School of Information Systems

A New Sustainable Cloud Computing Model for the Higher Education Sector in China

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HRE2018-0290.

Signature: YUCHAO DUAN

Date: 08 October 2019

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Abstract

Cloud computing is a virtualized information technology computing environment in which the data and applications are hosted. Businesses and individuals can have access to shared virtual machines via the Internet. Traditionally, organizations have needed to acquire hardware and software to support and improve their business processes. Moreover, in order to maintain the information systems infrastructure, an organization needs an IT support team, thereby incurring further costs. One way to change this situation is to implement cloud computing, which provides benefits and value to different organizations. Cloud computing also has great potential in education. With the assistance of cloud computing, teachers and students can implement collaborative learning such as online document editing. Cloud computing can increase computing resource accessibility, and the availability and integrity of learning materials for students. Moreover, it relieves faculties of most of the burden associated with maintenance.

Cloud computing developed very quickly in China (S. Zhang, Zhang, Chen, & Huo, 2010). However, prior to adopting cloud computing, it is necessary to first set up a governance strategy. Governance involves the strategic task of establishing objectives, directions, limitations and accountability frameworks. Once cloud computing has been adopted, operations management is required to ensure that the system operates as planned. Moreover, sustainable green IT attracts more attention nowadays. Therefore, in order to achieve sustainable development, issues of governance, operations management and sustainability should all be considered when developing a cloud computing model. While other academic research has been valuable in certain areas of the current frameworks, there are many research gaps that offer opportunities for research on sustainable cloud computing. This study aims to develop propositions to explain the linkages among the different components identified in this research, and to create a cloud computing model that includes cloud computing governance, operations management, and sustainability.

The purpose of this study is to develop a new sustainable cloud computing model for the higher education sector in China using a mixed-method approach. This research adopts the deductive approach, moving from the general to the specific. This research begins with a comprehensive literature review in order to identify the research gap. Various literatures related to cloud computing, particularly regarding cloud government, cloud sustainability and cloud performance domains are examined. The outcome of the literature review is an initial sustainable cloud computing model. The second stage involves conducting interviews in order

to validate the initial model. Through direct interaction with participants, the reviewer obtained valuable qualitative data. NVivo (Version 11) was utilised in this phase for the purpose of thematic analysis. In total, 25 interviews were conducted with participants from three different universities in three cities. Each interview took approximately 30 minutes. The results from the analysis of the interview data were used as the basis for a refined model that included new or updated components. The final phase involved the analysis of data obtained via an online survey. The refined model has three main themes, with each theme having three to four factors. However, most of those main factors contain broad categories or sub-factors, so the scope of the refined model should be more specific. That is why the online survey was conducted. The online survey phase generated quantitative data and sufficient variables correlated to each main factor were tested. The purpose of the online survey was to improve the sustainable cloud computing model by attaching sub-factors to the model, which were extracted from the online survey data. In total, 557 valid responses were received and the online survey data was analysed using IBM SPSS Statistics 22. Potential sub-factors were tested using Exploratory Factor Analysis in order to create the final model, which is presented towards the end of this thesis.

The outcome of this research is a new sustainable cloud computing model which can be applied to universities in China. It is hoped that this model will enable Chinese universities or organizations to make a smooth transition to the cloud. For those universities that are already using the cloud technology, this model offers valuable information to help improve their current cloud implementation strategy. Moreover, organizations and universities in other countries could also adopt this cloud model with certain culture-appropriate modifications.

Publications

Duan, Yuchao. "Cloud Computing in Higher Education Sector for Sustainable Development". *International Association for Development of the Information Society* (2016).

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Chapter 1 Introduction

1.1 Introduction

This chapter provides the background information for this research by presenting the definition of cloud computing, service models and deployment models. In addition, the current usage of cloud computing in higher education in China will be discussed in Section 1.5 to reveal the purpose of this research. This chapter also states the research objectives and significance in Section 1.7 followed by the research methodology that will be utilised to achieve the research aims. The research flow in Section 1.11 provides a brief summary of each chapter.

1.2 Background

Nowadays, cloud computing is having a significant impact on the development of Information Technology (IT). Cloud computing is not just a technology concept, but also a new way of conducting electronic commerce (W. Wang, Rashid, & Chuang, 2011). Traditionally, organizations have needed to acquire hardware and software to support and improve their business processes. Moreover, in order to maintain the information systems infrastructure, an IT support team is required, incurring additional costs for the organization. The rapid development in innovation and technology has pressured organizations to keep up with the current and latest innovations. Organizations constantly invest money, time and resources in IT to remain competitive so that they can survive in the market (Fruhling & Digman, 2000).

One way to change this situation is to implement cloud computing, which provides benefits and values to different organizations. Normally, cloud users are attracted by the features offered by cloud computing, including but not limited to, improving IT resources with minimum start-up costs. Consequently, organizations are slowly reassessing their in-house IT infrastructure and beginning to utilize computing services available on the Internet to meet their operational requirements.

Cloud computing offers online computing resources that enable companies to manage an increased volume of work without affecting system performance. Moreover, cloud computing provides noteworthy computing capability. This will especially benefit small and medium-sized organizations, as the IT infrastructure investment will be affordable. Cloud computing will reduce the capital costs of the IT investment. With the cloud technology provided by the cloud vendor, organizations can obtain adequate computing resources and then increase or reduce their computing capacity to meet peak and fluctuating service demands while paying for the actual computing capacity used. Cloud computing will also lower IT operating costs. Corporations can rent additional server capacity rather than maintaining in-house servers. For instance, whenever the current application needs updating, cloud users do not need to consider installation or maintenance, as the cloud vendor will handle the upgrading. In addition, cloud computing can optimize IT infrastructure as it does not require hardware and software installation or maintenance, and cloud infrastructure offers fast access to computing services.

In the last decade, cloud computing is arguably one of the most significant technological shifts in terms of IT infrastructure (W. Wang et al., 2011). In recent years, cloud computing has turned into an inexpensive product that is affordable and accessible to many organizations and individual clients. These features have attracted numerous organizations. Regardless of an organization's size, the IT start-up cost is normally less than the traditional way because there is no need for an organization to purchase any software or hardware. There is not much management required, and organizations can achieve an increased level of robustness in terms of IT development and implementation in a cloud computing environment.

Cloud computing also has great potential in the education domain. By means of cloud computing, teachers and students can engage in collaborative learning and activities such as online document editing. Students can easily get access to a virtual computing lab using their laptops at home or workstations on campus (Chandra & Borah, 2012). Cloud computing increases the accessibility of computing resources, and the availability and integrity of learning materials for students. The burden of maintenance by the faculty will be lightened. Moreover, cloud computing enables faculties to create customized images for specific units, and to schedule the delivery of assignment instructions and learning materials.

In order to achieve sustainable development, reducing the carbon footprint in cloud data centres has become a significant issue. Major cloud vendors such as Microsoft, Google, Facebook and Amazon depend greatly on data centres to support their daily operations and the increasing computational and application services demands from their customers (Buyya & Gill, 2018). However, by running such large IT infrastructures, cloud computing has negatively affected sustainability due to its financial costs and carbon footprint. Cloud service providers are facing the challenge of sustainable energy economy because of the huge energy consumption by their datacentres. As indicated in Figure 1.1, the energy consumption by cloud datacentres is increasing regularly and is expected to reach 8000 Tera Watt hours (TWh) by 2030 (Buyya & Gill, 2018). In order to improve the energy efficiency of cloud datacentres, cloud assets such as cloud servers, storage, memory, networks, and cooling systems should be managed appropriately using energy-aware resource management techniques.

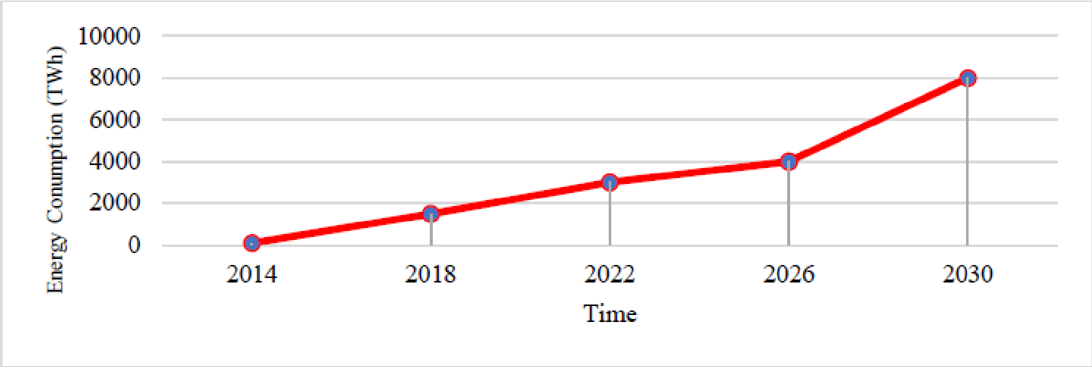


Figure 1. 1: Energy Consumption in Cloud Datacentres (Buyya & Gill, 2018)

Apart from the management of energy consumption, capacity management also plays a significant role in cloud computing implementation. The purpose of the capacity management process is to ensure that cost-justifiable IT capacity always exists and matches the current and future needs of the business (Sabharwal & Wali, 2013). One of the technical challenges of cloud computing is to effectively manage cloud capacity in response to the increased demand changes in clouds, as the usage rate of virtual machines keeps changing according to fluctuating requirements (Y. Jiang, Perng, Li, & Chang, 2012).

Data management is also crucial in cloud adoption. Accessibility of the cloud service should be available anytime. Moreover, cloud providers should have security and disaster recovery plans to ensure the safety of the data. Another concern is the location of the data. Cloud service providers could be in different countries and their datacentres could be anywhere in the world. Hence, some organizations have a strict rule requiring that the data, especially government data, be stored within the country's borders. Thus, it is essential to assure cloud users of this before cloud implementation.

Cloud computing enables businesses to implement IT infrastructures almost instantaneously, unlike traditional IT practices. This significant capability comes with its own set of issues regarding upgrading servers and software, etc. Thus, cloud computing demands meditation on the gap between policy and technology (Jaeger, Lin, & Grimes, 2008). The cloud governance should be taken into consideration before moving to the cloud. In this research, a set of factors in regard to cloud governance will be identified, along with performance management and sustainability concerns, to create the final sustainable cloud computing model.

1.3 Definition of cloud computing

Cloud computing is a virtualized information technology computing environment in which data and applications are hosted. Businesses and individuals can have access to shared virtual machines via the Internet. In other words, data and applications are stored and run in the 'cloud', rather than physically hosted within a use's organization. The characteristics of cloud computing include virtualization, dynamic distribution and extendibility (S. Zhang et al., 2010). A simple example of cloud computing usage in daily life is Google's popular email system – Gmail. When people use Gmail, the users are not actually hosting their own email server, but accessing the online server. Gmail is an example of a 'software as a service' cloud computing service model. In cloud computing, three types of cloud service models (infrastructure as a service, platform as a service and software as a service) can be deployed in four types of settings (private, community, public and hybrid clouds).

1.3.1 Service models

- Infrastructure as a service (IaaS): gives to cloud users access to hardware, storage, network capacity and other fundamental computing resources.
- Platform as a service (PaaS): gives cloud users access to basic operating software and services to develop and use software applications created by cloud users.
- Software as a service (SaaS): gives cloud users access to a provider's software applications.

Cloud computing is changing the implementation approaches of electronic commerce. There are many cloud suppliers that provide different types of cloud services to host various applications (W. Wang et al., 2011). Table 1.1 summarizes some of the most well-known cloud service providers.

Table 1.1. Major Cloud Services Providers (W. Wang et al., 2011)

	Service Type	Providers	Example
1	Infrastructure as a Service (IaaS)	Amazon Savvis GoGrid	Amazon Services Colocation hosting Cloud Hosting
2	Platform as a service (PaaS):	Google Microsoft Salesforce	Google Aps Azure Force.com
3	Software as a service (SaaS)	Salesforce.com	Sale Cloud

		Google NetSuite Apple	Google Docs NetSuite CRM+ iCloud

1.3.2 Deployment models

There are four different cloud deployment models, including private, community, public, and hybrid cloud. These different deployment models are named based on the locations of the cloud computing infrastructures.

- Private cloud: cloud uses will gain access via an intranet, hosted and used by a single enterprise internally;
- Community cloud: infrastructure accessible to a specific community (e.g. several organizations with common concerns); the infrastructure is hosted and managed internally or externally by a third-party company;
- Public cloud: cloud uses will get access via Internet, externally hosted and used by the public; and
- Hybrid cloud: a combination of two or more cloud models.

1.4 Cloud computing in higher education

There are many opportunities for cloud computing technology to be implemented in the higher education sector. For example, e-learning solutions, which are based on cloud computing technology, can bring education into a new era of learning. With e-learning, a variety of information can be made available to both educators and students via cloud-based services which can be accessed at any time and from anywhere (Isaila, 2014; Pardeshi, 2014; Yanyan & Linting, 2010). Experts believe Cloud computing can also host different learning management systems (LMS) like Moodle and Blackboard, which provide online education opportunities to students (Isaila, 2014). For instance, students who may not be able to attend a lecture can have access to iLecture or online lectures via cloud computing technology. Moreover, learning materials can be accessed easier which would contribute to effective learning in universities.

1.5 Governance, performance management and sustainability

In this research, three main themes constitute the initial model: governance, performance management and sustainability. This research aims to find the relationships among these themes and combine them in order to achieve the goal of sustainable development when adopting cloud computing technology in China.

1.5.1 Governance

Governance is about the context of corporate governance, the rules, practices, customs, policies and processes, which define and steer how an organisation conducts its daily business (Hill, Hirsch, Lake, & Moshiri, 2013). Cloud governance is the capacity to offer strategic direction, track performance, allocate resources, and make adjustments to guarantee that organizational goals can be achieved without compromising the compliance obligations, safety and reliability of the system. Cloud governance manages and oversees individuals, procedures and technology related to the daily operations and security cloud infrastructure. Further details are given in Section 2.4.

1.5.2 Performance management

Performance management in cloud computing is the process of monitoring cloud assets that support the performance of the application program. For instance, a significant objective of performance management is to give administrators the capacity to identify a critical issue immediately so the computing program can be terminated until the performance issue has been settled. Moreover, when an organisation starts to move data and applications to the cloud, performance management is essential to monitor the system availability and performance. Other factors related to performance management are introduced in section 2.5.

1.5.3 Sustainability

Sustainable business approaches help to generate profits by improving business practices without any negative impact on the global or local environment (Vikas Kumar & Vidhyalakshmi, 2012). There are three components associated with sustainability: society, economy and environment, details of which are presented in Section 2.6.

1.6 Current cloud computing development in China

In recent years, China has greatly improved in terms of carbon emission control. Experts believe the fast development in China brought investment to high technology industries, and growth rate of greenhouse-gas emissions has slowed in the past decade. Also, new sustainable development policies in China have boosted the usage of renewable energy and improved production efficiency ("Browner, but greener Environment," 2014). Although China is making progress towards greater adoption of Green IT, there is still much room for improvement. According to Y. Wang, Chen, and Benitez-Amado (2015), China has significant issues with environmental contamination and the national government has applied environmental guidelines and regulations to decrease the ecological degradation of the country. Y. Wang et al. (2015) claimed that IT could change a company's business procedures to seek environmental sustainability and slow down the degradation of the natural environment in China. Chinese manufacturing firms should utilise the new technologies to achieve environmental sustainability and decrease the impact of their business activities on the environment (Y. Wang et al., 2015). Recent research has shown Green technology tends to bring benefits to both the environmental and business performance of companies (Clark, Haytko, Hermans, & Simmers, 2019; Hou, Teo, Zhou, Lim, & Chen, 2018; M. Song & Wang, 2018; Y. Zhan, Tan, Ji, Chung, & Chiu, 2018). However, aimlessly reducing salaries and loosening environmental governances cannot give organizations the competitive advantages offered by sustainability. It is crucial that developing countries like China promote their economy and ensure environment-friendly performance simultaneously.

1.7 Purpose of research

The main purpose of this study is to develop a new sustainable cloud computing model for the higher education sector in China using a mixed-methods research approach.

These days, cloud computing technology is widely used in many different areas. For instance, it can be used in business to achieve business goals; in healthcare, it can help to analyse the data in real-time to diagnose and provide treatment for disease; it offers access to online movies and live streaming as the items people are watching are hosted on a cloud server. Cloud computing also plays a significant role in education. Students and teachers can access the IT infrastructure and application services anytime and anywhere with high speed and accuracy. Education online is now being offered by many universities. Moreover, the cost of IT infrastructure maintenance will be reduced because the cloud provider takes care of application management, installation and license renewal. Besides, cloud computing will reduce the cost of running IT equipment as different schools in a university can expand and share IT resources.

There are numerous studies on cloud computing as this concept was proposed many years ago and it has been widely used in many different areas as discussed above. However, most research addresses specific aspects such as data management and data security, while ignoring the issue of sustainable development and how it can be achieved. In other words, only a few studies have attempted to build connections with sustainability, which is important in cloud computing development especially from the perspective of environmental protection.

Therefore, this research seeks to identify key factors that would help to underpin the implementation of cloud computing in Chinese universities with respect to sustainability. This research presents a new sustainable cloud computing model that is refined according to the data obtained from the research participants, and a set of core factors with sub-factors are identified for this model. It is hoped that the outcome of this research can integrate the different aspects of cloud computing and guide further research on this topic.

1.8 Research significance and research objectives

As detailed in chapter 3.2, it is anticipated that this research is of both theoretical and practical significance. Theoretical significance refers to the exploration of new knowledge and the expansion of the existing knowledge on a certain topic. Practical significance refers to the empirical impact that the results of this research has in real life. From a theoretical point of view, the goal of this research is to explain how cloud computing technology can be adopted while simultaneously safeguarding the environment. It explores this topic from different angles such as governance, performance management and sustainability. Moreover, the outcome of this study can contribute to the future studies regarding the sustainable development of cloud computing in China. From a practical perspective, this study aims to identify a set of key factors that would facilitate the successful implementation of a new sustainable cloud computing model in the higher education sector in China. The outcome of this research would benefit cloud users, service providers, professionals and other stakeholders who could contribute to the sustainable development of the cloud computing. Moreover, the final model could also benefit students, IT staff and academic staff in different universities in China.

In order to create the model, the main objective of this research is:

- To determine the factors pertaining to governance, sustainability and performance management that should be taken into consideration when developing a new sustainable cloud computing model for higher education sectors in China.

It is also important to test the validity of those factors among cloud uses to see if it is necessary to include them, or to add more factors to the themes. Furthermore, the relationship among those themes needs to be identified.

Therefore, the secondary research objectives for this research are:

- To examine the perceptions and attitudes of students, academic staff and IT department personnel towards the new sustainable cloud computing model in Chinese universities.
- To identify the relationships among governance, sustainability and performance management.

1.9 Research design

This research is conducted using both qualitative and quantitative methods. An initial qualitative phase conducted via interviews was designed to discover the perceptions about cloud computing in the context of higher education in China. The data collected in this phase is used to refine the initial model. After that, the quantitative data collection phase gathers opinions from online participants, and the questionnaire responses are processed through factor analysis to further refine the model before its final release. Figure 1.2 below depicts the design utilised in this research.

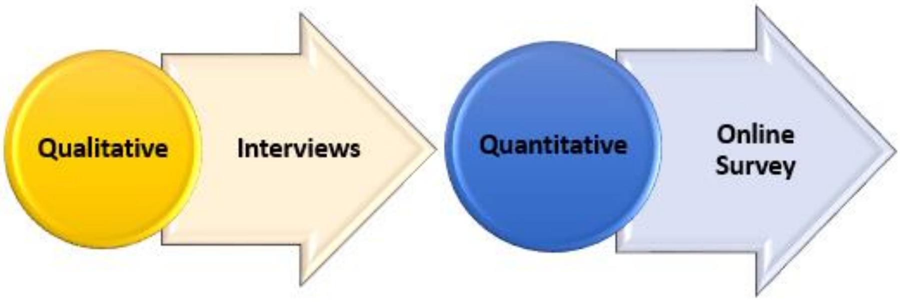


Figure 1.2. Design used for this research (prepared by the author)

As explained in more detail in Chapter 3, this study uses a mixed methodology comprising both qualitative and quantitative approaches. This enables an in-depth analysis of data as well as providing a large sample size that allows the researcher to validate and strengthen the research findings.

1.10 Overview of the research flow

The research flow is shown in Figure 1.3 below. A comprehensive literature review is conducted in the area of cloud computing with respect to the sustainability, performance management and governance. From the literature review, a set of factors related to this research is identified, forming the basis for the initial model. The initial model is tested via the interviews followed by qualitative data analysis using NVivo software (version 11). The results from the data analysis are used to refine the initial model and an online questionnaire survey is conducted to verify the applicability of the refined model. The quantitative data collected from the online survey is then analysed using IBM SPSS Statistics software (version 22) to determine the factors comprising the final model.

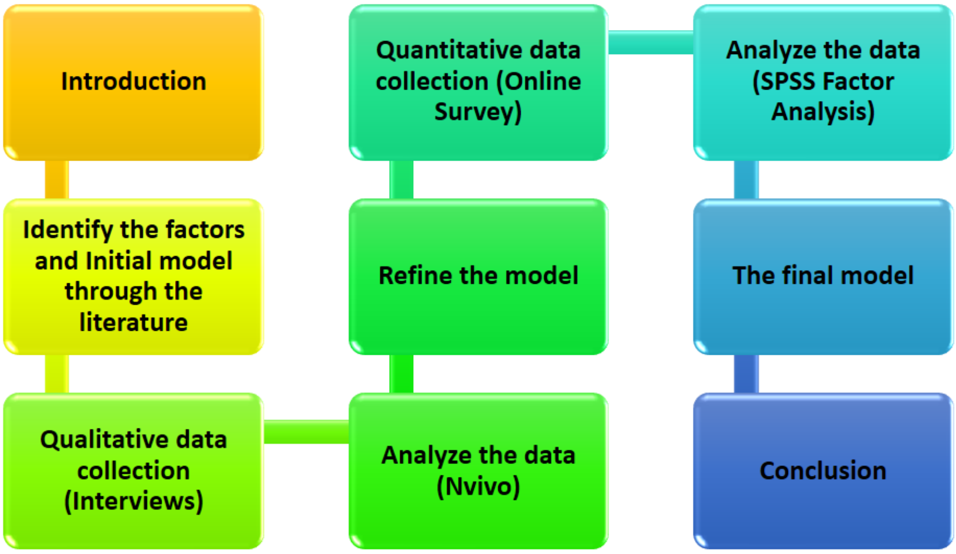


Figure 1.3. Research Flow (prepared by the author)

- **Chapter 1: Introduction**

  In this chapter, the background information regarding the thesis topic is introduced, including the definition of cloud computing, service models and deployment models. This chapter also examines the current usage of cloud computing in the higher education sector in China, followed by a brief discussion of the research method, significance and research questions.

- **Chapter 2: Literature Review**

  This chapter contains a detailed review of recent studies regarding sustainable cloud computing development. Starting with the background of cloud computing, along with a detailed explanation of cloud governance, performance management and sustainability, it provides a comprehensive review of those themes. This chapter also identifies and explains the key factors that are related to the themes that will form the new sustainable cloud computing model. The research gap is identified based on the literature review, followed by the initial research model.

- **Chapter 3: Research Methodology**

  This chapter begins with an explanation of the significance of research, both theoretical and practical. In this section, the researcher explains why this research is conducted. After that, the primary and secondary research questions are introduced which are answered in subsequent chapters. This chapter also defines the research methodology that is applied in the data collection and analysis phases. Section 3.11 presents the justification for the researcher's choice of methodology.

- **Chapter 4: Interview Data Collection and Analysis**

  This chapter discusses how the researcher conducted interviews with participants in China. The data collected via interviews is analysed, followed by a discussion of the results. Then the initial model is amended based on the interview data.

- **Chapter 5: Online Survey Data Collection and Analysis**

  This chapter discusses the development and distribution of the survey questionnaire. It also specifies the target research sample. The online survey data collected via the Curtin Qualtrics platform is analysed and discussed in order to refine the final model of this research. Lastly, based on the questionnaire outcomes, the researcher summarizes the amendments made to the new sustainable cloud computing model for the higher education sector in China.

- **Chapter 6: Research Finding and Conclusions**

  This chapter concludes the thesis by presenting the research outcomes and the research contributions. The limitations of this research are acknowledged, followed by the recommendations for further research.

1.11 Chapter summary

To sum up, this chapter outlines the background of this research by introducing the definition of cloud computing. This chapter also describes a range of service models and deployment models. Research objectives and significance are briefly discussed followed by a summary of each chapter.

The next chapter provides a comprehensive review of the literature relevant to the research topic in order to develop an initial model for the implementation of cloud computing in China's higher education sector.

Chapter 2 Literature Review

2.1 Introduction

In the previous chapter, the concept of cloud computing, along with research objectives, questions and significance were introduced. This chapter reviews various literatures related to cloud computing, particularly in regard to governance, sustainability and performance. The aim of this chapter is to develop an initial sustainable cloud computing model. In order to have a better understanding of cloud computing and its essential components, articles have been grouped and classified according to the author's requirements. To begin with, the definition of cloud computing, followed by service models and deployment models are introduced in the background section. Section 2.4 introduces the policy, process and resource factors related to cloud governance theme. In section 2.5, bandwidth, data management, energy consumption and capacity management are discussed with respect to performance management. Section 2.6 focuses on the three components of sustainability, which are social, economic, and environmental. This chapter also identifies the research gap by comparing various models in respect to cloud governance, performance management and sustainability. Cloud adoption in education is examined in section 2.8, followed by the status of environment performance and cloud computing development in China. A series of factors and sub-factors of cloud computing from peer reviewed journal articles, published reports and IT industry publications are identified in this chapter (Table 2.3, Table 2.5 and Table 2.8). An initial model (Figure 2.35) is proposed at the end of this chapter, which will be assessed and modified in subsequent chapters. Cloud governance, performance management and sustainability are the three fundamental pillars of this model. Chapters 4 and 5 will evaluate and test those themes in order to create the final model.

2.2 Scope of the Literature Review

Before starting the literature review, it is essential to determine its precise scope. In this section, various scholarly sources and their scope will be identified, and the structure of this chapter will be presented. Cloud computing is such a complex topic that it is impossible to cover all of its aspects. Thus, this chapter is focused mainly on three themes: cloud governance, performance management and sustainability of cloud computing.

Curtin University's online library served as the main source of the literature items reviewed for the purposes of this research. The databases most used include, but are not limited to IEEE/IET Electronic Library (IEL) Journals, ACM Digital Library, ProQuest and Science Direct. Approximately 130 articles have been utilised in this chapter, the majority of which are peer-reviewed journal articles. Hard copy books were borrowed from the Curtin Robertson Library if the electronic versions were not available online. Other reference types include journal article, conference paper, conference proceedings, electronic book section, etc. Reviewed materials are confined to those written in English; this review does not include researches reported in other languages. NVivo 11, aligned with EndNote X7, was utilised to justify the quality of literatures. Some of the literature items stored in the EndNote X7 were transferred to NVivo software to analyse in order to find the hidden patterns. Seventeen models related to "Cloud Governance" are introduced in this chapter as illustrated in Table 2.3. "Performance Management" has 16 models as shown in Table 2.5. The "Sustainability" section contains 11 models as indicated in Table 2.8.

As mentioned earlier, relevant material for this research was collected mainly from peer reviewed journal articles, published reports and IT industry publications. Table 2.1 below shows the key words most often utilized when searching the literatures.

Table 2.1. Key words of Literatures

Catalogue	Key Words
General	Cloud Computing, China, Education
Cloud Governance	Policy, Process, Resource
Performance Management	Capacity, Energy Consumption, Data Management
Sustainability	Environment, Finance, Social

The remaining part of this chapter has been divided into several sections in order to provide an in-depth review on cloud governance, performance management and sustainability. Section 2.3 defines cloud computing along with its service models and deployment models. Section 2.4 explains cloud governance by illustrating the correlations between cloud governance with other governance policies. Moreover, three components of cloud governance (policy, process and resource) are introduced in this section. Section 2.5 discusses the performance management theme from different angles. In this section, bandwidth, data management, energy consumption and capacity management are introduced. Section 2.6 concerns sustainability and its major components which are: society, the economy and the environment. Section 2.7 briefly discusses the most common risks and concerns about cloud computing. As the objective of this research is to develop a sustainable cloud computing model for the higher education sector in China, Section 2.8 and section 2.9 discuss cloud computing in education and the current status of environment performance and cloud computing development in China. Section 2.10 discusses the existing models of cloud computing. Here, various current models for cloud governance, performance management and sustainability are introduced. Section 2.11 presents the research gap by comparing all the models mentioned in section 2.10 together. Based on the previous discussion, the initial model for sustainable cloud computing in China is proposed in section 2.12, followed by section 2.13 which summarizes this chapter.

2.3 Background of Cloud Computing

This section presents background information about cloud computing technology. Various definitions of cloud computing are introduced together with cloud service and deployment models.

2.3.1 Definition of Cloud Computing

The term ‘cloud computing’ refers to the supply of reliable and scalable IT resources to the end users via the Internet, for instance, online operational capability and data storage (Winkler, 2011a).

Cloud computing is an Internet-based computing model whereby numerous servers and computers are connected to the Internet, resources, software or operating systems and can be shared by the users based on the requirements (Chi & Gao, 2011). As Armbrust et al. (2010) point out, cloud computing can be provided by applications which are running as services via the Internet. Vouk (2008) holds the same opinion: cloud computing is about moving the software, hardware, data and other different devices from the local data centres to the cloud-based servers, enabling end users to connect to those resources which are located in the cloud anywhere anytime via the client software. The main purposes of cloud computing are to minimize computing costs and maximize profits.

Cloud computing providers and guests as depicted in Figure 2.1. On the provider side, facilities such as application servers, service platforms, runtime environment and data centres will be offered to end-users. The guest side of cloud computing contains different end-users who may access the cloud service via laptops, desktops, tablets, mobile phones and enterprise centres. The guest side is the interface by means of which the authorized end-users can utilize online services (Barron, Yu, & Zhan, 2013a).

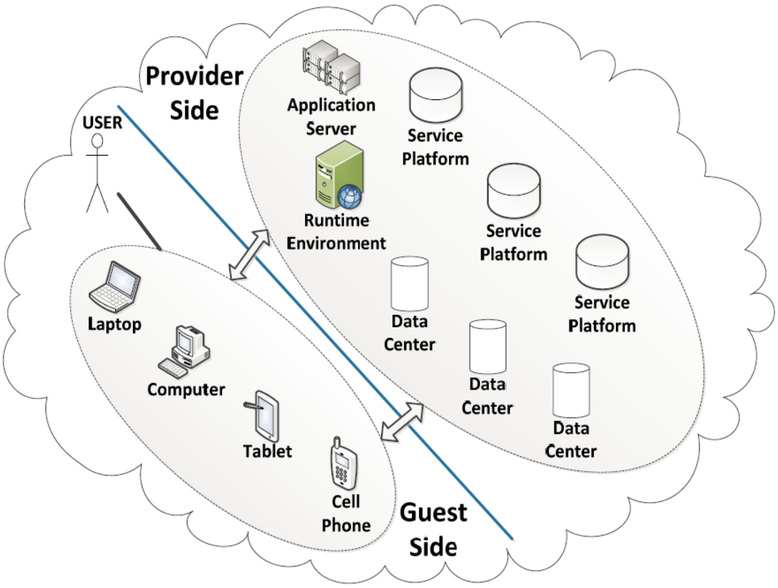


Figure 2.1. Provider side and guest side of cloud computing (Barron et al., 2013a)

As shown in Figure 2.2, the cloud computing environment is “a large cyber-physical system consisting of electrical, mechanical and IT systems running a variety of tasks on a multitude of server pools and storage devices connected with multitier hierarchy of aggregators, routers and switches” (Uchechukwu, Keqiu, & Yanming, 2014, p. 146).

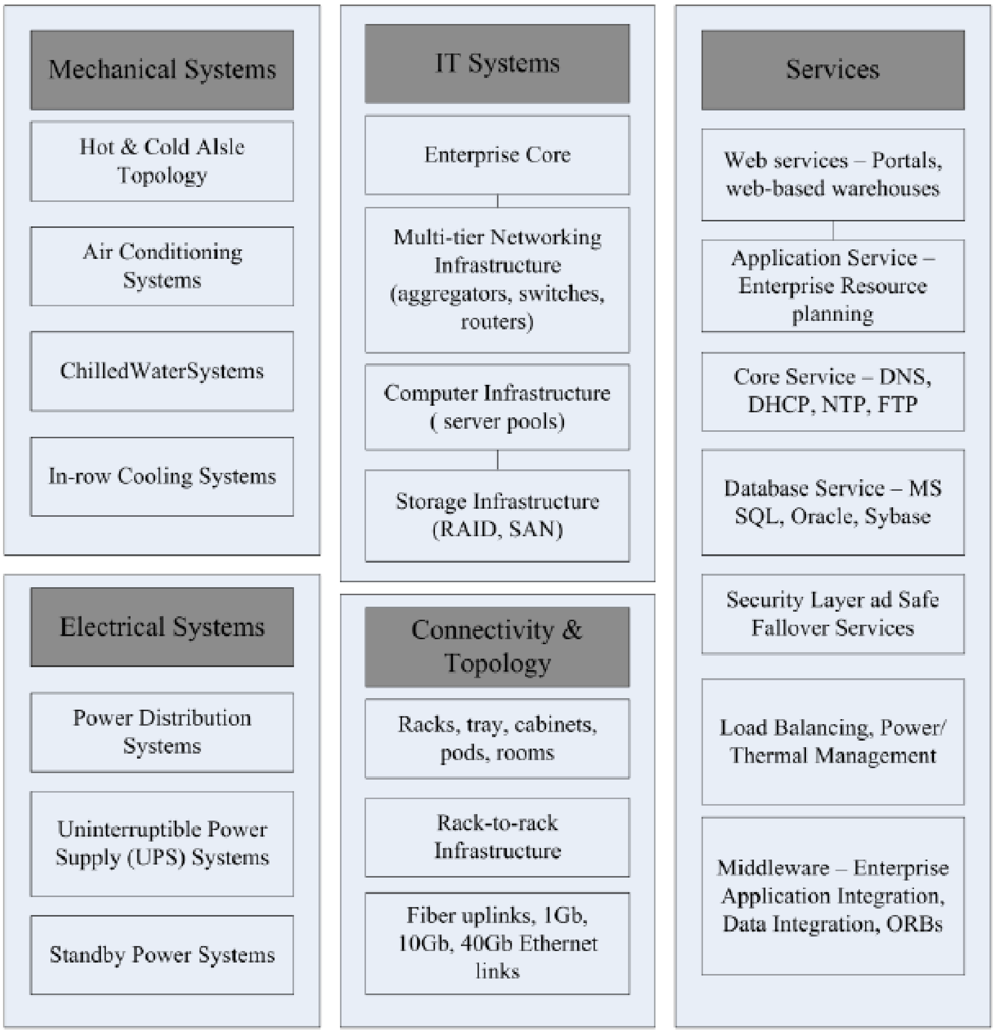


Figure 2.2. High-level components comprising cloud computing environment (Uchechukwu et al., 2014)

2.3.2 Service Models

Metz (2011) points out the NIST (National Institute of Standards and Technology) definition of the cloud outlines three ways to offer cloud services to users: Software as a service (SaaS) Platform as a service (PaaS); Infrastructure as a service (IaaS).

Software as a service means that an application or software is running on a virtual server which can be accessed anywhere anytime as long as there is an Internet connection (Cusumano, 2010). For instance, Google Calendar and Google Mail are examples of SaaS. The PaaS is another cloud server model which can provide required resources to users in order to create applications and services in the cloud; hence, users no longer need to download or install applications (Qayyum et al., 2011). The App Engine of Google is a type of PaaS. Storage space, hardware, servers and other devices can be offered by the IaaS platform provider; this equipment can be used directly and the platform provider is responsible for the maintenance tasks (Bhardwaj, Jain, & Jain, 2010).

2.3.3 Deployment Models

Just as cloud services have different models such as SaaS, PaaS and IaaS, there are also different deployment models of cloud computing. According to Metz (2011), the NIST definition offers four different deployment models for the cloud: private, public, hybrid and community. Private cloud is defined as an individual institution operating its own cloud (Metz, 2011). According to Wyld (2010), in the private cloud method, the cloud infrastructure is owned solely by a company and it may be managed by the organization or a third party and may exist on the premises or off-premises. Schubert, Jeffery, and Neidecker-Lutz (2010) point out that private clouds are normally operated by the respective organization; the functionalities are not exposed to the customers directly and it is similar to Software as a Service from the customers' perspective. A public cloud is a cloud service that is available for use by the general public (Metz, 2011). The cloud infrastructure can be accessed by the public cloud users or a large-scale industry group and is owned by the cloud provider (Wyld, 2010). Public cloud is based on the standard cloud computing model and the cloud service provider will make resources such as storage space or applications available to the general public cloud computing users through the Internet. The subscription models of public cloud services include a pay-per-usage model or may even be free. Hybrid cloud allows institutions to deploy an application or system using more than one type of deployment model (Metz, 2011). The term "private cloud" refers to a proprietary network or data centre managed by the organization; "public cloud" means that public cloud users can share the cloud infrastructure; the hybrid cloud is maintained by both internal and external providers. According to VMware (Chang, Wills, & De Roure, 2010), hybrid cloud is a cloud infrastructure consisting of two or more clouds; private and public clouds can be combined under standardized technology and specific rules that enable application and data portability. "The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise" (Kierkegaard, 2019, p. 1922). Schubert et al. (2010) believe that, generally, cloud systems are restricted to the local infrastructure; for instance, public cloud service providers offer their own computing infrastructure to users.

- **Private Cloud**

  A private cloud is operated exclusively for an enterprise that does not share equipment or infrastructure with other organizations (Chou, 2015a). Mell and Grance (2010) described a private cloud as "the infrastructure provisioned for exclusive use by a single organization comprising multiple consumers. It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises". A private cloud offers internal services to a firm through an organization-controlled intranet or data centre (Chou, 2015a). This cloud service can offer required features such as fault tolerance and security needed by the organization (Chou, 2015b).

- **Public Cloud**

  Public cloud has been embraced by the majority of companies for cloud computing implementation (Chou, 2015a). Public cloud service providers such as Google or Amazon can offer the cloud infrastructure to different companies to meet their requirements on a self-service, on-demand and pay-per-use basis (Chou, 2015a). There is no public cloud infrastructure inside the cloud client's organization; the cloud provider offers that to the cloud user (Chou, 2015b).

- **Hybrid Cloud**

  Another type of cloud service is the hybrid cloud. The cloud service contains a variety of cloud infrastructures to fulfil its particular requirements (Chou, 2015a). It combines public cloud, private cloud, and community cloud. An enterprise may consider its vital needs as well as security issues, and disseminate work capacities among separate cloud infrastructures (Chou, 2015b).

- **Community Cloud**

  A community cloud is comprised of shared concerns such as tasks, security necessities, approaches, and compliance consideration (Mell & Grance, 2010). A community cloud can be built and implemented by individuals or various enterprises in the community, situated inside or outside the enterprises (Chou, 2015a).

2.4 Cloud Governance

The concept of governance is vague and has no fixed definition (Raj, 2013). But generally speaking, governance is seen in the context of corporate governance, the rules, practices, customs, policies and processes, which define and steer how an organisation conducts its daily business (Hill et al., 2013). Irion (2012) believed that cloud computing essentially involves changing the manner in which computing is undertaken by offering universal, on-request access to computing assets.

Corporate Governance is defined as “the set of processes, customs, policies, laws and institutions affecting the way in which a corporation is directed, administered or controlled” (De Leusse, Dimitrakos, & Brossard, 2009, p. 1020). It addresses the need for a mechanism to ensure compliance with the laws, policies, standards and procedures under which an organization operates. Corporate governance covers every aspect of businesses ranging from the human resource department to purchasing and marketing. IT Governance includes the decision rights, accountability framework and processes to encourage desirable behaviour in the use of IT (Hardy, 2006). By definition, IT governance can be treated as part of corporate governance which pertains to Information Technology processes and supports the goal of business. It involves the management and control of IT assets, people, processes and infrastructures as well as the way in which the assets are managed and procured. Service-Oriented Architecture (SOA) governance is an extension of IT governance (Keen et al., 2007). SOA governance makes changes to IT governance to ensure that the concepts and principles for service orientation architecture are managed appropriately and that services are able to deliver in line with the business goals. Figure 2.3 indicates the relationships among corporate governance, IT governance and SOA governance, and Figure 2.4 shows the position of the cloud computing governance framework in the landscape. Governance in the cloud is all about defining right, realistic, and relevant policies for managing and overseeing cloud resources, tracking and enforcing the policies when applications are running. Cloud governance extends SOA governance in several ways. Policies need to be established formally to address the extraordinary challenges and changes posed by cloud adoption. Service design and development remain the same even in the forthcoming cloud era (Raj, 2013).

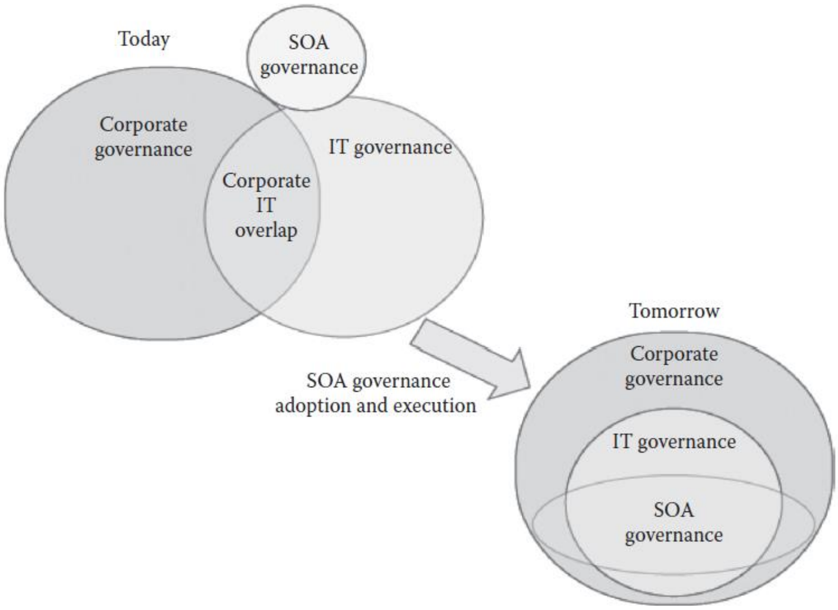


Figure 2.3. The growing importance of SOA governance in service-oriented enterprises (Raj, 2013)

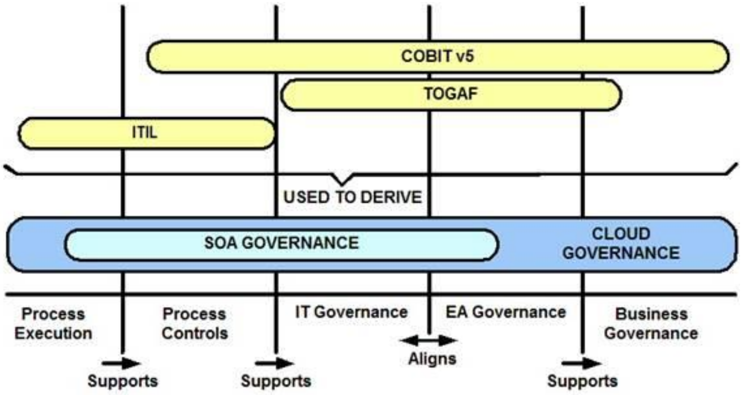


Figure 2.4. Position of the Cloud Computing Governance Framework in the Landscape ("Cloud Computing Governance Framework – Cloud Computing Governance (Informative),")

2.4.1 Policy

Cloud enables businesses to roll out changes to applications almost instantaneously, unlike the traditional onsite models. This distinct capability comes with its own set of issues in regard to versioning, upgrades, and compatibilities of services. Thus, given so many different policy issues, cloud computing must consider the gap between policy and technology (Jaeger et al., 2008). During the design and development stage, it is important to establish rules and policies that clearly specify how the various participating services in a cloud are going to be monitored and managed (Raj, 2013; Yoo, 2011). Well-defined and well-enforced policies are a must to ensure robustness and trustworthiness of cloud-based applications. Policies are the building blocks and fundamental pieces of cloud governance (Raj, 2013). According to Raj (2013), policies can be enforced through the following mechanisms:

- Change management reports, tracks and logs the changes occurring to cloud assets;
- Alerts and notifications ensure that changes are captured and conveyed to the decision makers in a timely fashion;
- Threshold-based actions are based on predefined rules; for example, rules can be established to automatically increase the footprint (i.e., the number of load-balanced cloud instances) if the performance of a system is below a certain threshold level.

Governance in many nations has very strict regulations to guarantee that data and information are secure. However, cloud computing is challenging in this regard as it becomes very difficult to have direct control over virtual resources (Irion, 2012). This is why numerous individuals have raised concerns about the ownership of data that is stored in the cloud. Reed (2010) talked about data “ownership” in terms of cloud services while recognizing that property rights for data do not exist. This raises the question of how an organisation’s data stored in the cloud can be guaranteed, particularly if data and IT frameworks are facilitated overseas (Irion, 2012).

Policy difficulties in cloud computing have already attracted scholarly attention, for the most part concerning the deficiencies of current administrative structures, international inconsistencies, and the requirement for an empowering environment for cloud services. Jaeger et al. (2008) mention that the cloud computing policy issues pertain to information technology policy, security, privacy and reliability. Nelson (2009) focuses on governments’ role in conducting research on consumer protection, accessibility, E-government, open standards, privacy and security. Kushida, Murray, and Zysman (2011) believed the core function of cloud computing services is to reduce the impact of policy issues on cloud development. Evaluation of cloud services is essential and there are some significant approaches shown in the following *Australian Government Cloud Computing Policy — Smarter ICT Investment* 2014):

- Evaluate information against authoritative and administrative necessities.
- Assess the market for cloud services including existing services by different agencies.
- Decide the appropriateness of the cloud service against the information prerequisites.
- Obtain and implement the cloud service.
- Monitor the performance and the compliance of the cloud service.
- Review the cloud service for continuous benefits achievement.

2.4.2 Process

Soňa and George (2016) summarized the cloud computing governance process into four phases: planning, definition, implementation and monitoring. Cloud Data Governance is a discipline involving the processes for managing and governing data in cloud computing environments (Ko, Goh, Mather, Jaini, & Lim, 2011). It can be seen that cloud standards must specify authorization, access entitlements and identity (Fortis, Munteanu, & Negru, 2012). IBM (Brown, Moore, & Tegan, 2006) believes the SOA governance lifecycle comprises a four-stage process:

- Plan phase, during which the need for governance is established and the existing mechanisms are assessed;
- Define phase, during which the desired governance framework, including new and modified principles, processes, organizational structures and roles are established;
- Enable phase, where the new governance framework is introduced into the enterprise;
- Measure phase, during which the metrics are gathered and analysed to refine the governance process.

As mentioned earlier, cloud governance is an extension of SOA governance. Hence, Raj (2013) separates the cloud governance process into these phases: Cloud Evaluation; Cloud Governance; Definition; Development of Relationship with Providers; Cloud Governance Execution; and Operational and Review Phase.

2.4.3 Resource

Fortis et al. (2012) believe that resource and scalability limits, resource discovery, tenant partitioning, session management, and service levels must be specified. According to (Mell & Grance, 2009), computing resources include networks, servers, storage, applications, and services. A cloud can be formed through the combination of distributed and decentralized IT resources. However, this reduces the level of visibility, thereby making controllability a major issue (Raj, 2013). To cope with the challenge, it is of paramount importance to develop efficient and flexible resource management strategies (Zhao & Li, 2013). Cloud clients should receive an acceptable Quality of Service (QoS) from a Cloud Service Provider (CSP) that offers and maintains on-demand computing services. Cloud clients are free from system maintenance, resource provisioning and service continuity, all of which are taken care of by CSPs (Al-Sharif, Jararweh, Al-Dahoud, & Alawneh, 2017). This allows cloud clients to focus on their business activities without wasting time on maintenance-related problems. Furthermore, the cloud computing model enables CSPs to perform multiple tasks on a single physical machine. This greatly reduces costs and power consumption and increases resource utilization.

One way to manage cloud resources is to use autonomic computing technology. Autonomic computing is a self-manageable information processing system (Singh & Chana, 2016b) consisting of a collection of autonomic segments which can deal with internal behaviours and associations with others based on a set of predefined rules. The autonomic computing system has many different features, among which are self-configuring, self-optimizing and self-protecting functions (Nurmi et al., 2009). It must be noted that an autonomic computing system can resolve various problems simultaneously instead of dealing with them individually. Autonomic computing in cloud is simply the ability of a cloud system to manage cloud resources with high-level objectives (Parashar & Hariri, 2006; Singh & Chana, 2016b). Cloud computing models are becoming enormous, complex, and expensive to manage; furthermore, workloads and environmental conditions are changing rapidly. That is why autonomic decisions and actions are required. The objective is to make self-management possible in cloud computing systems and cloud applications with minimal human intervention.

2.5 Performance management

This section explains performance management for cloud computing from different aspects, including bandwidth, data management, energy consumption and capacity management.

2.5.1 Bandwidth

Recently, the fast development and improvement of networks have had a positive impact on the performance of cloud-based applications in various ways (Gai, Qiu, Zhao, Tao, & Zong, 2016; Jeong, Tombor, Albert, Oltvai, & Barabási, 2000; Wu, Kumar Garg, & Buyya, 2012). The incredible improvements in networking deployments has enabled the networking capacity to play a significant role in offering a range of network services as required (Keke & Saier, 2012; Longbin, Yucong, Meikang, Jian, & Keke, 2015). One challenge worth attention is that the size of data is constantly increasing (Gai, Qiu, Chen, & Liu, 2015). Network congestion is a critical issue which can affect the performance of the entire network system (Gai, Qiu, & Zhao, 2016). This can also lead to significant network latency (Keke, Meikang, Hui, & Meiqin, 2016; H.-M. Sun, Chen, & Lin, 2011). Thus, sufficient bandwidth for networks is a crucial requirement for current cloud computing deployments (H. Jiang & Sun, 2017). Another challenging issue is that it is not easy to manage different network systems because of various new technologies emerging due to network developments (Gai, Qiu, & Zhao, 2016; Jean-Baptiste, Qiu, Gai, & Tao, 2015). H. Jiang and Sun (2017) discussed the benefits of network management for enterprises. It is also beneficial to create an efficient network management strategy based on the intended use of the network resource.

Cloud services have drastically changed the procurement of computing resources since software, for instance, can be purchased on a pay-as-you-go basis (Irion, 2012). Bandwidth on both vendor and customer sides is fundamental to achieving high efficiency in cloud computing. The majority of current task-scheduling strategies of cloud computing only consider task resource prerequisites in terms of memory capacity and CPU speed, without considering bandwidth necessities (Lin, Liang, Wang, & Buyya, 2014). From the cloud providers' perspectives, in order to use the infrastructure effectively to increase revenue, they need to offer resource allocation for different clients in a shared platform. Specifically, most cloud providers consider the sharing of network bandwidth to be a critical problem (Jing et al., 2012). Moreover, in a shared cloud environment, existing mechanisms for network resources control may not be able to prevent clients from interfering with each other (Doyle, Shorten, & Mahony, 2012). Most task-scheduling algorithms do not calculate the effect of network bandwidth capacity, but focus only on the availability of CPU and memory. Thus, computing tasks may deferred due to insufficient bandwidth capacity, which could lead to computing resources being wasted (Lin et al., 2014).

The utilization of rate-limiters is one possible solution to guarantee bandwidth (Benson, Akella, Shaikh, & Sahu, 2011; Guo et al., 2010; Rodrigues, Santos, Turner, Soares, & Guedes, 2011). Specifically, in order to ensure that virtual machines do not exceed their allocated bandwidth, a rate-limiter module can be incorporated into the hypervisor of each physical machine (Faizul Bari et al., 2013). The deployment of rate limiters located at end-hosts makes it possible to avoid bandwidth reservation at switches as long as the internet traffic passing each switch does not exceed link capacity (Faizul Bari et al., 2013).

