point for research focussing on selection of a suitable SaaS service for SMEs in a technologically developing region like Tamil Nadu.

Finally, this research can be further enhanced by employing a longitudinal research design and examining quantitative data collected over a period of time with a larger sample. As cloud computing is constantly evolving, a longitudinal research design will suit the research objective and help in obtaining more accurate results. By employing a longitudinal research design, the research can help management researchers identify diffusion and adoption of adoption of cloud adoption innovation in SME context.

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Appendix A

Classification of decision problems:

In the context of DSS, it is essential to identify the problems which require decision support. Some decision problem may be trivial and not require a systematic approach for decision making. In organisation, it does not make sense to establish systematic decision making approach for such problems. According to Bohamec (2009), decision problems can be classified into routine and non-routine problems based on frequency. Routine problems are instances which happen frequently and the decision maker will be familiar with the problem. Such decisions are usually easy. Non routine problems are problems which are very rare and may involve risks as the decision maker will be unfamiliar with the problem. In decision science literature, different classification exists based on nature, number of criteria and uncertainty of the decision problem.

Decision problems based on the number of criteria, takes the number of criteria into account when assessing alternatives (Pohekar and Ramachandran 2004). There are two types of decision problem under this category namely; Single criteria and multi criteria. Single criteria or single attribute as the name suggests considers only one attribute while making a decision. In organisation, decision problems have evolved from single criteria (cost or profit)

and have many attributes to consider while making a management decision. Therefore, most real life decision problems do not fit into single attribute problem.

At organisation level, the very important classification of decision problem is based on the nature of the decision to be made and the scope of the decision itself (Bohamec 2009). There are three types of decision problems in this category. They are structured, semi-structured and unstructured.

Structured decisions:

These are problems for which a well-defined procedure exists. In the case of structured decision problems all inputs, outputs and internal procedures are known to the decision maker. Example of such type of problems is routine problems like loan assessment in a bank for which a decision can be made by an individual by following the existing procedures. In the context of DSS, structured problems can be easily programmed as the information about the decision problem is known to the decision maker.

Semi-structured decisions:

Semi-structured or ill structured decisions problems are the most common type of problems which decision makers face in organisation. In this type, the decision problem may not be completely structured. Therefore, decision maker may know partial information about the problem. Adopting a new technology like cloud computing is a semi structured decision problem. (Bohanec 2009)

Unstructured decisions:

Unstructured decision problems are decision problems which are completely unstructured. The procedures and processes to approach such problems may not be known to the decision maker and therefore cannot be programmed into a computer program to provide decision support. This may be because the decision problem may be new, complex or rare. (Bohanec 2009)

As mentioned earlier, these three classifications of decision problems is very important and all organisational decisions fall in one of the three categories. Therefore, it affects different level of management in an organisation. The classification of the decision problem based on the level of management the decision problem impact is listed below.

Strategic decision:

This type of decision affects the whole organisation. This type of decision is usually made by the top level management. Most of the real life strategic decision that top level managers face are unstructured or semi-structured. Common examples of strategic decision are introducing new product or service and entering new market. Strategic decision usually results in organisational change and therefore decision makers must be prepared to manage change. (Bohanec 2009)

Tactical decision:

This type of decisions affects part of the business for a limited time. These decisions are made by middle managers and takes places as part of implementing a strategic decision to become successful. Examples of tactical decisions are recruiting new staffs to cover skill shortage to implement a new technology innovation. (Bohanec 2009)

Operational decision:

These are the type of decision which has very limited input for a short period of time. It does not affect any part of the organisation and does not involve any risks. Operational decisions are made by low level managers. Usually operational decisions are structured. Figure 3 shows the link between the classification of decision problems based on scope of management and nature of the problem.