2.5.2 Data Management

Data is always essential for any enterprise. It is not easy to utilise various cloud systems due to the different data models in different cloud systems (Truong & Dustdar, 2012). Hence, enterprises need to innovate in order to surge ahead of competitors by extracting all the right and relevant insights and intelligence from their accumulated data (Raj, 2013). Numerous studies have indicated that data security is a major consideration for any company, organization and government department that is intending to shift from traditional computing to smart technology (i.e. cloud computing) (Barron, Yu, & Zhan, 2013b; Curran & Carlin, 2011; Ogigău-Neamţiu, 2012a; Winkler, 2011b).

2.5.3 Energy Consumption

Cloud computing enables the sharing of computing resources, but it also requires huge amounts of energy (Ba, Heinzelman, Janssen, & Shi, 2013). The datacentre cooling system contributes to almost one third of total energy consumption (Garg & Buyya, 2012). Approximately 25% to 40% of the operating expense in data centres is incurred by power consumption of which 50% is consumed by cooling systems (Backialakshmi & Hemavathi, 2015, p. 1). Related to this, Vikas Kumar and Vidhyalakshmi (2012, p. 470) mentioned that cloud computing at present is responsible for almost 2% of the world's energy consumption, and the data centre energy footprint is considered to be enormous with energy consumption being over 600 billion kilowatts per hour. That is why energy efficiency is one of major challenges in terms of performance management. As suggested by Garg and Buyya (2012), it is necessary to construct power models which enable the system to know the energy consumed by a specific device, and how the energy consumption could be reduced. Sultan (2010) believed that a large part of the expenses of running an IT infrastructure comes from the cooling system which is intended to reduce the heat generated by the hardware, and the electricity consumption by hardware, PCs, servers, backup drivers, etc. Cloud computing can probably decrease this consumption.

Energy consumption is also related to operational costs. Currently, computing performance and customer satisfaction have been increased by utilising data centres, but energy consumption in data centres has often been overlooked. Singh and Chana (2016a) believed that a great amount of energy consumption could lead to high operational costs, thereby reducing return on investment. Many governments have imposed requirements to decrease carbon emissions so as to safeguard the environment. In order to address the carbon footprint issue, it is necessary to focus on energy efficiency along with resource management in cloud (Singh & Chana, 2016a). Larger IT organizations (e.g., Microsoft, Google and IBM) are expanding their data centres each year to provide better computing services to their cloud clients. Literature revealed that the challenge lies in balancing minimal energy consumption and providing satisfying Quality of Service (QoS) (Quang-Hung, Nien, Nam, Tuong, & Thoai, 2013). In order to address this issue, Singh and Chana (2016a) proposed an Energy-aware Autonomic Resource Scheduling Framework (EARTH), which is a "fuzzy logic-based energy-aware autonomic resource scheduling framework for cloud for energy efficient scheduling of cloud computing resources in data centres".

Another key issue for cloud computing is to minimize energy consumption in data communication (Jin, Sangmin, Namgi, & Byoung-Dai, 2013). Many studies have examined energy consumption of data transmissions by using cloud computing (Deng, Zeng, He, Zhong, & Wang, 2014; J. Song, Li, Wang, & Zhu, 2013; Uchechukwu et al., 2014; Williams & Tang, 2013), and valuable models have been presented, such as the energy-saving mechanism model proposed by (Uchechukwu et al., 2014). These studies focus mainly on bit stream transmissions over existing 3G networks or within Wi-Fi environments. Jin et al. (2013) investigated the energy efficiency of mobile devices when transferring data securely over various communication networks including high-speed 4G networks. According to Ba et al. (2013, p. 4451), the growing number of mobile devices such as cell phones and tablets account for an immense amount of potential idling computing power. If these mobile devices can work cooperatively, their computing power could support a cloud computing system, which will save 55% to 98% of the energy consumption while offering similar computing speed.

2.5.4 Capacity Management

The goal of the capacity management process is to ensure that cost-justifiable IT capacity, in all areas of IT, always exists and is matched to the current and future agreed-upon needs of the business, in a timely manner (Sabharwal & Wali, 2013). One of the technical challenges of cloud computing is to effectively manage cloud capacity in response to the increased demand changes in clouds, as computing customers now can provision and de-provision virtual machines more frequently (Y. Jiang et al., 2012). From previous studies in this area, it can be seen that the traditional capacity-planning process is typically achieved by taking the following steps: create a capacity model and baseline, evaluate changes and analyse the data to forecast future requirements. However, the pre-deployed and pre-configured capacities of a traditional rigid infrastructure will lead to more cost due to redundancy and waste because of an inappropriate initial capacity plan, and more energy will be consumed accordingly, as capacities are over-reserved for the rare peak (Y. Jiang et al., 2012; Josyula, Orr, & Page, 2011; Yuan & Zhu, 2011). Researchers are trying to identify better capacity management solutions for cloud computing. For instance, Yuan and Zhu (2011) presented the Autonomic Provisioning Mechanism to solve this problem. However, further research is required in this area.

2.6 Sustainability

Sustainable business approaches help to generate profit by improving business practices, without having any negative impact on the global or local environment (Vikas Kumar & Vidhyalakshmi, 2012). In this section, the three components of sustainability are discussed; that is, social, economic and environmental.

2.6.1 Society

According to Issa, Chang, and Issa (2010), the social factor must be considered when organisations intend to make the transition to cloud computing technology. The social aspect incorporates consumer awareness and attitudes as well as individual practices when utilizing services on the cloud. Nowadays, “corporate social responsibility (CSR) is a priority item on the agenda of almost every business organization” (Babin, Briggs, & Nicholson, 2011). The ”triple bottom line” comprised of people, planet, and profit, should be taken into consideration when evaluating a company’s performance (Elkington, 1994). Menz (2010) pointed out that corporate social responsibility has a positive impact on an organization. CSR should be “reflected in a superior long-term development of the company value”. It is imperative to incorporate social responsibility in modern technologies (McGlade, Quist, & Gee, 2013).

In order to fulfil their social responsibilities, many leading companies are using energy generated by solar systems, hydropower, wind or biomass to meet their electrical and lighting demands. Vikas Kumar and Vidhyalakshmi (2012) pointed out that cloud service providers should not only offer computing services to clients, but should also take care of the environment by using natural sources of energy for daily operations. The following companies have implemented various strategies in this regard:

- Google has a $300 million-dollar data centre named “Hamina”, which is located in Finland. This data centre utilises cold seawater drawn from 25 feet beneath the ocean surface to cool the equipment.
- Energy consumption in one of Microsoft’s data centre located at Dublin is 50% less than that of other typical data centres.
- One of Facebook’s data centres located in the small Swedish town of Lulea utilises the electricity that is totally generated by hydropower and is adequate for the cooling system.
- Rackspace has solar energy as its primary energy source.

- Intel utilises wind, solar, geothermal, biomass and hydropower in many data centres to meet electricity requirements (Vikas Kumar & Vidhyalakshmi, 2012).

Great decision-makers always have the most astounding effect on the success and sustainability of any business. Moreover, individuals should be supported by the most recent innovative technology in order to contribute their best (Vikas Kumar & Vidhyalakshmi, 2012). Cloud has been unanimously chosen as the best IT alternative in business because it has a wide range of applications in every sphere of all business models.

2.6.2 Economy

When computing operations are migrated to the cloud, one significant advantage is the cost savings achieved as a result of decrease in staffing expenses, and reduction in cloud services and their applications; for instance, SaaS could save a lot of investment in IT infrastructure (Vikas Kumar & Vidhyalakshmi, 2012). However, a business assessment ought to be done painstakingly before proceeding to the cloud. Advantages related to low entry barrier may not be applicable to an entrenched business, and the pay-per-use pattern may not be practical if the IT prerequisites are generally inflexible (Tak, Urgaonkar, & Sivasubramaniam, 2011).

According to Sultan (2010), the frequent IT technology changes will continue to place pressure on companies' financial plans. Constant upgrades of software and hardware have turned out to be essential things for a large number of organisations and will continue to be influenced by budget constraints. Cloud computing would save money. Cloud users have to pay only for the actual use of storage or resources consumed. Sultan (2010) also mentioned that cloud computing will decrease labour-related costs, as fewer individuals (e.g., technicians) will be required to run a cloud-based IT infrastructure. Nelson (2009) focused on the power of cloud computing offered by these features:

- Limitless flexibility. "By being able to use millions of different pieces of software and databases and combine them into customized services, users will be better able to find the answers they need, share their ideas, and enjoy online games, video, and virtual worlds".
- Better reliability and security. "No longer will users need to worry about the hard drive on their computers crashing or their laptops being stolen".
- Enhanced collaboration. "By enabling online sharing of information and applications, the Cloud provides new ways for working (and playing) together".

- Portability. “The ability of users to access the data and tools they need anywhere they can connect to the Internet”.
- Simpler devices. “Since both their data and the software they use are in the Cloud, users do not need a powerful computer to use it. A cell phone, a personal video recorder, an online game console, their cars, even sensors built into their clothing could be their interface” (Nelson, 2009, p. 72).

Data centres and computing services consume much energy, and the increasing cost of electricity cannot be ignored. Thus, computer users are looking at ways to reduce cost. Alongside this, energy consumption directly affects the environment and contributes a great deal to carbon emissions. Most organizations would like to help safeguard the environment in order to fulfil their corporate social responsibility. Cloud computing provides significant savings on energy consumption, as well as reducing carbon emissions (Vikas Kumar & Vidhyalakshmi, 2012). Cloud computing can reduce the expense and unpredictability associated with computing tasks and projects. By offering more computing power at lower cost, cloud computing could assist researchers and specialists with seemingly insurmountable research challenges in many areas such as genome research, environmental modelling, and analysis of dynamic systems. Moreover, cloud computing enables numerous dispersed research groups to have access to computing resources more effectively (Nelson, 2009).

2.6.3 Environment

The incorporation of cloud computing in ICT operations reduces the cost of operations as well as the emissions that pollute the environment (Vikas Kumar & Vidhyalakshmi, 2012; Uchechukwu et al., 2014). According to Amazon’s estimations (Hamilton, 2009), energy consumption-related costs amount to 42 percent of the total amount spent on the operating of servers. Moreover, currently, about 60 to 70 percent of the total energy expenses of data centres are just for the purpose of cooling down the ICT equipment; the more energy that is used, the more harm this does to the environment (Malone & Belady, 2006). Kepes (2011) mentioned that consolidated IT produces environmental benefits by improving data centre efficiency, maximizing server utilization rates, leveraging multi-tenancy and reducing total infrastructure allocation.

In a research project conducted by Microsoft, Accenture and WSP Environment and Energy, it was found that an organization with 100 employees utilizing cloud-based software can reduce energy consumption and emissions by approximately 90 per cent (Vikas Kumar &

Vidhyalakshmi, 2012). However sustainable development is not without barriers and conflicts. The capacity to deal with these issues might be the most significant prerequisite skill set which leaders and educators should have. It is beneficial for associations to determine how they can address sustainability issues and difficulties utilizing cloud computing for knowledge management (Mehrez, Lee, & Soliman, 2014).

2.7 Cloud Computing Risks and Concerns

In the previous sections, various studies on cloud governance, performance management and sustainability have been discussed. It can be seen that cloud computing has numerous advantages. However, many articles raise some concerns as well. This section will discuss briefly the most common risks and concerns associated with cloud computing.

2.7.1 Security

Security is a major consideration for any company, organization and government department that is considering a shift from traditional computing to cloud computing (Barron et al., 2013a). There are several security issues facing cloud computing implementation such as network availability, privacy and data, control over data, cloud provider viability, security incidents, disaster recovery and business continuity, system vulnerabilities, risk of common attacks and regulatory compliance, misunderstanding of responsibilities (Ogigău-neamţiu, 2012b; Winkler, 2011a). Prior to migrating to a cloud environment, an organization must be able to trust its cloud provider to provide data privacy (Fortis et al., 2012). According to U. Kumar and Gohil (2015), cloud computing faces various network attack threats such as Denial of Service Attack (DoS), Distributed Denial of Service Attack (DDoS), Flooding Attack and IP Spoofing.

With the emergence of cloud computing services, a large number of security incidents have attracted public attention. Cloud service providers consider encryption is the key to keeping the data safe; however, encryption is not always entirely helpful for data protection (Carlin & Curran, 2011). In the same vein, the China Academy of Telecommunication Research of MIIT (2012) confirmed that there are various causes of cloud failure, including software vulnerabilities or flaws, configuration errors, infrastructure failure and hacker attacks. The consequences of security incidents include data loss, information leakage and service interruptions. On 9th Dec 2009, a serious cloud computing data centre downtime occurred in the Amazon Company with its Elastic Compute Cloud (EC2) service went down due to inherent loopholes and defects (Bhola, Kaur, & Kumar, 2015, p. 15). The security incidents affected cloud-computing trust, increasing users' anxiety regarding the safety of their data. Various cloud security measures have been implemented on the cloud; these include: the firewall (Danish & Hassan, 2011), AES (Advanced Encryption Standard) algorithm (Sachdev & Bhansali, 2013), intrusion detection and prevention, integrity monitoring and log inspection. However, there are open research challenges in the cloud computing security area which require intensive research (Lokhande & Shelke, 2013), since many users and organizations are still reluctant to use it.

2.7.2 Other cloud computing threats

Bhola et al. (2015) discussed various physical and non-physical cloud computing threats (Figure 2.5).

Physical threats:

Bhola et al. (2015, p. 14) pointed out that "the latent source of an occurrence which cause may possibly effect in the loss and physical harm of the systems is known as physical threat. There are three types of physical threat":

- Internal threats, including fire hazard, power overload, etc.
- External threats, including "the floods, earthquakes etc."
- Human threats, including "theft, destruction of the communications and hardware, disturbance, unintentional or deliberate errors" (Bhola et al., 2015, p. 14).

If any of these occur to the service provider's data centre, the damage done to cloud users' data will be incalculable.

Non-physical threats:

According to Bhola et al. (2015, p. 14), the non-physical threats include virus, Trojan horse software and spyware, etc. These threats may lead to:

- Data loss or fraudulent data
- Interruption to the computing procedure which is running on the systems
- Loss of responsive information
- Cyber spying, or cyber espionage on the systems.

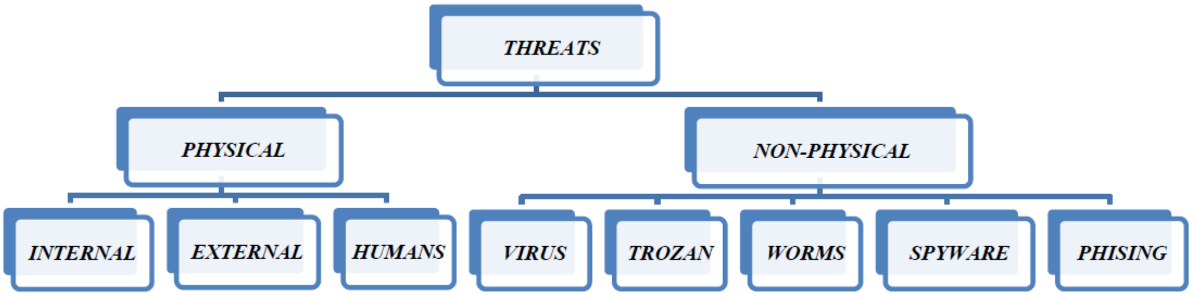


Figure 2. 5 Category of Threats (Bhola et al., 2015)

2.8 Cloud computing in education

China currently has the largest higher education system in the world (followed by the USA and India) (Bhatia & Dash, 2010). In 2014, it had 2,529 accredited universities and colleges, with a total student enrolment of 25.5 million (Shuiyun, 2016). Over the last decade, China has made considerable strides in the higher education sector, and government expenditures increased from $52.66 billion in 2003 to $311 billion in 2014. Moreover, the Project 211 and the Project 985 were designed to promote the development and reputation of the Chinese higher education system (Iryna, 2019).

The cloud computing can be implemented in many different areas. In education, e-learning solutions based on the cloud computing technology can steer pedagogical practices into a new era. With e-learning, a wealth of information can be made available to both educators and students via cloud-based services which can be accessed at any time and from anywhere (Isaila, 2014). Cloud computing can also host different learning management systems (LMS) such as Moodle and Blackboard which provide online education opportunities to the end users (Isaila, 2014).

E-learning systems play a significant role in cloud-based education. There are various advantages of using e-learning in the cloud environment:

- The institutions will reduce the costs by utilizing cloud applications on PCs, cell phones and tablets, with less configuration required; traditional hardware and software are not needed and payment is more flexible than before (Al-Jumeily, Williams, Hussain, & Griffiths, 2010);
- Cloud computing provides various applications, thereby improving the performance of e-learning. Cloud users can access resources easily without any problems (Rao, Sasidhar, & Kumar, 2012);

- Cloud providers offer an automatic software updating service, and cloud clients receive regular updates easily;
- Software compatibility is improved as e-learning applications run in the cloud (Isaila, 2014);
- E-learning brings numerous benefits to the students; for instance, students can access online courses and sample exams, and they can have online communication with the teaching staff (Pocatilu, Alecu, & Vetrici, 2009).

Moreover, in the e-learning cloud business model, the service provider is responsible for providing technical support and maintenance (Isaila, 2014).

2.9 Current Status of Environment performance and Cloud Computing Development in China

According to the research report from BAS Global Cloud Computing Scorecard, China has shown enthusiasm for ICT development and improvement compared with other countries, and China was ranked in 19th among 24 countries that account for 80% of the global ICT market in 2013 (see Appendix A). China has also made highly significant progress regarding broadband coverage, and in June 2012 carried out a magnificent national broadband project to meet the anticipated 800 million web clients in China in 2015 ("BSA Global Cloud Computing Scorecard," 2013). As for education, there is a significant lack of information about the provision of education in various districts, and there are disparities in educational offerings between urban and rural areas, and among various schools in the one region (Mundial, 2013; B. Wang & Xing, 2011; X. Wang, 2002). Because of the dense population and vast territory of China, some areas of public education, assets allocation and utilization are not adequately supervised. Human economic and social development are facing a severe challenge from global climate change caused by carbon emissions. The Chinese government has focused on implementing a series of emission reduction initiatives to accomplish carbon intensity targets by effectively promoting the green transformation of the industrial sector, which is the primary source of environmental pollution and energy consumption (Hou et al., 2018).

According to the article "Browner, but Greener Environment" from The Economist, China is one of the world's biggest polluters. In 2014, the Environmental Performance Index (EPI) presented a ranking of 178 countries, based on a variety of measures of their environmental performance. It is believed that numerous nations are doing admirably in improving access to safe drinking water and sanitation. Be that as it may, other areas like air quality, fisheries and wastewater treatment should be taken into consideration. China ranked in 118th in the overall environmental performance; Switzerland came out top and Somalia came last in 2014 ("Browner, but greener Environment," 2014). However, in terms of air pollution, China ranked at the bottom due to the unhealthy levels of PM2.5. In 2012, the average human exposure to PM2.5 was 48 micrograms per cubic metre in China; while the national figure for India was 32 (the World Health Organisation believed that it is unhealthy if the figure is above 10 units) (Hou et al., 2018).

Surprisingly, China has improved in terms of carbon emission control. The experts pointed out that the rapid development in China has increased investments in high technology industries, and the growth rate of greenhouse-gas emissions has been slowed down in the past decade. Also, new sustainable development policies in China have encouraged the usage of renewable energy and improved the efficiency ("Browner, but greener Environment," 2014).

Although China is making progress towards Green IT, there is still much to improve. According to Y. Wang et al. (2015), China has significant issues with environmental contamination and the national government has applied environmental guidelines and regulations to reduce the ecological degradation of the country. Y. Wang et al. (2015) claimed that IT could change the companies' business procedures and steer them toward environmental sustainability, thereby slowing down the degradation of the natural environment in China. Chinese manufacturing firms should utilize the new technologies to achieve environmental sustainability and decrease the impact of their business activities on the environment (Y. Wang et al., 2015).

Hou et al. (2018) constructed a distribution map regarding the industrial green transformation levels for the years 2010 and 2015 in China (Figure 2.6). In 2010, environmental pollution started to decrease after the government proposed the targets for emission reduction. With the on-going promotion of the green transformation, it can be observed that the areas with positive transformation are expanding and the growth tends to be intensive. By 2015, most areas in China had made significant progress towards industrial green transformation, and environmental pollution was carefully controlled. Tianjin Hainan, and Shandong were the leading provinces in implementing the green transformation. However, Hou et al. (2018) pointed out that the industrial growth in many areas still relies on resources, capital, labour and energy inputs. Consequently, attention ought to be paid to provinces where the progress toward green transformation is still inadequate.

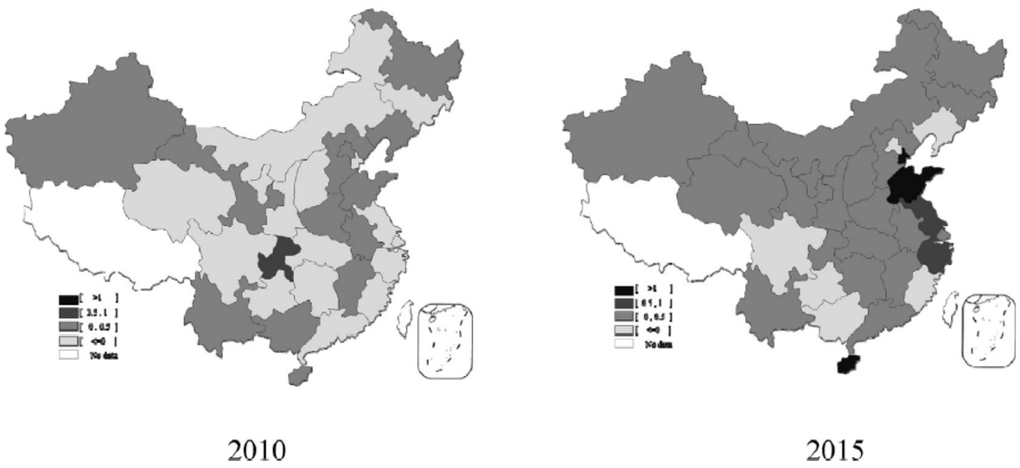


Figure 2.6. Spatial distribution of the industrial green transformation in China (2010 and 2015; the darker the better. White area are those with no data available.) (Hou et al., 2018)

As one of the Green IT technologies, the development of cloud computing has increased substantially in China. Figure 2.7 indicates the cities which have heavy investments and megaprojects in cloud computing. For instance, China Mobile, Baidu and Lenovo Group are private enterprises that are the main participants in the Beijing Xiang Yun ("Clouds of Blessing") plan. This project focuses on infrastructure-as-a-service, data searching and cloud storage (Wai-Ming, Lai, & Chung, 2013). Shanda Interactive Entertainment and China UnionPay developed Shanghai Yun Hai ("Sea of Clouds") project, which was constructed for the education sector and e-commerce. Hangzhou Yun Chao Shi ("Cloud Supermarket") project, which was designed by Aliyun, a subsidiary of Alibaba Ltd., was developed to deliver cloud services to small and medium-size enterprises (Wai-Ming et al., 2013).

Figure 2.7. Major cloud computing projects and programs in China (Wai-Ming et al., 2013)

Overall, recent research have shown that Green technology tended to bring a win-win relationship to an enterprise's environmental and business performance (Clark et al., 2019; Hou et al., 2018; M. Song & Wang, 2018; Y. Zhan et al., 2018). Aimlessly bringing down salaries and loosening environmental governances cannot bring the competitive advantages of sustainability to organizations. It is important for companies in developing countries like China to promote the economy and at the same time improve their performance for environmental responsibility. M. Song and Wang (2018, p. 201) believed that "under the slowing of economic growth, vigorous promotion of green technology progress, improvement of the quality, and the technical content of exported products, the establishment of national brand within the overseas market, as well as enhancement of China's international competitiveness, is needed".

2.10 Existing models for cloud computing

This section compares, from different angles, various current models of cloud computing. There are three themes in this research: cloud governance, performance management and sustainability. Different models for those themes are discussed and then summarized in Table 2.3, Table 2.5 and Table 2.8.

2.10.1 Cloud Governance

The aim of this section is to evaluate current models form various literatures for policy, process, and resource management in terms of cloud governance. A summary of these models will be provided in a table at the end of this section.

2.10.1.1 Policy

In the past few years, various IT governance frameworks have been created. Jäntti and Hotti (2016) proposed a generic framework for IT service governance which includes three components, "Direct, Evaluate and Monitor", as indicated in Figure 2.8.

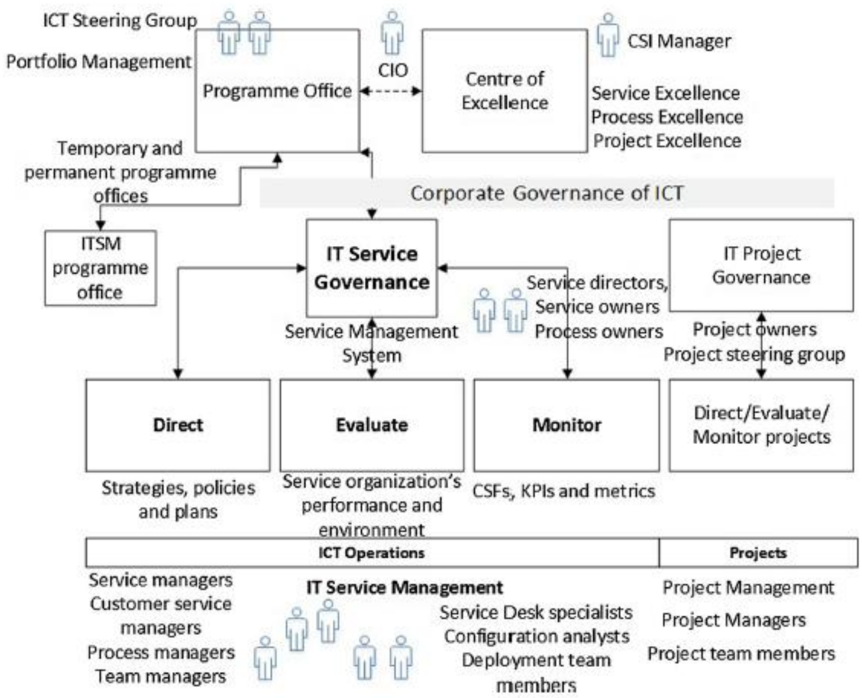


Figure 2.8. A generic framework for IT service governance (Jäntti & Hotti, 2016)

Brown et al. (2006) claimed that the SOA governance lifecycle has four phases (Figure 2.9):

- Plan phase. The requirements for governance are established and the existing mechanisms are evaluated in this phase.
- Define phase. Establishing desired governance framework, processes and principles.
- Enable phase. Implementing the new governance framework in the organizations.
- Measure phase. Refining the governance processes based on the feedback and metrics that have been gathered and analysed.

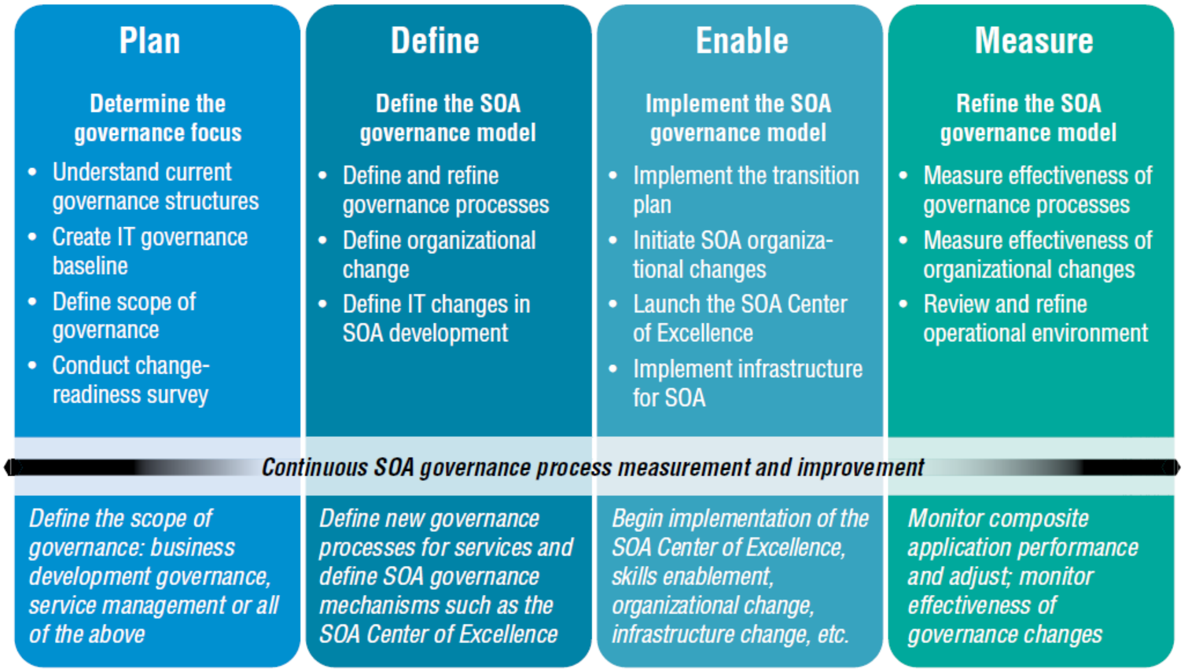


Figure 2.9. The IBM SOA Governance and Management Method (Brown et al., 2006)

Similarly, another article claimed that the process of evaluating cloud services should:

- **Assess** information against legislative and regulatory requirements
- **Evaluate** the market for cloud services including existing initiatives by other agencies
- **Determine** the suitability of the cloud service against the information requirements
- **Procure and implement** the cloud service
- **Monitor** the cloud service for performance and compliance
- **Review** the cloud service for ongoing benefits realisation (*Australian Government Cloud Computing Policy — Smarter ICT Investment* 2014).

Hardy (2006) proposed a Control Objectives for Information and related Technology framework (COBIT) which consists of four activities: plan and organize; acquire and implement; deliver and support; monitor and evaluate. COBIT offers an excellent approach for implementing IT governance-related activities in a controllable environment.

Hill et al. (2013, p. 235) summarized several common IT certification standards that are relevant to cloud computing provision as shown in Table 2.2, including the COBIT mentioned above.

Table 2.2. Common IT certification standards that are relevant to cloud computing provision (Hill et al., 2013, p. 235)

Standard	Remit
Control Objectives for Information and Related Technology (COBIT)	A set of process declarations that describe how IT should be managed by an organisation
National Institute of Standards and Testing (NIST) SP 800-53	The quality assurance of secure information provision to US government agencies, being audited against the Federal Information Security Management Act (FIMSA)
Federal Risk and Authorisation Management Program (FedRAMP)	Quality assurance is achieved by collectively achieving multiple certifications that are compliant with FIMSA. This is intended for large IT infrastructures where compliance can be a largely repetitive process
ISO/IEC 27001:2005—Information Technology, security techniques, information security management systems—requirements	Security controls to assure the quality of information service provision
Statement on Standards for Attestation Engagements (SSAE) No. 16, Reporting on Controls at a Service Organisation	This standard supersedes the Statement on Auditing Standards (SAS) No. 70, Service Organisations. SSAE 16 describes controls for organisations that provide services to users, including an assessment of the reliability and consistency of process execution
Generally Accepted Privacy Principles (GAPP)	This standard is primarily concerned with information privacy policies and practices

Besides different IT standards, the reliability of cloud technology has been mentioned in many articles. For instance, Jaeger et al. (2008) established the following basic thresholds for cloud computing reliability:

- Assignment of responsibility for misfortune or other infringement of the data
- Protections for privacy and data security
- Data accessibility
- International standards to promote and protect trans-border data flows in clouds

In order to improve the reliability of cloud technology, sustainability criteria and metrics should be considered when developing cloud-based software. Naumann, Dick, Kern, and Johann (2011) proposed the GREENSOFT Model, which is a conceptual reference model for "Green and Sustainable Software". The purpose of this model is to support software developers, administrators, and end users in building, maintaining, and utilizing software in a progressively sustainable manner. The model (see Figure 2.10) contains "a holistic life cycle model for software products, sustainability criteria and metrics for software products, procedure models for different stakeholders, and recommendations for action, as well as tools that support stakeholders in developing, purchasing, supplying, and using software in a green and sustainable manner" (Naumann et al., 2011).

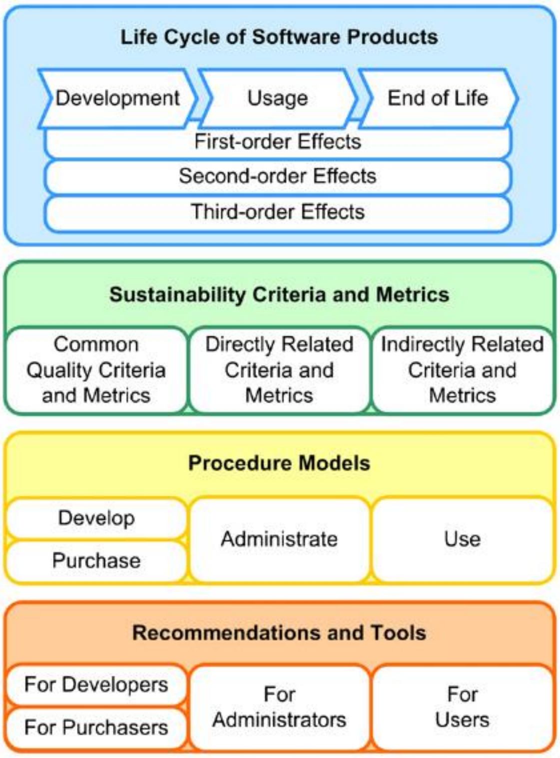


Figure 2.10. The GREENSOFT model (Naumann et al., 2011)

Similar to that, Shaw, Walters, Kumar, and Sprigg (2015, p. 532) developed the infrastructure asset life cycle shown in Figure 2.11. It includes design, construction, operations and maintenance and refurbishment decommissioning. The life cycle is also affected by governance policies.

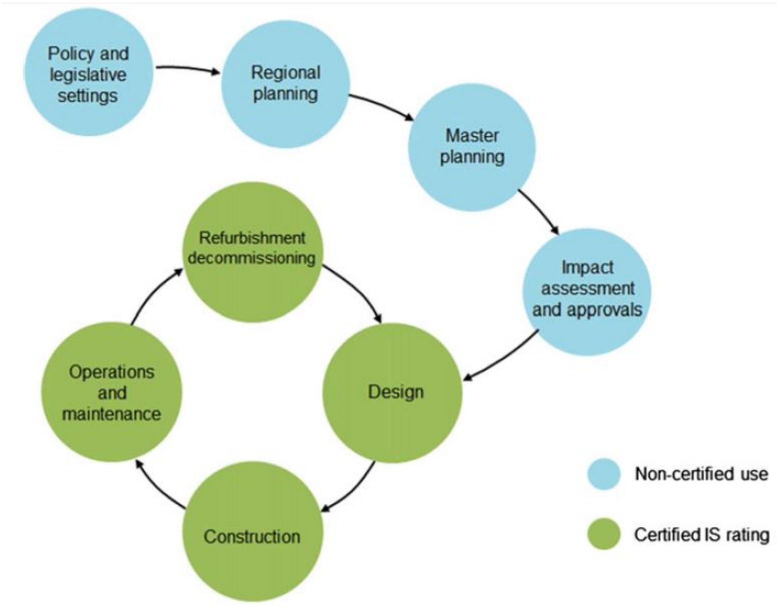


Figure 2.11. Infrastructure asset life cycle (Shaw et al., 2015, p. 532)

Cloud computing also requires that routers, networks and data centres be reliable, efficient, and secure; as well as having operational support for controlling and verifying the internet traffic via routes (Yoo, 2011). In order to meet these requirements, Yoo (2011) believed that policy implications and cloud architectural implications are essential. According to Yoo (2011), policy implications require industry structure and regulation; architectural implications pertain to networking accessibility (including bandwidth, reliability, quality of service/network management, ubiquity, privacy and security) and data centre interconnectivity (including high bandwidth networking, reliability, security and privacy, control over routing policies, standardization, metering and payment).

J. Zhang and Liang (2012) proposed an analytical framework for formulating green ICT policies as indicated in Figure 2.12. The starting point is to define an innovation system for green ICT; the scope and structural components of the system will be decided in this phase. This is followed by an assessment of the structural components in order to identify the system failures. Policy makers should not expect all of the issues to be resolved in a signal attempt, so priority should be given to the most significant barriers when formulating green innovation policies. The last two phases are policies formulation and policy measures implementation.

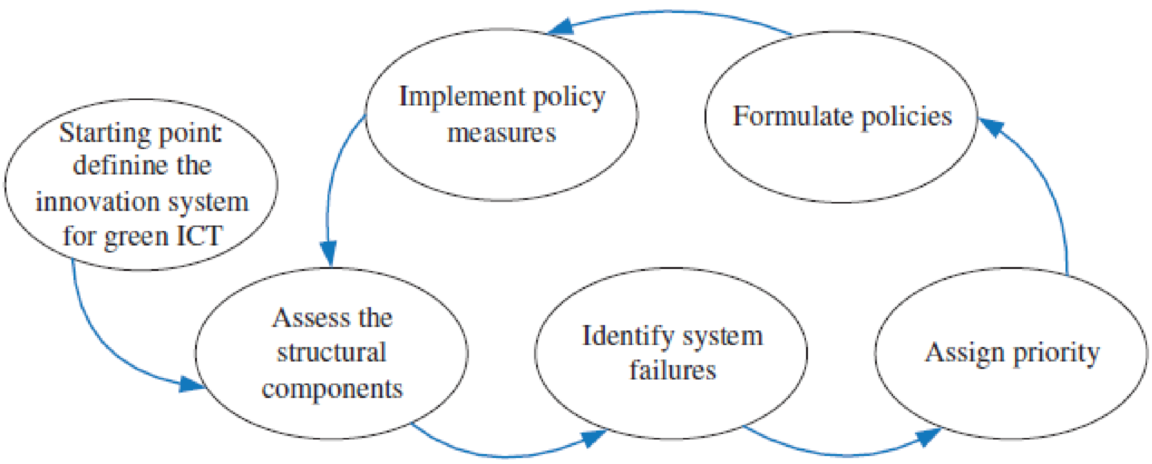


Figure 2.12. An analytical framework for formulating green ICT policies (J. Zhang & Liang, 2012)

2.10.1.2 Process

As shown in Figure 2.13, Soňa and George (2016) summarized the cloud governance process as planning, definition, implementation, monitoring.

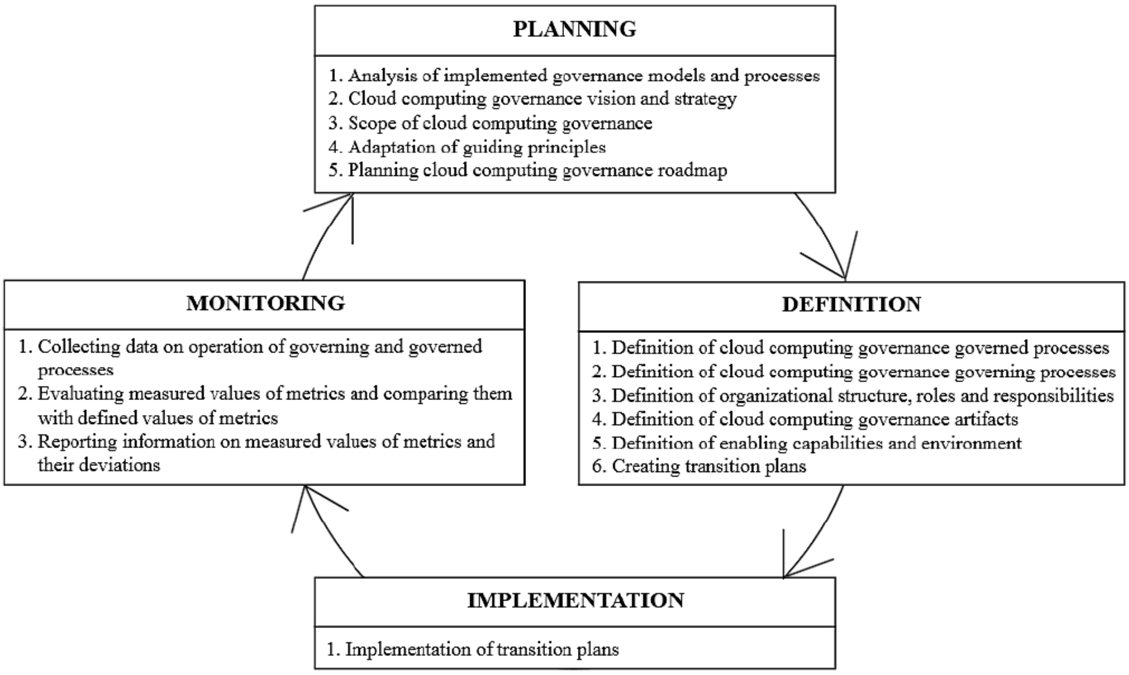


Figure 2.13. Cloud computing governance lifecycle model (Soňa & George, 2016)

An article published by Microsoft suggested that governance should proceed as follows:

- Establish IT Governance
- Assess, Monitor, and Control Risk
- Comply with Directives ("GRC Overview," 2008)

2.10.1.3 Resource Management

Parashar and Hariri (2006) believed that the resource management should cover monitoring, analysis, planning and execution as shown in Figure 2.14.

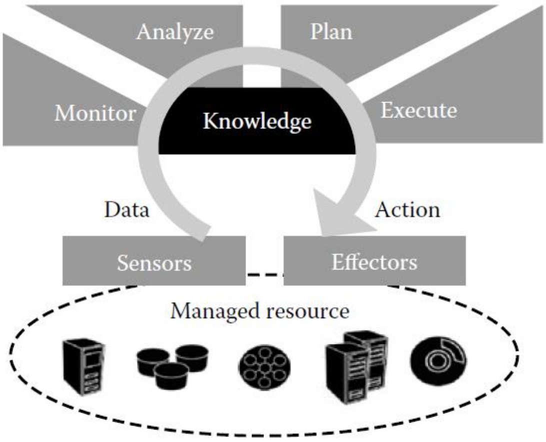


Figure 2.14. Autonomic Computing control loop (Parashar & Hariri, 2006)

Similar to that, Singh and Chana (2016b) also included monitor, analyse, plan and executor in their model shown in Figure 2.15.

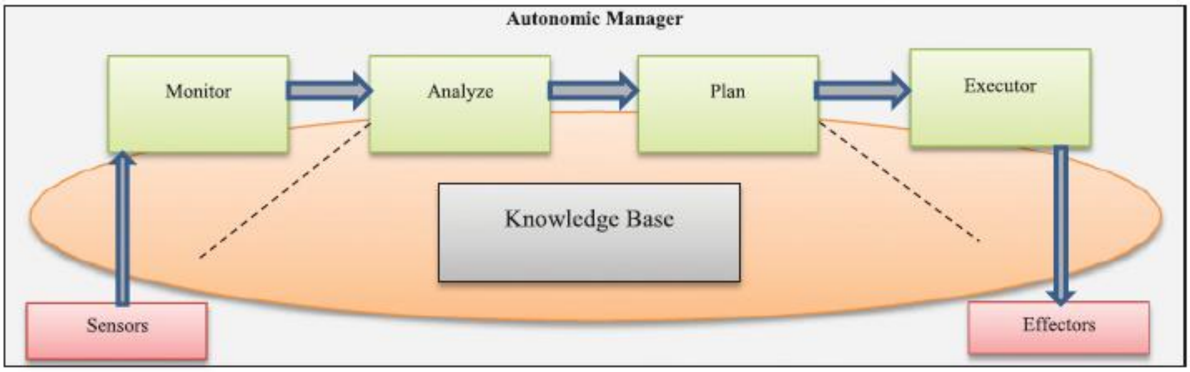


Figure 2.15. Architecture of an autonomic system (Singh & Chana, 2016b)

Z.-H. Zhan et al. (2015) summarized the resource management into three layers as shown in Figure 2.16. To begin with, when scheduling resources in the application layer, challenges do not originate only from deadlines and spending limitations of the cloud client, but also come from the service provider whose assets should be utilised to their maximum capacity. This classification is further divided into the sub-categories of ‘scheduling for user QoS’, ‘scheduling for provider efficiency; and ‘scheduling for negotiation’. Furthermore, when scheduling in the virtualization layer, challenges include how to schedule Virtual Machines (VMs) onto Physical Machines (PMs) efficiently with features such as cost effectiveness, load balance and energy conservation. Thus, this sub-category is separated into the following: ‘scheduling for load balance’; ‘scheduling for energy conservation’ and ‘scheduling for cost effectiveness’. Lastly, the deployment category is divided into ‘scheduling for service placement’; ‘scheduling for partner federation’ and ‘scheduling for data routing’.

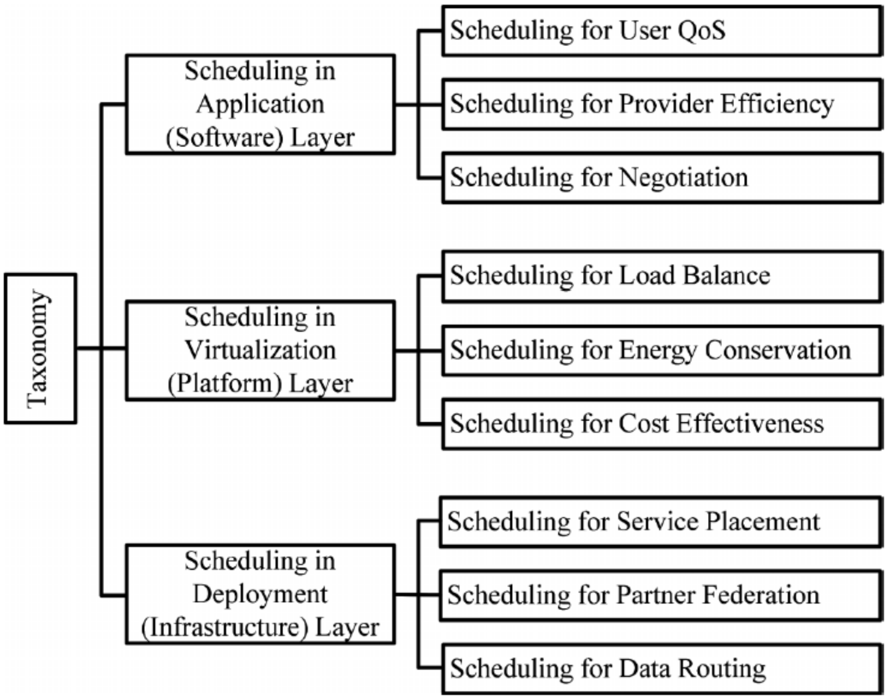


Figure 2.16. Taxonomy of cloud resource scheduling

In regard to resource management, virtualization is an essential part of cloud computing. Yuan and Zhu (2011) proposed a cloud-enabled system model for hosting applications or services in the cloud. As indicated in Figure 2.17, user applications and services are located in the top layer of the system and virtualization can be achieved via a virtualization toolkit.

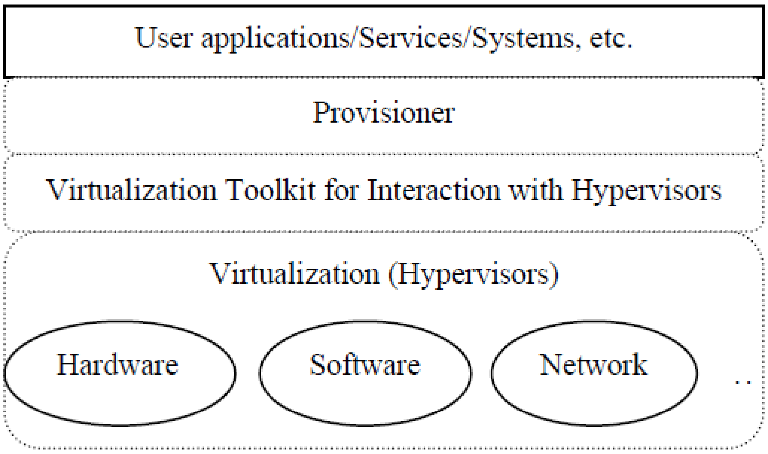


Figure 2.17. Cloud-enabled system model (Yuan & Zhu, 2011)

Virtualization also features in the CloudBay architecture designed by Zhao and Li (2013). The architecture of CloudBay is shown in Figure 2.18. One of the design objectives of CloudBay is to provide a suite of tools that facilitate computational asset sharing. CloudBay has a service-oriented architecture which can align resources and applications.

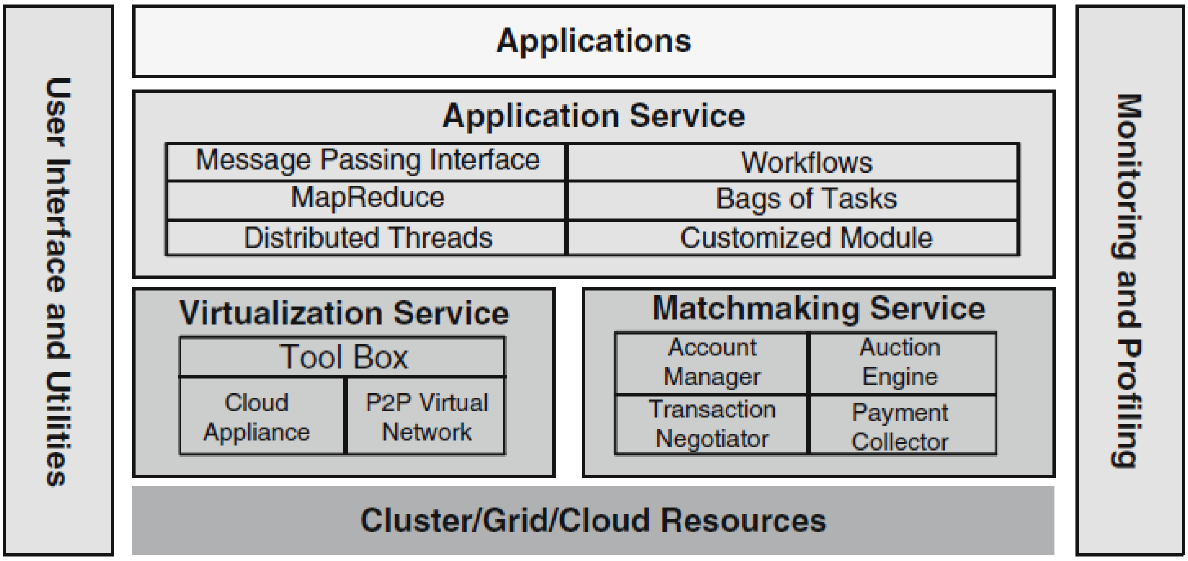


Figure 2.18. CloudBay architecture (Zhao & Li, 2013)

2.10.1.4 Summary of different models for cloud governance

Based on the previous discussion, the table below is generated to compare different models for cloud governance. In this table, all of the models are relevant to cloud governance, and the main factors extracted from these models are helpful when forming the initial sustainable cloud computing model for this research. As can be seen in the Table 2.3 below, the main factors are policy, process and resource management.