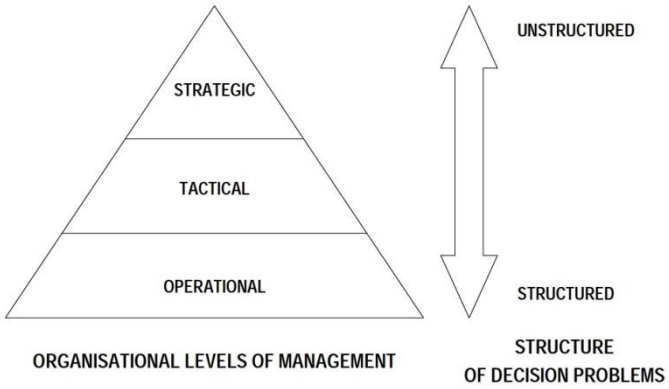

Figure 3: Relationship between decision problems based on scope and nature (Bohanec 2009)

The last classification of the decision problem is based on the uncertainty of the problem. Uncertainty refers to the state of limited knowledge or information so that something is unknown or is not perfectly known. Uncertainty in making a decision can occur if there are external factors that affect or influence the decision. Based on uncertainty the decision problems can be classified into decisions under certainty, decisions with risk and decisions with strict uncertainty.

APPENDIX B

PARTICIPANT INFORMATION SHEET

Project Title:

A decision support system for cloud migration for SMEs in Tamil Nadu

I would like to invite you to take part in my research project. Your participation is voluntary and choosing not to participate will not disadvantage you in any way. There is no foreseeable risk in taking part in this research study. Please read the below details carefully and do not hesitate to ask any questions or further clarifications.

Research background

The level of technology adoption and innovation among SMEs has increased in recent years and cloud computing has evolved from being a buzz word into being adopted by organisations according to their business needs. Current cloud adoption trend reveals that

cost, scalability, reliability and ease of use are the main reason for deciding to move data and application to a cloud environment. Recent research in the field computing suggests that issues like Data security, Broadband availability, interoperability and portability are the major barriers for adoption of cloud computing in India. This study aims to investigate and analyse the major factors that affect the cloud adoption decisions for SMEs in Tamil Nadu.

The purpose of this study is to answer to the following two main research questions:

1. What are the issues, challenges and other critical factors involved in migrating to a cloud environment specific for SMEs in India?

2. How can we develop and evaluate a Decision support system for cloud migration to advise SMEs in Tamil Nadu?

Why you have been asked to take part?

As someone who has been working in IT or Management with significant experience, your experience and input will be valuable to determine the outcome of the study

What will I be required to do?

You will take part in a semi-structured interview where some questions will be asked relating to cloud adoption in India and in particular to Tamil Nadu. You will share yours experiences, views and knowledge to help my study. The interview will be recorded or videotaped for the purpose of analysis

How often will I have to take part?

You will take part in an initial interview which will be followed by a follow up interview in which you will test my prototype

Who will have access to the data?

The data collected will be securely maintained in a password protected computer at Sheffield Hallam University and will be accessible only to me and my supervisory team.

What will happen to the information when this study is over?

The raw data collected will be destroyed once the study is complete. The tentative completion date for this research project is September 2017.

How will you use what you find out?

After data analysis, details will be anonymised and the results from the analysis may be used for journals, conferences or seminars. Neither the name of the company or the individual will be reported in my thesis

What if I do not wish to take part and change my mind?

Your participation is voluntary and you are free to withdraw from the study as specified in the information sheet

What are possible benefits of taking part?

Whilst there may not be any immediate commercial benefit, upon completion of this research my findings could help your business

Who has reviewed the study?

This research study has been approved by the Research Degree Sub-Committee at Sheffield Hallam University

Please Note: The research work, research based articles and any email correspondence between yourself and the research is strictly confidential

Who should I contact if I have any questions?

Should you have any questions, you can contact me directly, Berlin Mano Robert Wilson at Unit 12, Science Park, Sheffield Hallam University, City Campus, Sheffield S1 1WB, United Kingdom

APPENDIX C

Questionnaire survey

Cloud computing survey

Participation Information Sheet

The purpose of this questionnaire is to understand the decision factors that affects the adoption of cloud computing among SMEs in Tamil Nadu. The results of this questionnaire will help us understand the major factors, decision makers needs to be aware of while migrating to a cloud environment. The results will be used to develop a decision support system for cloud migration for SMEs in Tamil Nadu.

Brief Introduction to cloud computing:

In a traditional IT environment, Computational resources (e.g.: Networks, servers, storage, applications) will be maintained on premise by organisations. Cloud computing offers an alternative to the traditional IT environment by offering these resources in the form of services which are offered through third party cloud service providers (e.g. Amazon, Google, and Microsoft). This directly eliminates the need to purchase, install and maintain expensive IT infrastructure.

There are four Cloud deployment models; Private, Community, Public and Hybrid. Irrespective of the type of deployment model used, there are three types of cloud service delivery models; Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS)

Large enterprises build and maintain their own data centers which may not be their main area of expertise. This may result in inefficient date centers. Cloud computing eliminates this issue as cloud providers can provide computational resources like storage and network infrastructure as a service so enterprises whether manufacturing or service industry can focus on their core job.

Current cloud adoption trend reveals that cost, scalability, reliability and ease of use are the main reason for deciding to move data and application to a cloud environment. Recent research in the field computing suggests that issues like Data security, Broadband availability, interoperability and portability are the major barriers for adoption of cloud computing in India. This study aims to investigate and analyse the major factors that affect the cloud adoption decisions for SMEs in Tamil Nadu.

The purpose of this study is to answer the following main research questions:
1. What are the issues, challenges and other critical factors involved in migrating to a cloud environment specific for SMEs in Tamil Nadu?
2. How can we develop and evaluate a Decision support system for cloud migration to advise SMEs in Tamil Nadu?

About the survey:

Your participation will involve completing the survey which should take approximately 10-15 minutes. Your participation is voluntary and I assure you that complete confidentiality will be maintained. Only the answers of this survey will be collected and it will be stored in google drive provided by Sheffield Hallam university. The questionnaire is framed with an intention to identify the technological, organisational and environmental factors that affect cloud adoption among SMEs in Tamil Nadu.

As someone who has been working in IT or Management with significant experience, your experience and input will be valuable to determine the outcome of the study. The tentative completion date for this research project is September 2017. After data analysis, personal details (Eg: personal identity, company name) will be anonymised and the results from the analysis may be used for journals, conferences or seminars. Neither the name of the company or the individual will be reported in my thesis. Email address collected at the end of this section is only for validation purpose.The raw data collected will be destroyed once the study is complete.

This survey is a follow up to the initial survey conducted in July 2015. The results of the first survey has been published in a IEEE conference under the title "Enablers and Barriers of Cloud Adoption among Small and Medium Enterprises in Tamil Nadu". The result of this survey will help us determine the evolution of cloud computing among SMEs in Tamil Nadu in the last few years. The results will be used to develop a decision support system for cloud adoption for SMEs in Tamil Nadu. Whilst there may not be any immediate commercial benefit, upon completion of this research my findings could help your business understand the scope of cloud computing in India (in specific to Tamil Nadu).

There are no risks in agreeing to participate in this survey.If you have any questions about this research study, you can contact me directly.

I sincerely thank you for your cooperation in taking part in this survey

Berlin Mano Robert Wilson
Second year PhD student
Berlin.M.RobertWilson@student.shu.ac.uk
+447412539233

*Required

1. **Email address** *

Participant consent form

please read the following questions carefully and select appropriate answer (Answer to these questions are mandatory)

1. I have read the Information Sheet for this study and have had details of the study explained to me *

Mark only one oval.

- ◯ Yes
- ◯ No

2. I understand that I am free to withdraw from the study within the time limits outlined in the Information Sheet, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher *

Mark only one oval.