Table 2.3. Summary of cloud governance models

Author/Article	Model Name	Main Theme	Main Factor	Components
Brown et al. (2006)	The IBM SOA Governance and Management Method	Governance	Policy, Process	Plan phase, Define phase, Enable phase, Measure phase
Soňa and George (2016)	Cloud computing governance lifecycle model	Governance	Process	Planning, definition, implementation, monitoring
(*Australian Government Cloud Computing Policy — Smarter ICT Investment* 2014)	Process of evaluating cloud services	Governance	Policy	Assess, evaluate, determine, procure and implement, monitor, review
("GRC Overview," 2008)		Governance	Process	Establish; Assess, monitor, and control risk; Comply with directives

Parashar and Hariri (2006)	Autonomic Computing control loop	Governance	Resource Management	such as monitor, analyse, plan and execute
Singh and Chana (2016b)	Architecture of an autonomic system	Governance	Resource Management	monitor, analyse, plan and executor
Z.-H. Zhan et al. (2015)	Taxonomy of the cloud resource scheduling	Governance	Resource Management	Application, virtualization, deployment
Hardy (2006)	Control Objectives for Information and related Technology framework (COBIT)	Governance	Policy	Plan and organize; acquire and implement; deliver and support; monitor and evaluate.
Hill et al. (2013, p. 235)	Common IT certification standards	Governance	Policy	Standard and policy
Jaeger et al. (2008)		Governance	Policy	Reliability of cloud
Naumann et al. (2011)	The GREENSOFT model	Governance	Policy	Software development, sustainability criteria and metrics, procedure models
Shaw et al. (2015, p. 532)	Infrastructure asset life cycle	Governance	Policy	Design, construction, operations and maintenance
Yoo (2011)		Governance	Policy	Policy implications and cloud architectural implications
Yuan and Zhu (2011)	Cloud-enable system model	Governance	Resource Management	Virtualization
J. Zhang and Liang (2012)	An analytical framework for formulating green ICT policies	Governance	Policy, process	Innovation, identify failures, policy measures
Zhao and Li (2013)	CloudBay architecture	Governance	Resource Management	Virtualization
Jäntti and Hotti (2016)	A generic framework of IT service governance	Governance	Policy	IT service governance, Direct, Evaluate and Monitor

2.10.2 Performance management

The aim of this section is to evaluate current models from various literatures for capacity management, data management and energy consumption. A summary of these models is provided in a table at the end of this section.

2.10.2.1 Capacity Management

H. Jiang and Sun (2017) pointed out that networking capacity management in cloud should contain activities such as usage predictions, learning production cycle, discerning CRM and increasing risk management as shown in Figure 2.19.

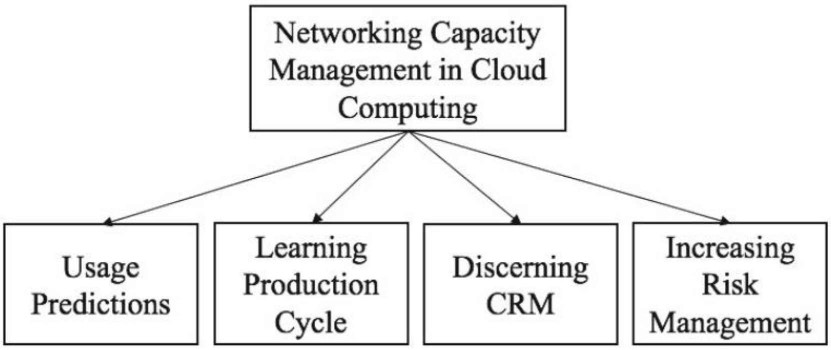


Figure 2.19. Structure for management of cloud-based networking capacity (H. Jiang & Sun, 2017)

They also proposed a networking capacity management framework (Figure 2.20). One of the significant features of this framework is that H. Jiang and Sun (2017) mentioned real-time data collection for capacity management.

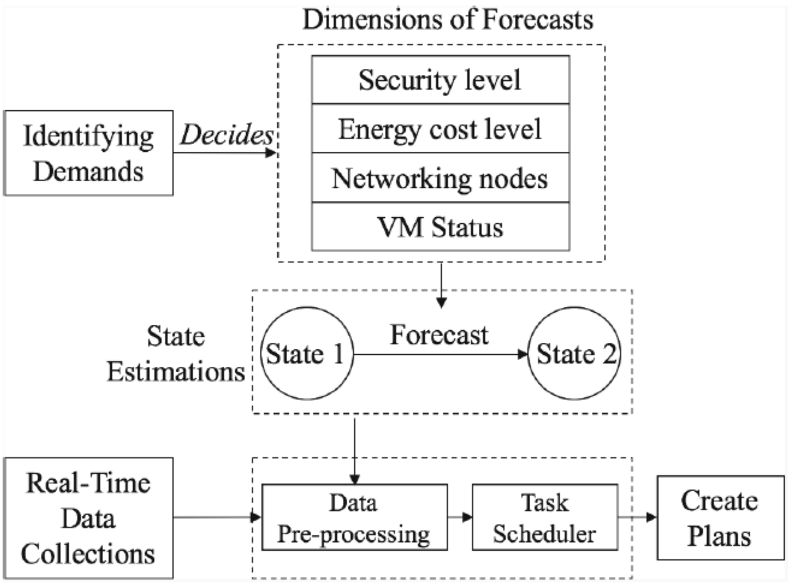


Figure 2.20. Networking capacity management framework (H. Jiang & Sun, 2017)

It is important to allow "a set of distributed traffic rate limiters to collaborate to subject a class of network traffic to a single, aggregate global limit" (Raghavan, Vishwanath, Ramabhadran, Yocum, & Snoeren, 2007, p. 337). While the traffic control policy is common in data centres and widely used in current networks, such limiters normally enforce policy autonomously in every area. Raghavan et al. (2007) developed a framework which contains Rate Limiting

Cloud-based Services and a Distributed Rate Limiter Design in order to control the cloud with distributed rate limiting.

Sabharwal and Wali (2013) proposed a capacity plan as shown in Figure 2.21. It depicts the inputs of the capacity plan, and how the capacity plan assists the ongoing capacity management. Capacity management begins with translating business activities into service prerequisites for the enterprise, and then works through the component necessities expected to convey the predefined levels of service.

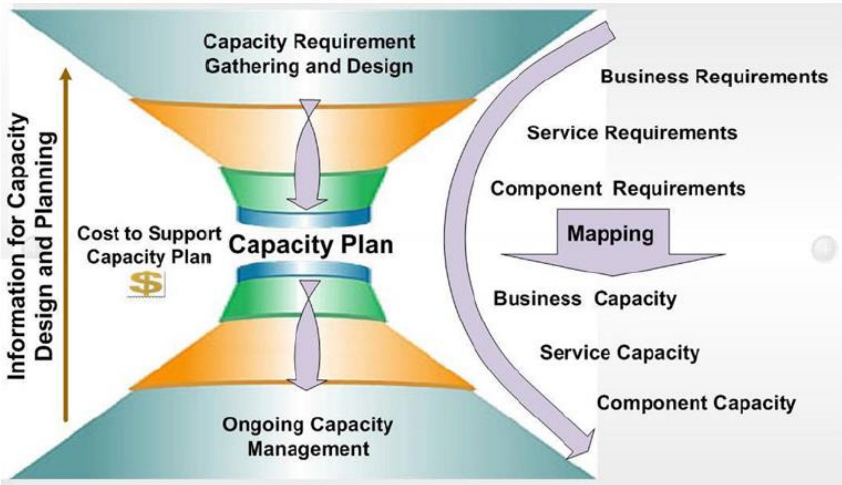


Figure 2.21. Capacity Plan (Sabharwal & Wali, 2013, p. 80)

2.10.2.2 Energy Consumption

Singh and Chana (2016a) proposed a framework (Figure 2.22) to measure energy, in order to monitor energy consumption, manage alerts, select an action and execute action.

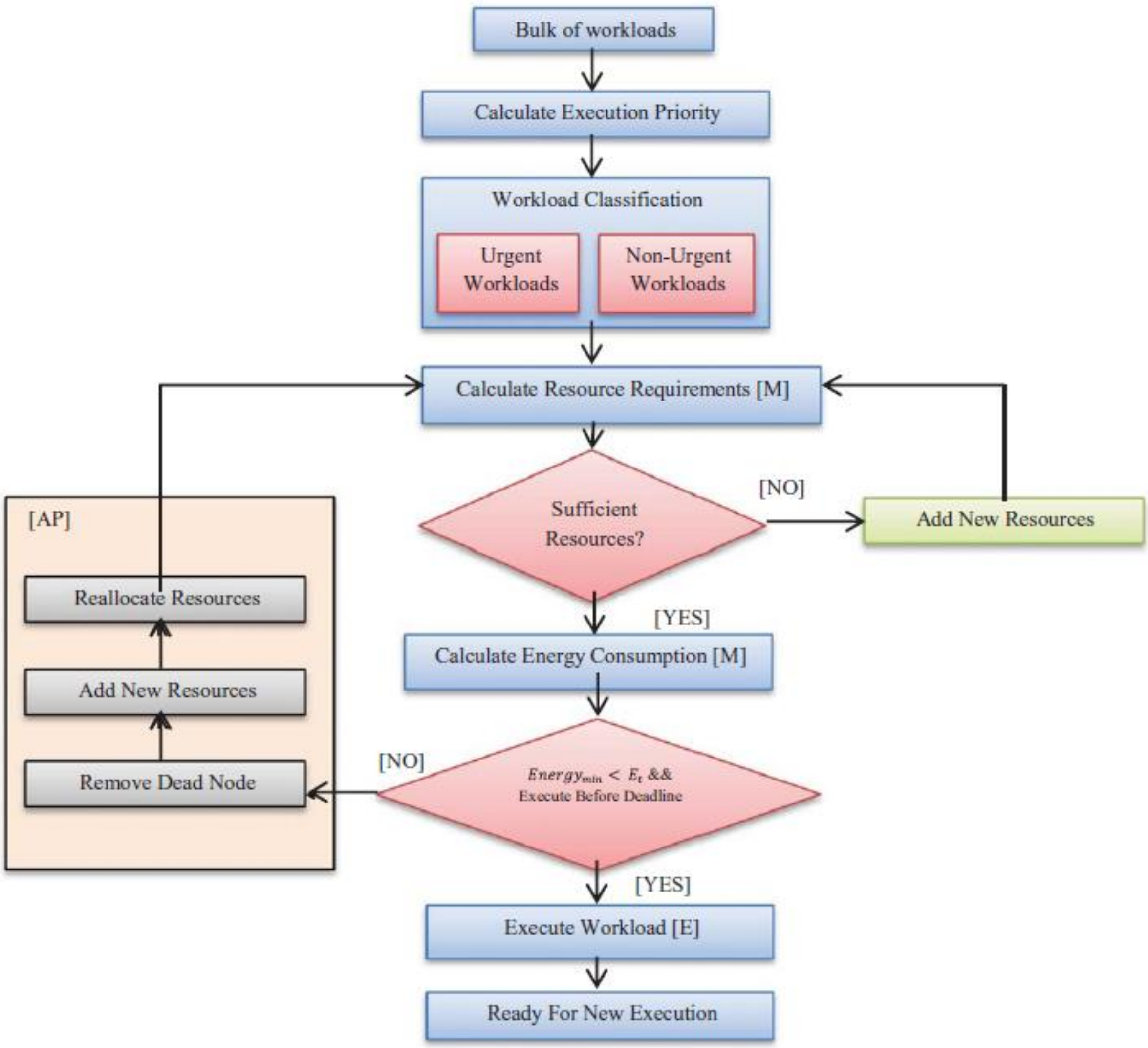


Figure 2.22. Flowchart of Energy Aware Autonomic Resource Scheduling Framework (Singh & Chana, 2016a)

Similarly, Uchechukwu et al. (2014) presented the architecture of an energy-saving mechanism (see Figure 2.23), which comprises Optimization, Reconfiguration and Monitoring of the energy consumption.

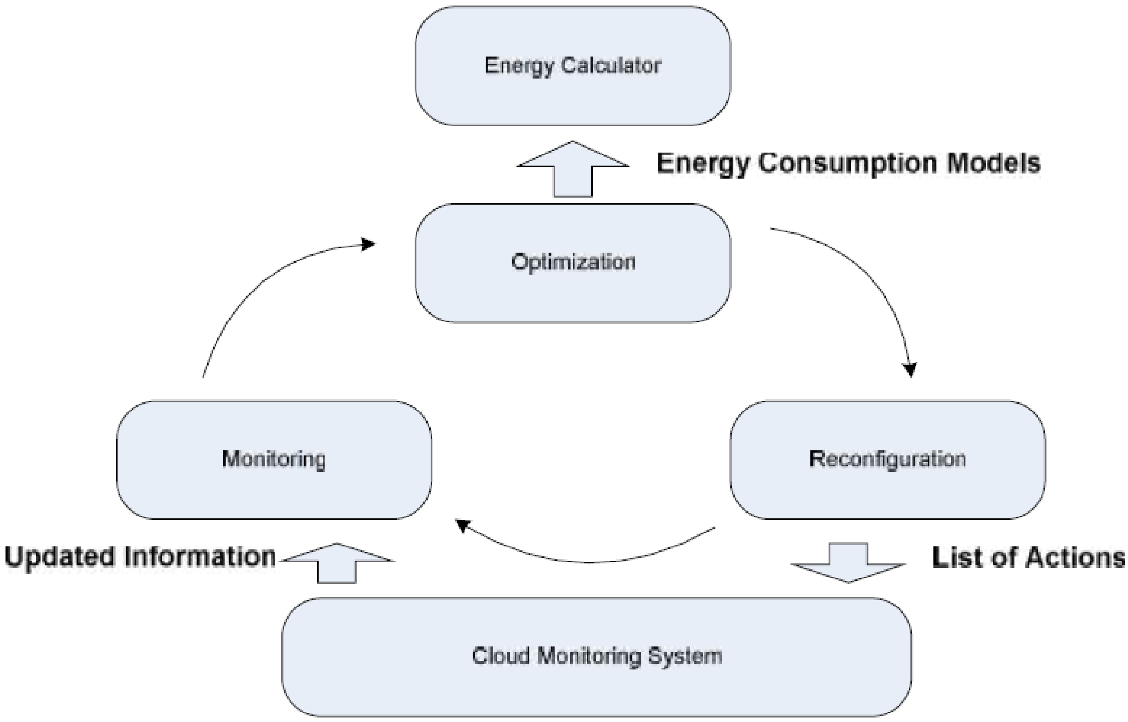


Figure 2.23. Energy consumption architecture (Uchechukwu et al., 2014)

Deng et al. (2014) proposed an energy optimization approach for cloud computing centres to address the energy consumption issues. The approach involves these major tasks: Firstly, an automation model is created for the cloud computing node. Secondly, a cloud system running a behaviour-measuring matrix is generated based on the cloud tasks analysis. Finally, an algorithm is designed to minimise the energy consumption. In Table 2.4, Faucheux and Nicolaï (2011) summarized a number of Green IT Eco-innovation applications for energy efficiency, sustainable building, renewable energies and clean transport.

Table 2.4. Green IT Eco-innovations (Faucheux & Nicolaï, 2011)

Areas of applications	Applications
Energy efficiency	• Regulation, metering, remote management • Low consuming technologies • Storage and management of micro-energy • Efficient distribution
Sustainable building	• Thermal modelling • Thermal, acoustic insulation • Intelligent building, home automation, remote management
Renewable energies	• Solar and wind production • Hydrogen • Electricity storage • Energy conversion • Decentralised distribution
Clean transport	• Sensors • Monitoring networks • Flow model • Regulation, metering, remote management.

Another aspect of research on energy consumption concerns the saving of energy. Hamilton (2009) investigated the dissipation of power in a high-scale data centre. The article explained how more research into energy savings would create value for organizations. Then, the author proposed a Collaborative Expendable Micro-slice Servers (CEMS) model which is a prototype hardware design for energy-saving purposes.

However, how much energy can be saved? It is challenging to measure the energy consumption. Some articles have tried to develop different methods to measure energy savings. Jin et al. (2013) carried out tests to gauge and analyse the energy consumption and transmission time in mobile devices when data are transferred to a cloud server in a different network environment. J. Song et al. (2013) performed another study on energy-consumption regularities of cloud computing systems using a novel evaluation model. M. Z. Johnson (2014) designed a green computer lab which conducts power management through clients and strategic software deployment. M. Z. Johnson (2014) also mentioned that power management is fundamental to green computer lab design and it requires the implementation of software and hardware with energy-efficient features.

2.10.2.3 Data Management

Abadi (2009) believed that transactional data management and analytical data management are the two most significant components of the data management market. The author argued that transactional data management applications should not be cloud-based due to architecture, maintenance and other risks. However, cloud computing is suitable for analytical data management because of its efficiency, fault tolerance, ability to maintain encrypted data and ability to integrate with business intelligence products.

Data storage and analysis are the most significant factors to consider when talking about the scalability challenges in large-scale monitoring systems, since that is the place where data from different sources is combined. Boulon et al. (2008) proposed a “Chukwa Pipeline model” (Figure 2.24) for data storage, which shows how long data is retained at each stage. In this model, every agent will reboot automatically in the event that it crashes. The agent provides three different features. To begin with, the agent will start or stop adaptors based on the external commands. Secondly, it will transfer aggregated data over the internet to the collectors. Thirdly, it is responsible for checking the adaptor status and restarting adaptors in the suitable position if an accident occurs. Then the data is collected and stored.

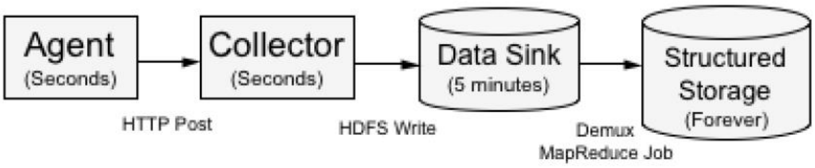


Figure 2.24. The Chukwa Pipeline (Boulon et al., 2008)

Litty, Lagar-Cavilla, and Lie (2009) believed that data management should be concerned with execution monitoring and file monitoring. Execution monitoring explains the binaries that are executed to the cloud provider, and the file monitoring provides valuable information about interpreted or dynamically generated code. For file monitoring, privacy protection is essential when designing cloud services. Pearson (2009) recommended several solutions such as: carrying out a privacy impact assessment; conducting assessments at different stages of design and using Privacy Enhancing Technologies (PETs) where appropriate. H. Zhang, Liu, and Li (2011) proposed a GRL strategic rationale (SR) analysis model shown in Figure 2.25, which illustrates the process of data management. Within the boundary of document owner, the objective ‘‘Documents be Managed’’ has been divided into two alternative activities ‘‘Use Paper-Based Document System’’ and ‘‘Implement Electronic Document System’’. What's more, each activity has been divided into smaller activities clarifying how the parent activity is being operationalized. The bottom-level activity for the document owner to ‘‘Store and Manage e-Document’’ contains a dependency link connects to the document storage service provider, outlining the work group relies upon the IT supporting group to store and deal with the electronic records. Inside the boundary of documents storage service provider, the service is conveyed utilizing either stand-alone server or virtual server.

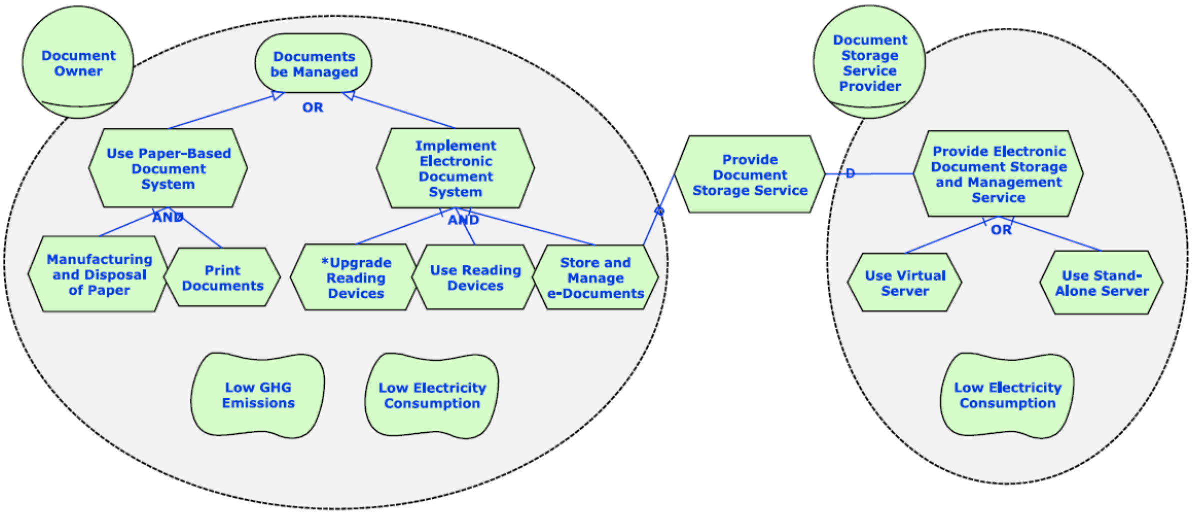


Figure 2.25. GRL strategic rationale (SR) analysis model (H. Zhang et al., 2011)

2.10.2.4 Summary of different models regarding the Performance management

Table 2.5 below shows the comparison of different models for performance management. In this table, all of the models are relevant to performance management, and the main factors extracted from these models are useful for establishing the initial sustainable cloud computing model for this research. As can be seen, the main factors are capacity management, data management and energy consumption.

Table 2.5. Model summary of performance management

Author/Article	Model Name	Main Theme	Main Factor	Components
H. Jiang and Sun (2017)	Networking capacity management framework	Performance management	Capacity Management	real-time data collections, usage predictions, learning production cycle, discerning CRM and increasing risk management
Singh and Chana (2016a)	Energy aware Autonomic Resource Scheduling Framework	Performance management	Energy Consumption	monitor energy, manage alerts, select an action and execute action
Uchechukwu et al. (2014)	Energy consumption architecture	Performance management	Energy Consumption	Optimization, Reconfiguration and Monitoring of the energy consumption

Abadi (2009)		Performance management	Data Management	analytical data management, efficiency, fault tolerance
Boulon et al. (2008)	The Chukwa Pipeline	Performance management	Data Management	data storage, data monitoring
Deng et al. (2014)	An energy optimization approach	Performance management	Energy Consumption	Energy optimization
Faucheux and Nicolaï (2011)	Green IT Eco-innovations	Performance management	Energy Consumption	Energy efficiency, Sustainable building, Renewable energies, Clean transport
Hamilton (2009)	Collaborative Expendable Micro-slice Servers (CEMS)	Performance management	Energy Consumption	Energy efficiency, Latency, Bandwidth
Jin et al. (2013)		Performance management	Energy Consumption	Energy consumption and transmission time
M. Z. Johnson (2014)		Performance management	Energy Consumption	Energy-efficient, power management
Litty et al. (2009)		Performance management	Data Management	Execution monitoring, File monitoring
Pearson (2009)		Performance management	Data Management	Privacy protection
Raghavan et al. (2007)		Performance management	Data Management	Bandwidth
Sabharwal and Wali (2013, p. 80)	Capacity Plan	Performance management	Capacity Management	Capacity requirement, ongoing capacity management
J. Song et al. (2013)		Performance management	Energy Consumption	energy-consumption regularities
H. Zhang et al. (2011)	GRL strategic rationale (SR) analysis model	Performance management	Data Management	Virtual server, stand-alone server

2.10.3 Sustainability

Garg and Buyya (2012) presented a high-level perspective on the green cloud architecture (Figure 2.26). The objective of this architecture is to build a green cloud to meet both user and provider's requirements. In the "Green Cloud architecture", clients present their cloud service demands through the middleware Green Broker that deals with the selection of the greenest cloud service provider to meet the client's requirement. A client service request can be one of three types: software, platform or infrastructure. The cloud service providers can list their services in the form of 'green offers' in a public catalogue which is accessible by Green Broker (Garg & Buyya, 2012).

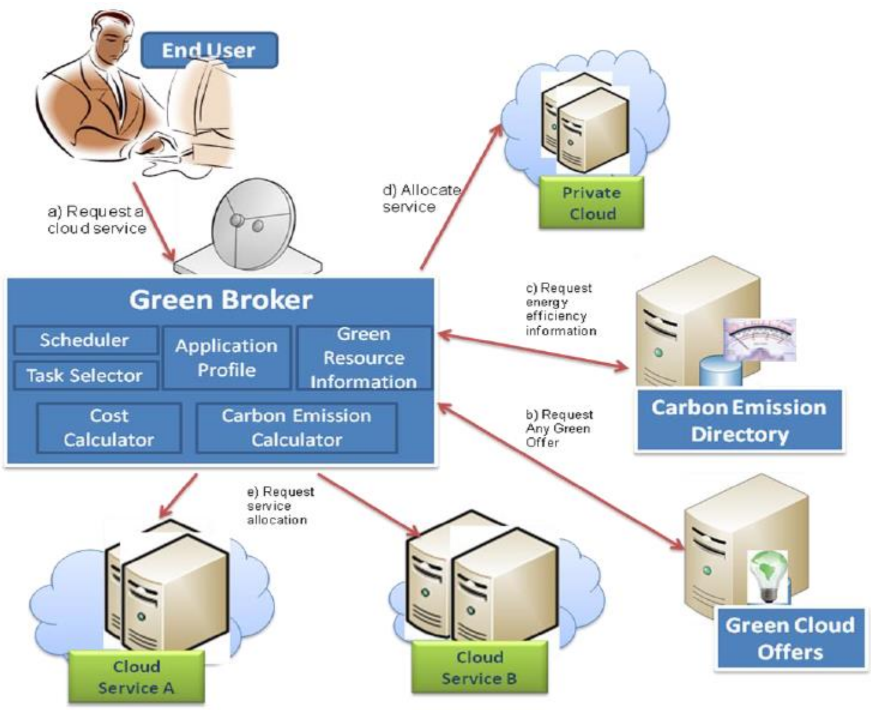


Figure 2.26. Green Cloud Architecture (Garg & Buyya, 2012)

Mehrez et al. (2014) pointed out the relationship between sustainability and education. The model (Figure 2.27) illustrates the interrelationships among the three components: sustainability, cloud computing and knowledge management. This sort of connection influences education in general and higher education in particular.

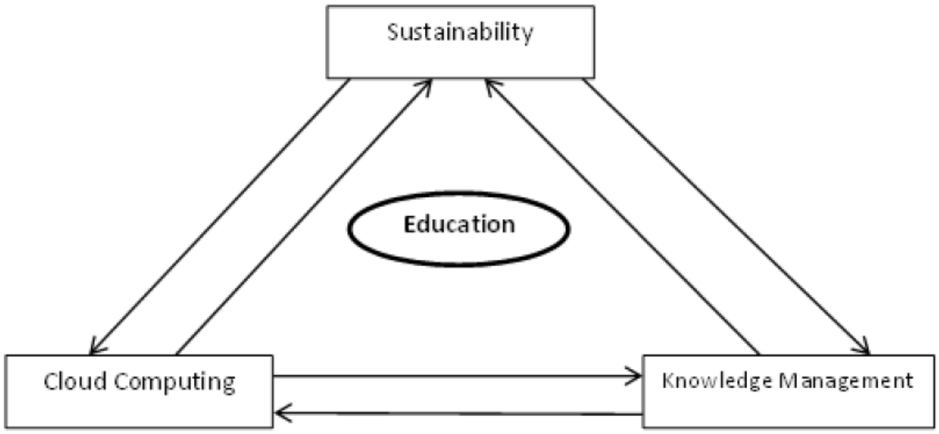


Figure 2.27. Sustainability, cloud computing and knowledge management in education (Mehrez et al., 2014)

Molla, Cooper, and Pittayachawan (2009) presented a model which is comprised of five components, and eight sub-components as shown in Figure 2.28. The G-Readiness model is helpful for determining whether organizations are able to address IT-related issues such as emissions and energy consumption. This model will enable IT managers to approach Green IT easily. Likewise, instead of viewing Green IT from the IT activity perspective, this model covers the development lifecycle including sourcing, operation and disposal.

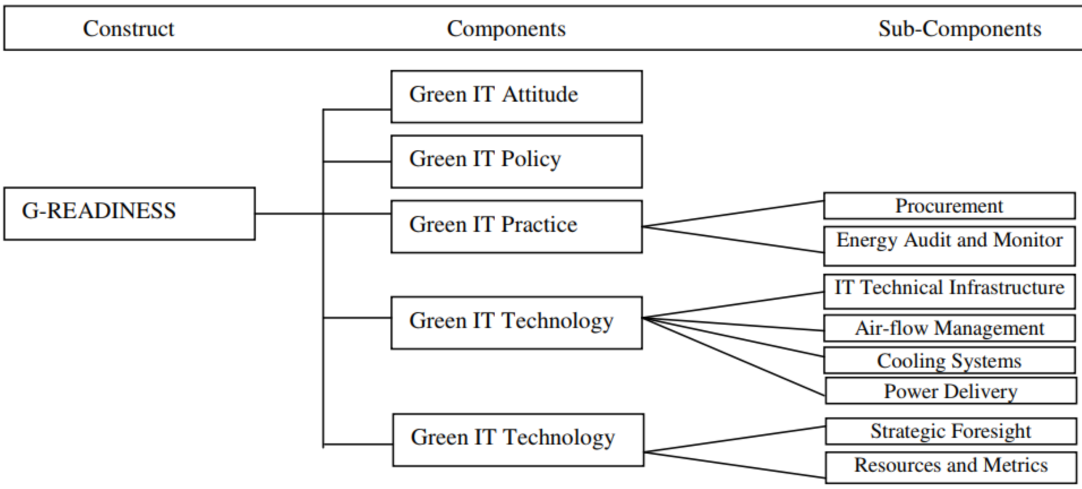


Figure 2.28. The G-readiness Model (Molla et al., 2009)

Cai, Chen, and Bose (2013) created a political–economic framework as shown in Figure 2.29. The political–economic framework contains two central concepts: polity, which refers to the power-and-control impacts of an organization on society, and people who have influence on organizational decision making; economy, which refers to the productive exchange system of an organization or society transforming ‘inputs’ to ‘outputs’ (Arndt, 1981). The political–economic framework explains how each of these components impact on the strategies of an organization when pursuing IT for environmental sustainability.

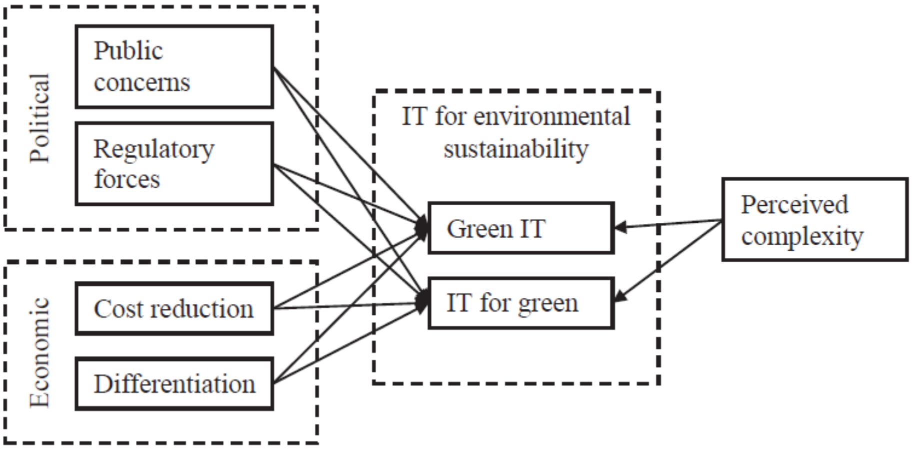


Figure 2.29. A political–economic framework (Cai et al., 2013)

The integrated sustainability framework (Table 2.6) proposed by Dao, Langella, and Carbo (2011) has four quadrants: internal today, external today, internal tomorrow and external tomorrow. While emphasizing the people factor, the framework inclines more towards adjusting the planet and profit factors. By creating sustainability capabilities, firms will be able to achieve the triple bottom line, and create sustainable value for both organizations and stakeholders (Dao et al., 2011).

Table 2.6. The integrated sustainability framework (Dao et al., 2011)

	Internal	External
Today	- *Strategy:* ○ Prevent pollution via optimizing operation to reduce cost and impacts on the environment. ○ Create organizational culture aimed towards sustainability, improve employee management practices within firms. - *Payoff:* Reduced costs, increased profitability, reduced risk.	- *Strategy:* ○ Improve extended supply chain to reduce pollution through material and processes choices and closed-loop supply chain, ○ Extend organizational culture aimed towards addressing sustainability issues affecting both internal and external stakeholders. - *Payoff*: Reputation and legitimacy, reduced environmental impacts, increased competitive advantage
Tomorrow	- *Strategy*: ○ Develop capabilities that enable radical clean technologies and processes that help solve social and environmental issues. - *Payoff*: Innovation, strategic positioning.	- *Strategy:* ○ Include core sustainability capabilities in all products, processes, and supply chains. ○ Sustainability vision: Open new, previously ignored dialogues with stakeholders to solve social issues and locate growth opportunities. - *Payoff:* Growth trajectory.

Jenkin, Webster, and McShane (2011) proposed a framework, presented in Figure 2.30, which provides a comprehensive guide for researchers who are interested in Green IT/S. Environmental attitudes, environmental cognitions and environmental behaviours are closely connected. The attitude towards cloud computing plays a significant role in cloud adoption.

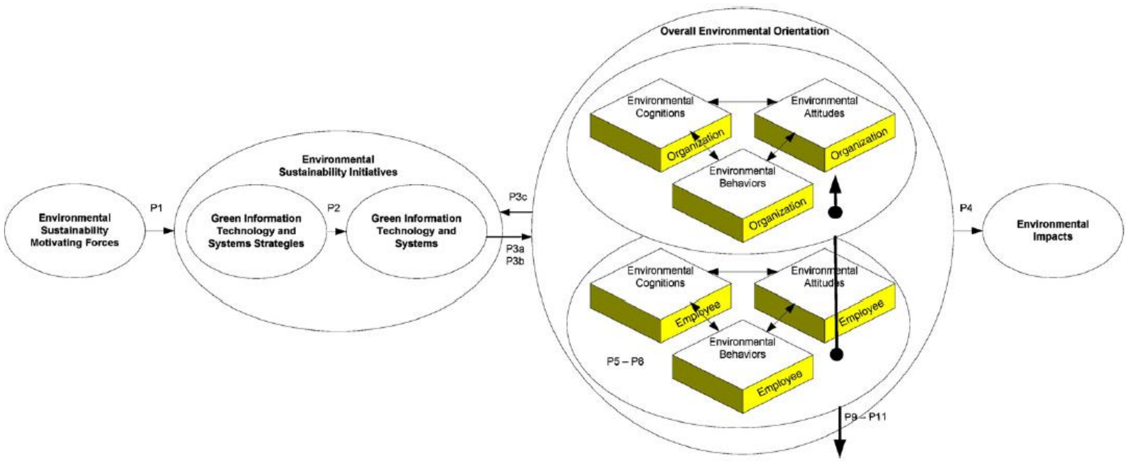


Figure 2.30. Multilevel Framework for Environmentally Sustainable IT/S Research (Jenkin et al., 2011)

Koo and Chung (2014) also considered the attitude towards Green IT use behaviour in their research as shown in Figure 2.31 below. In their Smart Green IT adoption model, the regulations would have impacts on the attitude towards Green IT.

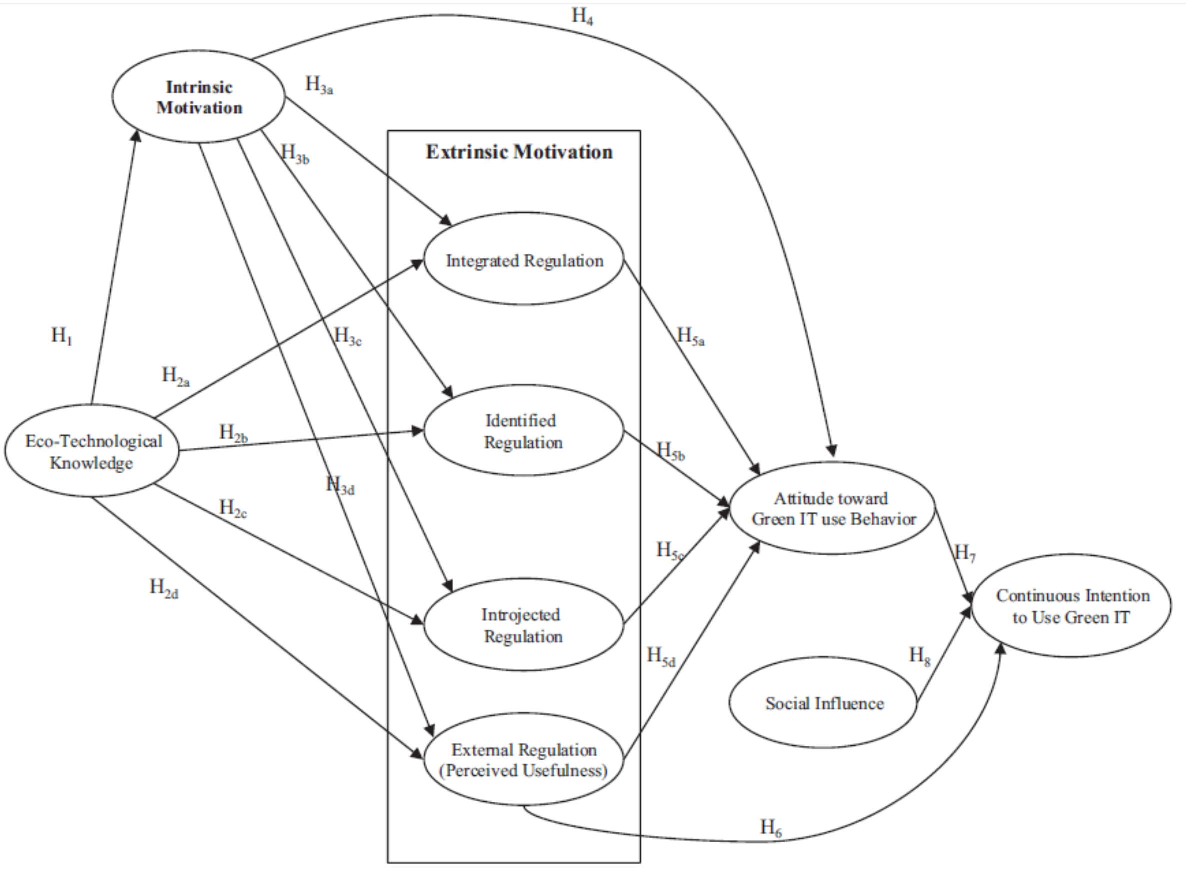


Figure 2.31. Smart Green IT adoption Model (Koo & Chung, 2014)

Murugesan and Gangadharan (2012, p. 6) described the OCED green IT framework (Figure 2.32), which consists of three analytical levels: Direct impacts of IT, Enabling impacts of IT and Systemic impacts of IT.

- Direct impacts of IT: "These are IT's first-order effects on the environment and include both positive and negative impacts due to the physical existence of IT goods and services and related processes. The sources of IT's direct environmental impacts are IT manufacturing and services firms, including intermediaries and goods producers and final consumers and users of ICTs" (Murugesan & Gangadharan, 2012, p. 6).
- Enabling impacts of IT: "These are the second-order effects that arise from IT applications that reduce environmental impacts across several economic and social activities" (Murugesan & Gangadharan, 2012, p. 6).

- Systemic impacts of IT: “These impacts and their application on the environment, also called third-order effects, involve behavioural change, process change and other non-technological factors” (Murugesan & Gangadharan, 2012, p. 6).

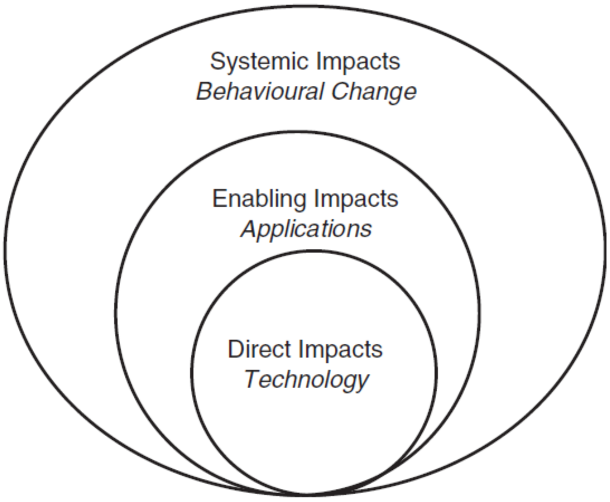


Figure 2.32. OCED green IT framework (Murugesan & Gangadharan, 2012, p. 6)

Many organizations have already done much to address the social and environmental consequences of their daily activities in order to minimize negative impacts. However, in some cases their efforts have not been entirely successful because organizations have not realised that business and society are interdependent and they view corporate social responsibility (CSR) in generic ways instead of in the way most appropriate to each firm's strategy. Hence, Porter and Kramer (2006) proposed the corporate involvement in society model in order to raise the awareness of the organizations towards their social responsibility as shown in Table 2.7.

Table 2.7. Corporate involvement in society (Porter & Kramer, 2006)

Generic Social Impacts	Value Chain Social Impacts	Social Dimensions of Competitive Context
Good citizenship	Mitigate harm from value chain activities	Strategic philanthropy that leverages capa-bilities to improve salient areas of competitive context
Responsive CSR	Transform value-chain activities to benefit society while reinforcing strategy	**Strategic CSR**

The costs should also be considered when moving to the cloud. Figure 2.33 (Tak et al., 2011) presents the classification of costs related to cloud migration. There are direct costs like hardware/software etc. and indirect costs (e.g. electricity used by the cooling system).

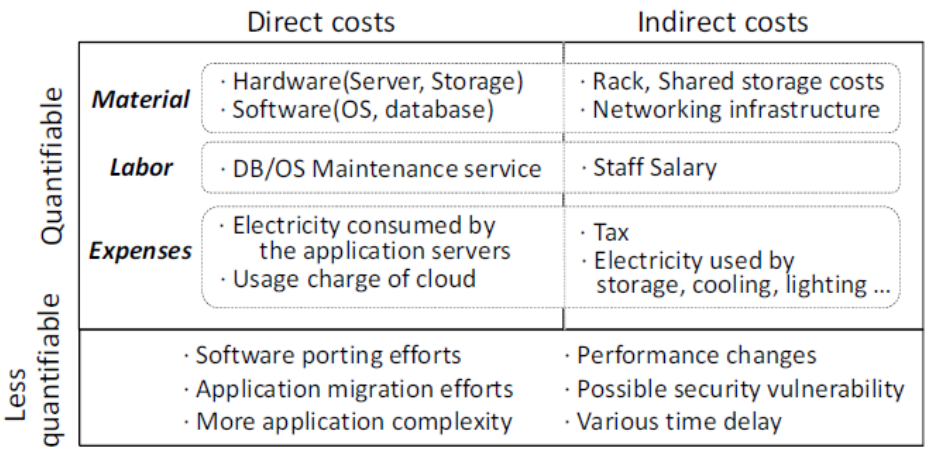


Figure 2.33. Classification of costs related to migration (Tak et al., 2011)

Y. Wang et al. (2015) proposed a model (Figure 2.34) in which IT competence empowers the organization to integrate the IT capabilities in the transformation of business processes to ensure environmental sustainability and performance in manufacturing activities. Furthermore, the impact of IT competence on environmental management and sustainability can be greater in those organizations with a more advanced development of environmental management activities.

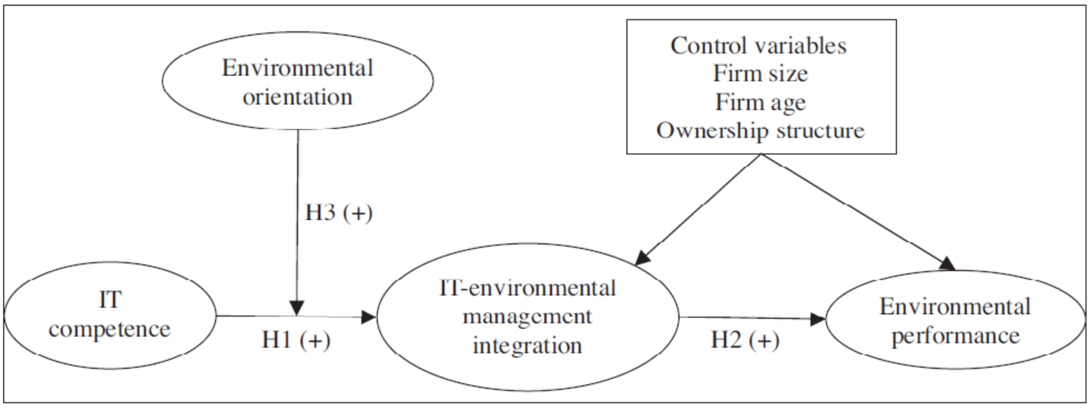


Figure 2.34. IT-environmental management framework (Y. Wang et al., 2015)

2.10.3.1 Summary of different models regarding Sustainability

The table below has been created to compare various models for sustainability. In this table, all of the models are relevant to sustainability, and the main factors extracted from these models are helpful for the creation of the initial sustainable cloud computing model for this research. Table 2.8 shows that the main factors are social, economic and environmental.

Table 2.8. Summary of sustainability models

Author/Article	Model Name	Main Theme	Main Factor	Components
Garg and Buyya (2012)	Green Cloud Architecture	Sustainability	Social, Economic, Environment	Cost calculator, Scheduler, Green resource Information
Mehrez et al. (2014)	Sustainability, cloud computing and knowledge management in education	Sustainability	Social, Economic, Environment	Education, Knowledge Management
Molla et al. (2009)	The G-readiness Model	Sustainability	Social, Economic, Environment	Monitor, attitude, policy, strategic foresight, resources and metrics
Cai et al. (2013)	A political–economic framework	Sustainability	Social, Economic, Environment	Public concerns, regulatory forces, cost reduction, differentiation.
Dao et al. (2011)	Integrated sustainability framework	Sustainability	Social, Economic, Environment	Balancing the people and profit factors
Jenkin et al. (2011)	Multilevel Framework for Environmentally Sustainable IT/S Research	Sustainability	Environment	Environmental attitudes, environmental cognitions and

				environmental behaviours
Koo and Chung (2014)	Smart Green IT adoption Model	Sustainability	Social, Environment	Motivation, regulations, attitude
Murugesan and Gangadharan (2012, p. 6)	OCED green IT framework	Sustainability	Social, Environment	Direct impacts, Enabling impacts and Systemic impacts
Porter and Kramer (2006)	Corporate involvement in society	Sustainability	Social, Environment	Corporate social responsibility (CSR)
Tak et al. (2011)	Classification of costs related to migration	Sustainability	Economic	Direct costs; indirect cost
Y. Wang et al. (2015)		Sustainability	Environment	Environmental orientation, environmental management

2.11 Research Gap

Governance involves the strategic task of establishing an organisation's goals, direction, limitations and accountability frameworks. It is necessary to establish the governance strategy up front, if universities or institutions consider adopting the cloud computing technology. Once cloud computing has been adopted, performance management is required in order to ensure that the system operates as planned. Moreover, sustainable green IT attracts more attention nowadays. Environmental sustainability has been defined as "development that meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs" (Hurlem, 1987, p. 43), and is therefore linked to ongoing economic growth and development (Jenkin et al., 2011). Thus, governance, sustainability and performance management should be considered together when developing a cloud computing model.

In integrating these areas, the literature review chapter reveals that, while other academic research has done a good job in certain areas of the current frameworks, there are many gaps that present opportunities for sustainable cloud computing research. To the best of this researcher's knowledge, none of the articles which have been reviewed so far has covered these three aspects together (shown in Table 2.9). Therefore, in order to guide future sustainable cloud computing studies, this study aims to explain the linkages among the different components identified in this research and to create a cloud computing model that includes cloud computing governance, sustainability and performance management. The existing models shown in Table 2.9 were collected from different journal articles. Therefore, they were not only applicable for China but in general.

Table 2.9. Research Gap

Author/Article	Model Name	Governance			Sustainability			Performance Management		
		Policy	Process	Resource	Social	Finance	Environment	Data Management	Energy Consumption	Capacity Management
Abadi (2009)		x	x	x	x	x	x	√	x	x
Boulon et al. (2008)	The Chukwa Pipeline	x	x	x	x	x	x	√	x	x
Brown et al. (2006)	The IBM SOA Governance and Management Method	√	√	x	x	x	x	x	x	x
Cai et al. (2013)	A political–economic framework	√	x	x	√	√	√	x	x	x
Dao et al. (2011)	The integrated sustainability framework	x	x	x	√	√	√	x	x	x
Deng et al. (2014)	An energy optimization approach	x	x	x	x	√	√	x	√	x
Faucheux and Nicolaï (2011)	Green IT Eco-innovations	x	x	x	x	x	√	x	√	x
Hamilton (2009)	Collaborative Expendable Micro-slice Servers (CEMS)	x	x	x	x	x	√	x	√	x
Hardy (2006)	Control Objectives for Information and related Technology framework (COBIT)	√	x	√	x	x	x	x	x	x
Hill et al. (2013, p. 235)		√	x	x	x	x	x	x	x	x
Jaeger et al. (2008)		√	x	√	x	x	x	√	x	x
Jenkin et al. (2011)	Multilevel Framework for Environmentally Sustainable IT/S Research	x	x	x	x	x	√	x	x	x
Jin et al. (2013)		x	x	x	x	x	x	√	√	x
M. Z. Johnson (2014)		x	x	x	x	√	x	x	√	x
Koo and Chung (2014)	Smart Green IT adoption model	√	x	x	√	x	√	x	x	x
Litty et al. (2009)		x	x	x	x	x	x	√	x	x
Murugesan and Gangadharan (2012)		x	x	x	√	x	√	x	x	x

Naumann et al. (2011)	The GREENSOFT model	√	x	x	x	x	x	√	x	x
Pearson (2009)		x	x	x	x	x	x	√	x	x
Porter and Kramer (2006)	Corporate involvement in society	x	x	x	√	x	√	x	x	x
Raghavan et al. (2007)		x	x	x	x	x	x	x	x	√
Raj (2013)		√	√	√	x	x	x	√	x	x
Sabharwal and Wali (2013, p. 80)	Capacity Plan	x	x	x	x	√	x	x	x	√
Shaw et al. (2015, p. 532)	Infrastructure asset life cycle	√	x	x	x	x	x	x	x	x
J. Song et al. (2013)		√	x	x	x	x	x	x	√	x
Tak et al. (2011)	Classification of costs related to migration	x	x	x	x	√	x	x	x	x
Y. Wang et al. (2015)	IT-environmental management framework	√	x	x	x	x	√	√	x	x
Yoo (2011)		√	√	x	x	x	x	x	x	x
Yuan and Zhu (2011)	Cloud-enable system model	x	x	√	x	x	x	√	x	x
J. Zhang and Liang (2012)	An analytical framework for formulating green ICT policies	√	√	x	x	x	√	x	x	x
H. Zhang et al. (2011)	GRL strategic rationale (SR) analysis model	x	x	x	x	x	x	√	x	x
Zhao and Li (2013)	CloudBay architecture	x	x	√	x	x	x	x	x	x
Soňa and George (2016)	Cloud computing governance lifecycle model	√	√	x	x	x	x	x	x	x
(*Australian Government Cloud Computing Policy — Smarter ICT Investment* 2014)	Process of evaluating cloud services	√	√	√	x	x	x	√	√	x
("GRC Overview," 2008)		√	√	√	x	x	x	x	x	x
Parashar and Hariri (2006)	Autonomic Computing control loop	√	√	√	x	x	x	x	x	x
Singh and Chana (2016b)	Architecture of an autonomic system	√	√	√	x	x	x	x	x	x
Z.-H. Zhan et al. (2015)	Taxonomy of the cloud resource scheduling	√	√	√	x	x	x	x	x	x
H. Jiang and Sun (2017)	Networking capacity management framework	x	x	x	x	x	x	√	x	√
Singh and Chana (2016a)	Energy aware Autonomic Resource Scheduling Framework	x	x	√	x	x	x	x	√	√
Uchechukwu et al. (2014)	Energy consumption architecture	x	x	√	x	x	x	x	√	√
Garg and Buyya (2012)	Green Cloud Architecture	x	x	√	√	√	√	x	√	x
Mehrez et al. (2014)	Sustainability, cloud computing and knowledge management in education	x	x	x	√	√	√	√	x	x
Molla et al. (2009)	The G-readiness Model	√	x	x	√	√	√	x	√	x
Jäntti and Hotti (2016)	A generic framework of IT service governance	√	√	x	x	x	x	x	x	x

2.12 Initial model

Based on the literature review, an initial model has been proposed below. It contains three main themes: Governance, Performance Management and Sustainability.

Each theme has several factors: policy, process and resource are included in the Governance theme; data management, energy consumption and capacity management belong to the Performance Management theme; and finally, the Sustainability theme has social, economic and environmental factors.

In the following chapters, these themes and factors will be refined, filtered and restructured. New factors may be added after the qualitative research phase (interview phase), and the model will be updated. The refined model will be tested in the quantitative research phase (online questionnaire). The data from the quantitative research phase will be analysed using SPSS software and the factors will be filtered and restructured. The final model of this research will be presented in the last chapter. Hence, the model shown in Figure 2.35 is an initial model generated from the literature review, with further changes and amendments carried out.

Figure 2.35. Initial Model for sustainable cloud computing in China

2.13 Chapter Summary

This chapter provides a comprehensive review of the literature pertaining to cloud computing to frame this research. More specifically, this chapter presents definitions of cloud computing, cloud governance, performance management and sustainability. Various models containing these themes are introduced in Section 2.10. This chapter also identifies the research gap by comparing different models in regard to cloud governance, performance management and sustainability. The missing piece in this research area is that none of the articles from the literature review has covered governance, performance management and sustainability together.

Major Findings including:

- Governance involves the strategic task of establishing an organisation's goals, direction, limitations and accountability frameworks.
- Performance management is required in order to ensure that the system operates as planned.
- Environmental sustainability is linked to ongoing economic growth and development

Cloud adoption in education is discussed in Section 2.8, followed by the status of environmental performance and cloud computing development in China. A series of main factors and components related to each main factor are summarised in Table 2.3, Table 2.5 and Table 2.8. An initial model (Figure 2.35) is then proposed towards the end of this chapter and that model will be evaluated and improved in the following chapters. Cloud governance, performance management and sustainability are the three main components of this model. Chapter 4 and 5 will evaluate and test those themes to form the final model for this research.

The next chapter explains the research methodology and discusses various research paradigms, approaches and strategies.

Chapter 3 Research Method

3.1 Introduction

In the previous chapter, a comprehensive literature review was conducted on sustainability, governance and performance management of cloud computing. The research gap was identified and an initial model of sustainable cloud computing model was created in Chapter 2 based on the discussion. This chapter explains the research significance and research objective formulated as research questions. It also discusses the selection of the research methodology that is best suited to this research.

More specifically, this chapter describes and examines various phases of the research onion and clarifies the concepts in each phase. To start with, the research significance, questions and objectives will be discussed in Section 3.2 to 3.4. After that, the research philosophy will be defined in Section 3.5. This provides the starting point for the appropriate research approach to theory development, which is embraced in the second stage (Section 3.6). In the third step, methodological choice is decided as indicated in Section 3.7, followed by strategy in Section 3.8. The fifth layer (time horizon) is dealt with in Section 3.9. The sixth step, where the data collection methodology is identified, is explained in Section 3.10. The advantage of the research onion is that it illustrates a progression of stages under which the various techniques are applied for data collection and analysis. This research utilizes the ‘research onion’ as the theoretical basis, and in Section 3.11, the chosen research method for this research will be discussed and then presented in a customised ‘research onion’ designed for this research.

3.1.1 Research introduction

In the modern world where information is generally accessible over the Internet, some people may believe that it ought to be relatively simple for organizations to obtain the information required for a better understanding of a certain phenomenon. Unfortunately, this is not always true for two reasons. Firstly, relevant information is not necessarily simple to find and distinguish from irrelevant information. Secondly, relevant information normally requires interpretation, which can be quite difficult (Firth & Swanson, 2005). That is why appropriate research approaches are required. Saunders, Lewis, and Thornhill (2016, p. 124) proposed the ‘research onion’ which provides an effective progression for designing the research methodology and indicates the steps that the researcher should follow when deciding on an effective research methodology. The benefit of this model is its adaptability and flexibility for practically any type of research methodology. The research onion shows the phases that should be included when developing a research methodology. Each layer of the onion depicts a more detailed phase of the research process when viewed from the outside. Thus, the outer layers of the onion are important and researchers should understand them rather than simply peel and throw away (Saunders et al., 2016).

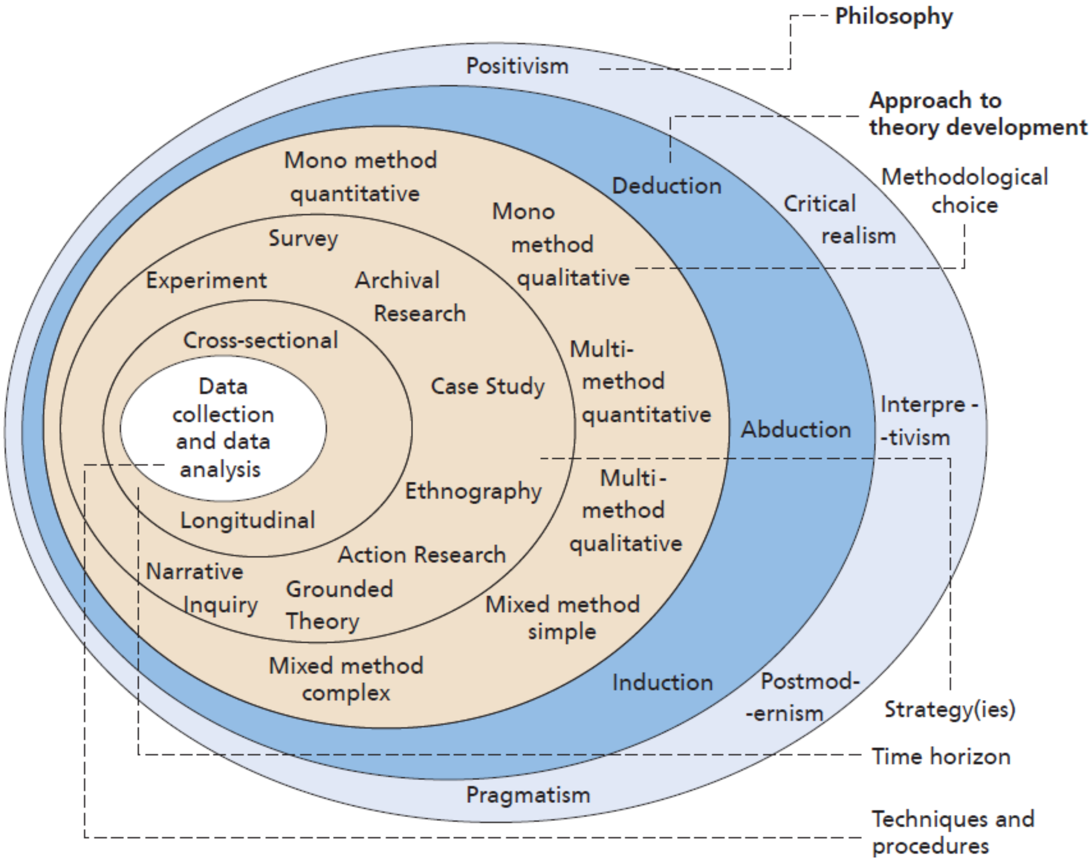


Figure 3.1. The 'research onion' (Saunders et al., 2016, p. 124)

As indicated in Figure 3.1, the research onion has six layers in total, and each layer contains several options. The first layer 'Philosophy' includes positivism, critical realism, interpretivism, postmodernism and pragmatism. The second layer 'Approach to theory development' contains deduction, abduction and induction. In the following sections, the appropriate option from each layer will be identified based on the requirements of this research. As for the 'Methodological choice' in layer three, mono method quantitative, mono method qualitative, multi-method quantitative, multi-method qualitative and mixed method are included. The strategy options in layer four consist of experiment, survey, archival research, case study, ethnography, action research, grounded theory and narrative inquiry. The 'Time horizon' in the fifth layer specifies cross-sectional and longitudinal. The sixth and final layer comprises 'Techniques and procedures', and contains the details of data collection and data analysis. In the following sections, each layer will be discussed separately, and selections for this research will be made and highlighted from the Figure 3.3 to Figure 3.10. The selections are combined in Figure 3.11.

3.2 Significance of Research

For any type of research project, it is essential to clarify the significance of the research, including both theoretical significance and practical significance. Theoretical significance refers to the exploration of new knowledge and the expansion of the existing knowledge on a certain topic. Practical significance refers to the empirical impact that the results of this research has in real life. The purpose of this study is to develop a new sustainable cloud computing model for the higher education sector in China using a mixed-method research approach. It is hoped that the outcome of this research can integrate the different aspects of cloud computing and guide further research on this topic.

3.2.1 Theoretical Significance

This research will provide a detailed description of and new perspective on cloud computing adoption in Chinese universities. The governance, sustainability and performance management of cloud computing will be explained and summarized. Also, this research will review the current cloud computing models. A series of solutions and standards regarding cloud computing will be generated in this research. Governance, sustainability and performance management are the key elements comprising this new sustainable cloud computing model. Governance clarifies the necessary procedures when moving to the cloud, performance management monitors the whole process to make sure everything is on track, sustainability will help the organization or institution to achieve sustainable goals. The proposed model aims to provide a broader view of the cloud technology by combining all these three elements together. Internal stakeholders such as students, staff and IT personnel will be the users of the new model, and external stakeholders including the service provider, researchers, software developers, government, research partners, etc. could also be affected by this model (see Appendix B). Finally, researchers, academics, PhD and Master students, locally and globally will benefit from this research outcome.

3.2.2 Practical Significance

Cloud computing in China is developing rapidly. However, the literature review indicates that few studies have focused on all three aspects -cloud governance, sustainability and performance management- simultaneously. Thus, this research aims to investigate these three domains of cloud computing that should not be ignored when adopting the cloud. From the practical perspective, this research will benefit potential cloud computing users and institutions. The outcome of this research is a new cloud computing model which can be applied to universities in China in the future. It is anticipated that this model will encourage Chinese universities or organizations to move to the cloud. For those universities who are already using the cloud technology, this model will also provide some valuable information to improve their cloud strategy. Furthermore, with certain modifications, this cloud model could be adapted for other organizations and universities in other countries. The new cloud computing model will be developed to support a great number of potential cloud users: business leaders (in the case of this study, educational leaders) and IT infrastructure managers who need to clearly understand the principles for cloud-related governance; enterprise architects, business analysts and software developers who are willing to adopt newer approaches to develop and deploy cloud services and infrastructures based on a new cloud computing model; cloud computing field researchers who would like to further increase their understanding of the governance, sustainability and performance management aspects of cloud computing; and students and lecturers who are interested in improving their cloud-related knowledge.

3.3 Research questions

A research question is "a specific question the research is designed to investigate and attempt to answer" (Collis & Hussey, 2009, p. 117). As mentioned earlier, the purpose of this study is to develop a new sustainable cloud computing model for the higher education sector in China. The statement of purpose guides the general direction of this research, and the research questions specify enquiries the research will pursue and attempt to answer. Collis and Hussey (2009, p. 117) point out that the research questions highlight what should be the focus of research efforts, but they are not the actual questions to be used in an interview or questionnaire. Formulating the research questions is a crucial step in the research process as it plays a significant role in research design. Figure 3.2 illustrates the steps involved in establishing research questions. The research is a process of enquiry; thus, the outcome of the research investigation will provide the solutions or answers to the enquiries. It is essential to ensure the research questions are interesting or important; otherwise, the value of the research would not meet the requirements. In addition, relevant literature should be reviewed before launching the investigations to make sure the questions have not already been answered. If the solutions already exist, the researcher may have to modify the proposed research in order to provide new findings and extend the existing knowledge. Otherwise, the research can proceed as planned.

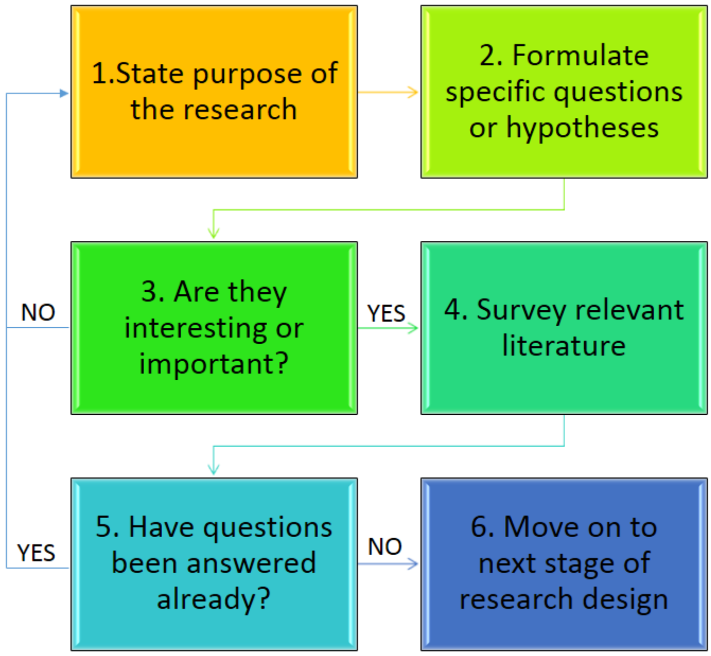


Figure 3.2. Identifying research questions. (Adapted from Collis and Hussey (2009, p. 118), prepared by the author)

Cloud computing has been widely used in higher education sectors around the world to provide access to online data storage, learning and teaching materials, etc. However, only a few studies have been conducted on the development of a framework which integrates sustainability with cloud computing. Moreover, sustainable development in cloud computing is often overlooked. Thus, this research aims to address this gap by identifying relevant factors that need to be considered when developing a new sustainable cloud computing model for the higher education sector in China.

3.3.1 Primary Research Question

One of the most important steps when designing a research is to identify a research problem or issue that requires investigation (Collis & Hussey, 2009, p. 111). In order to refine the research problem, specific research questions are developed before conducting the data collection. Cloud computing is like a double-edged sword. It can reduce IT operating costs, optimise IT infrastructure, and simplify the installation and maintenance. However, it is also subject to risks associated with disaster recovery, data privacy and security. Many researches have attempted to resolve these issues by developing new approaches and frameworks. This research takes a different perspective by considering the sustainable development of cloud computing. Three main themes emerged from the literature review: governance, sustainability and performance management. Before developing a framework, it is essential to identify the factors associated with the three main themes. Hence, this research aims to identify and evaluate a set of factors that will, together, constitute a general framework for the sustainable development of cloud computing in China.

Therefore, the main research question is:
What are the factors pertaining to governance, sustainability and performance management that should be taken into consideration when developing the new sustainable cloud computing model for the higher education sector in China?

3.3.2 Secondary Research Questions

To reiterate, this research aims to develop and evaluate a new cloud-computing model for the higher education sector (universities) in China. Once the factors pertaining to governance, sustainability and performance management are identified, it is essential to evaluate and filter them. The initial model for sustainable cloud computing in China shown in Figure 2.35 is developed based on the literature review. Each theme contains several factors: the governance theme contains policy, process and resource factor; the performance management theme has data management, energy consumption and capacity management factor; the sustainability theme includes social, economic and environmental factors. It is crucial to test the validity of those factors among cloud uses to see if it is necessary to include them, or to add more factors to the themes. Moreover, the relationship among those themes needs to be identified. Does governance have a positive effect on sustainability and performance management, and do the governance, performance management and sustainability have positive effects on the decision-making phase regarding the adoption of cloud computing? Do they have strong connections? Are the positions of the themes equal, or is one theme dominant? In order to address these issues, an in-depth analysis is required in order to have a better understanding of this topic. Therefore, the secondary research questions for this research are:

- *What are the perceptions and attitudes of students, academic staff and IT department personnel towards the new sustainable cloud computing model in Chinese universities?*
- *What are the relationships among governance, sustainability and performance management?*

3.4 Research Objectives

This research seeks to have a better understanding of sustainable cloud computing development and to create a new sustainability cloud computing model for the higher education sector in China. One of the most challenging tasks is to select the most relevant factors related to the topic. Numerous factors could potentially influence the implementation of cloud computing technology, so it is essential to narrow them down to the most salient ones. Besides, not only in the cloud computing area, but also in all IT-related researches, only a few studies have included environmental concerns when developing new frameworks. Therefore, this proposed cloud computing framework will take that into consideration. The structure of the framework consists of a set of core factors that relate to governance, sustainability and performance management, and a set of sub-factors which support those core factors in different ways.

Thus, based on the research questions, the objectives of this research are as follows:

- To determine the factors pertaining to governance, sustainability and performance management that should be taken into consideration when developing the new sustainable cloud computing model for higher education sectors in China.
- To examine the perceptions and attitudes of students, academic staff and IT department personnel towards the new sustainable cloud computing model in Chinese universities.
- To identify the relationships among governance, sustainability and performance management.

3.5 Research philosophy

The first layer of the research onion is the research philosophy or paradigm. According to Saunders et al. (2016, p. 143), the labels ‘philosophies’ and ‘paradigms’ are sometimes used interchangeably. Collis and Hussey (2009, p. 55) pointed out that a research paradigm is “a framework that guides how research should be conducted, based on people’s philosophies and their assumptions about the world and the nature of knowledge”. The research paradigm is related to the set of beliefs concerning the nature of the reality being learnt (Bryman, 2012, p. 630). It is the basic meaning of the nature of research. The assumptions generated by a research philosophy offer the justification for how the research will be carried out. Research philosophies can vary according to the objectives of research and the ideal way that they may be utilized to accomplish these objectives. Although these are not really inconsistent with one another, the choice of research philosophy is characterized by the type of knowledge being examined in the research project (May, 2011). Thus, understanding the research philosophy being utilised can help clarify the assumptions in the research procedure.

According to Figure 3.1, there are five major philosophies: positivism, critical realism, interpretivism, postmodernism and pragmatism. Table 3.1 provides a detailed comparison of those philosophies. After that, the philosophies will be discussed separately and the chosen one will be identified.

Table 3.1. Comparison of five research philosophies

	Philosophical assumption			
	Ontological assumption (the nature of reality)	**Epistemological assumption** (what constitutes Valid knowledge)	**Axiological assumption** (the role of values)	**Methodological assumption** (the process of research)
Positivism	Reality is objective and singular, separate from the researcher	Researcher is independent of that being researched	Research is value-free and unbiased	Process is deductive, well structured, large sample size
Critical realism	Objective structures, external, independent	Knowledge historically situated and transient	Value-laden research, researcher acknowledges bias by world views, cultural experience	Reproductive, in-depth historically situated analysis of pro-existing structures
Interpretivism	Reality is subjective and multiple, as seen by the participants	Researcher interacts with that being researched	Researcher acknowledges that research is value-laden and biases are present	Process is inductive, small sample size, in-depth investigations
Postmodernism	Socially constructed through power relations	What counts as ‘knowledge’ is determined by	Value-constituted research	Range of data types, typically qualitative

		dominant ideologies		methods of analysis
Pragmatism	Flux of processes, experiences and practices	Focus on problems, practices and relevance	Value-driven research	Following research problem and research question

Source: Adapted from Saunders et al. (2016, p. 144) and Collis and Hussey (2009, p. 58), prepared by the author

3.5.1 Positivism

Positivism assumes that reality exists independently of the objects being investigated. This implies that the significance of phenomena is consistent between subjects. Collis and Hussey (2009, p. 56) defined positivism as a "paradigm that originated in the natural sciences. It rests on the assumption that social reality is singular and objective and is not affected by the act of investigating it. The research involves a deductive process with a view to providing explanatory theories to understand social phenomena". Positivism identifies with the philosophical position of the natural researcher and involves working with a perceptible social reality to create law-like generalisations (Saunders et al., 2016, p. 144). Similar to that, Bryman (2012, p. 28) pointed out that positivism is an epistemological position that stands for the application of the methods of the natural sciences to the investigation of social reality and beyond.

3.5.2 Critical realism

Critical realism is a particular type of realism whose aim is to perceive the truth of the natural order and social world. Bryman (2012, p. 29) pointed out that "positivists take the view that the scientist's conceptualization of reality actually directly reflects that reality. Unlike positivists, critical realists are perfectly content to admit into their explanations theoretical terms that are not directly amenable to observation". According to Somerville (2012, p. 294), critical realism is a philosophy that can help to develop logical knowledge by clarifying conceptual disarrays, removing hindrances to clear discernment, and indicating how science should be developed. Saunders et al. (2016, p. 147) added that the philosophy of critical realism aims at clarifying what people experience, in terms of the underlying structures of reality that shape the noticeable events. According to critical realism, there are two stages to understanding the world. Firstly, the sensation of events that people experienced is established. Secondly, mental processing occurs at some point after the experience.

3.5.3 Interpretivism

The aim of interpretivism research is to generate better understandings and interpretations of social worlds and contexts (Saunders et al., 2016, p. 149). Interpretivism recommends that the characteristic significance of social phenomena is generated by each observer or group (Östlund, Kidd, Wengström, & Rowa-Dewar, 2011). Bryman (2012, p. 30) claimed that the differences between people and the objects of the natural sciences should be respected. Similarly, Saunders et al. (2016, p. 148) pointed out that individuals and their social worlds cannot be examined in the same way as physical phenomena; thus, social sciences research should be different from natural sciences research. According to Collis and Hussey (2009, p. 57), interpretivism is a “paradigm that emerged in response to criticisms of positivism. It rests on the assumption that social reality is in our minds, and is subjective and multiple. Therefore, social reality is affected by the act of investigating it. The research involves and inductive process with a view to providing interpretive understanding of social phenomena within a particular context”.

3.5.4 Postmodernism

Postmodernism accentuates the responsibilities of language and of power relations, trying to give voice to alternative marginalised views (Saunders et al., 2016, p. 149). As a methodology, postmodernism serves two purposes. The first purpose is to evaluate the nature of modern society and culture. The second purpose is to represent the nature of the social sciences as knowledge. Specifically, it is a distinctive sensitivity with respect to the representation of social scientific discoveries (Bryman, 2012, p. 382).

3.5.5 Pragmatism

According to Saunders et al. (2016), pragmatism aims to accommodate both objectivism and subjectivism, realities and values, exact and rigorous knowledge and diverse contextualised experiences. To achieve that, it is necessary to consider theories, concepts, ideas, hypotheses and research findings not in an abstract form, but distinguish them based on the roles they play in the research, as well as their practical consequences in specific contexts. Collis and Hussey (2009, p. 66) claimed that instead of been ‘constrained’ by a single paradigm, pragmatism means researchers ought to be ‘free’ to use a mix of methods from various paradigms, selecting them on their usefulness for solving the research questions. Pragmatists propose that the shortcomings of one paradigm can be counterbalanced with the strengths of the other by disregarding the philosophical discussion about reality and the nature of knowledge.

3.5.6 The chosen philosophy

The aim of this research is to identify the factors pertaining to governance, sustainability and performance management that should be taken into consideration when developing the new sustainable cloud computing model for the higher education sector in China. **Pragmatism philosophy** is selected for this research because a single paradigm is not appropriate for this research. The main benefit of pragmatism philosophy is that the researcher can utilise a combination of methods from various paradigms in order to address the research questions. A single paradigm may have limitations and weaknesses. For instance, since positivists believe that everything can be measured and calculated, positivism philosophy tend to be inflexible; interpretivism philosophy is more suitable for qualitative research, etc. In order to maximise the strengths and minimise the limitations of different paradigms, pragmatism philosophy seems to be the best option. As shown in Table 3.1, pragmatism philosophy focuses on problems and practices. It follows the research problem and research question, and is suitable for value-driven research. Therefore, based on the research needs, **pragmatism philosophy** is selected to assist the following stages of this research. The red rectangle in Figure 3.3 indicates the selected Philosophy.

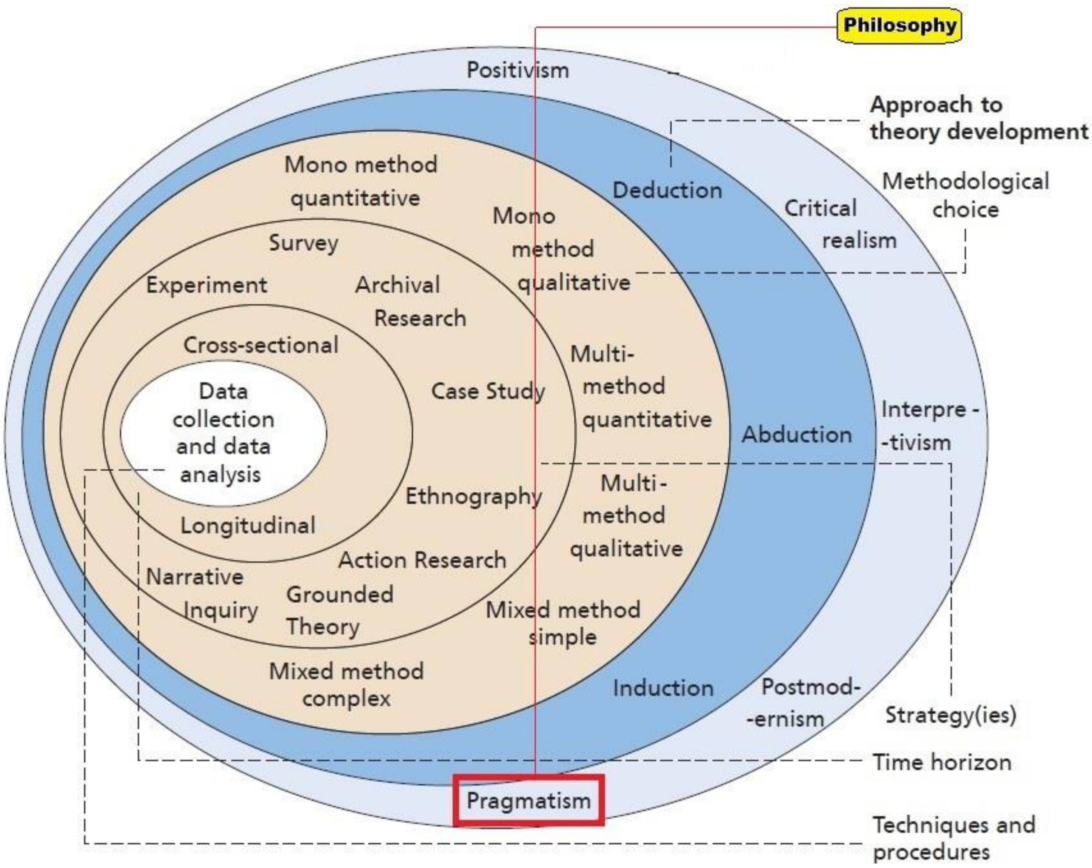


Figure 3.3. Selected philosophy

3.6 Research Approach

As the paradigm has now been selected, the next step is to determine the appropriate research approach. As indicated in Figure 3.1, there are three approaches: deduction, induction and abduction. Table 3.2 indicates the main differences among those approaches.

Table 3.2. Deduction, induction and abduction

	Deduction	**Induction**	**Abduction**
Logic	If the premises are true, the conclusion should be true as well	Known premises are utilised to generate untested conclusions	Known premises are utilised to generate testable conclusions
Generalisability	Generalised from general to specific	Generalised from general to specific	Generalised from the interactions between the specific and the general
Use of data	Data collected will be utilised to evaluate propositions or hypotheses related to an existing theory	Data collected will be utilised to explore a phenomenon, identify themes and patterns and create a conceptual framework	Data collected will be utilised to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection
Theory	Testing or verifying a conceptual and theoretical structure	Generating and building theory that is developed from the observation of empirical reality	Generating and modifying theory; incorporating existing theory to build new theory or modify existing theory

Source: Adapted from Saunders et al. (2016, p. 153) and Collis and Hussey (2009, p. 8), prepared by the author.

According to Collis and Hussey (2009, p. 8), deductive research "describes a study in which a conceptual and theoretical structure is developed which is then tested by empirical observation, thus particular instances are deducted from general inferences". In other words, if the research begins with a theory, which is generated from academic literature, and the researcher designs a strategy to evaluate the theory, it is a deductive approach (Saunders et al., 2016, p. 153). Therefore, the deductive approach shifts from the general to the particular.

Conversely, inductive research "describes a study in which theory is developed from the observation of empirical reality; thus general inferences are induced from particular instances" (Collis & Hussey, 2009, p. 8). Simply put, if the research begins by collecting data to explore a phenomenon in order to generate or build theory, it is an inductive approach (Saunders et al., 2016, p. 153). Thus, the inductive approach moves from the specific to the general.

With abductive research, Saunders et al. (2016, p. 153) state that if the research starts by "collecting data to explore a phenomenon, identify themes and explain patterns, to generate a new or modify an existing theory which researcher subsequently test through additional data collection", it is an abductive approach.

In this research, the initial model was developed following the literature review. The initial model will be evaluated through an interview phase, and based on the feedback from the interview, an amended model will be tested via an online survey to generate the final model. The themes and factors will be developed and identified systematically. Therefore, the approach selected for this research is **deduction**. The orange rectangle in Figure 3.4 indicates the selected approach.

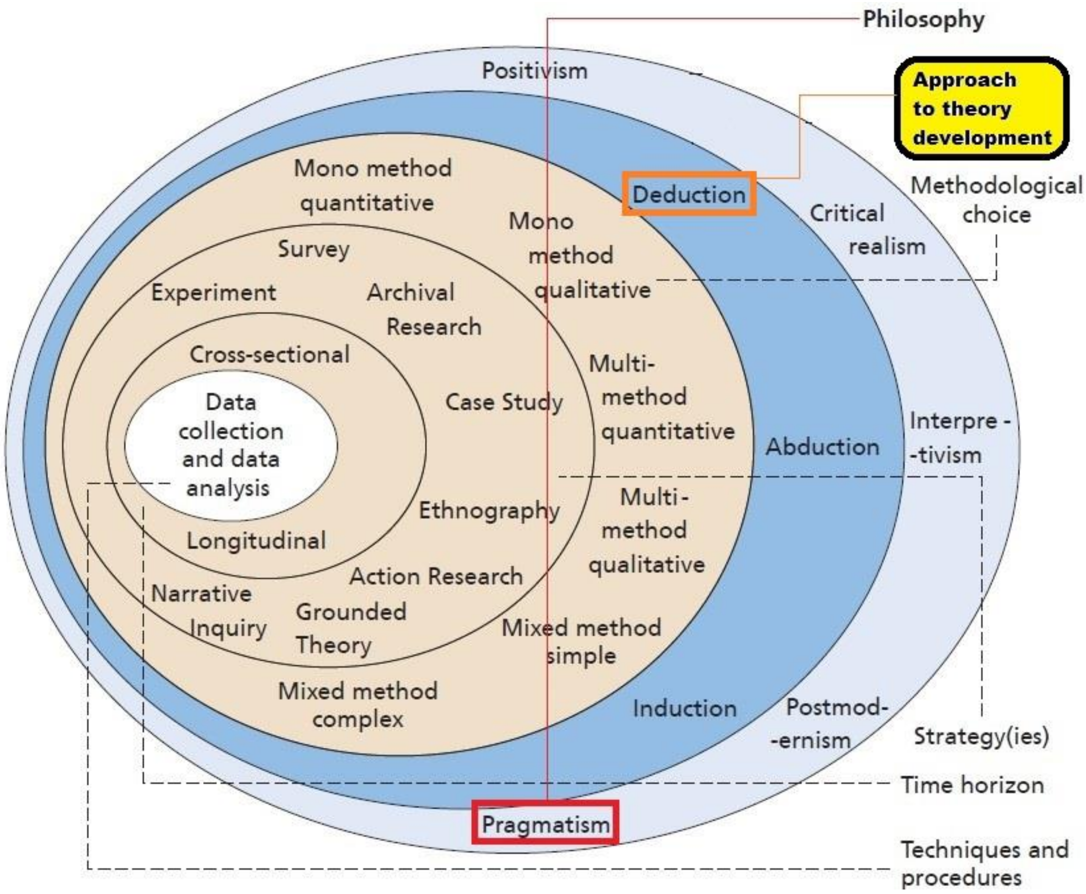


Figure 3.4. Selected approach

3.7 Methodological choice

It is essential to make a methodological choice in terms of choosing a quantitative, qualitative or multiple methods research design before conducting the research. One way of differentiating quantitative research from qualitative research is to distinguish between numeric data and non-numeric data (Saunders et al., 2016). Numeric data includes numbers, and non-numeric data contains pictures, words, video clips and other relevant materials. In other words, qualitative data is data in a nominal form, and quantitative data is data in a numerical form (Collis & Hussey, 2009, p. 63). As can be seen in Figure 3.5, mixed methods research is a branch of multiple methods research; it utilizes both qualitative and quantitative data collection techniques and analytical procedures.

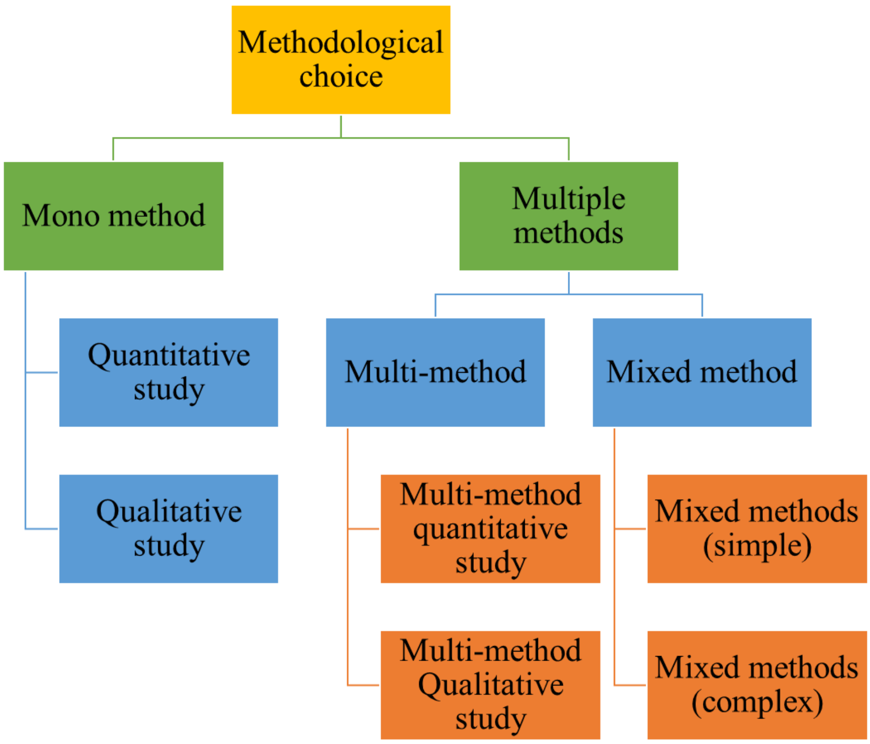


Figure 3.5. Methodological choice (Adapted from (Saunders et al., 2016, p. 167), prepared by the author)

3.7.1 The Quantitative research method

In a quantitative research design, a single data collection technique such as a questionnaire with corresponding quantitative analytical procedure can be applied (Saunders et al., 2016). This is called a mono-method quantitative study (Figures 3.5). Alternatively, as indicated in Figure

3.5, a quantitative research design can contain more than one quantitative data collection technique with a corresponding analytical procedure; this is a multi-method quantitative study.

As indicated by the name, this methodology deals with quantitative data (Flick, 2015). It contains various statistical standards for the validity of the methodology, such as the number of participants needed to establish a statistically significant outcome (Goddard & Melville, 2004). The quantitative research method can be applied to examine a broad range of social phenomena. It can be most successfully applied in circumstances where a large number of potential participants are accessible, and the data collected can be adequately measured utilizing quantitative data analysis techniques (May, 2011). Table 3.3 below outlines both the strengths and weaknesses of the quantitative research method.

Table 3.3. Strengths and Weaknesses of Quantitative Research

Strengths	**Weaknesses**
• It allows researcher to measure the responses from a number of participants based on a set of pre-designed questions, in order to assist the comparison and statistical aggregation of the data. • Testing and validating previously developed theories about how and why a phenomenon occurs. • Testing hypotheses which been developed before the data collection. Generalizing research findings when the data from random samples with sufficient size. • Generalizing research findings when same data appears on various populations and subpopulations. • Useful for getting data that enable quantitative expectations to be created. • The researcher could create a situation that eliminates the puzzling impact of numerous factors, enabling one or more credibly assess cause-and-effect relationships.	• The categories of the questions that are utilised may not reflect participants' understandings. • The theories of the research that are utilised may not reflect participants' understandings. • The researcher may overlook the occurrence of a phenomenon because the researcher may focus on theory or hypothesis testing rather than theory or hypothesis generation. • Knowledge generated might be excessively abstract and general for direct application to specific local circumstances, contexts, and individuals.

• Utilizing quantitative methods to collect data is relatively quicker (e.g., phone interviews). • Delivering precise, quantitative numerical data. • Utilizing statistical software to analyse data is relatively less time consuming. • Results from the research are relatively independent of the researcher. • It is helpful when conducting a research on a large number of individuals.	

Source: Adapted from R. B. Johnson and Onwuegbuzie (2004, p. 19) and (Yilmaz, 2013, p. 313), prepared by the author

3.7.2 The qualitative research method

According to Saunders et al. (2016, p. 168), a qualitative research design can utilize a single data collection technique such as semi-structured interviews with a corresponding qualitative analytical procedure. This is known as a mono-method qualitative study as indicated in Figures 3.5. In a qualitative research, multiple qualitative data collection techniques with corresponding analytical procedures can be applied; this is known as a multi-method qualitative study.

The qualitative approach is based on the constructivist paradigm (Bryman, 2012). Qualitative research is typically utilized for examining the significance of social phenomena (Feilzer, 2010). This methodology needs the researchers to abstain from imposing on the participants their own interpretations of the meaning of social phenomena. The aim is to elicit from participants their responses to statements or questions (Bryman, 2012). An effective way to do this is by means of open-ended questions in structured or semi-structured interviews (Feilzer, 2010). Moreover, a qualitative approach could motivate respondents to expand on their responses. Table 3.4 summarizes the strengths and weaknesses of the qualitative research method.

Table 3.4. Strengths and Weaknesses of Qualitative Research

Strengths	Weaknesses
• It looks at relationships within a system or face-to-face interactions among participants in a given social setting.	• Knowledge generated may not applicable to other individuals or other circumstance.

• The data and information are directly from the participants' own thoughts. • It is valuable for examining a limited number of cases in depth. • It is valuable for depicting complex phenomena. • It provides information based on different individual cases. • It can perform cross-case comparisons and analysis. • It provides understanding of individual's personal experiences of a phenomenon. • It describes a phenomenon in rich detail. • The researcher can study dynamic procedures. • Data a typically gathered in naturalistic settings in qualitative research. • Qualitative researchers are receptive to the changes that may occur during the research. • Qualitative data would help to investigate how and why a phenomenon occurs in terms of quality rather than quantity, amount, intensity, or frequency.	• It is not easy to make quantitative predictions. • It is increasingly hard to test hypotheses and theories. • It normally takes more time and effort to collect the data when contrasted with quantitative research. • Data analysis in qualitative research is normally time consuming. • The outcomes tend to be impacted by the researcher's personal biases.

Source: Adapted from R. B. Johnson and Onwuegbuzie (2004, p. 20) and Yilmaz (2013, p. 317), prepared by the author

3.7.3 Mixed methods

Mixed methods research is defined as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (R. B. Johnson & Onwuegbuzie, 2004, p. 17). The different sequences in which quantitative and qualitative research are combined would lead to a number of variations of mixed methods research. The summary offered by Saunders et al. (2016) is presented in Figure 3.6.

Firstly, as can be seen in Figure 3.6, concurrent mixed methods research contains the parallel implementation of quantitative and qualitative methods within a single phase of data collection and analysis. In other words, this is a single-phase research with two methods applied at the same time. It enables results from both quantitative and qualitative methods to be combined to provide a more comprehensive response to the research questions, more so than by using the mono-method approach.

Secondly, as indicated in Figure 3.6, sequential mixed methods research contains more than one phase of data collection and analysis. In this design, the data collection process consists of multiple phases, as researcher will use one method followed by another in order to confirm the research findings. There are two mixed-methods strategies in a double-phased research design, either a sequential exploratory research design (qualitative followed by quantitative) or a sequential explanatory research design (quantitative followed by qualitative). Sequential multi-phase design is more complicated involving multiple phases of data collection and analysis; for instance, the qualitative method is followed by the quantitative method, and then by an additional qualitative method phase (Saunders et al., 2016).

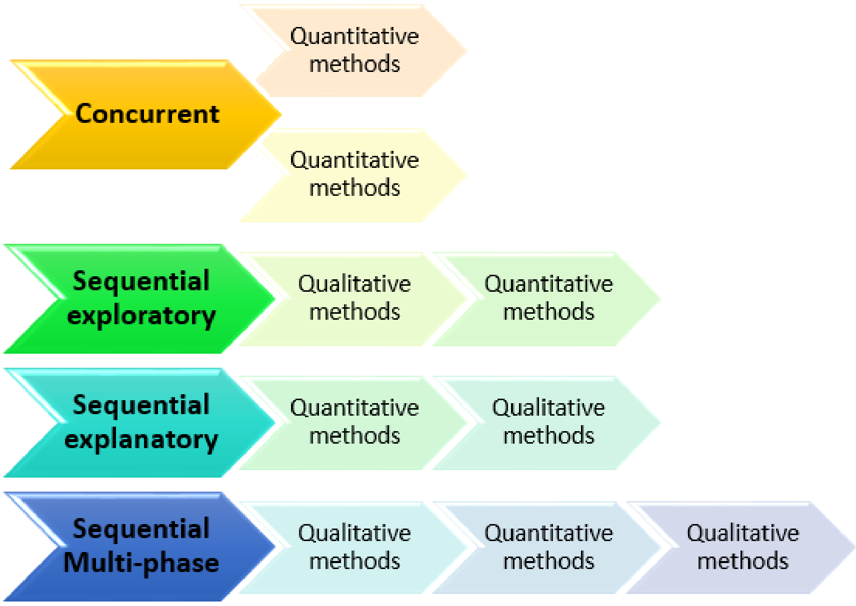


Figure 3.6. Mixed methods research designs (Adapted from (Saunders et al., 2016, p. 170), prepared by the author)

A mixed-methods approach offers the benefits of both qualitative and quantitative methods, but it also has drawbacks. The main disadvantage is the extra workload. Table 3.5 below summarizes the strengths and weaknesses of the mixed-methods research approach.

Table 3.5. Strengths and Weaknesses of Mixed Methods Research

Strengths	**Weaknesses**

• It is an expansive and creative form of research, rather than a limiting form of research. • Words, pictures, and narrative can be utilised to add meaning to numbers. • Numbers can be utilised to add accuracy to words, pictures, and narrative. • It contains both quantitative and qualitative research strengths. • Researcher is able to generate and test a grounded theory. • Can handle a broader research scope and more extensive research questions because the researcher is not bound to a single method or approach. • The strengths from one method can be utilised to overcome the weaknesses in another method if both methods applied in a research study. • It could provide stronger proof for a conclusion. • Can provide insights and better understanding that might be overlooked when only one method is applied in the research • Can be utilised to expand the generalizability of the outcomes. • Qualitative and quantitative research are combined together to provide more comprehensive results for the research.	• It might be difficult for one researcher to complete both qualitative and quantitative research, particularly if two or more approaches are expected to be utilised simultaneously; a research team might be required to complete a complex task. • Researcher needs to learn and practice multiple methods and approaches in order to understand how to use them properly. • Further study by research methodologists required to complete the mixed research methods. • More costly. • Time consuming.

Source: Adapted from R. B. Johnson and Onwuegbuzie (2004, p. 21) and R. B. Johnson and Onwuegbuzie (2004, p. 17), prepared by the author

3.7.4 Research Methodological Choice

Based on the previous discussion, the most appropriate research method for this study is **the mixed-methods approach**. To be more specific, the **sequential exploratory research design**

(qualitative followed by quantitative) is chosen as the research method for the following reasons:

- It contains both quantitative and qualitative research strengths.
- The strengths from one method can be utilised to overcome the weaknesses in another method if both methods applied in a research study.
- Can provide insights and better understanding that might be overlooked when only one method is applied in the research.

The mixed-methods research design has certain disadvantages as listed in Table 3.3. For instance, it is time consuming and imposes an extra workload on the researcher. However, as this is a four-year doctoral research, the impact of those disadvantages is not significant. The green rectangle in Figure 3.7 indicates the choice of methodology.

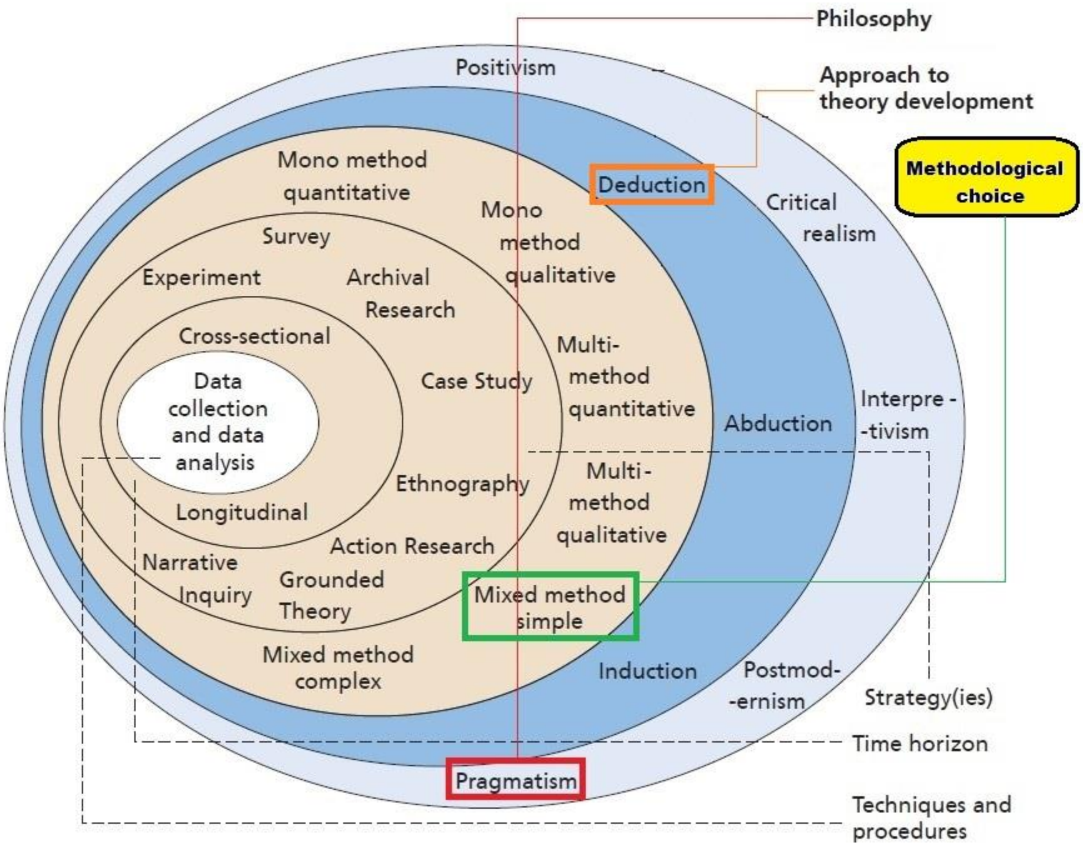


Figure 3.7. Choice of methodology

3.8 Examining research strategies

As shown in Figure 3.1, the next layer of the research onion is strategy. Generally speaking, strategy is defined as a plan of action to reach an aim (Saunders et al., 2016). The most commonly used strategies are: experiment, survey, archival research, case study, ethnography, action research, grounded theory and narrative inquiry.

- Experiment is a type of research which is related to the natural sciences, it also can be utilized in psychological and social science research (Saunders et al., 2016). An experimental study is suitable for investigating "the relationship between variables, where the independent variable is deliberately manipulated to observe the effect on the dependent variable" (Collis & Hussey, 2009, p. 74).
- The survey research strategy is normally connected with the deductive research approach (Saunders et al., 2016). It is a methodology intended to "collect primary or secondary data from a sample, with a view to generalizing the results to a population" (Collis & Hussey, 2009, p. 77).
- An archival research strategy utilizes historical records and documents as the primary source of research data (Saunders et al., 2016).
- A case study investigates a phenomenon or a research theme based on a number of real-life contexts (Saunders et al., 2016). This methodology is normally utilized to "explore a single phenomenon in a natural setting using a variety of methods to obtain in-depth knowledge" (Collis & Hussey, 2009, p. 82).
- Ethnography is utilized to examine different groups (Saunders et al., 2016). The idea of this methodology is that "the researcher uses socially acquired and shared knowledge to understand the observed patterns of human activity" (Collis & Hussey, 2009, p. 79).
- Action Research is "a methodology used in applied research to find an effective way of bringing about a conscious change in a partly controlled environment" (Collis & Hussey, 2009, p. 81). The purpose of it is to improve practical learning through problem identification, planning, implementation and evaluation (Saunders et al., 2016).
- Grounded theory is "a methodology in which a systematic set of procedures is used to develop an inductively derived theory about phenomena" (Collis & Hussey, 2009, p. 84).

Survey selected strategies research. According to Saunders et al. (2016), the questionnaire is not the only data collection technique that belongs to the survey strategy. The structured interview, where structured or semi-structured questions are prepared for all interviewees, also belongs to this strategy (Saunders et al., 2016, p. 182). Thus, this research uses an online survey to provide in-depth feedback on the initial model and the amended model will be tested in the online questionnaire. The blue rectangle in Figure 3.8 indicates the selected strategy.

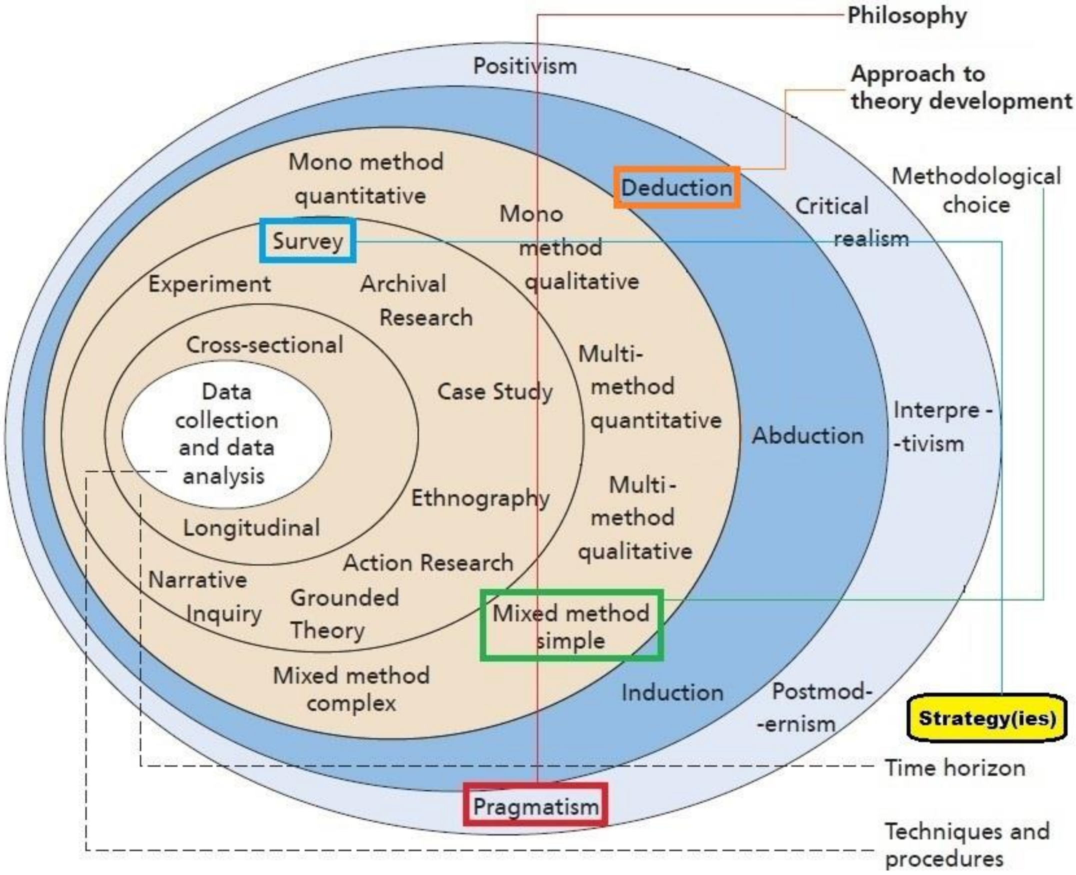


Figure 3.8. The selected strategy

3.9 Time horizon

The next layer of the research onion is the time horizon, and consists of cross-sectional studies and longitudinal studies as seen in Figure 3.1. A cross-sectional study is "a methodology used to investigate variables or a group of subjects in different contexts over the same period of time" (Collis & Hussey, 2009, p. 77). Cross-sectional studies are normally utilised to examine economic characteristics and they often employ the survey strategy (Collis & Hussey, 2009; Saunders et al., 2016). On the other hand, a longitudinal study is "a methodology used to investigate variables or a group of subjects over a long period of time" (Collis & Hussey, 2009, p. 78). The aim of a longitudinal study is to assess the dynamics of a research problem by evaluating the similar factors or group of people a few times. The longitudinal study also offers the researcher some measure of control over certain variables being evaluated (Saunders et al., 2016). In this research, **the cross-sectional study is chosen for the time horizon** because of time constraints. Another reason is that the research strategy selected for this research is the survey (discussed in Section 3.8) which is often employed in cross-sectional studies. The yellow rectangle in Figure 3.9 indicates the selected time horizon.