- ◯ Yes
- ◯ No

3. I agree to provide information to the researchers under the conditions of confidentiality set out in the Information Sheet *

Mark only one oval.

- ◯ Yes
- ◯ No

4. I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes *

Mark only one oval.

- ◯ Yes
- ◯ No

Phone number

Preferred contact method

Mark only one oval.

- ◯ Email
- ◯ Phone
- ◯ Prefer not to be contacted

Cloud computing survey

2.How many employees does your organisation have in total (approx)? *

Mark only one oval.

- ◯ 1. less than 50
- ◯ 2. 51- 100
- ◯ 3. 101-250
- ◯ 4. more than 250

3. How long your organisation has been in business? *

Mark only one oval.

- ◯ 1. less than 3 years
- ◯ 2. between 3-5 years
- ◯ 3. 5-10 years
- ◯ 4. more than 10 years

4. Please specify the primary industry your organisation belongs to: *

Mark only one oval.

- ◯ 1. Retail
- ◯ 2. Banking
- ◯ 3. Healthcare
- ◯ 4. Education
- ◯ 5. Information Technology (IT), Telecommunications and IT enabled services
- ◯ 6. Manufacturing
- ◯ 7. Media and Publishing Sector
- ◯ 8. Building & Construction Sector
- ◯ Cloud Service Provider
- ◯ Other: _____

5. What is your job role in your organisation? *

Mark only one oval.

- ◯ 1. Managing Director
- ◯ 2. Chief executive officer (CEO)
- ◯ 3. Chief Information Officer (CIO)
- ◯ Project Manager
- ◯ Team Leader
- ◯ Senior IT Executive
- ◯ Other: _____

Top management support for new innovation

6. Please rate the following statement on a scale of 1-5, My organisations Top management has a positive attitude towards the deployment of new IT innovation. *

(1. strongly disagree, 2.disagree, 3.neutral, 4.agree, 5. strongly agree)

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	strongly agree

7.Please rate the following statements (how likely) to indicate your organisations intention to adopt cloud computing. *

Mark only one oval per row.

	not at all	not really	neutral	somewhat likely	very much likely
1. My organisation intends to adopt cloud computing infrastructure	◯	◯	◯	◯	◯
2. It is likely that my organisation is taking steps to adopt cloud in the future	◯	◯	◯	◯	◯

8. Does your organisation use Google docs, dropbox or any similar cloud based services for your business (including any software as a service products). *

please specify the type and name of the service you use in the text box

Tick all that apply.

- ☐ Yes
- ☐ No
- ☐ Other: _____

Factors that affect cloud adoption

9. Which of the following is the major driver for adoption of cloud computing in your organisation? *

tick more than one as appropriate
Tick all that apply.

- [ ] Scalability
- [ ] Reliability
- [ ] Reduced Hardware costs
- [ ] Reduces software and licensing costs
- [ ] Agility and faster time to market
- [ ] Pay as you go model (Price models)
- [ ] Increased accessibility
- [ ] Other: _____

10. Do you think there will be any legal issues if you move your data to a third party cloud providers data center? *

Please type your answer (specifying the type of risk). please type N/A if you are not sure

_____

_____

_____

_____

_____

11.Please indicate the extent to which you are satisfied with the current data security regulations and level of security of the services offered by the cloud? *

(1. Very much, 2.Somewhat, 3. Neutral, 4. Not really, 5. Not at all)
Mark only one oval.

	1	2	3	4	5	
Very much	◯	◯	◯	◯	◯	Not at all

12. Does your organisation have to adhere to any data security regulations for the date you hold? *

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I don't Know what it is

13. What is the criteria for choosing a cloud provider? (or) How do you choose a cloud provider *

please rate on a scale of 1- 5 (based on the importance of the criteria)
Mark only one oval per row.