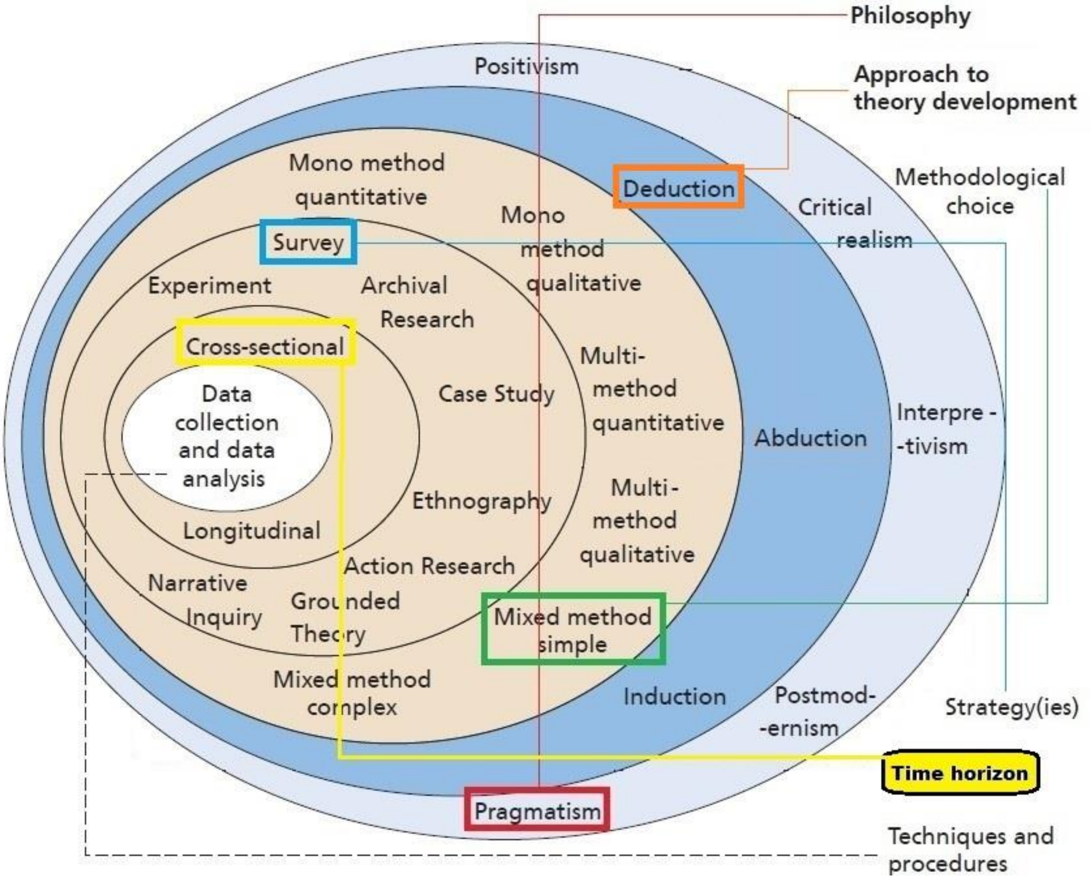


Figure 3.9. The selected time horizon

3.10 Techniques and procedures

The final layer of the research onion shows techniques and procedures in terms of data collection and data analysis. The black rectangle in Figure 3.10 indicates the selected techniques and procedures.

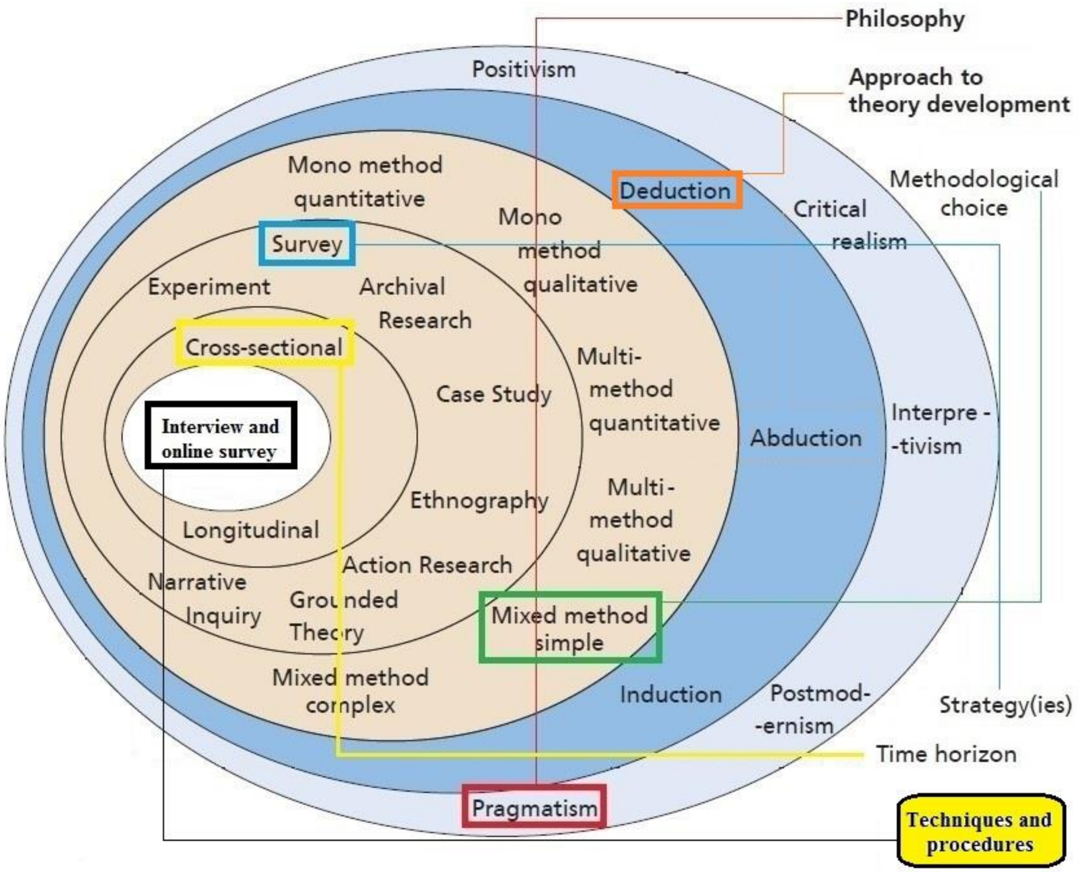


Figure 3.10. The selected techniques and procedures

As stated in Section 3.7.4, the mixed-methods approach has been chosen for this research. Mixed-methods research is a methodology for conducting research that involves collecting, analysing, and integrating quantitative and qualitative research in a single study or a longitudinal program of inquiry. The advantage of this form of research is that both qualitative and quantitative research, in combination, provide a better understanding of a research problem or issue than either research approach alone. This doctoral research uses an online survey and semi-structured interviews. In this research, all the data will serve to resolve the research questions, and the online survey will contain both close-ended and open-ended questions. Further information is provided in Table 3.6 below.

Table 3.6. Data collection approach

Data source	Data collection	Type of data produced
Semi-structured interviews	Face-to-face / Online	Information
Online questionnaire	Online Survey	Numerical and Information

3.10.1 Qualitative Interviews

An interview is "a method for collecting primary data in which a sample of interviewees are asked questions to find out what they think, do or feel" (Collis & Hussey, 2009, p. 195). Qualitative interviews can be used to gather information that cannot be obtained using other methods. Surveys might offer mass data about a particular issue, but they lack the depth of understanding that a qualitative interview provides (Tierney & Dilley, 2001). The aim of interviewing students, staff and IT personnel is to gather their opinions on the new cloud computing model factors and explore the obstacles to cloud adoption. Three main themes of this research have been identified in Chapter 2 literature review; thus, the thematic analysis will be utilised in the qualitative data analysis phase. Thematic analysis is a data analysis strategy which can be applied to various qualitative designs. Normally, thematic analysis "is used in research studies and subsequently labelled as qualitative research, without providing the necessary details about how the analysis reduced the data into workable themes and the emerging conclusions" (Castleberry & Nolen, 2018). In other words, thematic analysis is one of the most widely recognized types of analysis when performing qualitative research. This type of data analysis focuses on identifying, testing, and recording patterns of themes within data. In order to achieve that, NVivo (Version 11) is utilised in this research to perform the thematic analysis.

Interview questions will be developed based on the initial proposed model; interview questions will be general and later will be specific based on the initial model. The interview phase outcomes will be used to improve the initial model and develop the online questionnaire.

Different set of questions (at least 2 – 3 questions for each factor) will be developed for students, staff and IT personnel to determine their opinion of the new cloud computing model. The outcomes from this phase will assist the researcher to improve, enrich and release the new cloud computing model. For the analysis of the interviews data, the researcher intends to either use manual coding or to make use of qualitative research software such as NVivo (Version 11) which provides a workspace and tools that enable the easy organisation of information.

The academic literature on interviewing provides guidelines on the number of interviews that are needed. For instance, McCracken (1988) believes that eight in-depth interviews are sufficient for marketing and business researches; Warren (2001) believes that 20 to 25 interviews are usually enough; and Spradley (1979) claims that a research project should include between 25 and 30 interviews. Galvin (2015, p. 4) reviews 53 research papers and the average number of interviews in those researches was 19.3, and the number fell to 13.2 when "separated into the population-representing groups which some of the papers divide them into". On the other hand, Glaser (1967) and J. M. Johnson (2001) do not recommend a specific number of interviews or observations, but state that the researcher should continue until saturation is achieved.

The number of interviews needed to explore a given research question depends on the nature of that question and the type of knowledge the interviewer seeks. Thus, for this research, interviews will be conducted with 25 students, academic staff, IT personnel, service providers and researchers as shown in Table 3.7. If the required information cannot be elicited from them, additional interviews can be conducted. NVivo (version 11) will be used to analyse the interview data. NVivo is one of the most widely used qualitative data analysis software, since different data formats, including documents, PDF, audio, video and photos, can be analysed quickly and efficiently. It can assist researchers to search and restructure data, test hypotheses, and determine the connections between the information and the underlying theories (W.-W. Sun & Cai, 2013).

Table 3.7. Details of Interviews

Interviews	Total number of interviews with **CONSULTER**	Total number of interviews with Teaching **IT PERSONNEL**	Total number of interviews with **RESEARCHER**	Total number of interviews with **TEACHING STAFF**	Total number of interviews with **STUDENT**
	4	8	2	5	6
Total Number of Interviewees	**25**				

3.10.2 Quantitative Online Survey

The research also needs to be quantitative in order to meet the population statistics requirements. The primary data collection method for this research will be an online survey via Qualtrics, which has both English and Chinese versions; the online survey will be distributed randomly to participants in the selected target universities in China. A questionnaire is a method for collecting primary data in which a sample of respondents are asked a list of carefully structured questions chosen after considerable testing, with a view to eliciting reliable responses (Collis & Hussey, 2009, p. 192). The online survey aims to gather information from various stakeholders namely: students, staff and IT personnel regarding the new factors for the new cloud computing model.

The online survey will be developed for the initial identified new cloud computing factors, at least 3-4 statements will be developed for each factor to examine their significance to the Chinese universities' stakeholders, and to determine their importance in the new cloud computing model. In rating scale questions, the Likert-style rating is the most frequently used approach in which the respondent is asked how strongly she or he agrees or disagrees with a statement or series of statements, usually on a four-, five-, six- or seven-point rating scale (Saunders et al., 2016). In this research, a five-point Likert scale will be used to examine the extent to which subjects agree or disagree with statements (Sekaran, 2003). An even number of points (e.g. four) will force respondents to express their opinions on the statement; however, an uneven number (e.g. five) allows respondents to remain neutral by selecting the middle opinion (e.g. 'not sure') when considering an implicitly negative statement (Saunders et al., 2016). In order to allow participants to remain neutral, four and six- point rating scale will not be utilised in this research. A seven-point rating scale would be time consuming for participants as there are nearly fifty questions in the online survey. Therefore, a five point scale is selected in this research.

In terms of the online survey data analysis, the researcher intends to use SPSS (version 22) which supports statistical analysis of data and enables in-depth data access and preparation, analytical reporting, graphics and modelling.

The researcher will use the Qualtrics on-line survey platform to distribute the survey questionnaire in China. This research focuses on the current and future cloud computing models in Chinese universities. Therefore, the main target participants are the students, academic staff and personnel working in IT departments in Chinese universities.

The hyperlink of the online survey is sent to all potential participants, including students, academic staff and IT departments in selected universities via email and social networks. Based on the sample size calculation for online survey (see Appendix C), the minimum sample size for this research is 384. Considering the fact that defective data may appear, the appropriate number of completed online surveys for this research will be approximately 450.

In conclusion, this research involves semi-structured interviews (qualitative technique) and online survey (quantitative technique). The results from both approaches will be analysed and examined to answer the research aims and to determine the factors which are necessary for the cloud computing model for higher education in China.

3.11 The chosen research method

To sum up, based on the discussions from Section 3.5 to Section 3.10, the following selections have been made and then presented in **Figure 3.11- The refined 'research onion' applied in this research**.

- **Philosophy: Pragmatism**
  - As discussed in section 3.5, the main benefit of pragmatism philosophy is that the researcher can utilise mix methods from various paradigms in order to address the research questions. A single paradigm may have different limitations and weaknesses; for instance, since positivists believe everything can be measured and calculated, positivist philosophy tends to be inflexible; interpretivist philosophy is more suitable for qualitative research, etc. In order to maximise the strengths and minimise the limitations of different paradigms, pragmatism philosophy seems to be the best option.
- **Approach: Deduction**
  - As indicated in section 3.6, the initial model is developed based on the results of the literature review. Then, the initial model will be evaluated though the interview phase, and according to the feedback from the interview, an amended model will then be tested via the online survey to create the final model. The themes and factors will be developed and identified systematically. Thus, the suitable approach for this research is deduction.

- **Method: Mixed method**
  - Based on the discussion in section 3.7, the mixed-methods approach is the most appropriate for this research. To be more specific, the sequential exploratory research design (qualitative followed by quantitative) is chosen as the research method. It offers the advantages and strengths of both quantitative and qualitative approaches, and it can provide insights and better understanding that might not emerge when only one research method is applied.
- **Strategy: Survey**
  - As discussed in section 3.8, the research strategy selected for this research is the survey. The questionnaire is not the only data collection technique that belongs to the survey strategy. The structured interview, where structured or semi-structured questions are prepared for all interviewees, also belongs to this strategy. The interview elicits in-depth opinions about the initial model and the amended model is tested via an online questionnaire. Thus, this research uses an interview survey and an online survey.
- **Time Horizon: Cross-sectional**
  - As indicated in section 3.9, the cross-sectional study is chosen for the time horizon because of time constraints. Another reason is that the selected research strategy for this research is the survey, and this strategy is often employed in cross-sectional studies.
- **Techniques: Interview and online survey**
  - The techniques utilized in this research are interview and online survey as they provide in-depth knowledge about this research topic. Section 3.10 discussed the details of qualitative interviews and the quantitative online survey for this research.
  - The interviews are conducted first because they provide in-depth data related to the topic of interest. It is necessary to ensure the researcher is on the right track before developing the online survey. In other words, if there is a major failure or mistake in the initial developed model which was based on the literature review, the interview data helps to identify it before the online survey is conducted. Moreover, participants provide further information during the interview, and this helps to shape the sustainable cloud computing model.

- Interviews offer the researcher the opportunity to ask complex questions and follow-up questions, which is not possible with a self-completion online questionnaire. Therefore, further information can be obtained via interviews (Collis & Hussey, 2009, p. 197). In an online survey, the participant completes the questionnaire. It is cheaper and less time consuming compared with interviews (Collis & Hussey, 2009, p. 192). These two data collection methods complement each other, making them better than other data collection methods.

Figure 3.11. The refined 'research onion' of this research

3.12 Target Population

This section indicates the number of participants who will be involved in this research, as well as the software which will be utilised to analyse the research data.

3.12.1 Data Collection

Qualitative data collection is the first data collection phase in this research. Data collected from individual interviews will be organised and filtered, and then transferred to NVivo and coded as shown in section 4.3.2. The findings from the qualitative data collection is useful for the next phase of the research.

Based on the results from the interviews, the sustainable cloud computing model will be modified and refined. The next phase of the research is the quantitative data collection. A questionnaire is developed based on the interview results, and then uploaded to Qualtrics. A link generated from Qualtrics is distributed to the participants in China via email and social media such as WeChat. According to Comrey and Lee (1992) and Maccallum, Widaman, Zhang, and Hong (1999), if the sample size is less than 200, it is inadequate for factor analysis. An acceptable sample size is around 300. It is good if the sample size is above 500 and excellent if more than 1000.Thus, the desired sample size for factor analysis for this research is 500. The feedback from participants is stored in Qualtrics for further analysis.

3.12.2 Data Analysis

Qualitative data collected from interviews is analysed using NVivo 11 as indicated in section 4.4. NVivo software helps to identify word frequency and the opinions of participants. Moreover, different nodes are generated and presented by NVivo.

Quantitative data collected from the online survey will be analysed using IBM Social Science Statistics Software (SPSS) version 22. As indicated in Chapter 5, different statistical data analysis tools, including Factor Analysis and Descriptive Statistics, are utilised to filter and identify factors and sub-factors related to governance, performance management and sustainability in cloud computing.

3.13 Ethical approval

Prior to undertaking the research project, ethical issues should be taken into consideration (Morse & Field, 1995) such as anonymity and protection of sensitive data. A professional translator who is authorized by the National Accreditation Authority for Translators and Interpreters (NAATI) will translate the online survey questions from English to Chinese language and responses from Chinese to English if it is required. Therefore, the online survey contains two languages, and the Chinese language is the default one. Participants can easily switch from one language to another by clicking the language option button. The ethics application form (low risk) was submitted to Curtin Human Research Ethics Office before the survey is conducted. All the information provided by the survey participators is treated as strictly confidential. Information is not provided to any parties apart from the researchers, unless required to do so by law. The researchers ensure that published material does not contain any information that can identify participants.

3.14 Reliability and Validity

Reliability refers to “the absence of differences in the results if the research were repeated” (Collis & Hussey, 2009, p. 64). The findings are considered to be reliable if other researchers repeat the research and achieve the same results. In other words, the research process is believed to be reliable if the research results can be reproduced via a similar methodology. One of the common ways of estimating the reliability of the responses to questions in an interview or a questionnaire is the ‘internal consistency method’, whereby “every item is correlated with every other item across the sample and the average inter-item correlation is taken as the index of reliability" (Collis & Hussey, 2009, p. 206). If an alpha value is greater than 0.6 in the SPSS software, the internal consistency is acceptable; if it is more than 0.9, then the internal consistency is considered as excellent. Excellent internal consistency indicates that survey items are answered in a consistent pattern (George & Mallery, 2006).

Validity means “the extent to which the research finding accurately reflect the phenomena under study” (Collis & Hussey, 2009, p. 65). It is concerned with the extent to which the findings from the research accurately represent what is happening in the real world. Simply put, the research methods would enable the researcher to achieve the research object. Sometimes the responses to the survey questions might be highly reliable, yet the outcomes are less useful if the questions do not quantify what the researcher expected them to measure where the validity is low. Therefore, it is important that survey questions correspond to the explanation the researcher gives respondents with regards to the purpose of the study (Collis & Hussey, 2009, p. 206).

3.15 Phases of the Research

This research aims to develop and evaluate a new cloud-computing model for the higher education section in China with a focus on sustainability. The phases of this research are depicted in Figure 3.12.

Phase 1 Literature Review and Ethics Approval: In this phase, a rigorous literature review regarding cloud computing and sustainability was carried out in chapter 2 to examine the cloud computing in general and China to identify the research gap, and to formulate concise and manageable research questions. The factors that may possibly have an effect on cloud computing and sustainability have been identified. Then the purpose of this research and the initial research model have been created. Subsequently, since this research involves human participants, ethics approval has been sought from the appropriate ethics review body.

Phase 2 Interviews and Analysis: At least twenty interviews will be conducted, targeting students, academic staff and IT personnel in the selected Chinese universities in order to obtain the most accurate information regarding the research topic. Participants will be invited into an online chat room to share their knowledge and provide more detailed information which may be difficult to acquire via the online survey. Information gathered in this phase will be analysed using NVivo qualitative (version 11) data analysis software. The results will be used to refine and adjust the initial cloud computing model.

Phase 3 Online Survey and Refinement: At the beginning of this phase, the online survey will be translated into Chinese by a qualified translator. The hyperlink of the online survey will be provided to potential participants working in IT departments in China via email and social networks to determine the attitudes of the target participants to the cloud computing, sustainability and initial model. Then the data will be analysed using IBM SPSS Statistics (version 22) to identify the factors for the new cloud-computing model for Chinese organizations. The outcomes from this phase can be used to refine the proposed model.

Phase 4 Modelling, Thesis Writing and Submission: The final version of the sustainable cloud computing model will be released; also, this phase includes thesis write-up and referencing, proofreading, amendments and submission. The new sustainable cloud computing model will be developed and the thesis will be sent to an editor for proofreading prior to the final submission.

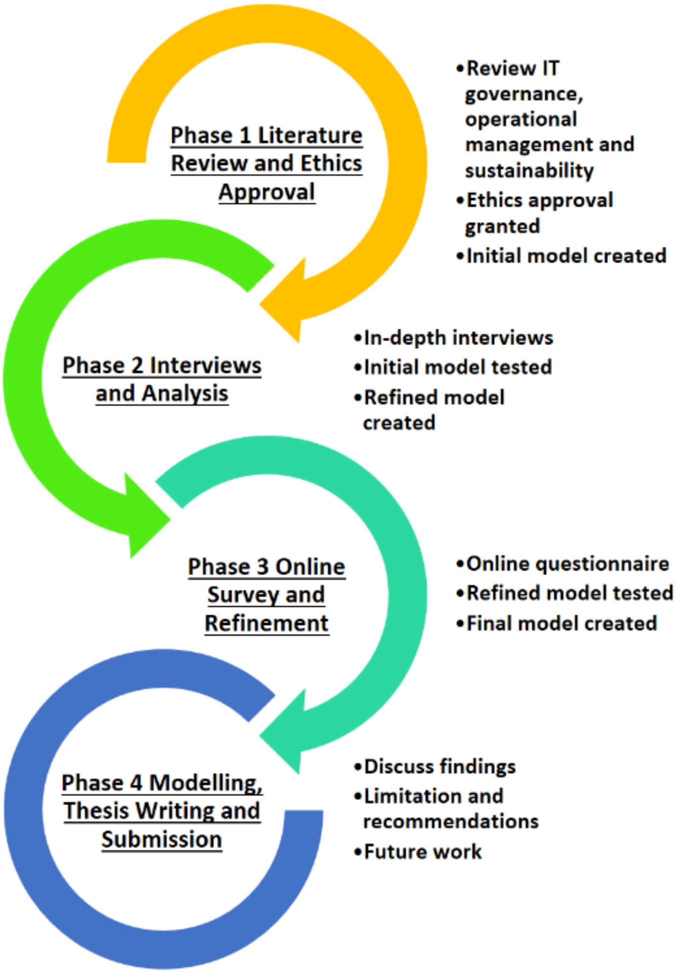


Figure 3.12. Research process flow chart

3.16 Chapter summary

This chapter is focused on the research onion. To start with, the research significance, questions and objectives have been discussed in sections 3.2 to 3.4. After that, the research philosophy has been defined in second 3.5. There are five major philosophies: positivism, critical realism, interpretivism, postmodernism and pragmatism. Pragmatism philosophy is chosen in order to maximise the strengths and minimise the limitations of different paradigms. The selected research approach is justified in section 3.6. There are three approaches: deduction, induction and abduction; the approach selected for this research is deduction. Methodological choice is decided in Section 3.7. The options include quantitative, qualitative and multi-methods approaches. Both the strengths and weaknesses of each method are discussed and compared in that section. The appropriate research method for this study is the mixed-methods approach which involves a sequential exploratory research design (qualitative followed by quantitative). In section 3.8, research strategies, including experiment, survey, archival research, case study, ethnography, action research, grounded theory and narrative inquiry are introduced, and the chosen research strategies of this research is survey. In the time horizon section, both includes cross-sectional studies and longitudinal studies are introduced, and the cross-sectional study is chosen in this research. In section 3.10, details of the qualitative interviewing and quantitative online survey are discussed, and in section 3.11, the research method chosen for this study is discussed and then presented in a customised ‘research onion’ designed for this research. This chapter also reviews ethics-related issues. The research process flow chart is depicted in Figure 3.12 prior to the chapter summary.

The next chapter will discuss the interview phase of this research.

Chapter 4 Interview Analysis and Results

4.1 Introduction

In the previous chapter, the research methodology selected for this research was discussed. The "research onion" was evaluated based on the requirements of this research. In Section 3.11, the chosen research method was discussed and then presented in a customised 'research onion' designed for this research.

In this chapter, the interview phase of this research will be discussed. As mentioned in the previous chapter, this research involves both qualitative and quantitative data analysis. Through direct interaction with interviewees, the researcher can obtain qualitative data. The results from interviews were extremely helpful when refining the initial model and creating questionnaire items as the interview phase provided detailed and in-depth knowledge to the researcher on the research topic. In the interview phase, because the themes of this research have been selected based on the literature review, the deductive research approach is utilized as discussed in section 3.6. As indicated in section 3.10.1, thematic analysis is applied in the qualitative data analysis phase. Castleberry and Nolen (2018, p. 809) point out that "themes are patterns in the codes; they take the numerous pieces of related code to show a bigger picture of what is being portrayed". In order to evaluate and test the themes when analysing the qualitative data, the codes and categories for each concept are identified in the context (Castleberry & Nolen, 2018). NVivo (Version 11) is utilised in this chapter to perform the thematic analysis.

4.2 Interview data gathering

As discussed in section 3.10.1, a total of 25 interviews were conducted. Participants were from three different cities and three different universities. Each interview lasted for approximately 30 minutes. Interview questions are shown in Appendix D. A Participant Information Sheet (Appendix E) and an Interview Consent Form (Appendix F) were provided to the interviewees.

4.2.1 Organization descriptions

Participant organizations involved in this study were coded in order to preserve the anonymities. Participants were from three universities and two cloud service providers. The code "Uni" is used to represent university, each code is followed by "Stu", "Te", "IT" or "Re", and they stand for student, teaching staff, IT personnel and researcher. The code "Csp" stands for cloud service providers, and is followed by "Con" for consulter. The numbers indicate the interview sequence. For instance, Uni2_IT3 means this participant is the third IT staff who has been interviewed in the second university. Csp1_Con1 stands for the first interviewee from the first cloud service company. Table 4.1 below shows the code legend and details of participants.

Table 4.1. Legend of participant codes

Participant code	Organisation	Occupation
Csp1_Con1	Cloud service provider 1	Consulter
Csp1_Con2	Cloud service provider 1	Consulter
Csp2_Con1	Cloud service provider 2	Consulter
Csp2_Con2	Cloud service provider 2	Consulter
Uni1_IT1	University 1	IT personnel
Uni1_IT2	University 1	IT personnel
Uni1_IT3	University 1	IT personnel
Uni1_IT4	University 1	IT personnel
Uni1_Re1	University 1	Researcher
Uni1_Stu1	University 1	Student
Uni1_Stu2	University 1	Student
Uni1_Stu3	University 1	Student
Uni1_Te1	University 1	Teaching Staff
Uni1_Te2	University 1	Teaching Staff
Uni1_Te3	University 1	Teaching Staff
Uni2_IT1	University 2	IT personnel
Uni2_IT2	University 2	IT personnel
Uni2_Re1	University 2	Researcher
Uni2_Stu1	University 2	Student
Uni2_Stu2	University 2	Student
Uni2_Stu3	University 2	Student
Uni2_Te1	University 2	Teaching Staff
Uni3_IT1	University 3	IT personnel
Uni3_IT2	University 3	IT personnel
Uni3_Te1	University 3	Teaching Staff
Legend	"Con" = consulter	
	"Csp" = Cloud service provider	
	"IT" = IT personnel	

	“Re” = Researcher
	“Stu” = Student
	“Te”= Teaching Staff
	“Uni” = University

4.2.1.1 University 1 (Uni1)

Uni1 is a university which was established in 1956 and is located in Inner Mongolia province. With continuous construction and development over the past 50 years, Uni1 has grown into a multiversity. Engineering is the main discipline; it also has diverse branches of learning such as science, arts, management, economics and law. The size of main campus is 1210 thousand square metres with over 20,000 students on campus. Uni1 provides 52 specialties for the bachelor degree, and 25 specialties for the master degree. In 2008, Uni1 passed the MOE (Ministry of Education) undergraduate course teaching work appraisal with outstanding results and successfully attained national Doctor’s Degree conferring unit accreditation the following year. Uni1 has also established associative relationships with universities and research institutions in the U.S., Canada, Australia, England, Germany and Japan for staff training, scientific collaboration, and academic exchange.

4.2.1.2 University 2 (Uni2)

Uni2 was founded in 1956 in Beijing. It is one of the earliest institutions of higher learning to offer Traditional Chinese Medicine. Uni2 has over 10,000 full-time students enrolled, comprising approximately 6,600 undergraduates, 1,400 vocational students, 2,000 master degree students and 570 doctoral degree candidates. Since 1957, many overseas students graduated from Uni2. Total number of oversea students is around 1500, including undergraduate, master or doctoral degree candidates and senior or general scholars. Uni2 has successfully trained over 300,000 domestic traditional Chinese medicine professionals, and 13,000 overseas professionals from 87 countries and regions. It has a great reputation among traditional Chinese medicine universities in China in terms of standard of education, curriculum and development, scientific research, medical treatment, international cooperation etc.

4.2.1.3 University 3 (Uni3)

Uni 3 was established in 1958. The size of the campus is 341 thousand square metres with over 10,000 full-time students and 700 teaching staff on campus. Uni3 offers nineteen different majors, including clinical medicine, nursing, stomatology, pharmacy, and traditional Chinese medicine, acupuncture and massage, midwifery, medical examination technology, medical imaging technology, rehabilitation treatment technology, medical marketing, health inspection and quarantine technology, dentistry, health accounting statistics.

4.2.1.4 Cloud service provider 1 (Csp1)

Csp1 is located in Inner Mongolia province and focuses on building public IT infrastructure, supporting the application of government, public service, and industrial informatization. Csp1 adopts the methods of "corporate investment, government support, commercial operation, and industrial linkage" to construct and operate, and plans to implement it in accordance with the principles of "overall planning and step-by-step implementation". The calculation capacity of Csp1 reaches 500 trillion times/second and the storage capacity reaches the PB (petabyte) level. Csp1 provides data storage services, disaster recovery, cloud technology applications, and promotes the development of green IT.

4.2.1.5 Cloud service provider 2 (Csp2)

With fifteen years of research and development in the field of high-performance computing, Csp2 has mastered a range of cloud computing core technologies and products including cloud infrastructure, cloud management platform, cloud security, cloud storage, and cloud services. Csp 2 provides end-to-end cloud computing solutions for users. With the increasing number of information centre equipment, the energy consumption of data centres attracted more attention in recent years, and green energy has become more important to society. Csp2 has an integrated data centre infrastructure solution that includes a variety of infrastructure products and related services. With their solution, the energy consumption of the data centre can be greatly reduced.

4.2.2 Interviewees

As can be seen in the Table 4.2 below, six students were involved in the interview; the number of teaching staff from universities is one less than for the student group. The number of IT personnel interviewees is eight, and the number of service providers and researchers who have participated in this phase are four and two respectively.

Table 4. 2 Occupations of interview participants

Interviews	Total number of interviews with **CONSULTER**	Total number of interviews with **IT PERSONNEL**	Total number of interviews with **RESEARCHER**	Total number of interviews with **TEACHING STAFF**	Total number of interviews with **STUDENT**

	4	8	2	5	6
Total Number of Interviewees	**25**				

4.2.3 Interview Preparation

The first step of the interview phase was the design of the interview questions. Based on the literature review, a series of questions was proposed and discussed with the researcher's supervisors; questions were related to the research topic and initial model and designed to reflect the initial model and include the themes of governance, sustainability and performance management. The final version of the interview questions was then submitted to Curtin University Human Research Ethics Committee; subsequently, ethics approval was granted.

4.2.4 Conducting the Interview

Participants were contacted via email, phone or WeChat software first to confirm their availability, interview location and time. Interviews were conducted face-to- face or online. Some participants preferred more time to prepare for the interview, or write down the answers rather than talking to the researcher face-to-face. Thus, the questions were sent to them and the answers were sent back to the researcher afterwards.

4.3 Data Preparation

This section will discuss how the data was prepared for analysis, and includes the data transcription process and data coding details.

4.3.1 Data transcription

The interview data was documented in Microsoft Word format for the purpose of analysis. NVivo (version 11), which is a qualitative data analysis computer software package produced by QSR International, was utilised to analyse the interview data.

4.3.2 Data coding

A number of nodes were created based on the themes by using NVivo (version 11) as shown in Figure 1 below. There are three themes: governance, performance management and sustainability. Each theme contains several factors.

Nodes

Name	Sources	References
Sustainable Cloud Computing Mode	0	0
Background and cloud usage sta	0	0
Q1 Do you know cloud com	1	25
Q2 Which cloud service mod	1	22
Q3 What data would be uplo	1	23
Concern about cloud	1	23
Governance	0	0
Policy	1	10
Process	1	16
Q5 have cloud computing g	1	19
Q9 Any other component	1	11
Resource Management	1	16
How to improve current model	1	16
Other questions	0	0
Q19 IT support needed	1	11
Q20 Major	1	6
Q21 Do you use servers duri	1	17
Q22 What task	1	18
Performance Management	0	0
Capacity Managemnt	1	18
Data Management & Backup	1	18
Energy Consumption	1	20
Personal thoughts on PM	0	0
Performance manageme	1	3
Who is responsible for p	1	22
Sustainability	0	0
Definition	1	24
Environmental	1	23
Fianacial	1	22
Social	1	24

Figure 4.1. Interview analysis nodes

4.4 Interview content analysis

This section will analyze the results from the interview in order to shape the sustainable cloud computing model. As discussed in Section 3.10.1 under Qualitative Interviews, thematic analysis was applied to the interview data. Qualitative data analysis involves “Decontextualisation” and “Recontextualisation” (Tesch, 1990). “Decontextualisation” enables portions of the topic to be extracted and examined more closely, together with various components of the qualitative data related to similar issues. “Recontextualisation” will ensure that the patterns still concur with the context from which they were gathered, and is critical to avert reductionism (Malterud, 2001). Bengtsson (2016) points out that the qualitative data should be analysed in four stages as shown in Figure 4.2. Stage 1 is “Decontextualisation”, in which the meaningful units are identified. In this research, the transcripts of interviews are inputted into NVivo data analysis software (version 11) and meaningful contents are identified. Stage 2 is “Recontextualisation”, which is a process that extracts content from its original context. The next stage is “Categorisation”, where content is placed into classes in order to identify homogeneous groups. The final stage is “Compilation” which comprises a summary of realistic conclusions by assembling information collected from the interview.

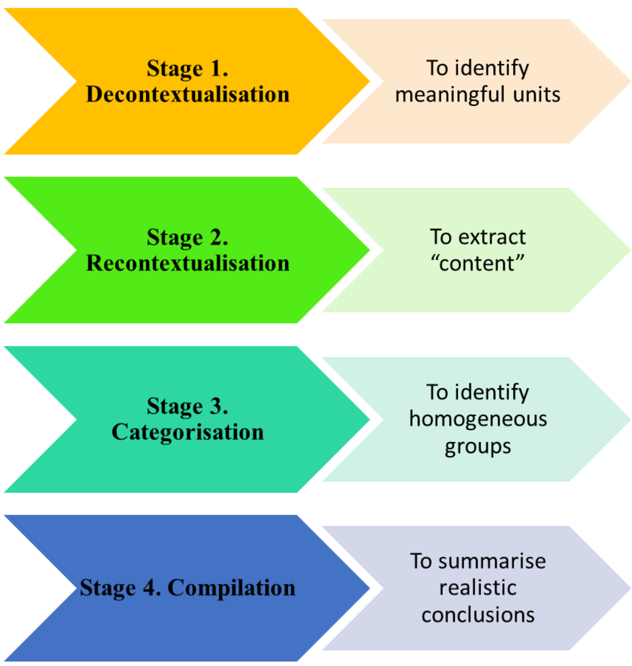


Figure 4.2. An overview of the process of a qualitative content analysis (Adapted from Bengtsson (2016) and Malterud (2001), prepared by author)

4.4.1 Structure of the interview questions

There are twenty-three interview questions in total. The following diagram shows the structure of these questions.

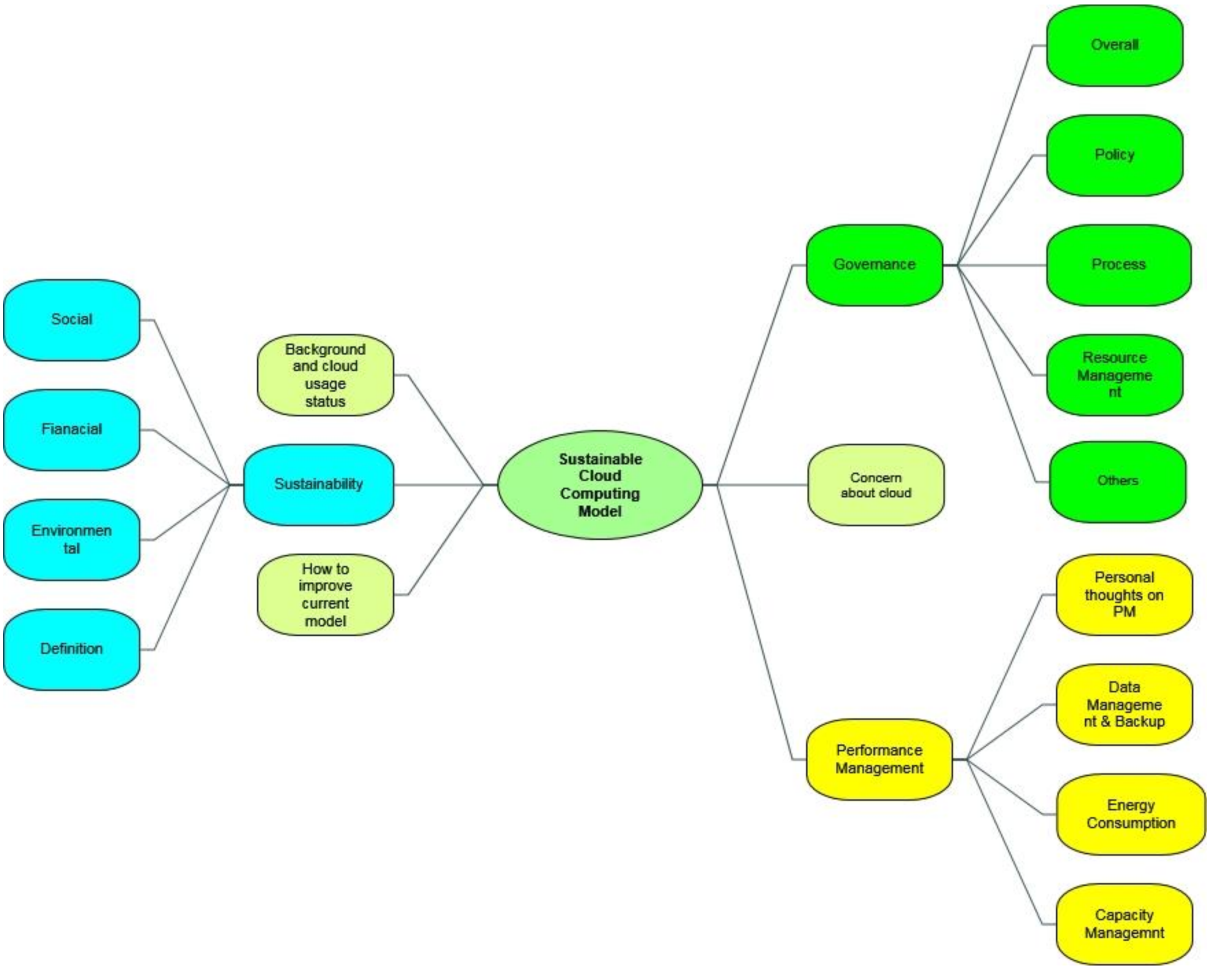


Figure 4.3. Structure of the interview questions

4.4.2 Results analysis

In this section, all the results will be summarized and analysed in order to identify any deficiencies in the initial model. Interview questions have been divided into six parts as can be seen in Appendix D.

Table 4.3. Interview questions grouping

Section	**Question**
Section 1: Cloud background	Question 1-4
Section 2: Governance (Theme 1)	Question 5-9

Section 3: Sustainability (Theme 2)	Question 10-13
Section 4: Operation Management (Theme 3)	Question 14-18
Section 5: Daily use	Question 19-22
Section 6: Comments on current model	Question 23

4.4.2.1 Cloud background

This section contains four questions intended to elicit information about participants' experience with cloud computing.

4.4.2.1.1 Cloud adoption

Cloud computing technology is no longer beyond the reach of enterprises. Csp1_Con1 believes that a good cloud service needs to have an insight of customers' needs, including function, technology, price, speed, security and compatibility. Uni2_IT1 offered a good description of cloud: "*Cloud computing is just like carpooling or ride-sharing*". A group of people share car journeys so that if three people work in a company and live near to each other, instead of driving three cars to work every morning, they can share one car, thereby saving on fuel and other travel costs. Also, carbon emissions can be reduced, promoting eco-friendliness and sustainability. Similarly, cloud computing can save money and reduce pollution.

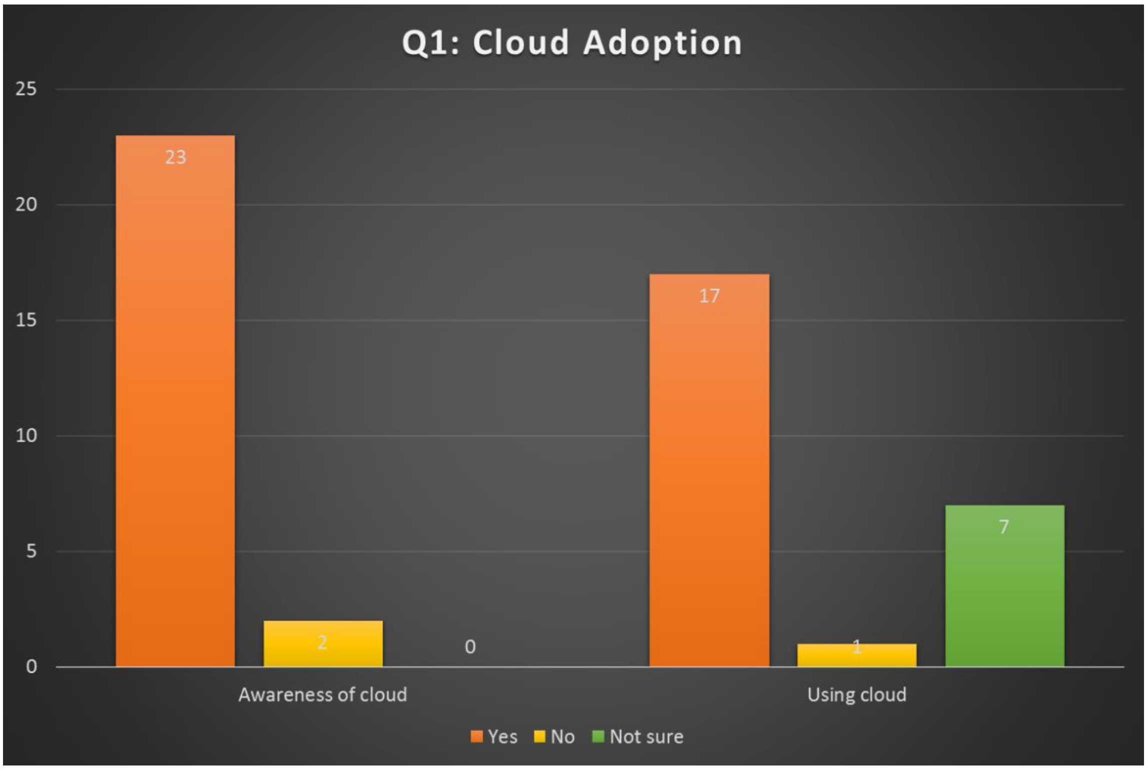


Figure 4.4. Cloud adoption status

Figure 4.4 indicates that the majority of participants understand the meaning of cloud computing and use cloud computing in their jobs. From the cloud provider's perspective, many people already use cloud computing technology without realizing it. If you ask employees whether they are using cloud computing, maybe only a few people will raise their hands. However, Uni1_Re1 mentioned that "*if you ask whether they use Salesforce.com, Concur, SuccessFactors, WebEx, or some other technology, most people would say yes*". Cloud providers are also cloud users sometimes. One provider said that their company provides Infrastructure as a Service not only to customers; they are using cloud computing in different departments as well. They host their own infrastructure within the company.

From the IT staff's perspective, cloud computing will help them to "*improve efficiency of getting educational IT resources*", according to Uni3_IT1. Cloud computing is useful to integrate information technology and education, improve teaching and research, promote the sharing of quality teaching resources, and improve the level of education and management. For Universities, it is costly to invest in building a computing centre and it is difficult to match the rapid growth and diversification requirements of the information systems. Through the IT infrastructure offered by the cloud computing provider, users save costs and do not need to invest in the purchase of expensive hardware equipment, or frequent maintenance and upgrades. Moreover, cloud computing will also effectively eliminate the "island" phenomenon in the information system. Uni1_IT1 mentioned that they are using Sina SAE cloud computing which enables different information systems to share data.

Another widely used cloud system is the cloud-based information management system. Uni1_IT2 said "*university has different systems, for example, teaching system, course-selecting system, library system, network management system. Each faculty may have their own teaching system, experiment platform. Moving all the system to the cloud, and can be accessed via client program. May be there are conflicts between different systems, but we just move all systems to the cloud and provide access point to users, rather than integrating them into one system*". This makes information management easier.

From the student's perspective, cloud provider offers computing resources to end users, so the user needs just a digital device and internet connection to access different software and that is cloud computing. According to Uni1_Stu1, a good example is the iCloud which enables them to upload contact lists and photos to cloud. Cloud computing is also a technology that has been widely used to improve computing efficiency. It uses a centralization method whereby a huge computing service centre can provide massive computing power to all the cloud users. Students can access their university's online resources and submit their assignments online.

According to teaching staff, cloud computing allows them to run apps which are hosted by the provider. Uni3_Te1 said they "*integrate Moodle into 'Wechat', which is multi-purpose social media mobile application software, so students can learn and view learning materials via their smart phones*". Cloud computing allows students or other users to create a personal space in cloud. This needs a cloud-based storage space. The size of individual storage space can be allocated based on the total resource volume of the university. The purpose of cloud space is to provide online storage for students or other users so that they do not need to carry a thumb disk all the time. Some universities are using cloud computing to provide e-learning services to students. Students no longer need to spend time in the library; they can use terminal equipment to access learning materials and resources. Moreover, teachers can upload useful learning materials to a shared cloud space and students can download or access the data for self-learning. The cloud-based online video system is another example of cloud computing. Many universities have a campus video network where they can upload online lectures or other video resources. However, because of the internal problem of bandwidth allocation, the loading time of some videos is very long. Cloud computing can allocate resources according to the current number of viewers, the number of people updating the video, and the current usage. The administrator reviews all the videos before releasing them to campus network users.

On the other hand, cloud computing might not be suitable for all organizations. Uni2_Te1 stated: "*I have heard about that, but I don't think our department is using cloud. The implementation is complicated and when you have a new system, you need to spend a lot of time on training in order to adopt the new system. I think unless the servers can't hold the increasing data or traffic anymore, there is no reason for us to use cloud computing*".

In conclusion, cloud computing refers to computing power that can be used anytime anywhere, on a pay per use basis. Many universities are using cloud computing technology for teaching, learning, management and administration purposes. Cloud computing is also changing people's daily lives. A good example is voice assistant. If you ask iPhone voice assistant, Siri, the location of the nearest cinema, the voice message will be sent to the server, and compared with the cloud database. Siri will understand and give you the answer, which is also from the cloud server. The cloud computing market will continue to grow, and cloud computing is definitely not just a buzzword, but a synonym for computing resource sharing. In the future, there will be no need to refer to the world of cloud computing; it will become a common thing, just like water and electricity, where you pay for what you have used. Other notable feedback regarding cloud awareness and cloud usage from participants is summarised in Table 4.4 below.

Table 4.4. Notable feedback on cloud awareness and cloud usage

Participant code	Notable feedback
Csp2_Con1	*"Our company provides Infrastructure as a Service. Not only our customers, but ourselves using cloud computing as well, in different departments, such as financial department, accounting department. We host our own infrastructure within our company."*
Csp2_Con2	*"I will give you an example to explain what is cloud computing, if we go back to 1870, you want to invest a large scale modernised textile mill, your financial consultant will tell you that if you invest $100, only 20% will be used on the production, the rest $80 will be used on building electric generator, transformers and maintenance. You only want to focus on your own business; however, 80% of your investment is spending on something that is not relevant to it. Lucky, not long after that, large-scale power plant appeared and problem solved.* *Similar to that, the cloud computing is like the electricity usage. Simply put, companies no longer need to invest in traditional complicated IT infrastructure and data centre implementation and maintenance. The IT resource is just like the power generated from the plant, you can use it whenever you want, as much as you want, and pay as you go. So, the real thing we need is "the service that the cloud computing technology could bring to us", rather than the technology itself. The technology is always there, but the cloud service is more important. What can we do as a service provider? Doesn't matter, what matter is to meet customers' requirements. A good cloud service provider should deliver a powerful and multi-functional cloud service."*
Csp1_Con1	*"Cloud computing is no longer an unreachable technology to enterprises, but a service close enough to touch. A good cloud*

	service is requiring an insight of customers' needs, including function, technology, price, speed, security and compatibility".
Uni2_IT1	*"Cloud computing is just like carpooling or ride-sharing. A group of people share the car journeys, for example if three people working in a company and living near to each other, instead of driving three cars to the company every morning, they can share one car. In that case, they can save money on travel cost, fuel cost. Also, the carbon emission can be reduced, and that is eco-friendly and sustainability. Cloud computing, just like that, save money and reduce pollution".*
Uni1_Te1	*"Yes, I know cloud computing, we are currently using cloud. Cloud computing will allow students or other users to create personal space in cloud. This just needs a cloud-based storage space. The size of individual storage space can be allocated based on the total resource volume of the university. The purpose of cloud space is to provide online storage for students or other users, so they don't need to carry the thumb disk all the time. Also, the data can be shared with other users".*
Uni1_IT3	*"We are using cloud computing to provide e-learning service to students. Students are no longer need to stay in the library; they can use terminal equipment to access learning materials and resources. Meanwhile teachers can upload useful learning materials to a shared cloud space and students can download or access the data for self-learning".*
Uni1_Stu2	*"I think our university has cloud computing, the access to the public class can be optimized because of the cloud computing. Another example is the university bought many online books and databases, and students can access the online book for free. We can access anytime from anywhere".*
Csp1_Con2	*"Online video system. Many universities have campus video network where they can upload online lectures or other video resources. But because the internal bandwidth allocation problem, the loading time of some videos are very long. Cloud computing can*

	allocate resources according to, like how many people are watching it now, how many people are updating video, the current usage. Administrator reviews all the videos before releasing them to campus network users".
Uni3_IT1	*"Our university aims to improve efficiency of getting educational IT resources. Cloud computing can help us to integrate information technology and education, improve teaching and research, promote the sharing of quality teaching resources, and improve the level of education and management".*
Uni1_IT1	*"For Universities, it is costly to invest in building a computing centre and it is difficult to match the rapid growth and diversification requirements of the information systems. Through the IT infrastructure provided by the cloud computing, you can save costs, do not need to invest in the purchase of expensive hardware equipment, or frequent maintenance and upgrades. At the same time, cloud computing will also effectively eliminate the "island" phenomenon in the information system. We are using Sina SAE cloud computing".*
Uni2_Stu2	*"Let's take voice assistant as an example, if I ask Siri, where is the nearest cinema, my voice will be send to the server, and compared with the cloud database, Siri will understand and give me the answer, the answer is also from the cloud server, so that is a good example of cloud computing".*
Uni1_Stu1	*"Yes, I know, just like the iCloud, I can upload my contact list, my photo and many other things to cloud. So, if I change a new phone, I can download all that to my new phone via internet".*
Uni2_Re1	*"Some people say that cloud computing is just a buzzword, it is close to the end of the golden age, but I still believe that cloud computing market will continue to increase, and definitely not just a buzzword, but a metaphor of computing resource sharing".*
Uni1_IT4	*"If consulting a technical expert what is cloud, I believe you will soon be dragged into the discussion of virtualization, automation management and data centre design. If you talk to business people,*

	they talk about how they will use the application to achieve resource sharing, and how to keep in touch at any time in different geographical location. May be businessmen are more realistic: the most important advantages of cloud computing connectivity technology are the incredible speed and agility, and it can support business transformation".
Uni2_Stu3	*"I have learned this before in class. It is a technology that has been widely used to improve the computing efficiency. It's using centralization method; a huge computing service centre can provide massive computing power to all the cloud users. I think our university has the online resources, that's cloud computing, and we can submit our assignment online".*
Uni1_Te3	*"Yes, cloud computing refers to computing power that can be used anytime anywhere, pay per use. This university is using the cloud, for teaching management and admin".*
Uni2_IT2	*"In the future, there will be no need to mention the world of cloud computing, it will become common thing, just like water and electricity, on-demand, you pay what you have used. I believe that very few people will ask, "Do you use electricity today? So, I think more and more people know this term nowadays".*
Uni1_Stu3	*"Yes, I know, one of our course last semester was about cloud computing. Cloud company offers computing resources to end users, so the user just needs a digital device and internet connection to access different software, that is cloud computing".*
Uni3_IT2	*"When a cloud provider offers computing power to end user, that is cloud computing. Cloud based software are wildly used nowadays".*
Uni1_Re1	*"If you ask a business CIO: Does your company use cloud computing? I believe few people will raise their hands. However, if you ask whether they use Salesforce.com, Concur, SuccessFactors, WebEx, or some other technology, I believe most people will say that they are using them. As cloud computing becomes more mainstream, it is less likely to be mentioned because it has become a default option".*

Uni3_Te1	*"Yes, cloud computing allows us to run apps which are hosted by provider. We use a mobile learning software 'Wechat', to integrate Moodle to it, so student can learn and view learning materials via their smart phones".*

4.4.2.1.2 Cloud service model deployment

As shown in Figure 4.5, PaaS is the most widely used cloud service model. Cloud providers offer a platform to customers, and even though customers may not have any programming knowledge, they can still customise the software module to meet their requirements. In the PaaS service model, the service provider offers the platform, and the cloud users design the user interface. Uni3_IT1 mentioned that "*with the development of cloud technology, SaaS cannot meet our requirements anymore, we want customise software quickly based on our needs, so PaaS is a simple development platform, which allows us to develop our software*". With the PaaS platform, users can develop their own applications, and the platform provides essential support. For instance, 'Wechat' provides this platform, students just need to scan a QR code and subscribe to the learning website.

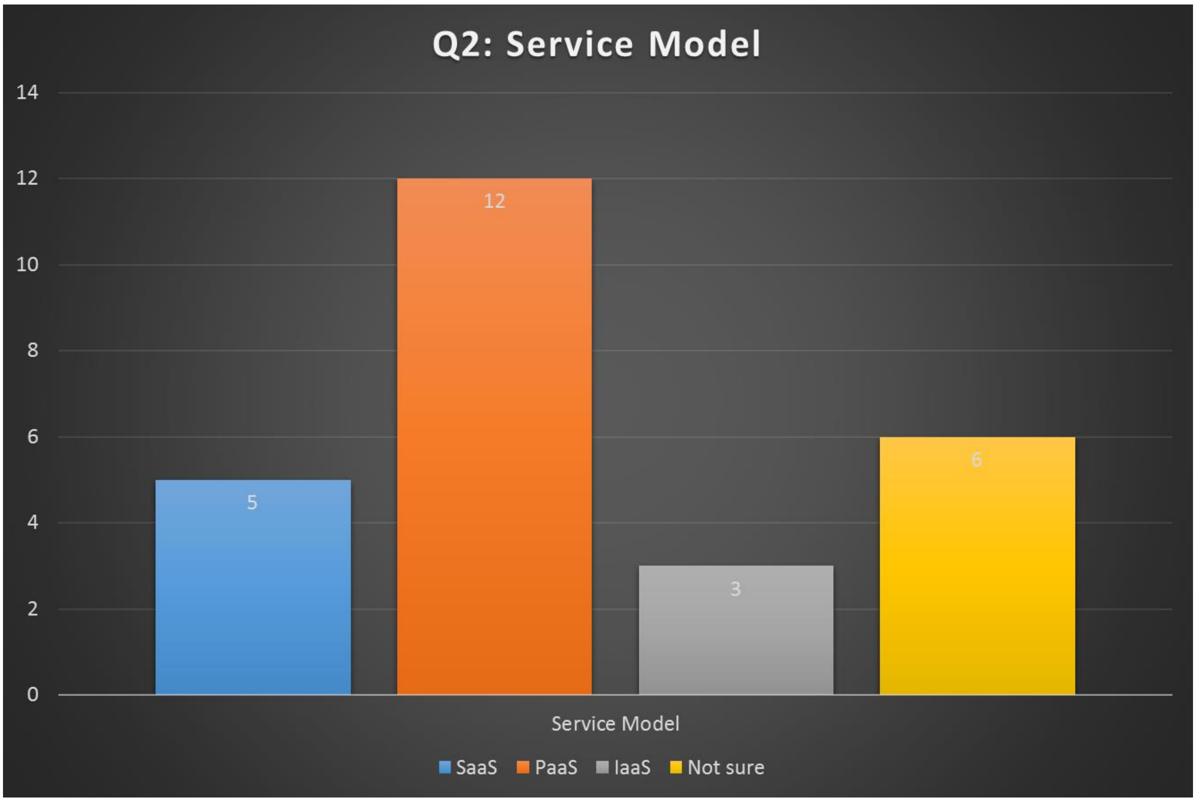


Figure 4.5. Cloud service model

Csp2_Con1 mentioned that his company provides "*IaaS and SaaS to customers, mainly IaaS. It depends on what customer's requirements. For IaaS service, the customer can use the infrastructure as a service, they can get cloud-computing resources from cloud provider, then to use the resources to build server, application, use that as a service, or they can resell the resources to their customer*". The only thing that cloud infrastructure providers have to do is manage the infrastructure and sell it to the customer; they do not have to provide any management services; hence, they can focus on infrastructure management only, rather than having to manage every single aspect of the cloud computing services. Other valuable feedback offered by participants regarding cloud service model selection is presented in Table 4.5.

Table 4.5. Cloud service model usage

Participant code	Feedback
Csp2_Con1	*"Mainly IaaS, also SaaS used in our company. We provide IaaS and SaaS to customers, mainly IaaS. It depends on what your company is trying to achieve. For IaaS service, the customer can use the infrastructure as a service, they can get cloud-computing resources from our company, then to use the resources to build server, or to build application, or use that as a service, or they can resell the resources to their customer. So for us, as a infrastructure provider, the only thing we need to do is that we need to manage the infrastructure and sell it to customer, we don't need to do any management services, so in this way, we only focus on infrastructure management, rather than manage every single parts of the cloud computing services, so for us, it is an easy way to sell cloud computing services and manage the services, and also it is easy to provide customer services".*
Uni1_Te1	*"PaaS. Service provider offers the platform, and we design the user interface".*
Csp1_Con2	*"We provide PaaS to our customers".*
Uni1_IT1	*"It's PaaS. PaaS is the second layer of cloud computing three layers. Cloud company provides platform to customers, and even customers don't know any programming knowledge, they can still customise the software module to meet their requirements".*

Uni2_Re1	*"PaaS, with a platform, you can develop your own applications, and the platform will provide everything you need".*
Uni1_Te3	*"As far as I know, we have private cloud; I guess that's for security concerns".*
Uni2_IT2	*"Most of universities don't need IaaS. SaaS has limitations because you cannot modify the software, so we use PaaS".*
Uni1_Re1	*"PaaS, I think this one is more popular now".*
Uni3_Te1	*"PaaS. 'Wechat' provides this platform, students just need to scan a QR code and subscribe to the learning website".*

4.4.2.1.3 Cloud data

Cloud users can upload anything to cloud as long as it is legal. Cloud users can use cloud resources to build a web server or a terminal server. From Csp2_Con1's perspective, because they only sell resources as a service, they do not know what kind of data customers will upload to the cloud. "*According to contract, terms and conditions, service providers are not allowed to access customers' data*" Csp2_Con1 said. Moreover, cloud users can create passwords or they can encrypt their data. Even though the service provider can have some access to the data, they will not be able to see it as the data has been encrypted by customer. Cloud providers guarantee that the customers' data are safe, and that no one can access the data. So, it is entirely up to the customers to decide on the kind of data they want to upload.

From the perspective of IT personnel, students need to submit their work after the lab tutorial. However, the servers sometimes become overloaded and stop working because there are too many students and the data is massive when they upload their work simultaneously. That is why they are using the Hadoop programming model to create an experimental cloud computing platform. Uni1_IT3 mentioned that "*we use multiple Dell PowerEdge R905 servers, other hardware and VMware vSphere to build our own cloud infrastructure. R905 is suitable for building virtualization platform. Because R905 has great virtualization advantage, I/O performance and extended functionalities, we use it to build infrastructure platform via the virtualization software. Every physical host has more than ten virtual servers*".

Researchers and teaching staff usually upload research data, and online teaching and learning materials to the cloud. Students can upload assignments and weekly homework to the website, and they can download useful learning materials from the website. Other noteworthy feedback regarding the data that will be uploaded to cloud by participants is summarised in Table 4.6 below.

Table 4.6. Cloud data uploading

Participant code	Feedback
Csp2_Con1	*"Could be anything. Customers can build a web server, or they can build a terminal server, so really depends on what they want to do, because we only sell resources as a service. So, we cannot really tell what kind of data they will upload to the cloud. We do have limited access to customer data, but in our terms and conditions, we are not allowed to access customers' data without permission. We do have password protection to customers' data. Actually when I say 'access to customers' data', we can only access the ...limited access...because, after we hand out the cloud computing resources to customer, they can build their own server, and they can create passwords or they can encrypt their data by themselves. So basically, we can only have limited access to the data, but if the data has been encrypted by customer, we won't be able to see it, and all the data is controlled by the customer".*
Csp1_Con1	*"We guarantee customer's data is safe, and no one can access the data except themselves. So, it's entirely up to the customers what kind of data they want to upload, and as service provider, we will not access the data".*
Uni2_IT1	*"For example, in the lab tutorial, students need to submit their work after class. However, there are too many students, when they upload their works, if the data is massive, our servers sometimes get overloaded and stop working. This is a big problem for us for a long time. Thus, why we use Hadoop programming model to create an experimental cloud computing platform".*
Uni1_Te1	*"Research data. Online teaching and learning materials".*
Uni1_Stu2	*"We submit homework and assignments online".*
Uni1_Te2	*"I think when students submit their assignments, that is cloud computing".*

Csp1_Con2	*"Customers care about their data, and they always want to know who can access their data. So, in the contract, we will clarify that our staff and admin people don't have the access to their data store".*
Uni1_IT2	*"Something like research materials, reports, public notifications".*
Uni3_IT1	*"Course-related materials, like the practise file, homework details, assignments, even the staff payslip, and many other things".*
Uni1_IT1	*"Official website and all related data will be on cloud".*
Uni2_Stu2	*"I upload my assignment and weekly homework to the website, and also I can download useful learning materials from the website".*
Uni1_Stu1	*"I would upload my music, assignment, research files and other things to the cloud".*
Uni2_Re1	*"Research data, literatures, exams, and many".*
Uni2_Te1	*"If we have cloud computing system, I think any data from our department can be stored in the cloud. For example, the lecture slides, the student data, even the exams".*
Uni1_IT4	*"It's all cloud based now, so our system is directly connected to the cloud server, and all the data is stored in cloud server".*
Uni2_Stu3	*"We do online assignment, and we have online spaces that we can save our own data online, we call it campus network".*
Uni1_Te3	*"New timetable, leave request, payment".*
Uni2_IT2	*"We integrate many sub-systems into one, so lots of data stored in cloud. For example, student details, online resources, internet lectures".*
Uni1_Stu3	*"It depends, I think. Some data can be uploaded to cloud, but sensitive data, if it's me, I would keep it to myself".*
Uni3_IT2	*"Only some of the data is on cloud, like the course selection system. We have our data centre as well, so not all of the servers are cloud services".*
Uni1_Re1	*"Various data, like payroll system is online, teaching and learning system".*
Uni3_Te1	*"Everything that is related to the course. Students can upload as well, their assignments, their thoughts, comments, etc".*

4.4.2.1.4 Concerns about cloud

As seen in Figure 4.6 below, participants consider data security to be the main concern when moving to the cloud. Data security includes safety, authorisation, data recovery and data backup. The next concern is the price, which was mentioned by six participants. This is followed by the issue of reliability which includes stability, data traffic control and service downtime. In addition, the accessibility of cloud service is important as users should have 24/7 access to the cloud service. Usability of cloud computing was mentioned by two participants, who believed that the cloud application should be easy to use, and proper training should be provided to users.

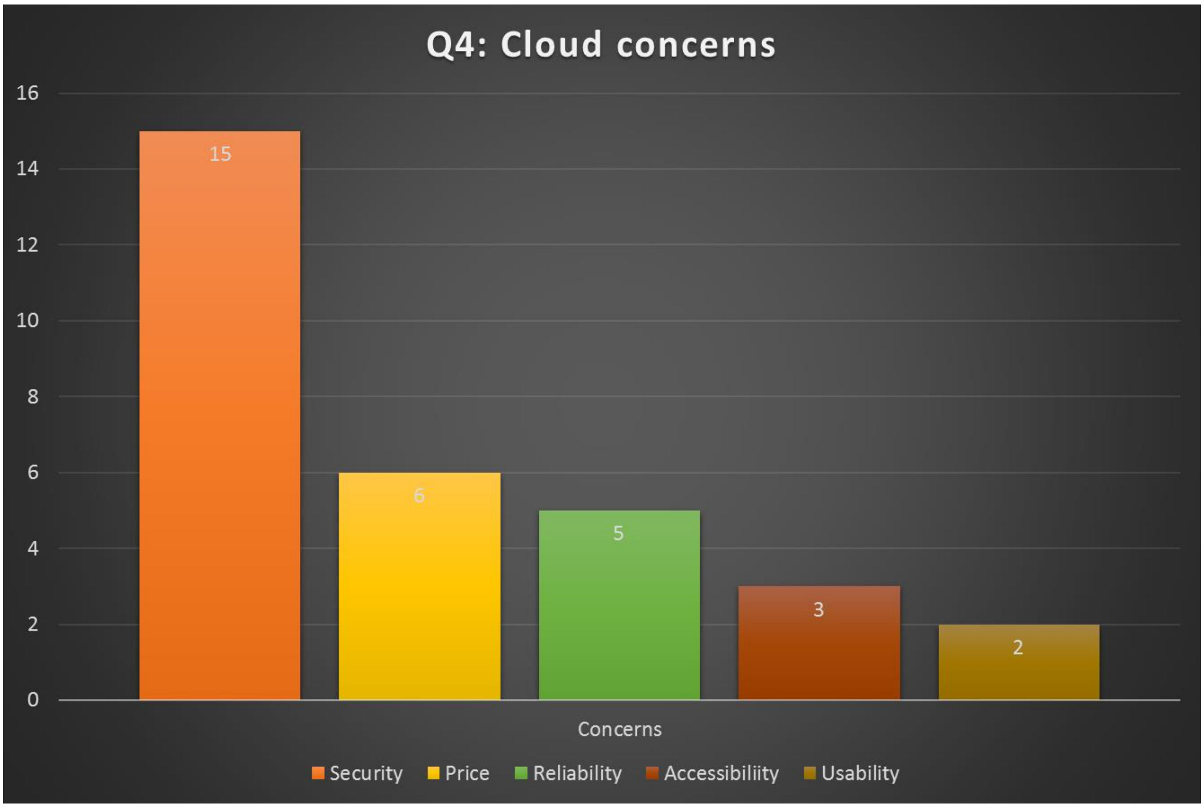


Figure 4.6. Concerns about cloud computing

From the cloud user's perspective, factors such as costs, security, reliability, performance, service, and the reputation of cloud vendor should all be considered. However, cheaper is not always better. Different providers have different plans, so users need to compare their services in terms of individual requirements. Another concern is data integrity. When they move to cloud, they do not want to lose any valuable data. Stability is also important since there are so many different devices and smart phones. Uni3_Te1 said, "*android smart phones have different size of screens, so the stability of the mobile learning environment is the important for teaching staff and students*". Other concerns were expressed by Uni2_Re1: "*What we do if vendor's server is down? What if the access is denied? How the vendors handle the traffic? Can they confirm if the visitor number increases rapidly for some reason, they can still meet the requirement? Not only for cloud computing, but for all of the information systems, we need to make sure the data is safe, only authorized person have access*".

From the cloud service provider's perspective, most cloud users are concerned about the security and price. According to Csp2_Con1, "*customers need to know which platform they want to use, like IaaS, SaaS or PaaS. In addition, they need to have an idea like how much cloud computing resources they need to purchase. Moreover, how do they assure the security of the data, how do they protect their data after they upload the data to the cloud. I think they would need to have a new disaster recovery plan, because the way to restore data on cloud is different to restore data physically/locally. We do not provide recovery plans, but we do provide data recovery products, will cost extra money, so customer can make their own decision to purchase their data service or data recovery services, it is up to them*". In addition, customers may sometimes want to buy add-on services such as extra storage, which also concerns them. Other concerns include data leakage, loss of data, and unsafe application program interfaces.

Other concerns worth mentioning are those expressed by Csp1_Con1, "*firstly, as the third-party cloud computing services are increasingly using multiple hardware resource pools, unpredictable interactions between load balancing and various loose cloud services can lead to 'cloud downtime'. Secondly, the unclear layered architecture makes a lot of 'independent' cloud computing service providers in fact sharing some resources at the bottom, if something happens to one provider, others may get affected. Thirdly, cloud computing makes it difficult to store data for a long time*". In the past, the centralized data backup model has been very efficient, but now only cloud computing service providers can "back up" cloud applications and cloud data.

In conclusion, security, reliability, accessibility and price are the most common concerns that cloud users have about moving to cloud. They want to know the location of data, who has access to data and what occurs if data is lost. Cloud vendors should have a disaster recovery plan and to ensure data security. Other important feedback regarding participants' concerns about the cloud is summarised in Table 4.7 below.

Table 4.7. Concerns about cloud computing

Participant code	Feedback
Csp2_Con2	*"Most of the customers would concern about the security and price".*
Csp1_Con1	*"Firstly, I'm thinking as the third-party cloud computing services are increasingly using multiple hardware resource pools, unpredictable interactions between load balancing and various loose cloud services can lead to "cloud downtime."* *Secondly, the unclear layered architecture makes a lot of "independent" cloud computing service providers in fact sharing some resources at the bottom, if something happens to one provider, others may get affected.* *Thirdly, cloud computing makes it difficult to store data for a long time. In the past, the centralized data backup model is very efficient, but now only cloud computing service providers can "backup" cloud applications and cloud data".*
Uni2_IT1	*"Reliability of the cloud computing, we need to make sure students can upload their work to the server smoothly".*
Uni1_Te1	*"Where is the cloud data? Who has access to it? What if data get lost? Is it possible to recover data if data lost"?*
Uni1_IT3	*Reliability and data backup.*
Uni1_Te2	*"If I'm the IT staff, I will think about the time that we need to spend on implementing the new system, the money we have to spend, and also the training to all staff. This is not only for cloud, for any new system or any new practice, when you introduce something new, there are many things to consider. I know it's a hot topic, but it is also necessary to evaluate the potential risks as well before moving".*
Csp1_Con2	*"Customers may want buy add-on service sometimes, like extra storage; they are concern about this part as well. There are other*

	concerns for example data leakage, loss of data, unsafe application program interface".
Uni1_IT2	*"Costs, security, reliability, performance, service, and the reputation of cloud vendor. But of course, I don't mean the cheaper the better, different providers have different plans, so we need to compare their services with our requirements".*
Uni3_IT1	*"The cost, that's the first one, you need to compare the price. Secondly, security, we need to know if our data is safe or not".*
Uni1_IT1	*"Location of our data, where are they stored? Does the provider have backup plan"?*
Uni2_Stu2	*"Reliability, unlike the traditional way, you point out the assignment and submit it, when you do it online, the server must be reliable".*
Uni1_Stu1	*"I would concern about the accessibility; can I get my data anytime"?*
Uni2_Re1	*"What we do if vendor's server is down? What if the access is denied? How the vendors handle the traffic? Can they confirm if the visitor number increases rapidly for some reason, they can still meet the requirement"?*
Uni2_Te1	*"Not only for cloud computing, but for all of the information systems, we need to make sure the data is safe, only authorized person have access, how long it will take us to learn the new system".*
Uni1_IT4	*"Not only for our department, I believe everyone will concern the data safety the most".*
Uni2_Stu3	*"I concern the upload/download speed and the security of my data".*
Uni1_Te3	*"When you move to cloud, everyone will consider this: is it hard to use? Do I have to spend a lot of time to learn the new system? So, I think, the most important thing is how do you persuade people to try the new thing".*
Uni2_IT2	*"Security concerns. Where is the data, who can have access"?*
Uni1_Stu3	*"Security I guess, when you upload it to other people's server, do you trust them? And can you rely on them"?*

Uni3_IT2	*"Cost is the first thing to concern, and when you move to cloud, you need to think about data integrity, you don't want to lose anything when you move to cloud".*
Uni1_Re1	*"Security as always. When you upload the data, you have to make sure it is in a safe place".*
Uni3_Te1	*"Stability. There are so many different devices, smart phones, for example, Android smart phones have different size of screens, so the stability of the mobile learning environment is the most important thing. We don't worry about the security too much, because it is based on 'Wechat', and the security protocol of 'Wechat' is very good".*

4.4.2.2 Theme 1: Governance

In this section, five questions were used to test participants' attitudes towards various cloud factors including strategy, policy, process and resource.

4.4.2.2.1 Governance strategy

As indicated by Figure 4.7, approximately half of the participants believe that their organisations have strategies in place for cloud computing governance. For instance, they have legal and service agreements in order to achieve efficiency and improve performance. Moreover, they have warning alarms, performance tuning, report and troubleshooting systems. Hence, if anything goes wrong, they can track the problem.

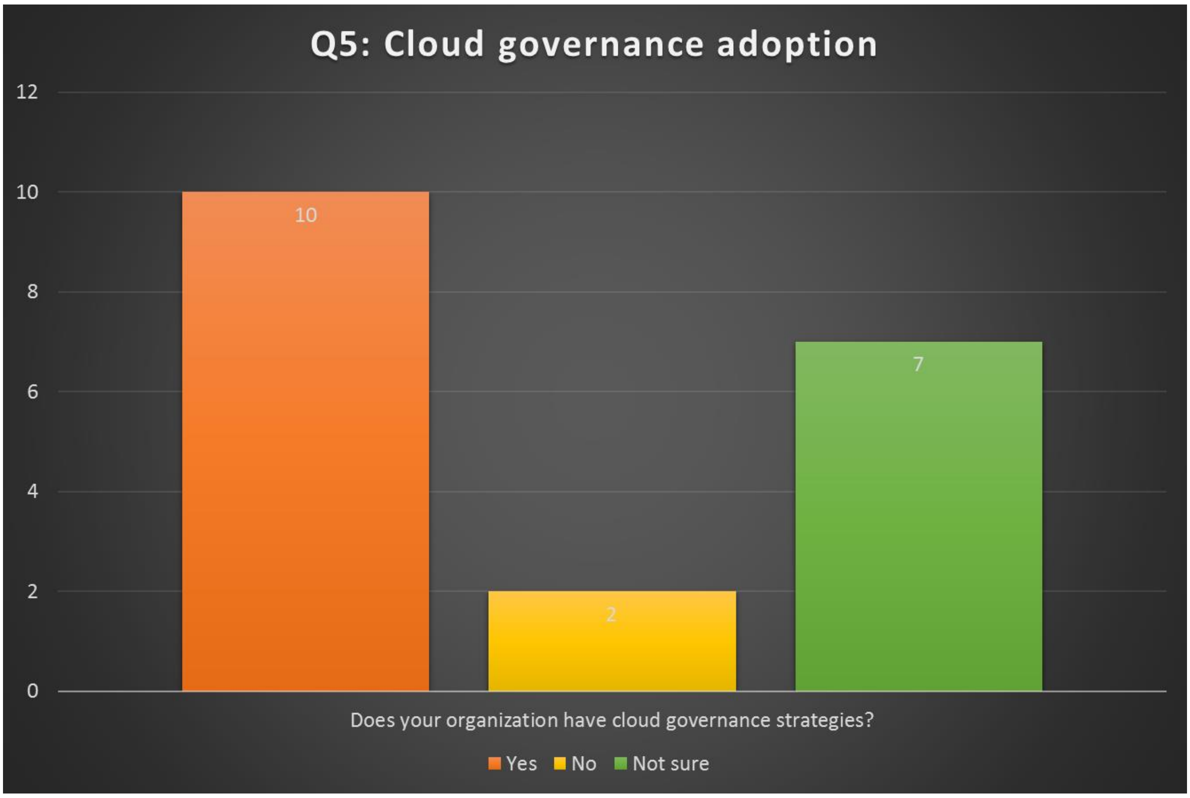


Figure 4.7. Cloud governance adoption

However, other participants think that governance is often overlooked. There is no clear governance strategy in their departments. They simply do things from experience. Therefore, the lack of governance strategies could create security, privacy and financial problems for the organization. Csp2_Con2 mentioned that "*the definition of cloud governance is very blurry, or unclear. But basically, governance is about strategic direction, including service delivery, service lifecycle management and service operation. Customers can define their requirements regarding the cloud services; they can also go through our recommended practices for managing cloud-based services; responsibilities and roles in terms of cloud services management could also be clarified*".

In conclusion, appropriate governance strategies will help the organization to keep things on track and under control. To support a good strategy, the first step is to evaluate current practices, to know what needs improvement. Then all departments must be contacted to be informed of why they need cloud, to get some new ideas, and to know their requirements. A good solution must also be found by consulting with different suppliers and finding the best one. The final step is the integration. Different departments need to work together and to adopt the cloud simultaneously. Participants' feedback regarding the implementation of cloud computing governance is summarised in Table 4.8 below.

Table 4.8. Cloud governance adoption

Participant code	Feedback
Csp2_Con1	*"I'm not sure, because this question is for the management level. I'm not part of the management team, so I don't know, but I believe we have".*
Csp1_Con1	*"Governance is like policy and standard. Sometimes customers come to us and say they need cloud computing, but their requirements are quite unclear.* *So, lack of governance strategies creates security, privacy and financial problems to the enterprise, for example, if they don't know how much storage space they need, and later on when they purchase additional storage space, their project may over budget".*
Uni2_IT1	*"First step is to evaluate the current practice, to know which part needs to improve. Then communicate with all departments, explain why we need cloud, get some new ideas, know their requirements. After that, it's about finding a good solution. Talk to different suppliers and find the best one. Finally, it's integration. Different departments need to work together and to adopt the cloud together".*
Uni1_Te1	*"I'm not sure about that. I think decision makers would know".*
Uni1_IT3	*"Without the strategies, complexity and confusion may occur. Strategy is like a map; it tells you where to go. Of course, you can go ether on foot or by car, which means there are many solutions to solve the problems, but without the map, you will get lost. So, strategy is guideline".*
Uni1_IT2	*"Yes, before talking to cloud providers, we had meetings and everyone had opportunities to express their concerns. Based on that, all requirements have been documented".*
Uni3_IT1	*"Yes, we do, for example the alarm warning, performance tuning, report and troubleshooting systems. So, if there is something wrong, we can track the problem".*
Uni1_IT1	*"We have some policies, to make sure that everything is under control and our monitor".*

Uni2_Te1	*"No, because we don't use cloud computing at this moment".*
Uni1_IT4	*"Yes, we have, for example, legal and service agreements in order to achieve the efficiency and to improve the performance".*
Uni2_IT2	*"There are no clear governance strategies. We just do things from experience".*
Uni1_Stu3	*"Sorry I don't know, but there should be someone watching it, taking care of it to make sure everything is under control".*
Uni3_IT2	*"Yes, I think we have, because proper governance strategies will help you to keep things on track".*
Uni1_Re1	*"If you mean management, I think yes. Management team will have regular meetings to decide everything".*
Uni3_Te1	*"I think governance is often overlooked. We do have some guidelines".*

4.4.2.2.2 Cloud policy

Most participants were unsure about the details of their organizations' cloud computing policies. The main reason is that most of the participants are teaching staff, IT staff and students. The policy makers or the management team may know this but, unfortunately, they are not included in these interviews, and that is one of the limitations of this research.

However, there are some interesting answers. Uni1_IT2 pointed out that *"security is the most important thing, so who will have access to the data in cloud? How to make sure that people working in the cloud computing service company will not have unauthorised access to our data? What solutions does the provider have to avoid hacking? What will happen if the provider closes down? These things need to consider"*. Policies should consist of rules, roles and responsibilities. For instance, if students upload something to their cloud drive, then others should not be able to see it. Also, copyright issue should be considered. Cloud users should not share anything that has copyright, via cloud server, with others. Uni1_IT1 suggests that the "*regular report is essential, so report management should be part of the cloud policy*". Also, different people should have different levels of access, which involves identity and access management. For example, a lecturer will have access to student's name, student ID, and the grades, etc. Admin staff will have different access; they can access the student's contact details, phone number. In fact, some participants mentioned that there was a terms and conditions page presented the first time they activated their accounts, but they did not go into all the details.

Other common cloud policies like resource scheduling management, resource monitoring and management were mentioned a couple of times during interviews.

In conclusion, everything uploaded to the server by the teacher and student must follow certain rules, and they must comply with the behaviour standards. The idea is to protect data, so it is necessary to monitor and enforce the system, find the potential risks and report the issues to managers. Moreover, there should be different access levels in the cloud system. Last, but equally important, when the cloud users share data via cloud technology, anything that has copyright should be forbidden. Participants' feedback regarding cloud computing policies is summarised in Table 4.9 below.

Table 4.9. Cloud computing policies

Participant code	Feedback
Uni1_Te1	*"Policies should consist of rules, roles and responsibilities. So, for example, if students upload something to their cloud drive, then others should not see it. Different people should have different access level".*
Uni3_IT1	*"Well we have some cloud policies, for example the resource scheduling management, resource monitoring and management as well".*
Uni1_IT1	*"We need the regular report, so we have report management. Also, different people should have different access levels, that's why we have identity and access management. For example, a lecturer will have access to student's name, student ID, and the grades, etc. Admin staff will have different access; they can access the student's contact details, phone number".*
Uni2_Re1	*"There was a terms and conditions page when first time you activate your account, but I didn't go through, just click next and next".*
Uni1_IT4	*"The idea is to protect data, so we need to monitor and enforce the system, find the potential risks and report the issues".*
Uni3_IT2	*"For users, we don't really have policies, for example, users of the server, they will not receive terms and conditions".*
Uni1_Re1	*"For example, like copy right, you can't share anything that has copy right via our server".*

Uni3_Te1	*"Everything uploaded to the server from the teacher and student must follow certain rules, and they cannot go against the behaviour standards".*

4.4.2.2.3 Cloud process

Cloud data governance is a discipline involving the processes for managing and governing data in cloud computing environments (Ko et al., 2011). Any strategy should start with problem identification. In this stage, cloud vendor and cloud user need to collect current data, define the needs of the organization, and list all requirements. The second step is to propose a solution and process, and then evaluation, refine, followed by creating solutions, testing and implementing. Uni2_IT1 said that "*governance lifecycle is similar to strategies, identify needs by discussing with stakeholders, find a proper solution, then evaluate this solution, have a pilot test, then implementation, followed by re-evaluation*". Similar to that, Uni1_IT3 said *"I think first of all, you need to set up a series policies and standards of the cloud computing, or the needs, requirements. Then, you need to evaluate the risks, for example, if you put data into cloud, what about security issue? After that, you need to evaluate and monitor the cloud performance".* From the literature review, it can be seen that cloud standards must specify authorization, access entitlements and identity (Fortis et al., 2012). Another interesting answer from Uni1_Stu1 is: "I *think it is a loop, there is no beginning or ending, you can say starts with evaluating, then design, implementing, but I think in a lifecycle, we can find new issue, and then the evaluation phase could happen anytime, so it is a loop*".

From the service provider's perspective, users should help them to define the requirements. After that, customers can evaluate the proposed plan or may even compare the price with other suppliers, and then test the solution before implementation. It is necessary to evaluate the solution first, and test it to make sure it works. Also, there should be a maintenance team to take care of the new system.

From the cloud user's perspective, before introducing a new system, it is important to find out current problems first, and subsequently find the solutions. In other words, users should find out what they need. After that, they need to find a group of professionals who have the knowledge to be able to create a detailed strategic plan, and then talk to at least two suppliers, find the better one, evaluate their proposed solution, and run a pilot test. Only then should this be followed by implementation and maintenance. Lastly, the cloud is deployed to achieve the strategic goals.

In conclusion, both cloud users and services providers should work together to evaluate current performance, and determine the user's needs and accommodate their requests. Then the provider proposes a strategy based on requirements. The best solution is designed, a pilot test is conducted, the solution is modified if necessary, and followed by implementation. Participants' feedback regarding the cloud governance process is summarised in Table 4.10.

Table 4.10. Cloud governance process

Participant code	Feedback
Csp1_Con1	*"Define the needs, talk to us, or may be even compare the price with other suppliers, and then evaluate the plan before implementation".*
Uni1_Te1	*"Any strategy should start with problem identify, second step is to propose solution and process, and then evaluation, refine, followed by creating solutions, test and implementation. So, the cloud computing governance lifecycle should be similar like that".*
Uni1_Te2	*"I'm not sure about the cloud governance, but you know there always regulations to make sure everything in order. When you introduce something new, first of all is to collect current data, find out current problems, and based on that, find the solution. So, I would say we find out what we need, we talk to at least two suppliers, find the better one, evaluate their proposed solution, run a pilot test, implementation and then maintenance".*
Uni3_IT1	*"Firstly, you need to understand the needs of your organization. After that, we need to find a group of professionals who have the knowledge, then create a detailed strategic plan. Lastly, deploy the cloud to achieve the goal".*
Uni1_IT1	*"Define our needs, list all requirements, talk to service providers and find the best solution. Then test it and apply the new system".*
Uni2_Stu2	*"Evaluate, test, apply and maintenance. I mean you need to evaluate the solutions first, and test it make sure it works. After you apply the new solution, there should be a maintenance team to take care of the new system".*

Uni2_Re1	*"User request, report, review, possible solution, evaluation, selection, implementation".*
Uni1_IT4	*"Design phase, test phase and apply phase".*
Uni1_Te3	*"For any governance lifecycle, it is always about these things, for example, define the needs, find possible solutions, measure and monitor, then apply it".*
Uni2_IT2	*"Design, test, re-evaluate, modify, implementation. I think five steps should apply".*
Uni1_Stu3	*"Have a meeting first, find out the requirements, find a good provider or a famous provider, and sign a contract. Oh, and of course, maintenance".*
Uni1_Re1	*"First, you need to evaluate current performance, and find out the needs. Then based on requirements, come up with a strategy. Find the best solution, then do a pilot test, if all good, we apply the new technology".*
Uni3_Te1	*"Find the needs, and then discuss basic rules and regulations, decide different access levels and assign the admin team, set up some forbidden keywords, review the performance every week".*

4.4.2.2.4 Cloud resource management

Cloud assets should be monitored, so that both cloud providers and cloud users know the performance status of all services. In that case, the IT department will have access to real-time data from server and sensor. Then they will know when to add more computing power and when to have less. Moreover, trends can be found from the historical data. Fortis et al. (2012) believe that resource and scalability limits, resource discovery, tenant partitioning, session management, and service levels must be specified. Cloud assets are managed dynamically. This is like a resource pool, and computing power is shared by users. When the end user needs more computing power, the resources will be assigned to the user automatically. This is why dynamicity is one of the most important features of cloud. Cloud vendors can receive status summary for all services every day from the server. They use different software such as Nagios to monitor the host and servers, the CPU load and disk usage status. A system alarm will be triggered if there is overload. Csp2_Con1 pointed out that *"we do have the infrastructure architect, who is the person to manage the organization cloud services, and he is the person* *who do the plans or make the policies about how do we manage the cloud resources and data. We have a team, the architect is the team leader, and we have several engineers work as a team".*

Most cloud users do not have to worry about hardware or software. This is one benefit of virtualization as the service provider handles all the updating, restoration, and backup. However, cloud users can have access to the background management program in order to see the kind of data that is going into the system and who has access to the data. The digital dashboard is a good example of visualization. The status of all cloud assets can be displayed and monitored via the digital dashboard. The monitoring software should also allow users to monitor the traffic and other things; for instance, users can see how many online visitors they have over a certain period of time. There is a computing centre or computing department in most universities whose IT staff manage the cloud resources and assets.

To sum up, the system needs to be managed to ensure that it meets expectations. The cloud provider usually has a maintenance team that checks all the hardware assets to make sure everything is in working order and on track. It is better to have a control room, so that if software or something else goes wrong, the maintenance team will know immediately and fix it as soon as possible because many end users are relying on it. Participants' feedback on cloud resource management is summarised in Table 4.11.

Table 4.11. Cloud resource management

Participant code	Feedback
Csp2_Con2	*"Customers have a possible control where they can actually see what kind of data is going into the system; who has access to the data; and what kind of access level they have to the data".*
Csp1_Con1	*"Cloud assets are managed dynamically. It's like a resource pool, and computing power is shared by users. This time you may need more computing power, so that part will be assigned to you automatically. Dynamic, I think that is one of the most important characters in cloud".*
Csp1_Con2	*"We have a maintenance team, and they will check all the hardware assets to make sure everything is in working order".*

Uni1_IT2	*"We don't have to worry about hardware or software, this is a benefit of virtualization, so service provider handles all the updating, restore, backup things".*
Uni3_IT1	*"We can receive status summary for all service group every day from the server. We use some software, like Nagios to monitor the host and servers, for instance the CPU load, disk usage. If it's overload, we will receive an alarm".*
Uni1_IT1	*"By using background management program, to monitor the traffic and other things".*
Uni2_Stu2	*"Computing centre will do this job; they will take care of everything".*
Uni1_Stu1	*"We have computing department, people working there, they will manage the cloud resource and assets. You need to manage it because that is how to ensure the system meet the requirements".*
Uni2_Re1	*"Cloud assets should be monitored, you need to know all the services performance status, so the IT department will have access to real time data, date from server and sensor, they will know when to add more computing power, when to have less, because they have the real time data. Moreover, form the historical data, then can find the trend as well".*
Uni1_IT4	*"There must be a management team in our university, they will manage it. Because they need to ensure the cloud working well".*
Uni1_Te3	*"A group of IT people will manage the cloud assets, to make sure everything is on track, when we find some errors, just call them".*
Uni2_IT2	*"We have a control room, if a software or something wrong, we will know immediately".*
Uni3_IT2	*"We will manage because you need to know the performance of the software. For example, we can see how many visitors we have in a period of time".*
Uni1_Re1	*"Visualization. They have management software, with dashboard, all assets status can be monitored".*

Uni3_Te1	*"We have a maintenance team, if there is a bug or error; we need to fix it as soon as possible because many students are relying on it".*

4.4.2.2.5 Other factors of governance

Participants' suggestions are listed below.

- Csp2_Con2: "*You can think about different guidelines, for example virtual machine guidelines, subscription and accounts guidelines, storage infrastructure and networking infrastructure guideline*". The guideline is similar to the policy factor related to this theme, so it is not necessary to add this factor.
- Csp1_Con: *"Finance management. To make sure it's within budget".* This is a good suggestion; however, in regard to the process factor, when a company evaluates a new system, finance will be taken into consideration. Thus, there is no need to add finance again.
- Uni1_Te1*: "If the governance is about policy, regulations, then you can add operation management into it"*. This is close to performance management. As this model already has a performance management theme, there is no need to add operation management.
- Uni3_IT1: "*What about resource scheduling management? So, if one server is overloaded, you can reschedule the resource to solve the problem*". This is similar to the resource management factor, so it is not necessary to include this factor.
- Uni1_IT3: "*Cloud service provider management. Companies and providers should work together in order to establish the service framework, for example, the system boundary is needed. They also need to think about what kind of responsibilities each party has. Customers need to discuss the contract details with the service providers as well*". This is a great suggestion. Cloud users and service providers should cooperate with each other in order to obtain a better understanding of the organization's needs and the required solutions. Also, in the service level agreement, the responsibilities of each party should be clearly identified. This could be added to the process factor.

Lastly, some participants mentioned risk management. Many cloud users are concerned about data security; thus, risk management is essential. They need to evaluate the potential risks and discuss the solutions with the service providers before moving to the cloud. Risk management is part of the process factor, so it will be discussed in the process section. Other feedback from participants regarding other factors of governance is presented in Table 4.12.

Table 4.12. Additional factors for governance

Participant code	Feedback
Uni1_IT2	*"Maybe 'risks'".*
Uni2_Te1	*"For the governance model, besides resource, process and policy, maybe you can think about identify roles and responsibilities, strategic planning and support".*
Uni1_IT4	*"Structure of the management team? Like who is responsible for what".*
Uni1_Re1	*"Management".*
Uni3_Te1	*"Hierarchy. A hierarchy of all potential users, who have access or influence of the cloud".*

4.4.2.3 Theme 2: Sustainability

This section contains four questions used to evaluate the sustainability theme of the model.

4.4.2.3.1 Social effect

As indicated in Figure 4.8, most participants believe that cloud computing will make people's lives easier and have positive impacts on society. For instance, customers can use mobile applications to order food online; all the details about restaurants are stored in cloud rather than on mobile phones. Speech recognition technologies like Siri increase the efficiency of communication with smart devices. Csp2_Con1 said "*cloud users can also save data, personal or work data to the cloud; many people are now using iPhone and iCloud service and upload photos to the Apple cloud service. The maintenance of computing assets is simplified; users do not have to worry about operation and maintenance anymore, because cloud provider has professional operation and maintenance operations personnel. It can also shift the way that people interacting with others*". Another aspect concerns education, as students can access learning resources from different locations, anywhere at any time.

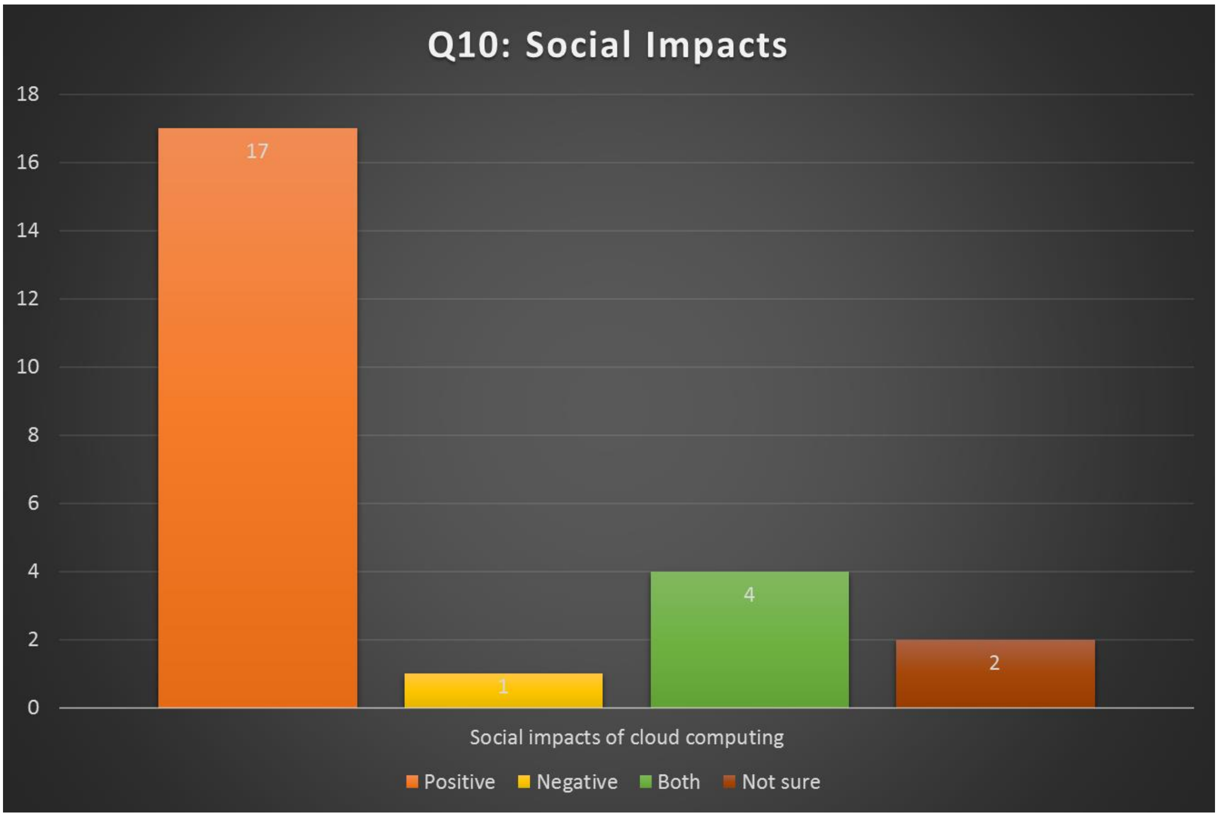


Figure 4.8. Social impacts of cloud computing

On the other hand, some social concerns have arisen with the development of cloud computing. Everything has two sides, like the smart phone; people spend too much time on it nowadays, online charting, and gaming. Traditional businesses will be forced out of the market. Eventually, the software industry will disappear because of cloud computing, and most of the applications will be online-based apps with extended modules or functions. Maybe PCs, even laptops, will disappear, as people will need only a display device to perform different tasks online. Another risk is the security or privacy issue because the data is on cloud and there is a chance that data can be hacked. An organization must trust its cloud provider in terms of data privacy in order to migrate to a cloud environment (Fortis et al., 2012). Moreover, copy issue should not be ignored. One example is the Baidu cloud, one of the most popular cloud-based file backup and data sharing platform. People can share music and movies on the cloud. Luckily, the government has noticed that, now the Baidu cloud has been regulated, and most of the pirated music and movies have been removed. Other feedback from participants regarding the social effects of cloud computing is presented in Table 4.13.

Table 4.13. Cloud computing social effects

Participant code	Feedback
Csp2_Con1	*"I think there are a lot of benefits. This is a new technology, people can save data, personal or work data to the cloud, it gives you a place you can put whatever you want put to the cloud, so you can take your data anywhere, don't have to take a hard drive or a USB stick. If you travel overseas, you can access your data on cloud, so that are the good things for people who want to access data in different locations without taking anything with them.* *But the most significant impact for using cloud computing is the security or privacy issues that people don't want to put their data on cloud because cloud can be accessed via Internet, so in this case, if anything can be accessed via Internet, they also could be hacked".*
Csp2_Con2	*"Cloud computing is affecting almost everyone, especially the new generation. For example, many people are now using iPhone and iCloud service; you can upload your photo to the Apple cloud service".*
Csp1_Con1	*"I think in the future, may be 10 years later, PC, even laptops will disappear. Internet will cover every corner in this world; people only need a display device with a built-in network module to perform different tasks online".*
Uni2_IT1	*"Many educational institutions have realized the potential advantages of cloud computing technology. Students can access learning data from different locations, 24/7. Also like the e-learning, students can interact with others via computer. Students can submit the digital work online, instead of printing it out, they can enrol online. So, these advantages will help the educational institutions reduce expenses".*
Uni1_Te1	*"Cloud computing is reshaping the teaching and learning. Because I remember many years ago, we only have the physical books in library if you want to find something. But now there are many ways to find we need, like the internet, or E-book".*

Uni1_IT3	*"Just like WeChat, Weibo and many other social media applications shifting the way that people interacting with others, cloud computing is changing the business activities these days.* *For example, businesses are now easily to get data from cloud-based social media applications or platforms, for making decisions and addressing customers' requirements".*
Uni1_Stu2	*"Online social media is changing us; we can now communicate with friends online".*
Uni1_Te2	*"We hear this word from news, from internet, and like you told me we are already using it in daily life just didn't realise. So, I think such a powerful technology must be regularized. If it can be accessed by public, then there is a social impact, some people may get benefit from that, but some may not. Everything has two sides, like the smart phone, I think people spend too much time on it nowadays, online charting, gaming... So, there's a lot of work to be done".*
Csp1_Con2	*"Let's take Meituan software as an example, customers an order food online, and they can leave the feedbacks. Those restaurants using this cloud-based software to attract customers, the restaurants won't have data centre I bet, but look, they take the advantage of cloud, they can review customer's feedbacks to make necessary changes, in order to attract more customers. That's how the cloud technology changing the society".*
Uni1_IT2	*"Five years ago, a lot of people even never heard about cloud computing, now things are different, well many people nowadays know this term, may be they can't explain it, or not familiar, but at least they've heard about it, from TV, from* newspaper. *For example, iPhone users know there is an iCloud where they can store the photo".*
Uni3_IT1	*"It's changing our behaviour. Not only the cloud computing, but also all the modern technologies. People are using smart phone all day, you can live without anything, but you must have a phone, internet on you".*

Uni1_IT1	*"We see many good things about cloud computing, but on the other hand, many companies will be in trouble because of the development of cloud computing. Technologies always have two sides, behind the success of new cloud business, many traditional businesses will out of the market. No doubt, this will bring negative impact to society development. Because the large-scale impact of capital investment, tens of thousands of workers need to find new employment opportunities, many people have to be retrained to be qualified for new challenges. The most important issue is that big companies have spent years to build social influence and it is not easy to eliminate, they can influence the policy makers".*
Uni2_Stu2	*"It's changing the way that we doing things, no there are many online games for example, I like to play online games, on my smart phone, I have 2 games. I believe they are connected to cloud service, because it allows multi-player, so the phone send data to cloud server first, and then the server send new data back to me. Email is cloud computing as well, many years ago we send letters, but now just email, many people don't realise that email is kind like cloud computing, because you don't store all emails on your phone, when you search, it will search from cloud server, this will save space, especially for me, I use my phone to take lots of photos, so I don't have enough space. By the way, I can also upload photos to the cloud servers".*
Uni1_Stu1	*"The cloud computing is changing our daily life now. For example, we know that speech recognition technology is available for many years, thanks to cloud computing, the accuracy has improved a lot these years".*
Uni2_Re1	*"Cloud computing will bring a lot of business opportunities to different organizations. Generally speaking, it is a platform which is connect to the global network resources, and cloud computing has changed many industries. We can see the development of media, publications, retail, advertising, marketing and information technology. In the future, organizations will use the network to*

	develop new business opportunities, and to promote the rapid growth of products and services. Cloud software is rapidly developing and changing the whole world".
Uni2_Te1	*"Simplified maintenance: cloud provider has professional operation and maintenance operations personnel, so we don't have to worry about our operation and maintenance, so IT staff can concentrate on the development of applications".*
Uni1_IT4	*"Cloud computing will drive the rapid centralization of global resources. A variety of resources will be classified and centralised through technical means in accordance with market rules, this centralization will help the use of resources to reach the maximum efficiency, and the allocation of resources is fair because of effective monitoring".*
Uni2_Stu3	*"Cloud computing, or ICT is affecting us a lot. There are advantages and disadvantages. For example, it makes our life easier, you can access online resources faster, but there are some issues, like copyright issue, we can easily download free music and movie online, and when everyone upload their data or photo to the internet, the data may be stolen by someone and be used illegally".*
Uni1_Te3	*"Eventually software industry will disappear because of cloud computing. With the development of cloud computing applications, people will develop their own software based on their needs just like you use Microsoft word to edit text. Programming software industry will gradually disappear".*
Uni2_IT2	*"Cloud computing will lead us to a significant change in the way of thinking. People will learn to deal with different problems on the whole point of view".*
Uni1_Stu3	*"People commonly use Google or Baidu search engine, entering the keyword, search engine will quickly show you thousands of related information. This process is done by Google or Baidu's cloud computing centre located in different places".*
Uni3_IT2	*"In the past, it would be difficult to let the phone understand speech. Because the mobile phone itself has weak computing power, and*

	people's accents are different, the phone is hard to identify the voice. Now the mobile phone operating system will quickly upload your voice to Google or Apple's cloud computing centre through the network. There is a lot of voice data and text information, and the cloud system can quickly calculate the meaningful text to match the voice. Then it goes back to your phone through the network. So, the accuracy of this recognition reached a new height. The reason why it can identify some new words or internet language accurately is because the new words appear a lot on the internet, and this massive statistical information will help the machine to understand us more accurate".
Uni1_Re1	*"There are many benefits, but also drawbacks. For example, there are many network disk or online storage, people upload movies and music to the cloud-based storage, and share the link to others, I think this is a drawback of cloud computing, the copyright issue".*
Uni3_Te1	*"It's changing the way we communicate and study. Like other technologies, cloud computing making our life easier".*

4.4.2.3.2 Financial effect

According to Sultan (2010), the frequent IT technology changes will keep on placing pressure on financial plans. Constant upgrades of software and hardware have turned out to be essential for a large number of organisations and will keep on putting pressure on their budgets. That is why most interviewees agree that cloud computing would save money. Figure 4.9 below shows that most participants believe that cloud computing has positive impacts on finance. Cloud users have to pay only for the actual use related to storage they have used. Sultan (2010) also mentioned that cloud computing will decrease labour-related costs, as fewer individuals (e.g., technicians) will be required to run a cloud-based IT infrastructure.