	Very unimportant	Unimportant	Neither important or Unimportant	Important	Very important	Don't Know
Cloud provider reputation						
Based on cloud benchmarks						
Based on data center location						
Based on the cost benefits (Cheapest option)						
Based on after sales IT support provided by the cloud provider						

14. Do you have experts in cloud computing within your organisation? *

Mark only one oval.

- Yes
- No
- Planning to employ a third party provider

15. On a scale of 1-5, please rate the following factors which can affect cloud adoption among SMEs in Tamil Nadu. *

1.very unlikely, 2. unlikely, 3. Neither, 4. likely, 5. very likely
Mark only one oval per row.

	Very unlikely	Unlikely	Neither	Likely	Very likely	Don't Know
Broadband availability and bandwidth costs						
Security issues						
Privacy concers						
Interoperability issues						
Vendor lock-in						
Lack of awareness and expertise						
Complex migration process						
Management resistance to change						

16.Does your organisation have high speed and reliable internet connection sufficient to support cloud based services. *

Mark only one oval.

- Yes
- No

17. Which solution do you see as the most suitable for an SME operating in Tamil Nadu, according to the Cloud Computing taxonomy? *

Mark only one oval.

- ◯ Public Cloud (owned and managed by an cloud provider)
- ◯ Private Cloud (owned and managed for a particular organisation)
- ◯ Hybrid Cloud (Combination of Public and Private cloud)
- ◯ Other: _____

18. Which of these types of cloud computing is your organisation currently using or most suited for your organisation? *

Mark only one oval.

- ◯ 1. Software as a Service; e.g. Exchange online, Business Productivity Online, Suite, CRM Online, Salesforce.com
- ◯ 2. Infrastructure as a Service; e.g.Private cloud, VMWare and Windows server
- ◯ 3. Platform as a Service; e.g. Windows Azure, Force.com, Google App Engine etc.
- ◯ Other: _____

19.Which of the following disaster recovery options is most suited for SMEs? *

Mark only one oval.

- ◯ Fully outsourced cloud provider disaster recovery
- ◯ A contingency plan based on internal resources (i.e. leveraging services/platform/infrastructure already in use before the Cloud)

20. Migrating to a cloud environment can have a number of benefits and disadvantages. Please rate the following statements between 1 - 5 based on its suitability for your business *

(1. strongly agree, 2.agree, 3.neutral, 4.disagree, 5. strongly disagree)

Mark only one oval per row.

	Strongly disagree	Disgree	Neutral	Agree	Strongly agree	Don't Know
1. Migrating to a cloud infrastructure will Increase Scalability and flexibility						
2. Cloud Infrastructure can reduce costs (IT, server, network etc)						
3. Cloud infrastructure can increase reliability of the application and increases productivity						
4. Migrating to a cloud environment minimises software licensing costs						
5. System downtimes are reduced by migrating to cloud environment						
6. Migrating data and application to a cloud environment is complex						
7. There are security concerns for my data in the cloud						
8. Cloud infrastructure is dependent on internet and the performance of our system can be affected because of this factor						
9. We are unsure of the technology yet and our employees might need to be upskilled to make use of the services offered by cloud providers						
10. We might be locked to a particular provider due to interoperability issues						

21. The above question was around the benefits and disadvantages of cloud computing. considering the statements on the above question what benefit of cloud computing is important driver for adoption of cloud computing among SMEs in Tamil Nadu *

(Tick more than one if applicable)

Tick all that apply.

- [ ] Scalability
- [ ] Reduced Hardware costs
- [ ] Fast to market (Agility)
- [ ] Reduced software costs
- [ ] Pay per Use model

22.Please indicate how much you agree or disagree to the following statements *

(1. strongly agree, 2.agree, 3.neutral, 4.disagree, 5. strongly disagree)

Mark only one oval per row.