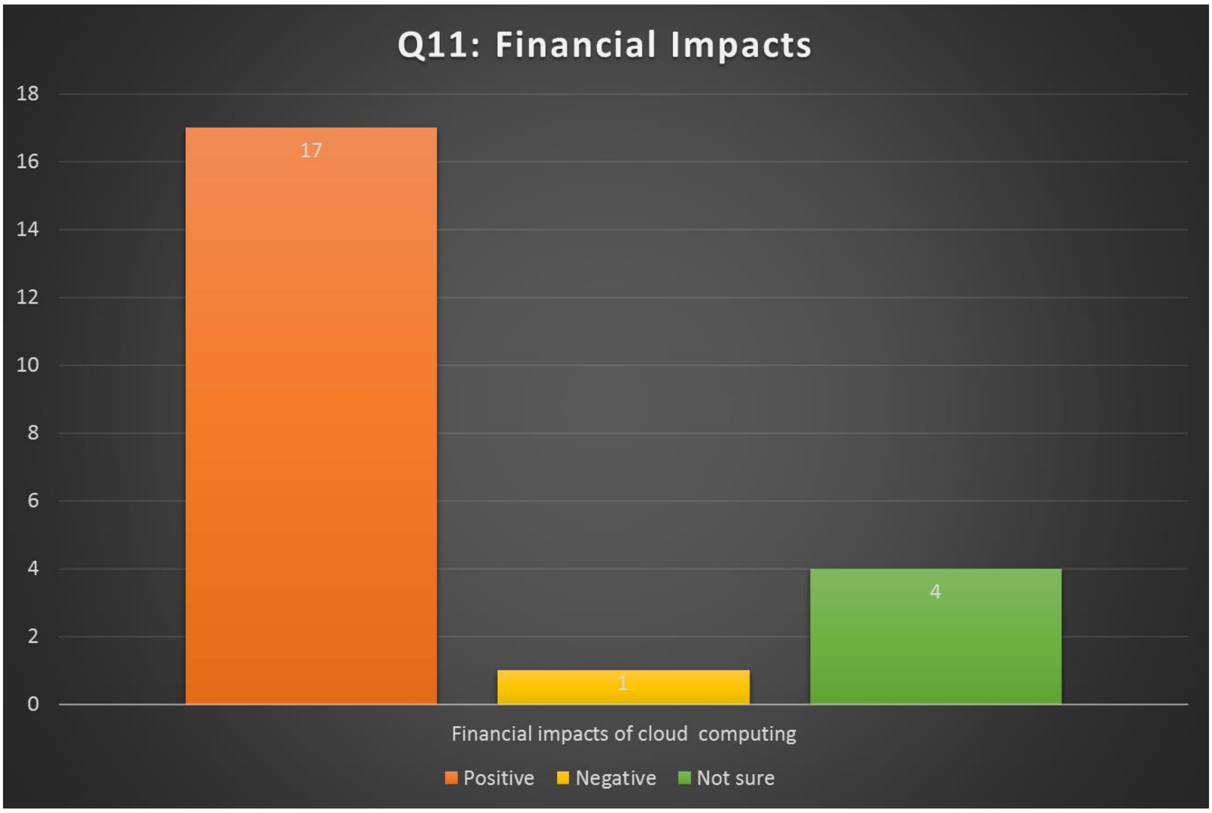


Figure 4.9. Financial impacts of cloud computing

Another financial benefit is flexibility. If customers need extra computing power, they can choose the additional or add-on services and applications. Small-scale companies especially will benefit from this feature. When starting a new business, they may have a limited budget and not be able to afford a dedicated server room or other essential computing resources in some cases. Thus, it might be a good idea to start by renting a few servers from the cloud service provider to meet the current requirements, and then add extra services as the business grows. Hence, the on-demand payment method will help cloud users to save a lot of money as they do not have to buy hardware and software. Sometimes, the financial benefits of cloud computing can only be achieved in the long term. Based on the requirements, the set-up fee may vary in different cases. It may take a long time to recoup the initial investment in cloud.

For universities, cloud computing has the ability to reduce dramatically the IT operation budget. For instance, instead of hosting the official website in-house, the cloud provider can host it in the cloud, the school's operations expenditure will decrease as there is no need to purchase hardware and software for maintenance. Moreover, students and teaching staff can save money in terms of learning and teaching. Uni1_Te1said "*E-book is getting popular these days and it normally cheaper than printed book*".

With the development of the cloud infrastructure, cloud pricing is decreasing. Cloud computing is more affordable than ever before, and customers have more options these days as many new cloud providers, such as Huawei, enter this market.

Overall, the majority of interviewees believe that cloud computing could reduce the expenditure on computing hardware and software as all the services are available online. If companies use an in-house IT infrastructure, they need to invest a lot on servers, hardware and software in order to provide computing services. With cloud computing, companies pay only for what they have used. Cloud computing also saves energy, meaning less spending on software and hardware as well as electricity. Moreover, this technology could save money for cloud users by reducing the number of IT staff. In small scale organizations, it is not necessary to have an IT department to manage the IT resources, as computing tasks can be undertaken online. They can upload all data in the cloud, and the cloud service provider takes care of the data. As a result of the competition, cloud service fee is becoming much cheaper these days. Cloud computing can bring financial benefits for both users and cloud providers. Users can save money on hardware purchase, software development and other things, and cloud providers will derive profits from the users that can be used to improve their services. Hence, if everything goes well, users and providers are both winners. On the other hand, training costs should be taken into consideration. When adopting a new technology, the organization needs to first of all train the staff. Other feedback from participants regarding the financial effects of cloud computing is given in Table 4.14 below.

Table 4.14. Cloud computing financial effects

Participant code	Feedback
Csp2_Con1	*"I got a chance to chat with our sales team, those people who deal with our customers, they also help customers to migrate from their own infrastructure to cloud. So, what they have told me was the main reason people want to migrate to cloud is because the cloud can save their money. So I believe, cloud computing can actually save a lot of money for people, not only the money, but the human resources, they don't need to have their own IT department to manage the IT resources, they can put everything to cloud, and cloud service provider is the person or the organization who can*

	help them to manage their data or cloud computing resources. So, in this way, company can save a lot of money for hiring less people".
Csp2_Con2	*"Companies only need to pay for the actual resources that they have used, for instance, how many minutes of computing time, how many bytes of storage they have used; also, it includes the usage of additional or add-on services and applications".*
Csp1_Con1	*"Companies will save money, especially for small companies, the beginners. At the beginning, they don't have money to buy physical server room or computing resource".*
Uni2_IT1	*"There are many financial benefits in terms of hardware saving, software saving. The price is getting cheaper and we have more options, like Huawei came into this market as well recently".*
Uni1_Te1	*"It should have positive effect in terms of financial. For example, E-book is normally cheaper than the physical book".*
Uni1_Te2	*"Save money? Otherwise why people moving to the cloud right"?*
Csp1_Con2	*"When you apply cloud technology, you are not only saving energy, but also saving money. If companies use in-house IT infrastructure, they need to pay a lot of money on servers, hardware and software in order to provide the services. With the cloud computing, companies only pay what they use. This will bring lower electricity bills and lower requirements of software and hardware".*
Uni1_IT2	*"Accounting and finance department may know the numbers, but I believe the financial benefit for cloud computing is long-term benefit. The investment at the beginning, the set-up fee may cheap, may expensive, depending on the requirements. But because of the competition, cloud service fee is getting cheaper these days".*
Uni3_IT1	*"At the beginning, you have to pay a lot for the set-up fee and extra, but in long-term, I believe it will save money for most of the companies".*
Uni1_IT1	*"Cloud computing can greatly reduce the operating costs for the university: because our university's website is a non-profit website, if we rental server, it will cost a lot. So, if SAE hosting our official website, the school's operations expenditure will reduce".*

Uni2_Stu2	*"You pay for the resources you actually use, this is a new way of saving money, cloud computing can do that, and it will save money for users. For example, if I only 10GB data storage in cloud, then I just pay for that, later on if I need extra space, just pay for the extra, no waste".*
Uni1_Stu1	*"Maybe it will save money and cost, because you don't have to buy servers, and providers will have that ready for you in their data centre".*
Uni2_Re1	*"The on-demand payment method will help university to save a lot of money, besides, university doesn't have to buy hardware and software, so there are financial benefits with the cloud technology".*
Uni2_Te1	*"I'm not sure about this question. May be cloud computing can save budget, but on the other hand, to let us know how to use the new system, we need training as well, and that will cost a lot".*
Uni1_IT4	*"For cloud computing users, this technology will save cost. Not only for the university, but for our daily lives, cloud computing is like a data and computing power pool, we can upload our data to cloud, this will help us to save money on hardware".*
Uni2_Stu3	*"It can bring financial benefits for both users and cloud providers. Users they can save money on hardware purchase, software development and other things, cloud providers will get money from the users and to improve their services. So, if everything goes well, users and providers are both winners".*
Uni1_Te3	*"If this new technology can survive, it means it have benefits. Why many organizations move to cloud? I believe positive financial effect is the reason".*
Uni2_IT2	*"It will save the cost on hardware and software. Because it is cloud computing, everything is on cloud, so we don't have to worry about that".*
Uni1_Stu3	*"Saving money, so companies don't need to pay for physical servers, and maintenance. Cloud computing service provider will do that for users".*

Uni3_IT2	*"I think the biggest advantage of cloud computing is easy maintenance, so the financial effect is not that obvious".*
Uni1_Re1	*"It has the potential to save the cost on computing resources. However, the result may be not that obvious in a short term".*
Uni3_Te1	*"I don't know that. May be saving money"?*

4.4.2.3.3 Environmental effect

Most participants agreed that cloud computing could save power, decrease CO_2 emissions and have positive impacts on the environment (Figure 4.10). Csp1_Con1 pointed out that "*if we can save energy, we save the environment*". ICT energy consumption is one of the causes of pollution; however, cloud computing is eco-friendly and cost-saving. It would be a good start to move to cloud because cloud computing is part of green IT, and moving to cloud is a step toward going green. Most people nowadays care about the environment and want to reduce pollution. Centralization is one of the advantages of cloud computing: everything is in the resource pool, and it could minimize the negative environmental effects of ICT; hence, cloud computing helps to safeguard the environment. Centralization technology can reduce energy consumption, and less energy consumption means fewer trees will be cut down, so the environment performance of ICT will be improved. In other words, centralisation and virtualization are the two most important characteristics of cloud computing, and they both helpful for our environment by reducing the carbon footprint.

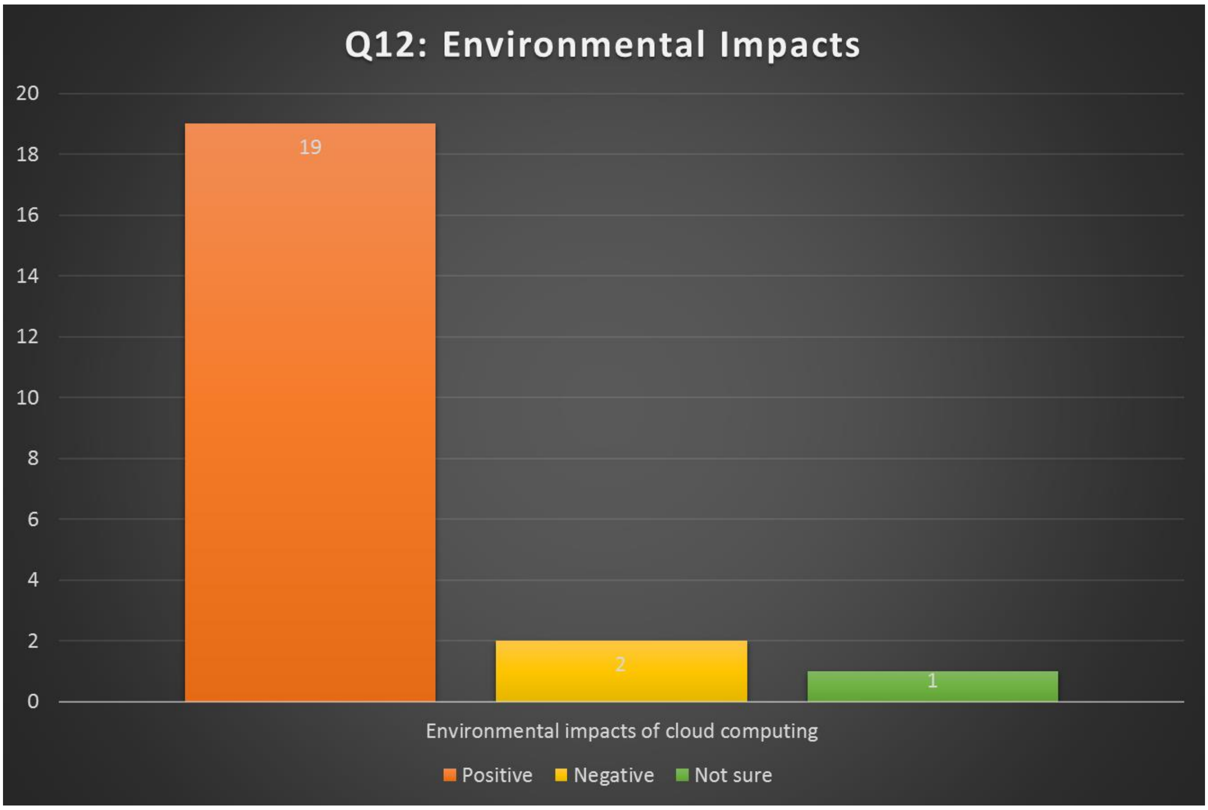


Figure 4.10. Environmental impacts of cloud computing

On the other hand, some participants believe that the environmental effects of ICT have been overrated. According to Uni3_IT2, "*nowadays, more and more companies are using cloud computing, but the environment in some places is getting worse. There are many things can affect the environment, including car exhaust, factory pollution. Compare with those factors, computing just use very few energy*". Because there are too many pollution sources, even if cloud computing is widely used in future, nothing will change.

Another question raised by participant is that if people use providers' computing resources, energy can be saved on the users' side, but what about the providers' side? The more users they have, the more energy they will consume. Other feedback regarding cloud computing environmental effects from participants is given in Table 4.15.

Table 4.15. Cloud computing environmental effects

Participant code	Feedback
Csp2_Con1	*"In my opinion, cloud computing can save power, as we are cloud computing provider, we have our own data centre and storage, so for our customers, they only to purchase cloud resources, they don't need to have a server room, and don't need to pay the power for*

	the server room, just pay the cloud computing resources. If customers their server room, it may cause a waste of the computing capacity, as they don't need the full capacity all the time. We have a large data centre, with many servers, all the servers are connected with VMware-a cloud system, to integrate all the servers. We call that 'cluster'. So, we have a large computing resource pool, and this resource pool could be divided into smaller resource pools, so we can sell this smaller 'resource pool' to customer, that's what customers have paid for. And if this part of 'resource pool' is not utilised at a time, this 'resource pool' will be assigned to others. In other words, customers are buying the 'computing capacity'. Of course, with in our company, the servers won't run at 100% capacity, but in here there will be a higher utilization rate, which could save power".
Csp2_Con2	*"I think cloud-based computing brings significant decreases in CO2 emissions compared with on-premises delivery of applications".*
Csp1_Con1	*"Coal brings energy to us, but also pollution to air, so if we can save energy, we save the environment".*
Uni2_IT1	*"Eco-friendly and cost-saving are the most often used words when cloud service providers trying to promote their solutions".*
Uni1_Te1	*"In developing countries, we normally focus on economy, and pay a little attention to environment. Until recently, the haze finally attracted our attention. Although there are many reasons for this, but ICT energy consumption is one of them, not the major reason, but one of the causes. Moving to cloud is going green, cloud is not the final solution, but it is a good start".*
Uni1_IT3	*"Cloud computing is often referred to eco-friendly and green IT, and general public nowadays are care about the environment. So, organizations can use 'going green' as a marketing strategy. I mean, the public want green, then we take that advantage, claim that we are going green, to attract more attention. It's like a slogan, which can be used to promote the brand image. Also mention the 'energy efficient' to maximise the impact on public relations in order to*

	attract investments, or get more businesses. You may need to pay a lot to get other green solutions, like computer recycle and disposal. However, cloud computing is cost saving; besides it can bring more customers. Therefore, when the business owners want to shift the business from the traditional one to a more eco-friendly one, the cloud is the solution and they don't have to worry too much about the budget".
Uni1_Stu2	*"Reduce the pollution".*
Csp1_Con2	*"I'm sure it has positive effects on our environment. Centralization is the advantage of cloud computing, everything is in the resource pool, in order to minimize the negative environmental effects".*
Uni1_IT2	*"It will help up to achieve Green IT goal".*
Uni3_IT1	*"Reduce pollution, if we use centralized computing resources".*
Uni1_IT1	*"Should be good impacts. Cloud computing will reduce electricity consumption, and I know some of the service providers, they will reuse the heat generated by their data centre".*
Uni2_Stu2	*"It can reduce energy consumption, because it's using centralization technology".*
Uni1_Stu1	*"It will help us to protect the environment, and people are care about the environment".*
Uni2_Re1	*"Less energy consumption then may be fewer trees will be cut down. It is a long-term effect, cloud computing being introduced to us not long ago, so the environmental effect is not clear enough at this stage, yes, it could benefit the environment, but we still need more evidence to prove that".*
Uni2_Te1	*"They say cloud computing is part of green IT, so I guess it can help with environment protection".*
Uni1_IT4	*"Centralisation and virtualization are the two most important characteristics of cloud computing, and they both helpful for our environment by reducing the carbon footprint. When you centralise the computing source, less energy required".*
Uni2_Stu3	*"Cloud computing is one aspect of green ICT, it has less energy consumption, so it will improve our environment performance".*

Uni1_Te3	*"If everything is on cloud, we don't need so many physical devices, electronic devices waste harm the environment, so we are saving the environment".*
Uni2_IT2	*"It can help human to protect the environment by helping us reduce energy consumption".*
Uni1_Stu3	*"I think it is positive effects. It can save energy for us".*
Uni3_IT2	*"The environmental effects have been overrated. We all agree that nowadays, more and more companies are using cloud computing, but how about the environment? It's getting worth right? Of course, it is not cloud computing fault, but I will say, there are many things can affect our environment, including car exhaust, factory pollution. Compare with those factors, computing just use a little energy, so is cloud computing will save the world? No, because there are so many pollution sources".*
Uni1_Re1	*"The carbon footprint will drop if we use computing resources more wisely. Cloud computing is a good start, but not the end".*
Uni3_Te1	*"If we use providers' computing resources, yes, we can save energy from our side, but what about the provider side? More users they have, more energy they will use, so that is a question".*

4.4.2.3.4 Meaning of sustainability

Sustainability itself is a very broad topic. It is a development concept used to improve the ecological environment, improve the efficiency of resource usage, and facilitate a positive interaction between humans and nature. According to Uni2_Re1, "*Sustainability is not simply equivalent to environmental protection, it consists three aspects, Ecological, social aspect and Economic aspect. So, the first one ecological, we need to minimize the environmental damage, we need to be eco-friendly. Secondly, we need to need human's needs, sustainable development doesn't require all of us to go back to primitive society, but we need to protect the environment, to raise the society awareness. Lastly, profit is important, we need to find the balance, to keep the organization running and to protect the environment in the same time*".

The majority of participants believe that economic development and environmental protection should be taken into consideration simultaneously. In other words, it should encompass saving money while saving energy and protecting our world, and doing no harm to the environment.

It is about economic development that is eco-friendly and attempts to reduce pollution. Other key words associated with sustainability, mentioned by respondents, include ‘energy’, ‘recycle’ and ‘business performance’. Uni1_IT4 mentioned that “*it is also about the balance between environment protection and origination’s growth. The environment needs to be protected. On the other hand, companies need profit, so the balance between environment protection and economic development is important. Simply put, not only the environment, but also the organizations’ profits need to be protected, because naturally, a company needs profit to survey. If the company could not feed itself, how could they protect the environment*”?

From the perspective of a cloud computing service provider, cloud users in small and medium-size organizations do not have to make significant changes in terms of cloud infrastructure in the long term once they purchase cloud computing or IT resources; nor do they have to change many IT components to the current infrastructure, because changing the infrastructure cloud can lead to many potential issues. For instance, if an organization upgrades the hardware, the applications running on the previous hardware might not be compatible with the new hardware. Csp2_Con1 pointed out that “*cloud computing service provider will provide computing resources, so customers do not need to know what is the underlying hardware running at the back, all they can see is just computing resources, like how may gig bite CPU/RAM. However, the customers or the cloud users need to care is how much gig bite RAM they need. In other words, the beauty of virtualization is that the users do not have to worry about the underlying hardware, and all the resources are integrated by provider*”.

“*Could computing service provider can do better than on-premises IT in carbon emission reduction, because energy consumption is relevant to centralisation, distribution, production, disposal of hardware etc., and service provider optimises the management of hardware selection and disposal*”, said by Csp2_Con2. When the service providers centralise the computing resources, customers consume less power, which means less electricity consumption. That leads to less pollution. Cloud computing activity could also reduce electronic device waste; this is another benefit of centralisation.

The data centre cooling system contributes to almost one third of total energy consumption (Garg & Buyya, 2012). Traditional computing consumes an exorbitant amount of energy for cooling the servers and some participants point out those service providers should not waste the heat from the cloud servers or hosts. Rather, they could collect the waste heat and use it to heat water and buildings in winter, which is an excellent approach to saving energy. If the energy consumption of cloud service provider is reduced, the price of the cloud may become cheaper.

Uni1_Te2 mentioned that "*the environmental problem becoming a major issue in China, the air quality is getting worth, haze everywhere especially in winter. So, while developing the economy, general public needs to pay attention to environmental protection, protect it for next generation*". This means appropriate development to meet the current needs while ensuring that future generations have enough resources to meet their own needs as well. Cloud computing or sustainable computing will help to achieve this.

Although most participants agree that a healthy relationship among people, resources and environment ensure sustainability, and people need to protect the environment, some participants admit that they do not care too much about environmental issues. According to Csp2_Con1, when promoting the service to customers, "*saving cost must be the priority of marketing practices*".

In conclusion, cloud computing can help to reduce the carbon footprint by centralising computing resources. Also needing improvement is the general public's awareness of sustainability. For service providers, eco-friendliness could be a feature or a promotion slogan for their services. Everything needs to be kept running without doing harm to the environment. Hence the need for new technologies and new ideas. It goes without saying that economic growth, social responsibility and environment are all equally important, and the environmental impact of modern technologies should not be ignored. Other valuable feedback from participants regarding cloud computing sustainability are presented in Table 4.16 below.

Table 4.16. Cloud computing sustainability

Participant code	Feedback
Csp2_Con1	*"Sustainability is a very large topic. In my opinion, for small/medium size organization, once the purchased cloud computing or IT resources, in a long period of time, they don't have to make big changes in the cloud infrastructure, or they don't have to change too many components to the current infrastructure, because changing the infrastructure an cause many issues. For example, if you upgrade the hardware, the applications running on the old hardware may not compatible with the new hardware, we had a customer who used accounting software, and after they*

	upgraded the hardware, they cannot use the software anymore, so it would cause some problems. *Most customers or people working at my level will not care too much about the environmental performance, for us, when promoting/selling our service, saving cost must be the priority of marketing practices".*
Csp1_Con1	*"We use lot energy for cooling the servers and I think we shouldn't waste the heat from the cloud servers or hosts, maybe we can gather the waste heat and use it to heat water and buildings in winter, that's a way to save energy. Since the energy consumption from cloud service provider can reduce, the price of the cloud may cheaper".*
Uni2_IT1	*"The healthy relationship among people, resource and environment is sustainability. We need to protect the environment. Cloud computing can help to reduce the carbon footprint".*
Uni1_Te1	*"Sustainability is a development method, in order to improve the ecological environment, improve the efficiency of resource usage, and coordinate between human and nature".*
Uni1_IT3	*"Saving money while saving energy, that's sustainability".*
Uni1_Stu2	*"Protect our world, no harm to the environment".*
Uni1_Te2	*"I believe sustainability is sustainable development, if we do little or no harm to the environment, that's sustainability. Environmental problem is a major issue in China, we see the air quality is getting worth, smog everywhere especially in winter. So, while developing the economy, we need to pay attention to environmental protection. Protect it for next generation".*
Csp1_Con2	*"It means proper development to meet our current needs, and future generations will have the same chance to fulfil their needs. Cloud computing or sustainable computing will help us to achieve it".*
Uni1_IT2	*"Not only to protect environment, but also we needed to protect the organizations' profit. So naturally, a company needs money to survey, if the company couldn't feed itself, how can they protect the environment"?*

Uni3_IT1	*"It means reduce pollution, protect the world, meanwhile development. I mean the company needs to grow as well".*
Uni1_IT1	*"It means economic development and environment protection should happen in the same time".*
Uni2_Stu2	*"It means protect our planet and green IT".*
Uni1_Stu1	*"Economic growth, social responsibility and environment, they all very important, we should not ignore the environment impact that modern technologies have".*
Uni2_Te1	*"I think sustainability stands for making enough profit but not hurting our environment. Cloud computing could reduce the carbon footprint by centralize the computing resources".*
Uni1_IT4	*"It's about the balance between environment protection and origination's growth. The environment needs to be protected, we all know that, especially these years the haze issue in China. On the other hand, all companies they want to grow, so we need to find the balance".*
Uni2_Stu3	*"The key words of sustainability I can think of are: energy, recycle and business performance".*
Uni1_Te3	*"If cloud computing activity is reducing electronic device waste, then we are saving the world. That is sustainability from my understanding".*
Uni2_IT2	*"Well we have heard this word lots of times these years, people are now having the awareness of sustainability development. We need to keep everything running but we cannot harm the environment. That's why we need more new technologies, more new ideas".*
Uni1_Stu3	*"It means continue development, nonstop. But eco-friendly".*
Uni3_IT2	*"Green development. All the industries, not only IT, work together to reduce pollution".*
Uni1_Re1	*"When you centralise the computing resources, we use less power, less power means less electricity consumption, less consumption means less pollution. Sustainability means protect earth; human development should not harm earth".*

Uni3_Te1	*"It means a company create enough profit but do no harm to the environment. If the cloud computing can save energy, then it makes sense; cloud computing is good for our environment".*

4.4.2.4 Theme 3: Operation management

This section contains five statements to determine the factors that should be included in operation management theme.

4.4.2.4.1 Performance management responsibility

It is said that people cannot not improve what they cannot measure (Garg & Buyya, 2012). From a cloud service provider's perspective, the technical support team is responsible for the performance management of the cloud resources. Csp2_Con1 said "*we use VMware platform, and resource management software which is called 'V-COP' to generate performance report and capacity report for cloud services during peak hours. We have approximately 100 servers; each cluster may have a group of servers, e.g. 10-12 servers in a group. If one cluster has 10 physical servers, and each physical server for example has 10 virtual servers running, there is an automation policy, and in slack hours, this policy would migrate all virtual servers to 2-3 physical servers, so the rest physical servers would stop working, and the system/software would keep an eye on those running physical servers, when their performance is reaching the warning line, the other servers would start operating and some of the virtual servers would be moved to other physical servers to balance the performance. But it is managed by software. Of course, customers are buying the resource pool / computing capacity, so if they buy 5 gig bite resource pool, they still have to pay for that even they don't use it at night. Each physical server may have 2 to more than 60 CUPs, and each CUP has 4, 6 or 8 cores, each core may dual-thread, each virtual may only need one thread from one CUP, so each physical server could have more than 100 small virtual servers, depending on virtual server requirements*". Cloud vendors could also provide digital dashboard services to clients, so the cloud users can keep tracking the performance, and if the clients need more resources, they can always expand the computing capacity by contacting service provider.

In addition to the cloud service provider, IT managers, IT department and decision makers are also responsible for performance management. As indicated in Figure 4.11, although the majority of participants point out that IT departments should take responsibility for performance management, some interviewees believe that cloud users should contribute as well. Uni1_IT2 mentioned that “*not only the IT people, but also everyone who is using it. If the users find anything wrong, they will let the IT team know*”. Although any system or software will be tested before being launched, the testing team cannot test every scenario, so all cloud users are responsible as well. Then the service provider resolves the issue based on the users’ feedback. However, some people believe that instead of performance management, the feedback from users is more important. The end user is the best judge of whether a performance is good or bad.

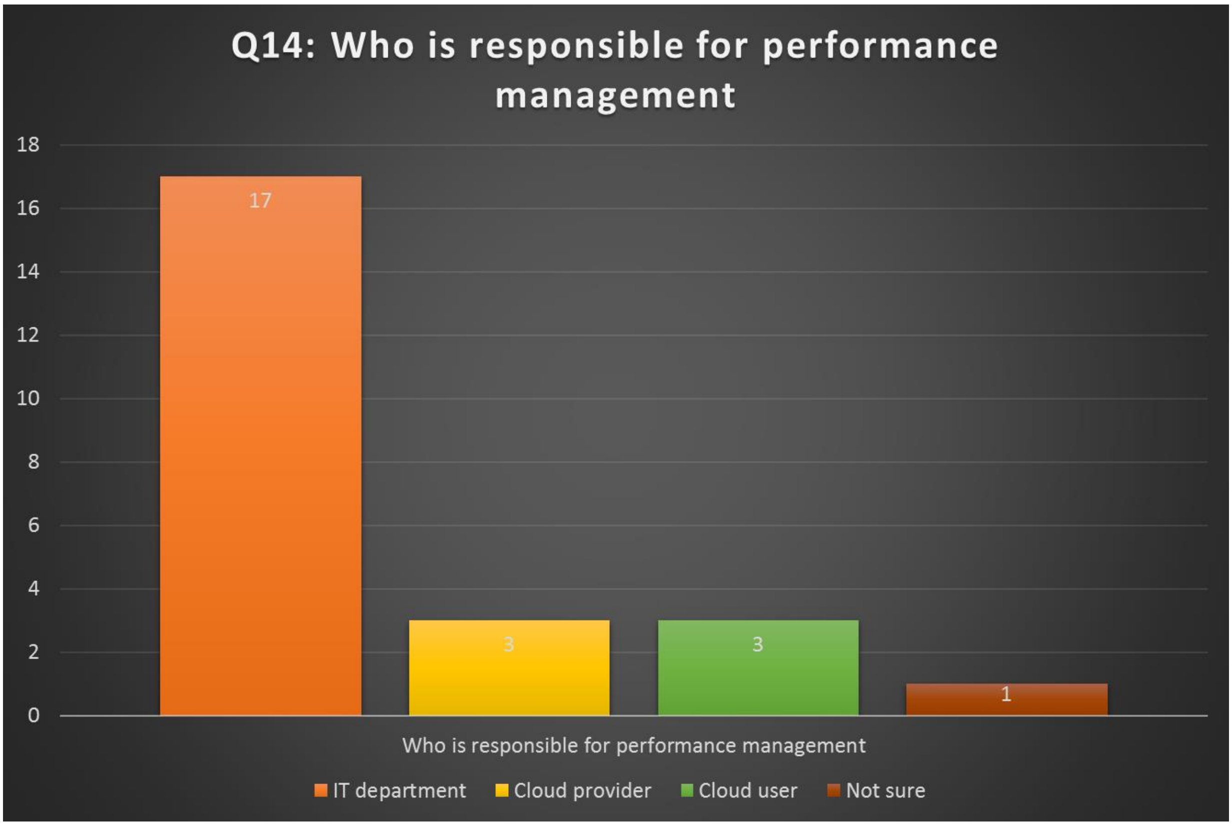


Figure 4.11. Performance management administrator

In conclusion, the traditional requirements of IT include smooth performance, security, cost-efficiency and uptime. Now, IT also needs to deliver speed and agility for today's business in this fast-changing world. Performance management plays a significant role in this positive economic climate. Cloud vendors, IT staff, IT department, IT management team, maintenance group and end users are responsible for the performance management. IT personnel require access to the control software in order to manage the computing assets based on certain criterions and check the performance via a daily report to ensure the performance is satisfactory. Once end users they identify any uncommon issue, they should let the IT management group know in order to resolve the issue as soon as possible. Other feedback from participants regarding cloud computing performance management responsibility is shown in Table 4.17 below.

Table 4.17. Cloud computing performance management responsibility

Participant code	Feedback
Csp2_Con1	*"Technical support team is responsible for the performance management for the cloud resources".*
Csp2_Con2	*"We provide digital dashboard service to clients, so they can keep tracking the performance, if they think they need more resources, they can always contact us".*
Csp1_Con1	*"Traditional requirements of IT include smooth performance, security, cost-efficiency and uptime. Now, the IT also needs to deliver the speed and agility for today's business in this fast-changing world".*
Uni2_IT1	*"Cloud vendor and us, the IT department".*
Uni1_Te1	*"IT managers, IT department. Decision makers".*
Uni1_IT3	*"IT department".*
Uni1_Stu2	*"May be IT department".*
Csp1_Con2	*"Our managers, they will check the daily report to ensure the performance is ok".*
Uni1_IT2	*"Everyone who is using it, not only the IT manager. I mean if there is a problem, then we should report it, so the service provider will act, and solve the issue".*
Uni3_IT1	*"Both IT team and provider".*
Uni1_IT1	*"Instead of using performance management, I feel the feedbacks from users are more important. End user is the judge who can decide whether the performance is good or bad".*
Uni2_Stu2	*"Computing centre should be responsible for the management".*
Uni1_Stu1	*"Computing department, so they have the control, they will manage the performance".*
Uni2_Re1	*"IT staff will be responsible for the performance management, they will have access to the control software, and they can manage everything from there".*

Uni1_IT4	*"Computing centre is responsible for the performance management".*
Uni2_Stu3	*"Our computing centre and people working there, and also the cloud providers, they both responsible for the performance management".*
Uni1_Te3	*"IT management team".*
Uni2_IT2	*"Maintenance group".*
Uni1_Stu3	*"Must be IT department and managers".*
Uni3_IT2	*"Management team and the IT manager. They have certain criterions, in terms of performance management".*
Uni1_Re1	*"IT department".*
Uni3_Te1	*"All of the users. If we find anything wrong, we will let the IT team know. Because they cannot test everything, so all of us should help".*

4.4.2.4.2 Importance of performance management

Performance management is important for all information technologies, because IT departments have to track the performance of the system or software, and to provide adequate support to users. All of the participants who responded to this statement agree that performance management is essential, as indicated in Figure 4.12. If there is an error, it should be fixed immediately. Hence, performance management is the means by which an organization can ensure that everything is on track. An organization needs to know how much computing power it needs according to its requirements, and needs to make this known to the provider.

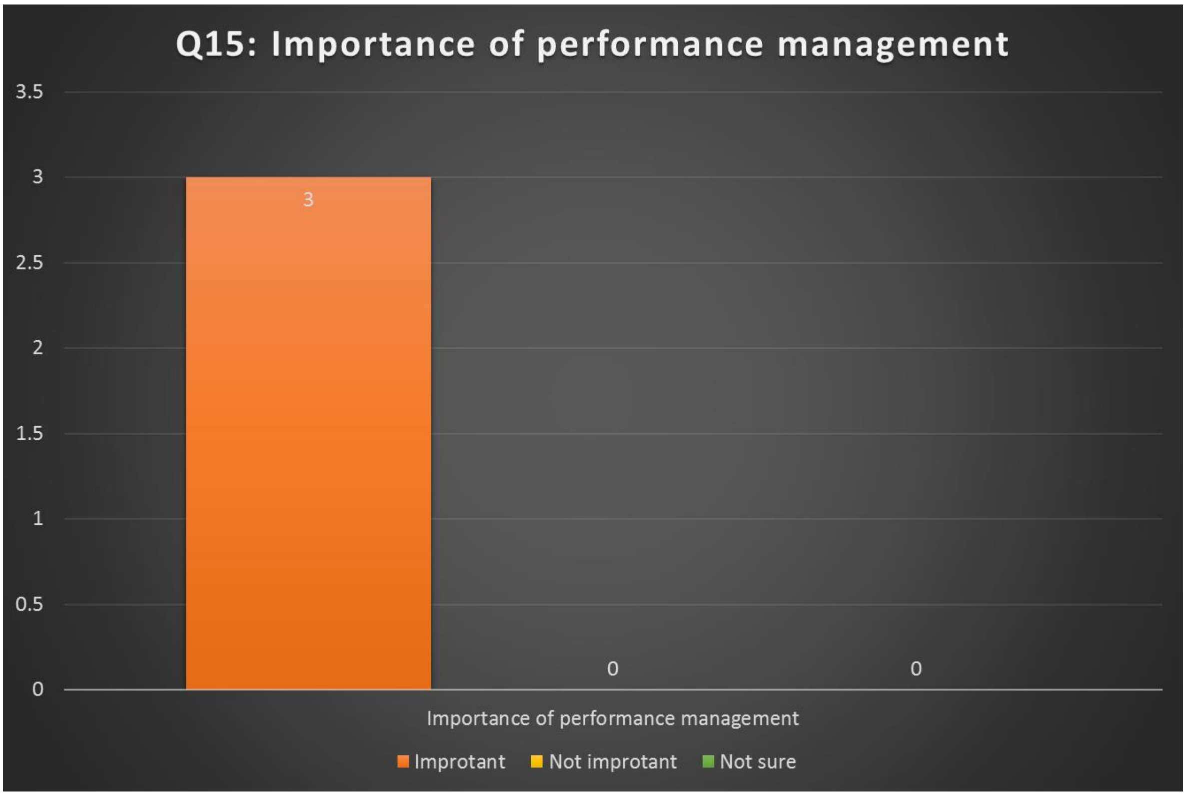


Figure 4.12. Importance of performance management

Overall, there were limited responses to this statement. If the question had asked 'currently using cloud computing' instead of 'not currently using cloud computing', more replies would have been elicited. However, generally speaking, it can be seen that regardless of the type of technology, performance management is always important, and system performance needs to be monitored either by the user or by the provider. Other feedback from participants regarding the importance of cloud computing performance management are presented in Table 4.18 below.

Table 4.18. Importance of cloud computing performance management

Participant code	Feedback
Uni1_Te2	*"Well, performance management is always important; it is a way you can make sure everything is on track".*
Uni3_IT1	*"Yes, it is. You need to know how much computing power you need, and tell provider your needs based on that".*
Uni2_Te1	*"Yes, it is important for all information technologies, because we have to track the performance of the system or software, and to provide proper support to users. If there is an error, it should be fixed as soon as possible".*

4.4.2.4.3 Data security

According to U. Kumar and Gohil (2015), cloud computing faces various network attack threats such as Denial of Service Attack (DoS), Distributed Denial of Service Attack (DDoS), Flooding Attack and IP Spoofing. Data security is one of the most significant concerns of cloud computing. The majority of participants believe that cloud providers should take the responsibility for data backup and data security. Some interviewees, on the other hand, believe that cloud users should work with cloud provider to ensure the data security; in other words, data backup and data security requires collaborative efforts from both users and providers. Almost all participants mentioned that their organisations or their service providers have some sort of backup procedures (Figure 4.13).

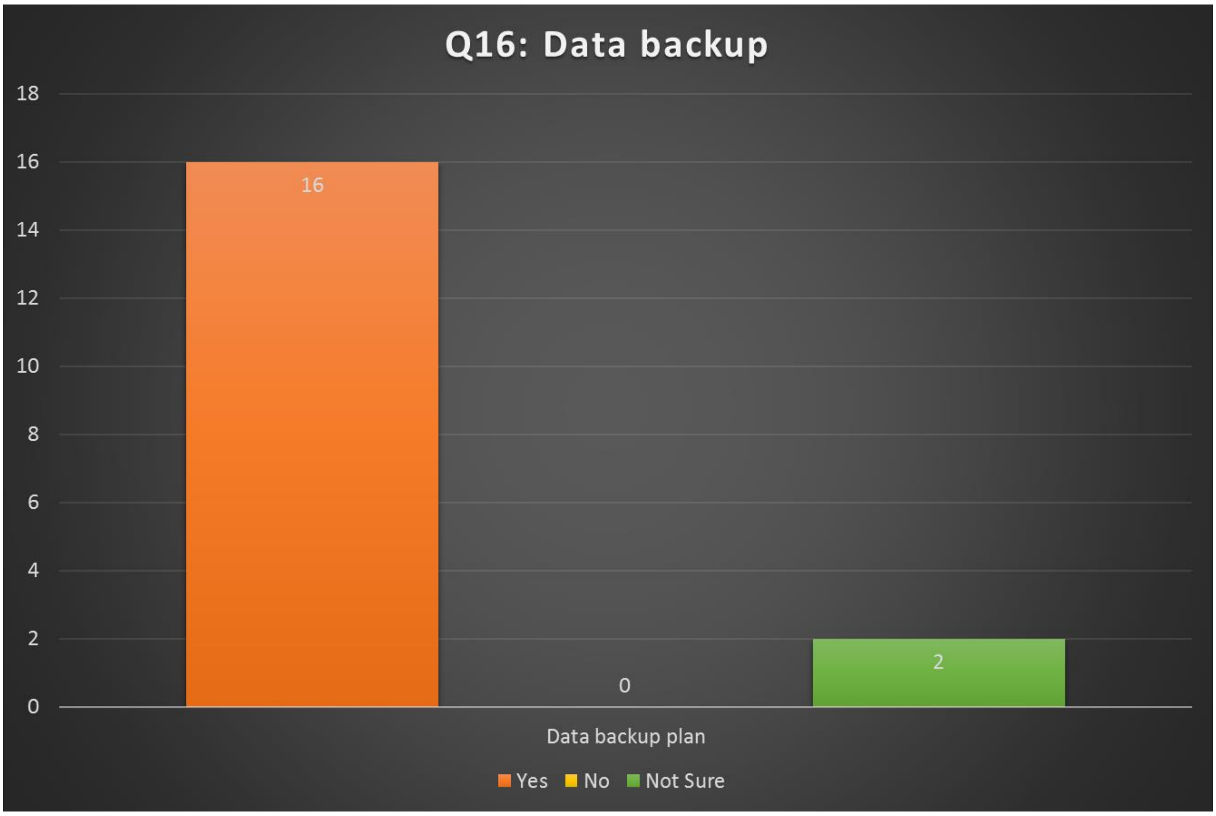


Figure 4.13. Availability of data backup procedures

Csp2_Con1 mentioned that "*both customers and provider could responsible for data loss. If the data loss caused by service provider, of course they are responsible. But customers are responsible for the data backup and they should review the backup, if the data lose caused by human mistake at customer's end, customers or the cloud users should take the responsibility. For cloud service providers, the computing resources and storage resources are at different* *locations, also they will save data in different locations, for example, one participant said that they have three data centres, even one of those data centre has issue, the data can still be accessed from other data centres*". The worst-case scenario is where the data becomes lost in one of the data centres, and cloud vendors still have backup in other data centres. In this case, they should ensure that the data are protected. Csp2_Con2 mentioned that "*We have two data centres in two different cities, six backups stored in those data centres, scheduled maintenance time is less than 4.38 hours per year. We want to make sure customers' data is safe here*". Some cloud vendors provide customised online backup services, and customers can choose how many backups they want.

From cloud users' perspectives, they believe the cloud service provider has backup data centre, and the backups should be in different locations, so the data is safe. Cloud users can have their backups in cloud, and the data backup function is a standard feature of cloud products nowadays. Cloud vendors offer customers the backup functions and users can choose the data that they want to back up. Some cloud users have more than one backup. Uni2_Re1 said "*I back up my personal files in different devices, like in the USB disk. I have backups for my most important data, like my essay, our lecturer told us always keep at least 2 backups for it*". About the data loss, depending on whose fault it is, if cloud users delete the data, that is their mistake; but if something happen to online server, then it is provider's responsibility. In other words, if the data loss is caused by the vendor, then the vendor should take full responsibility. Although some of cloud users' computing tasks are performed in the cloud, sometimes tasks are not cloud- related, in which case the cloud users should have their own data centre.

Backups should be offsite or at different locations, so that if a mishap occurs in one area, the other backups would not be damaged. Uni1_IT3 stated: "*we have data backups in different hosts*"; however, although hosts are located in two buildings, they may still be very close to each other, and that is a potential risk.

In conclusion, data backup is essential for both cloud vendors and cloud users. The best method is to have multiple backups, and update backup regularly. For instance, users could use a parallel updating method: they can update backup files number one every Monday, and backup number two every Tuesday. Most cloud providers have data backup solutions. Cloud vendors gives users software that can easily back up everything. Some backup software also supports automatic backup, and online data has passcode protection. They distribute host machines among multiple buildings, and their customers' data is highly secure because it is decentralized.

If a mishap occurs to one of the data hosts, and the data is endangered for some reason, cloud providers can restore the data via other backups. However, if the data loss is caused by user error, like deleting a file by accident, then of course the user is responsible. If this occurs because of hardware failure or a security breach, then the provider should take responsibility. Moreover, the responsibilities for data loss should be identified in the service level agreement. In addition to the aforementioned points, the literature review indicates that it is not easy to utilise various cloud systems as there are different data models for different cloud systems (Truong & Dustdar, 2012). However, this was not mentioned by any interviewees. Other valuable feedback from participants regarding the data security and backup is presented in Table 4.19 below.

Table 4.19. Data security and backup

Participant code	Feedback
Csp2_Con1	*"Both customers and provider could responsible for data loss. If the data loss caused by us, of course we are responsible. But customers are responsible for the data backup and they should review the backup, if the data lose caused by human mistake at customer's end, they are responsible. It really depends.* *For our company, the computing resources and storage resources are at different locations, also we will save data to different locations, we have redundancy for data, for example, we have three data centres, even one of our data centre has issue, the data can still be accessed from other data centres. So even the data lost in one of the data centres, we still have backup or redundancy in other data centres. So, in this case, we could ensure the data are protected".*
Csp1_Con1	*"Yes, we have online backup service, and customers can choose how many backups they want".*
Uni2_IT1	*"The cloud service provider has backup data centre, and the backups are in different locations, so the data is safe".*
Uni1_Te1	*"The best method is to have multiple backups, and update backup regularly. For example, backup one updates on every Monday, backup two updates on every Tuesday…"*

Uni1_IT3	*"We have data backups in different hosts, however, although our hosts are located in two buildings, but they still very close to each other, and that is a potential risk. The service level agreement needs to identify the responsibilities for data loss".*
Csp1_Con2	*"I believe majority cloud providers have data backup solutions. For example, we distribute our host machines among multiple buildings and data from our customers' data is highly secure because it's decentralized, if something happens to one of the data host, and the data is in danger for some reason, we can restore the data via other backups".*
Uni1_IT2	*"We can have our backups in cloud. More than one backup. About the data loss, depending on whose fault it is, if we delete the data, that's our problem; but if something happens to online server, then it is the provider's responsibility".*
Uni3_IT1	*"They should have. Date with pass code protection. If the data loss is caused by vendor, of course they will take the responsibility".*
Uni1_IT1	*"Although some of our tasks performed in cloud, I mean there is a cloud vendor providers some services, we still have some tasks are not in cloud, and yes we have our own data centre as well, there is also two backups in different location. You don't put backups in the same building because if something happens to the building, you will lose them all".*
Uni2_Re1	*"I think so, data backup is important, so yes. I back up my personal files in different devices as well, like in the USB disk".*
Uni2_Te1	*"We have backup data centres, and they are in different locations, if something happens to one of the data centre, it will not affect other backups".*
Uni1_IT4	*"Yes cloud vendor provides us with the backup functions, we can choose what data we want to backup, and also, we have a local copy as well just in case, we update this copy regularly".*

Uni2_Stu3	*"I'm not sure, but I think yes. Just like me, I have backups for my most important data, like my essay, our lecturers tell us always to keep at least 2 backups for it".*
Uni2_IT2	*"Cloud vendor gives us a software that can easily backup everything. It's also supports automatic backup. So, it is easy for us. As long as we have backup, we don't need to worry about data loss too much".*
Uni3_IT2	*"Cloud providers have their own backup centre. I believe all of the providers have backup centre, that becomes a standard".*
Uni1_Re1	*"Cloud provider should have a backup data centre I believe, but I'm not sure. About the data loss, if it's because of the user error, like deleting a file by accident, then of course users are responsible. If it's because of the hardware failure, security breach, then the provider should take responsibility".*
Uni3_Te1	*"We should have, I think. I never heard that we have data loss issues. But well, it is possible. I guess that's why we all need backup".*

4.4.2.4.4 Energy consumption

Sultan (2010) believed that a large part of the cost of running an IT infrastructure comes from cooling systems which are expected to reduce the heat generated by the hardware, and electricity consumption by hardware, PCs, servers, backup drivers, etc. Cloud computing can reduce energy consumption in these areas.

Some participants believe that it is possible to measure the energy saving. On the other hand, most people think it is not necessary to do so. Cloud providers would not mention that when promoting their services and cloud users simply do not care about that normally.

The amount of energy consumed by computing activities is actually quite astonishing. Nowadays, an increasing number of enterprises and institutions are outsourcing the computing processes and data storage to cloud-based computing. Overall, the number of cloud data centres is increasing rapidly. Meanwhile, people are expecting more from the cloud, in terms of security, services, performance and, especially, the cost. For cloud providers, energy consumption accounts for a sizeable portion of the running costs. According to Csp2_Con2, "*a* *medium-scale data centre may have 60-70 hosts, so in fact, the amounts of electricity consumption is unbelievable. All of the cloud servers around the world can use as much energy as a small country. Server rooms produce waste heat, so in order to keep the temperature down, numerous air conditioning systems keep running all the time and that will consume a lot of energy*". Similar opinions emerged from the literature review. Approximately 25% to 40% of the operating expenses in data centres are incurred by power consumption, 50% of which is consumed by cooling systems (Backialakshmi & Hemavathi, 2015). That is why energy efficiency is one of the major challenges in terms of operation management.

Some cloud providers claim that it is hard to measure (Figure 4.14). In the real-world cloud computing system, one important thing in energy management is the visualization of energy consumption. This allows decisions to be made about energy management manually or automatically based on the visualized information. This raises an important question: how to measure energy consumption on a virtual machine? Because of the internal needs of modern data centre in regard to energy consumption management, most new servers have a built-in energy consumption management function in the hardware layer. Csp1_Con1 mentioned that "*there are some solutions to the old services, for example, using power distribution units (PDU) to measure the system energy consumption via power source. However, in a virtualization environment, the energy consumption of virtual machine cannot be measured directly from hardware measurement. So, it is quite hard to measure*". Moreover, they cannot tell how much energy has been saved because they do not know how much energy had been used by customers before they migrated to cloud.

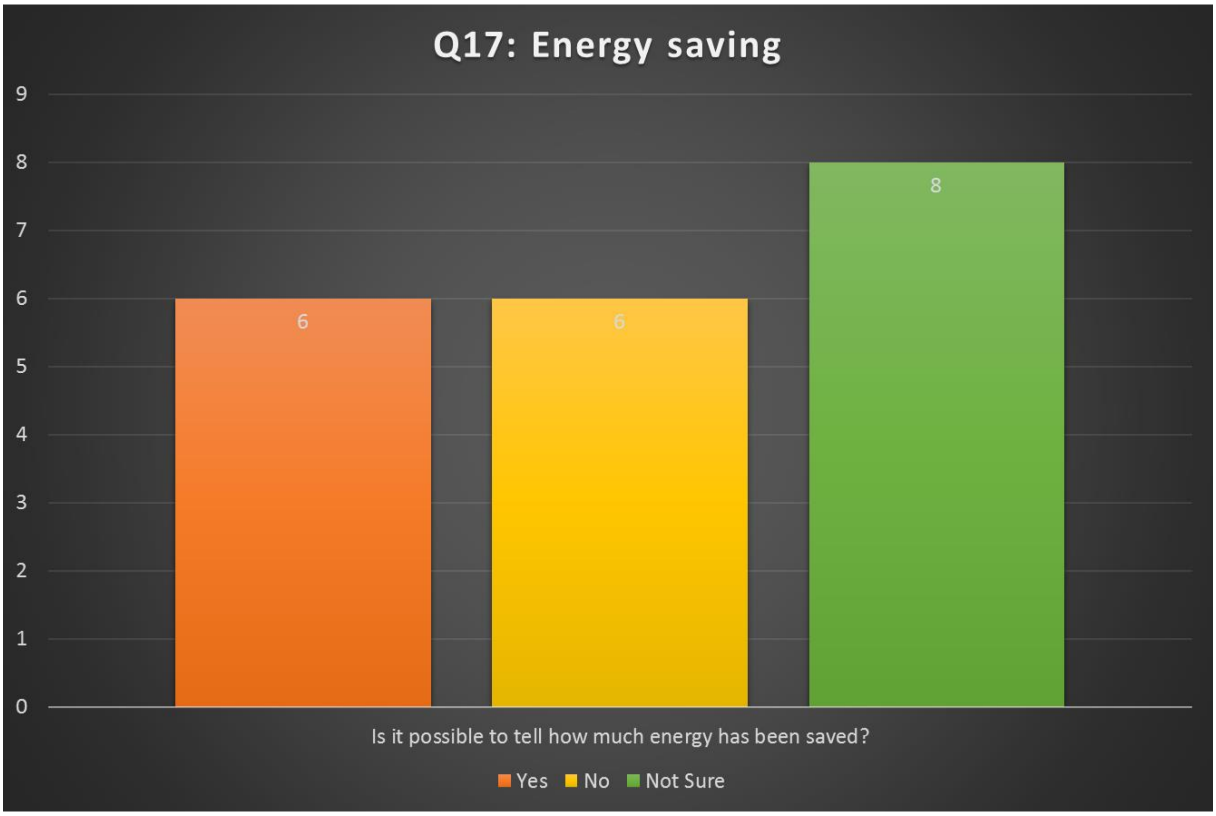


Figure 4.14. Energy saving measurement

There is a method, although not perfect, for estimating the virtual machine energy consumption. Csp1_Con2 said "*the basic idea of virtual machine energy consumption measurement is to create an energy consumption model first, build connection between utilization rates of specific type resources, like CPU, with the energy consumption of overall system. Then use monitoring tools to measure the utilization rate of different resources for each virtual machine. Finally, we can evaluate virtual machine power consumption by inputting resource utilization rate into the resource energy consumption model, thus, we can estimate the virtual machine energy consumption*".

According to participants, many cloud users are not concerned about energy consumption. When a company moves to cloud, it is possible to measure how much energy has been saved from their end, simply by checking the electricity bill. However, one also has to include the energy consumption on the cloud provider's side, and that is the difficult part because one provider may have many users, so the dynamic cloud computing power usage is hard to measure. Moreover, energy consumption comes from different sources such as computers, lights, and air-conditioners. How to distinguish them from one another could be very difficult. Uni1_Te3 said "*In our university, it is not hard to figure out the total energy consumption. However, I know that the energy consumption from cloud vendors is huge, they have to lower* *the temperature in the server rooms for example, cooling down, and that is a huge number*”.

When talking about the energy consumption, some participants also mentioned that cloud computing saves energy. When a university or enterprise stores their data, information or conducts computing tasks on site using their own servers, servers are constantly running regardless of whether it is peak time or off-peak time. In other words, the full potential of the computing capacity and storage is not always utilised. Thus, from a company's perspective, this will lead to unnecessary energy consumption. However, if several institutions and organizations can share the hardware and computing resources via cloud computing technology, the machines’ efficiency can be optimised which in turn saves energy. As Kepes (2011) stated, consolidated IT can have environmental benefits by improving data centre efficiency. So institutions and enterprises using cloud services instead of buying servers, hardware and software is a good way to reduce waste and help safeguard the environment.

In conclusion, it is not easy to measure how much energy has been saved by using cloud-computing technology and one of the reasons is that virtual machine power consumption cannot be measured directly. However, the technical difficulties will be resolved sooner or later; the real problem is the general public’s awareness of energy consumption. Most participants do not really care much about energy consumption. Hopefully, this attitude will change in the near future. As suggested by Garg and Buyya (2012), it is necessary to construct power models which enable the system to know the energy consumed by a specific device, and how the energy consumption can be reduced. Other feedback from participants regarding the energy consumption is given in Table 4.20.

Table 4. 20 Energy consumption

Participant code	Feedback
Csp2_Con1	*“Can’t tell. As a provider, we can’t tell how much energy has been used because we don’t know how much energy has been used by customers before they migrate to cloud, so it's very hard to say”.*
Csp2_Con2	*“Ok, now we see an increasing number of enterprise and institutions are outsourcing the computing processes and data storage to the cloud-based computing. Overall, the number of cloud data centres is increasing at a really fast rate. Meanwhile, people are expecting more from the cloud, for example the security, services, performance, and especially the cost. For cloud providers,*

	energy is a big part in term of the cost. A medium-scale data centre may have 60-70 hosts, so in fact, the amounts of electricity consumption is unbelievable. All of the cloud servers around the world can use as much energy as a small country. Server rooms produce waste heat, so in order to keep the temperature down, numerous air conditioning systems keep running all the time and that will consume a lot of energy".
Csp1_Con1	*"Virtual machine power consumption can't be measured directly. In the real-world cloud computing system, one important thing in energy management is the visualization of energy consumption. Then we can make decisions on energy management manually or automatically based on the visualized information. This refer to an important question, how to measure the energy consumption on virtual machine. Because of the internal needs of modern data centre towards energy consumption management, most new servers have built-in energy consumption management function in hardware layer".*
Uni2_IT1	*"It's quite hard to measure that".*
Uni1_IT3	*"It is possible, but I'm not quite sure about this part".*
Uni1_IT2	*"When we talk about the energy consumption, I believe cloud computing is saving energy. When university or enterprise stores their data, information or conducts computing tasks on site using their own servers, servers are constantly running not matter its peak time or off-peak time. In other words, the full potential of the computing capacity and storage has not been optimised. Thus, from a company's perspective, this will lead to unnecessary energy consumption. However, if different institutions and organizations can share the hardware, computing resources together via cloud computing technology, so the potential of the machines is optimised and that is energy efficiency. So basically, institutions and enterprises using cloud services instead of buying servers,*

	hardware and software is a good way to reduce waste and help to protect the environment".
Uni3_IT1	*"You know when the provider promotes the cloud computing to you, they will tell you cloud computing will save your energy, but I wonder if their energy consumption will go up".*
Uni1_IT1	*"From our side, maybe it's very hard, but from provider's side may be possible. But honestly, I don't think anyone cares about that".*
Uni2_Stu2	*"I don't think so, form my learning, it is very hard to tell the accurate data of this".*
Uni1_Stu1	*"Maybe it's possible, not very sure about this question".*
Uni2_Re1	*"I think that is not easy, when a company moves to cloud, it is possible to measure how much energy has been saved from their end, simply check the electricity bill. However, you also have to add the energy consumption form the cloud provider's side as well and that is the difficult part, because one provider may have many users, and the dynamic cloud computing power usage is hard to measure".*
Uni2_Te1	*"It is possible to find out how much energy we can save, the administrative or maintenance staff should know that".*
Uni1_IT4	*"Yes, it is possible but…financial department may know the figure".*
Uni2_Stu3	*"I think it is possible. But the energy consumption comes from different sources, like computers, lights, air-conditions, so it may be very difficult".*
Uni2_IT2	*"Technically, it is possible. But no one care".*
Uni3_IT2	*"I guess not. It is quite hard to measure".*
Uni1_Re1	*"In our department? No. That's impossible. However, from the university's perspective, I think may be possible".*
Uni3_Te1	*"In our university, it is possible, but no one will do that, I think. May be finance department"?*

4.4.2.4.5 Capacity management

Sometimes the peak hour is hard to predict, since the traffic reaches the maximum or a very high level for no reason. However, most of the time it is predictable. Universities require more computing resources during exam weeks and at the beginning of each semester, especially in

March and September. Every semester, universities upgrade servers based on previous usage. Generally speaking, at the beginning of each semester, the computing capacity reaches its maximum, then the trend decreases; two or three weeks before the final exam, the curve increases rapidly. Uni3_IT1 said, "*most of the time, course selection system will have to deal with many students before a new semester begins, through the dynamic expansion solution, the cloud platform is able to sense the bottleneck of the hardware and software of the cloud information system and automatically expand or recycle resources to solve the problem of insufficient resources. It enhances the satisfaction rate of students and teachers*". Similar to that, Uni1_IT1 added that "*the university's website has traffic jam, especially when students are selecting courses. The reason is if the students select the course late, they have to choose another as this unit may have reached the capacity. If the users buy the extra computing resources, the computing power will be wasted during off-peak hours*". Hence the need for flexible expansion which is more cost-effective.

Other cloud users usually need more computing resources during business hours. After work hours, organisations would need only a few computing resources. Uni1_Re1 point out that "*There's no peak hour actually, because it's cloud-based server, I don't feel any slow, delay or anything. Even there is a peak hour; I believe the cloud provider should have proper solutions for that*".

When it is reaching the maximum computing capacity, service providers power up all the available hosts to provide sufficient computing capacity and they can automatically relocate the resources in seconds even millions of users access the site same time. The customer just need to pay for the actual amount of cloud resources utilised, thus, the cost is manageable. Cloud computing can provide dynamic computing power. For instance, Uni1_IT4 mentioned that "*Monday to Friday, during the daytime, we have more users. That's why cloud computing is powerful, it can meet your needs, this is dynamic computing source, if we need more, the system will add more computing power automatically for us*".

Overall, universities reach their maximum computing capacity at the beginning of each semester (teaching staff will upload the learning materials and students will select courses) and by the end of each semester (teaching staff will upload grades and students will check their grades). Cloud computing can provide dynamic computing resources based on real-time usage. Other feedback from participants regarding the capacity management is summarised in Table 4.21.

Table 4.21. Capacity management

Participant code	Feedback
Csp2_Con2	*"When it's reaching the maximum computing capacity, we can relocate the resources in seconds automatically even millions of users access the site same time. The customers just need to pay for the actual usage so the cost is manageable".*
Csp1_Con1	*"When it reaching the maximum, we power up all the available hosts to provide sufficient computing capacity".*
Uni2_IT1	*"Sometimes the peak hour is hard to predict, the traffic reaches the maximum or a very high level for no reason. But most of the time it is predictable".*
Uni1_IT3	*"Every semester, we will upgrade our servers based on previous usage. Generally speaking, at the beginning of each semester, the computing capacity will reach the maximum, then the curve goes down, two or three weeks before the final exam, the curve increases rapidly".*
Uni1_IT2	*"At the beginning of new semester, especially in September. Cloud computing is dynamic, so that's OK".*
Uni1_IT1	*"The university's website has traffic jam, especially when students are selecting courses. If we buy the extra computing resources, the computing power will be wasted during off-peak hours. That's why we need flexible expansion. It is more cost-effective. You pay what you have used, this payment mode is great".*
Uni2_Stu2	*"I think when everyone is selecting new unit for next semester, the system will reach the maximum computing capacity. The reason is if you are late, you have to choose another unit, limited seats only. Of course, we want to choose the easy one".*
Uni1_Stu1	*"In some units, we have final exam in lab, so that is the maximum capacity we have. So far, it is all good".*
Uni2_Re1	*"I believe during the working hours, after that, the traffic is better".*
Uni2_Te1	*"At the beginning of each semester and by the end of each semester. I guess it's because teaching staff will upload the grades and students will check their grades".*

Uni1_Te3	*"Must be the exams. During the exam. We have lab exam, so lots of students access the server in the same time".*
Uni2_IT2	*"When we have online exam, it will reach the maximum, so we do a lot of tests, make sure the system can handle that".*
Uni3_IT2	*"9am-12pm, and then 2pm-4pm, when students have classes".*
Uni3_Te1	*"Maximum computing capacity, we normally have more classes in the morning, so every morning there should be more internet traffic then the afternoon and evening".*

4.4.2.5 Daily use

This section is designed to discover the tasks that cloud users undertake when using cloud technology.

4.4.2.5.1 IT support

It is important to know how the students and teaching staff use computing resources and what kind of support they need. Most interviewees mentioned that they need IT support for study or research. For instance, online resources, e-book, and online data storage are the most common requirements. Students and researchers need access to various databases and journal articles for assignments or papers. It is easier to read an e-book than a printed book; moreover, it is cheaper, and they do not have to carry the text book to class. Regarding the internet connection, they hope free WIFI can cover the entire campus, not only the library. Internet speed is not fast enough in dormitories, and the connection is not stable sometimes. For instance, Uni1_Stu2 stated: "*sometimes I cannot access the enrolment page, especially when many of us selecting classes for next semester in the same time. For those popular units or class, they will full in three hours, so if I can't get access, I will loss that opportunity*". Another requirement is that at the end of each semester, students prefer to stay in the library where there are not enough computers or workstations for everyone. Researchers and teaching staff need access to data analytic software for research. Besides the IT support, there was another question designed to study the correlations between students' major and the IT resources usage status. Unfortunately, the sample size was not big enough, making it impossible to analyse the correlations at this stage. According to the responses, two students are undertaking a computing science major, two are majoring in information technology, one in anthropology and another in automation. Not surprisingly, IT students tend to use IT services more often.

In conclusion, a fast and reliable internet connection is necessary. However, internet connection is not stable in some campus areas. Researchers need access to various databases and software. Students do enrolments online and make payments online at the beginning of each semester, so the servers should be able to handle the internet traffic that increases dramatically during that time. Other notable feedback from participants regarding the IT support requirements is presented in Table 4.22.

Table 4.22. IT support requirements

Participant code	Feedback
Uni2_Stu1	*"Internet on campus, system for course selection, Internet connection in library.* *Because I need to do some research for my assignment, and also…watch TV, we have campus online TV, we watching it in dormitory".*
Uni1_Te1	*"When I do research, I need access to different databases and journal articles, I also need the updated software running on my computer".*
Uni1_Stu2	*"Online enrolment, online payment, e-book".*
Uni2_Stu2	*"I hope all of the text book can have online version, so we don't have to carry all the books".*
Uni1_Stu1	*"I need faster internet connection on campus, and if our online library can have more books, that will be great, because sometimes we can't find what we want, then we need to go to Baidu to search".*
Uni2_Re1	*"I need access to different research database to find related journal articles, also need online space to store data".*
Uni2_Stu3	*"I need IT support on my study, like online resource, online book, online data storage, it will be easier to read eBook than printed book".*
Uni1_Te3	*"I don't need extra IT support at this moment".*
Uni1_Stu3	*"The internet speed in our university is not fast enough, and the connection is not stable sometimes. We need to use the computers in the lab to do some homework, but sometimes we don't have enough computers for everyone to use".*

Uni1_Re1	*"I need some software, like the data analytic software or so, to do the research".*
Uni3_Te1	*"Faster and reliable internet connection. Some area on campus, the internet connection is not very good".*

4.4.2.5.2 Server usage during semester break

As indicated in Figure 4.15, the majority of participants do not use their university's servers quite as often during the semester break, especially the students. Researchers and IT staff, on the other hand, do use the IT services for researching and maintenance purposes.

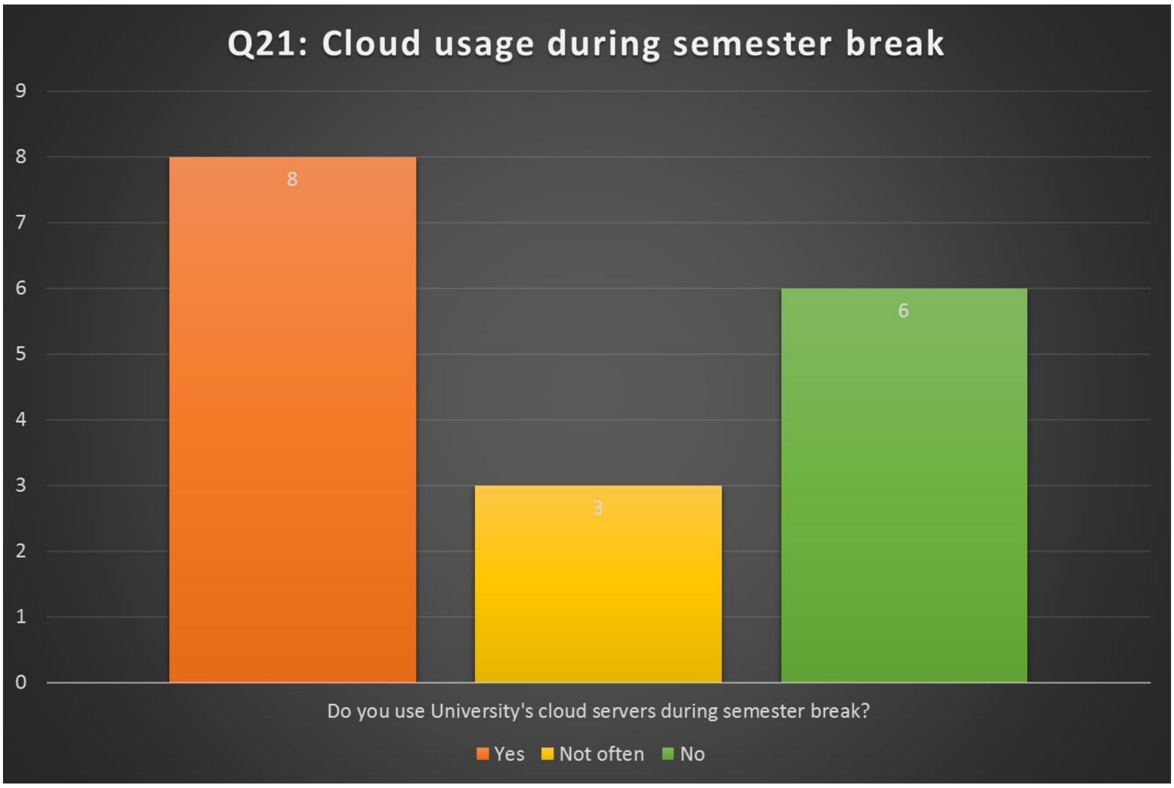


Figure 4.15. Cloud server usage during semester break

Students need access to the university's servers to check exam results and other assessments, and to enrol in units for the new semester. IT staff undertake regular maintenance. During the semester break, the internet traffic and servers load is low, so they do not have to work every day as they take different shifts to make sure at least one staff member is on duty, Researchers and teaching staff need access to different databases and journal articles in order to continue with their research.

This question is designed to ascertain whether universities need less computing power during the semester break. Cloud computing can provide dynamic resources. If the university has in-house servers, most servers can be shut down, and if the universities are using cloud-based servers, this could save costs. Of course, IT staff are responsible for maintenance, and use the servers more often than others during the semester break or holidays. Other feedback from participants regarding the IT service usage during semester break are given in Table 4.23.

Table 4.23. IT service usage during semester break

Participant code	Feedback
Uni2_Stu1	*"Yes, we use it in the dormitory, and if we do the research during the study break, we need to log in to the VPN, in order to have access to the servers at home. We need to search journal articles via university's library server for research purpose".*
Uni2_IT1	*"Yes, sometimes, not often though".*
Uni1_Te1	*"Yes, even during the semester break, sometimes I need to continue my research, so the IT service is important to me".*
Uni1_Stu2	*"Not often. Normally before the new semester starts and after final exam. We check our results online, and before the semester begins, we need to enrol into new units. Rest of the time, no".*
Uni1_Te2	*"Not often, but sometimes, maybe once a week".*
Uni1_IT2	*"Yes, to do the maintenance. We don't have to come work every day; we take different shifts to make sure at least one staff is on duty in this office".*
Uni3_IT1	*"We still have to work as IT staff, so yes we use the servers during the semester break as well".*
Uni2_Stu2	*"Most of the time, I don't need it. However, when they release the exam results every student will use the servers. Another time I use the server is when I select the new units for next semester during the break".*
Uni1_Stu1	*"When they release the results and before new semester, we need to select courses online".*
Uni2_Re1	*"Yes, I need the access during the break, I may continue with my research during that time".*

Uni2_Stu3	*"I don't need to, most of the time not, so I think during the semester break, our university just need a little computing resources".*
Uni1_Te3	*"No, I don't have to. Emails only".*
Uni1_Stu3	*"To check the exam results during the semester break, and also do the enrolment before new semester".*
Uni3_IT2	*"Not often, occasionally".*
Uni1_Re1	*"Most of the time, I don't need the access to the servers".*
Uni3_Te1	*"No, I will enjoy my vacation".*

4.4.2.5.3 Daily cloud tasks

Students normally use the campus network for learning, research, assignment, course selection, data analysis and web surfing. Uni2_Stu2 stated: "*We can download lecture slides and other e-book from the server, review the lecture, for example if I missed a class, I can view the online version. We can submit our assignment online; we can discuss with our group as well*". Researchers and teaching staff use the campus network for data analysis and projects. Also, they need access to email and online data storage. Online communication channel is also important. Participants' feedback regarding the daily usage of cloud computing is given in Table 4.24.

Table 4.24. Daily usage of cloud computing

Participant code	Feedback
Uni2_Stu1	*"Research, assignment, data analysis, projects, selecting course".*
Uni1_Te1	*"Project, internet, data analysis".*
Uni1_Stu2	*"Web search, Baidu, find articles, watching online videos".*
Uni1_IT1	*"Data analysis, searching resources, communication".*
Uni1_Stu1	*"Daily learning, personal website, school site, online library".*
Uni2_Te1	*"We have different projects and data analysis tasks; we also need data storage space".*
Uni2_Stu3	*"I want to do daily learning, to access school site and to use the internet".*
Uni1_Te3	*"Teaching, like accessing emails, and so on".*
Uni1_Stu3	*"Daily learning, internet browsing and school website".*
Uni1_Re1	*"Research, online apps, data storage, communication".*

4.4.2.6 Comment on current model

In regard to governance, governance supports, risk evaluation, identify roles and responsibilities, and strategic planning could be added. Regarding performance management, some participants suggested that the new model should contain the 'bandwidth' or the 'capacity', instead of the energy consumption. As aforementioned, it is hard to manage energy consumption. The capacity or the internet access capacity includes outbound bandwidth (from provider's side) and inbound bandwidth (from the customer's side). Moreover, it is better to use 'operation management' instead of 'performance management'.

This model has three themes: governance, sustainability and performance management. They are like three isolated subjects at this moment; maybe some dependent variables can be added. For instance, the governance could affect performance management; governance could include sustainable management, and performance management could affect sustainability. So, the next step is need to identify their relationships, and the reason for putting them together. Similar to that, it is possible that there might be no strong connection between governance and performance management, and performance management seems to be part of the governance. Also, in regard to governance, does it apply to the cloud vendor, the cloud user or both? This should be taken into consideration as each has different governance strategies.

Uni1_Te2 said "*about the target audients, who is going to use this model? Is it the supplier, the IT staff or teaching staff? Because I think, some of the elements are relevant to suppliers and some are for the users. If you want to put them together, then you have to explain under what situation, it is suitable for whom*". The final product of this research will be a new sustainable model with different versions that can meet the various requirements of different target audients. Another option is to choose one potential user and develop the model for that particular user group. Other participant feedback regarding the current model is presented in Table 4.25.

Table 4. 25 Comments on current model

Participant code	Feedback
Csp2_Con1	*"In the performance management, I think you should consider the 'bandwidth' or in other words the 'capacity', instead of the energy consumption. As been mentioned, it is hard to manage the energy consumption. The capacity or the internet access capacity includes*

	outbound bandwidth (from provider's side) and inbound bandwidth (from the customer's side)".
Csp2_Con2	*"It seems that there is no strong connection between governance and performance management. Performance management seems part of the governance".*
Csp1_Con1	*"I think virtualization and cloud computing are closely connected, maybe you can add the virtualization into your model"?*
Uni2_IT1	*"So, the governance is for cloud vendor, for cloud user or for both, you can think about this part. Because they have different governance strategies".*
Uni1_Te1	*"This model is divided into three segments, so you need to identify their relationships, why do you put them together".*
Uni1_IT3	*"I think I would to use 'operation management' instead of 'performance management'. It seems that the elements you mentioned in the model, in the performance management part, they are related to the IT operation phase".*
Uni1_Te2	*"The target audients, who is going to use this model? Is it the supplier, the IT staff or teaching staff? Because I think, some of the elements are relevant to suppliers and some are for the users. If you want to put them together, then you have to explain under what situation, it is suitable for whom".*
Csp1_Con2	*"You mentioned that you want to replace the energy consumption with 'bandwidth', I think that won't be necessary, why not keep them both".*
Uni1_IT2	*"You can add risk evaluation in the governance part, because I think to make any new IT decisions, you have to think about the risks first".*
Uni3_IT1	*"As I said maybe you can add resource scheduling management to the governance part".*
Uni2_Te1	*"The connection of the three aspects are not strong enough, I think. And like I mentioned in the governance model, governance support, identify roles and responsibilities, and strategic planning can be added".*

Uni2_IT2	*"Maybe you can try to add more aspects in the sustainability part, because as you said, social, economic and environment, these three aspects appear in many articles, so why not try to add something new"?*
Uni1_Re1	*"Governance, sustainability and performance management, they are like three isolated subjects at this moment, maybe you can try to add some dependent variables, I'm thinking maybe the governance could affect performance management? Governance could include sustainable management, and performance management could affect sustainability".*
Uni3_Te1	*"If your target audiences are students, academic staff, IT staff, and service provider, your model should have at least two or more versions to meet different requirements. Otherwise, you can choose one potential user and develop the model for that particular user group".*

4.5 Refine the initial model

The initial model is shown in Figure 4.16.

Figure 4.16. Initial model (generated from literature review)

Based on the interviews, changes and improvements were made in accordance with the following recommendations:

- “Bandwidth” will be added to Performance Management section.
- No strong connection between elements
- Virtualization
- The potential users of the model should be redefined
- Relationships of three segments should be identified.
- Use ‘operation management’ instead of ‘performance management’
- Add risk evaluation in the governance part.
- Add resource scheduling management to the governance part.
- In the governance model, governance support, identify roles and responsibilities, and strategic planning can be added.
- Add some dependent variables; the governance could affect performance management, Governance could include sustainable management, and performance management could affect sustainability

- Target audiences are students, academic staff, IT staff, and service provider, model could have two or more versions to meet different requirements. Or choose one potential user and develop the model for that particular user group only. (not decided yet)

The refined model is shown below in Figure 4.17 (major changes are highlighted in the red rectangles):

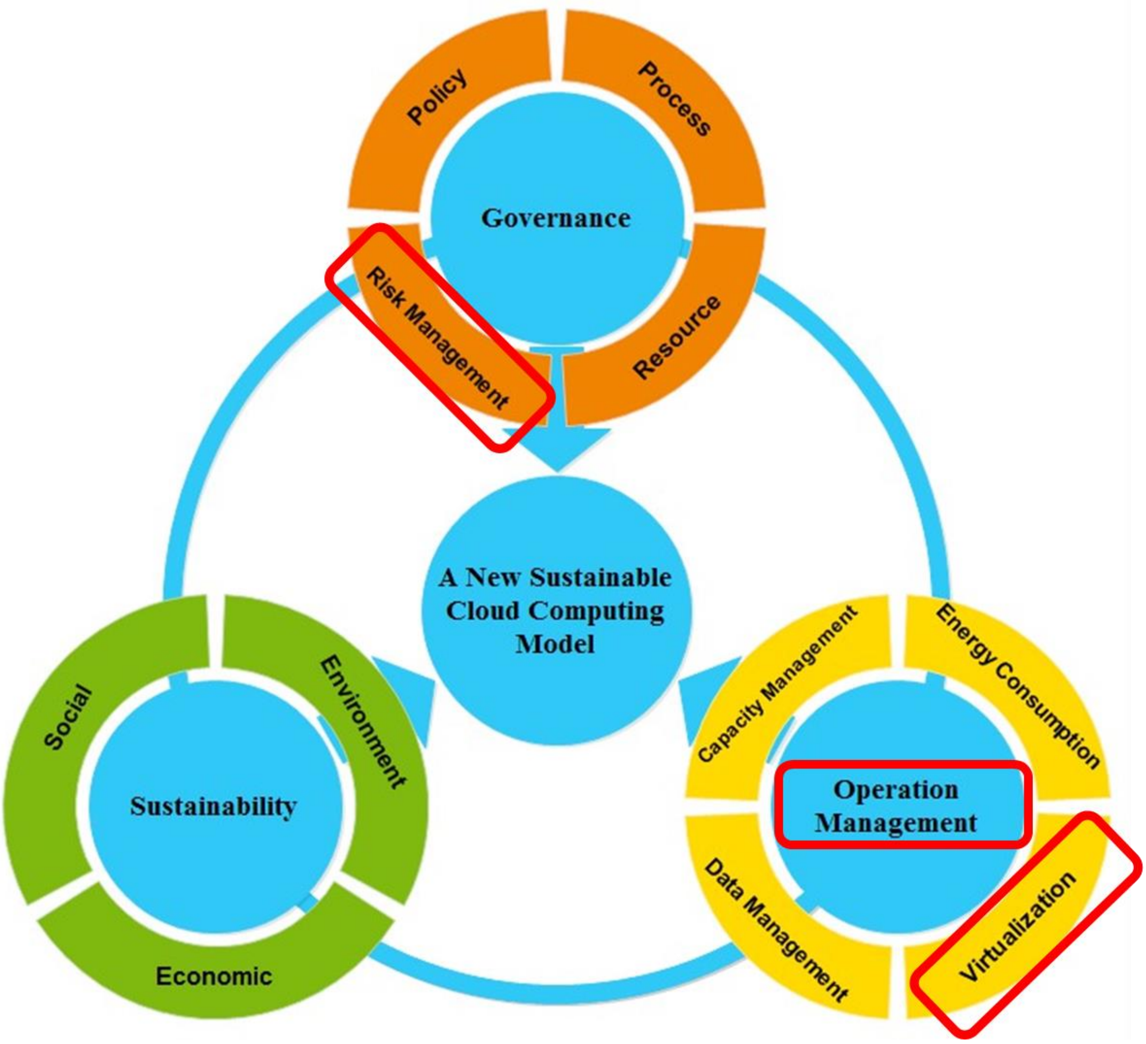


Figure 4.17. Refined model (based on the interview analysis)

4.6 Chapter Summary

This chapter contained an in-depth discussion of the interview phase. The data was collected from twenty-five participants comprising service providers, IT personnel, researchers, teaching staff and students, most of whom have experience using cloud computing technology. The purpose of this phase is to refine the initial model and to have a better understanding of cloud-related concepts. The results obtained from this phase inform the structure and contents of the online questionnaire. NVivo software (version 11) played a significant role in this phase as it improved the efficiency and effectiveness of the data analysis process.

However, most of the main factors in the refined model are too broad or not stated precisely enough. For instance, when considering the process of establishing cloud governance, activities such as identifying risk, analysing and prioritizing risks, identifying controls, analysing controls, planning and scheduling implementation, tracking and reporting risks and controls are all part of the process. In other words, those main factors contain broad categories or sub-factors. Therefore, the scope of the final model should be more specific. In order to specify the most relevant sub-factors for each main factor, the online survey is conducted. In the online survey, an adequate number of variables correlated to each main factor are tested. The purpose of the online survey is to improve the initial model by adding sub-factors to it, which are extracted from the online survey data.

Thus, the next chapter contains the second phase of the data collection process, which is the analysis of the quantitative data obtained from the online survey. In the next chapter, the refined model (Figure 4.16) will be evaluated and the sub-factors of those main factors are determined in order to form the final sustainable cloud computing model.

Chapter 5: Online Survey Results and Analysis

5.1 Introduction

In the last chapter, data from interviews was analysed and the results contributed to the refined sustainable cloud computing model presented in Figure 5.1.

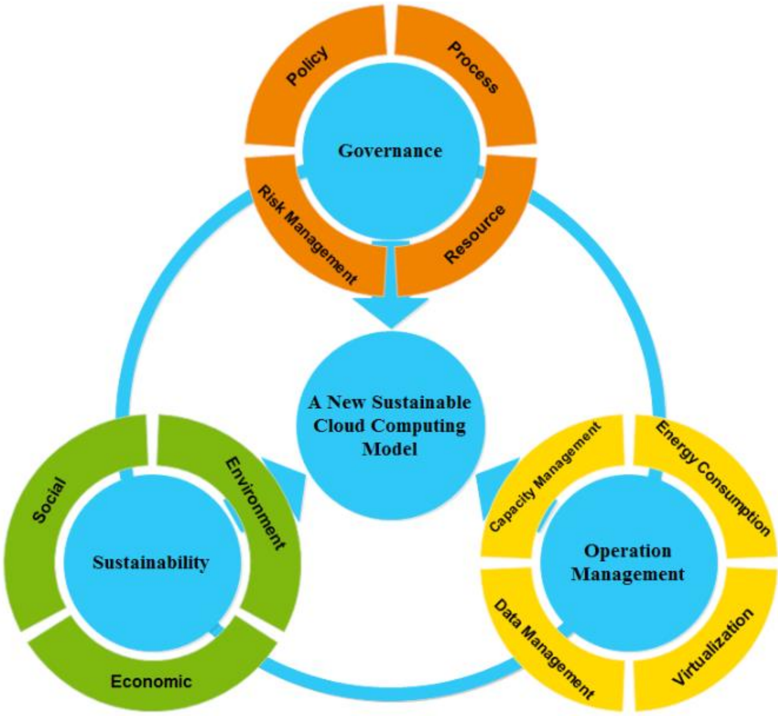


Figure 5.1. Refined model based on the results from interviews

This chapter reports the online survey that was conducted in order to further refine the new sustainable cloud computing model. The main factors were generated from the literature review and the interviews to form the model. However, most of those main factors contain broad categories or sub-factors. In other words, the scope of the final model should be more specific. That is why the online survey was conducted. In the online survey, sufficient variables correlated to each main factor were tested. The purpose of the online survey was to improve the model by adding sub-factors, and the sub-factors were extracted from the online survey data.

Details of the survey design and data collection phases are given in this chapter. This chapter also includes statistic techniques used for online survey data analysis, followed by the analysis results to improve the current model. The findings from the online survey are used to produce the final model. For instance, significant components extracted from the online survey will be added to their corresponding sections in the model.

5.2 Designing the online survey

The main purpose of this survey is to verify the factors and to discover the sub-factors. Factors for each theme were selected based on the interviews, and they are verified in this section. Moreover, each factor contains a number of sub-factors. Thus, the objective of this online survey is to confirm the factors and, more importantly, reduce the number of sub-factors to form the final model.

5.2.1 Structure of the online survey

An excellent questionnaire structure will ensure the quality of the online survey. This questionnaire contains five sections as illustrated in Figure 5.2. The first section pertains to demographic information about participants, followed by the cloud adoption status section. The second section is intended to determine the current usage of cloud computing technology. The other three sections are concerned with the model's themes of cloud governance, operation management and sustainability. All the major aspects of the new sustainable cloud computing model are covered in this online survey.

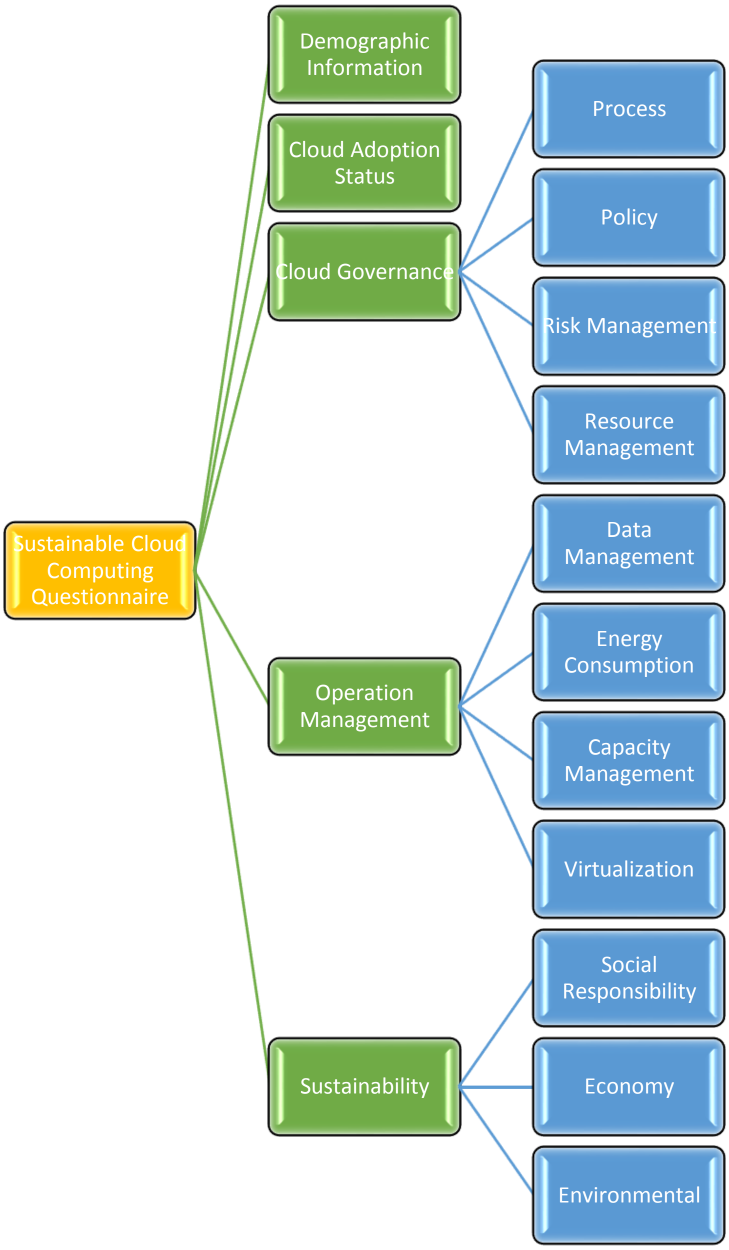


Figure 5.2. Structure of the new sustainable cloud computing model (questionnaire)

5.2.2 Developing the online survey questionnaire

The Qualtrics Online Survey Platform was utilised to develop the online questionnaire. The first demographic section pertains to participants' personal details such as gender, occupation, etc. In section two, a series of questions regarding the cloud adoption were added to discover what are the most popular service models, deployment models and pricing models in participants' organisations. Section three focuses on cloud governance, one of the three themes in this model. In this section, a number of sub-factors associated with process, policy, risk management and resource management are presented. Those sub-factors are presented in tables with five-point Likert scale. Respondents are offered a choice of five pre-coded responses ranging from “strongly disagree” to “strongly agree”. This allows individuals to express the extent to which they agree or disagree with a particular statement. Similarly, section four and section five utilise the five-point Likert scale statements to examine a number of sub-factors related to operation management and sustainability.

To ensure the quality of the questions, PhD supervisors reviewed the questionnaire and a pilot test was conducted. Based on their feedback, some options were re-coded and some questions were merged into groups or rewritten to improve the readability. To obtain ethics approval, the questionnaire was then sent to Human Research Ethics Committee of Curtin University. After that, the questionnaire was uploaded to the Qualtrics Online Survey Platform. The final version of the online survey questionnaire is presented in Appendix G.

5.3 The online survey population

The hyperlink of this online survey was distributed to potential respondents via many channels, such as social networks, emails. In total, 709 responses were received, of which 557 were valid. Based on the occupations of participants, they were divided into three groups for data analysis, academic group (140 responses), student group (112 responses) and IT professional group (254 responses). In the academic group, 44.3% participants are male and 55.7% are female; over 45% participants in this group hold master’s degree or doctoral degree. In the student group, majority respondents are female (70.5%), and 50% participants in this group hold bachelor’s degree. In the IT professional group, just over half (52.4%) participants are male and majority respondents in this group hold bachelor’s degree (42.5%), followed by master’s degree (37%).

5.4 Descriptive statistics

This section provides the analysis of the descriptive statistics obtained from the online survey, including demographic analysis, cloud adoption, governance, operations management and sustainability descriptive statistics. Results are presented in bar graphs or tables for easier understanding.

5.4.1 Respondents’ demographic profiles

This section describes the details of the demographic profiles of the participants in this online survey, including gender, education, occupations and organisation category.

The total sample (n = 557) consists of 242 male participants (43.4%) and 315 female participants (56.6%) as indicated in Figure 5.3. The data is analysed as a whole although the percentages in terms of gender are different.

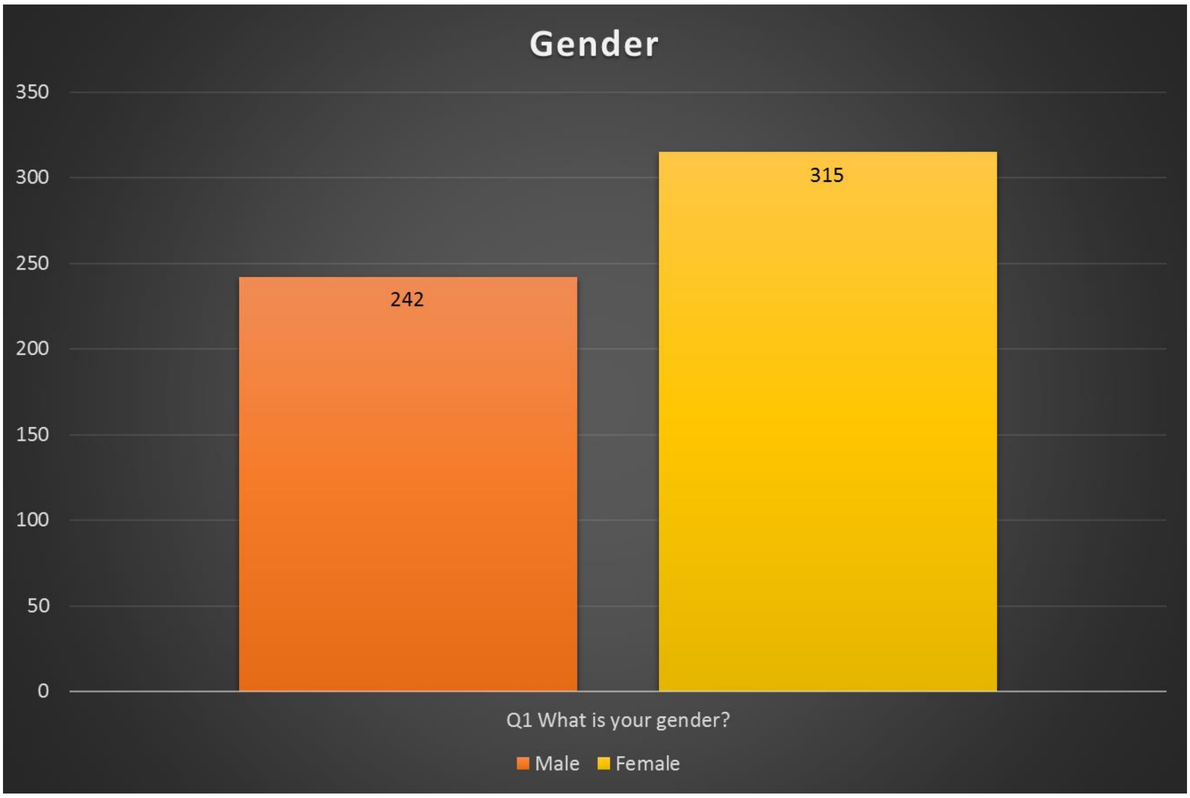


Figure 5.3. Gender breakdown of full sample

The majority of participants have a bachelor degree (40%), 145 participants (26%) have a master's degree and 73 participants (13.1%) have a PhD. Figure 5.4 shows the breakdown of the participants' education levels.

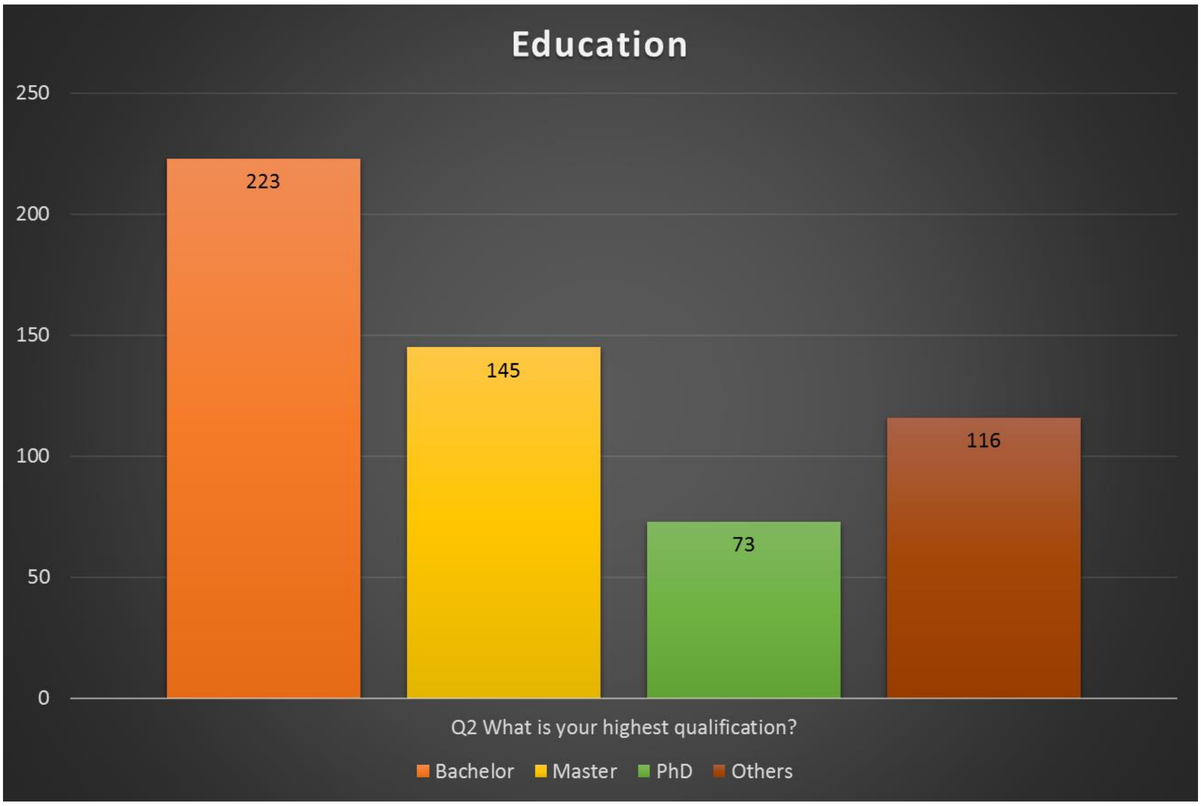


Figure 5.4. Education breakdown of full sample

The bar graph in Figure 5.5 illustrates the occupation breakdown of the full sample. It can be seen that the teaching staff category has the highest number, which is 118 (21.2%). The student category is slightly less at 112 (20.1%), followed by researchers (16.5%) and IT staff (7.9%).

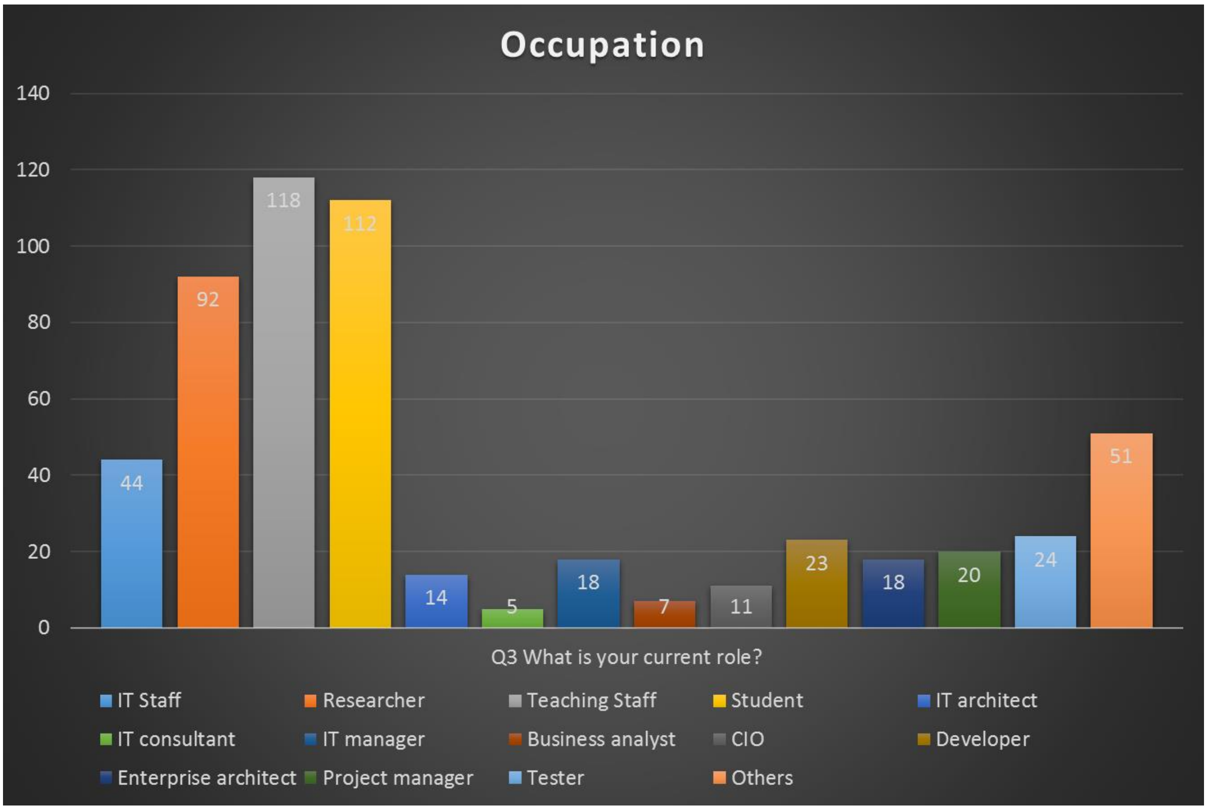


Figure 5.5. Occupation breakdown of full sample

Of the 557 participants, 385 (69.1%) are from the public sector while 172 are from private sector as indicated in the Figure 5.6 below.