	Strongly disagree	disgree	Neutral	Agree	Strongly agree	Don't Know
1. Cloud computing is compatible with my organisations IT infrastructure and business strategy	◯	◯	◯	◯	◯	◯
2. Cost of high bandwidth and availability of internet will be an issue for my organisations decision to adopt to cloud	◯	◯	◯	◯	◯	◯
The attitude towards cloud computing adoption is generally positive and favourable in my organisation	◯	◯	◯	◯	◯	◯
4. Our organisation has the required expertise to plan and go ahead with the cloud computing adoption (Eg: Migration strategy, choice of cloud provider, choice of target application)	◯	◯	◯	◯	◯	◯
5. Interoperability and portability issues might require our systems to be redesigned or redeveloped to be deployed in the cloud	◯	◯	◯	◯	◯	◯
6. I am satisfied with the security features provided by the cloud provider	◯	◯	◯	◯	◯	◯
7. Our main competitors have adopted to a cloud computing model	◯	◯	◯	◯	◯	◯
8. Our competitors who have adopted cloud computing appears to have benefitted greatly	◯	◯	◯	◯	◯	◯
9. Our competitors who have adopted cloud computing are favoured by our clients	◯	◯	◯	◯	◯	◯
10. There are government policies and guidelines to safeguard SMEs in instance of data security breach	◯	◯	◯	◯	◯	◯
11. Cloud computing enables us to outsource IT services and focus on core competencies	◯	◯	◯	◯	◯	◯

23. Has your organisation already adopted the use of cloud computing? *

you can consider your company has adopted cloud computing if 1. your company has conducted any market study or any business research in cloud 2. Planning on cloud adoption 3. company has made commitment to implement adoption in immediate future

Mark only one oval.

◯ Yes

◯ No *After the last question in this section, skip to question 37.*

24.If your organisation is intending to adopt cloud computing, how soon do you think your organisation will adopt? *

Mark only one oval.

- 1. Less than 6 months *Skip to question 37.*
- 2. 6-12 months *Skip to question 37.*
- 4. more than 18 months *Skip to question 37.*
- 5. no plans as yet to adopt *Skip to question 37.*
- 6. Already use atleast one cloud service *Skip to question 31.*

25. If you have already adopted the use of cloud computing, please indicate the percentage of your company's workload that are in Public cloud? *

(Please indicate your answer in whole number. For example: if 20% workloads are in public cloud, please mention 20 in the box). If you do not use public cloud on not sure, enter 0 in the box below

26. Please indicate the percentage of your company's workload that are in Private cloud? *

(Please indicate your answer in whole number. For example: if 20% workloads are in private cloud, please mention 20 in the box). If you do not use private cloud or not sure, enter 0 in the box below

27. Please indicate the percentage of your company's workload that are virtualised? *

(Please indicate your answer in whole number. For example: if 20% workloads are virtualised, please mention 20 in the box). If your workload are not virtualised not sure, enter 0 in the box below

28. What benefits is your company getting from cloud adoption. *

Mark only one oval per row.

	Already can see the benefit	Expect to get	Don't Know
Faster access to IT resources			
Scalability			
Business continuity			
Cost benefits			
Increased IT efficiency			

29. What challenges did you face while adopting cloud for your business.

(Tick more than one as appropriate)
Tick all that apply.

- [ ] Lack of expertise
- [ ] Security issues
- [ ] Governance and legal issues
- [ ] Managing multiple cloud vendors
- [ ] Performance issues after cloud adoption
- [ ] Don't Know

30. What tools are you using to manage your cloud infrastructure?

(Please write your response in the box below. If you are not sure of the cloud management tool used in your organisation, you can leave it blank)

31. According to you, What is the scope of cloud computing for SMEs in Tamil Nadu? Do you think there are particular issues needs to be addressed?

(please type your views (optional))

32. Will you be interested for a follow up survey to help this study.

Mark only one oval.

- ◯ Yes
- ◯ No *After the last question in this section, stop filling in this form.*

If yes, please leave your email address: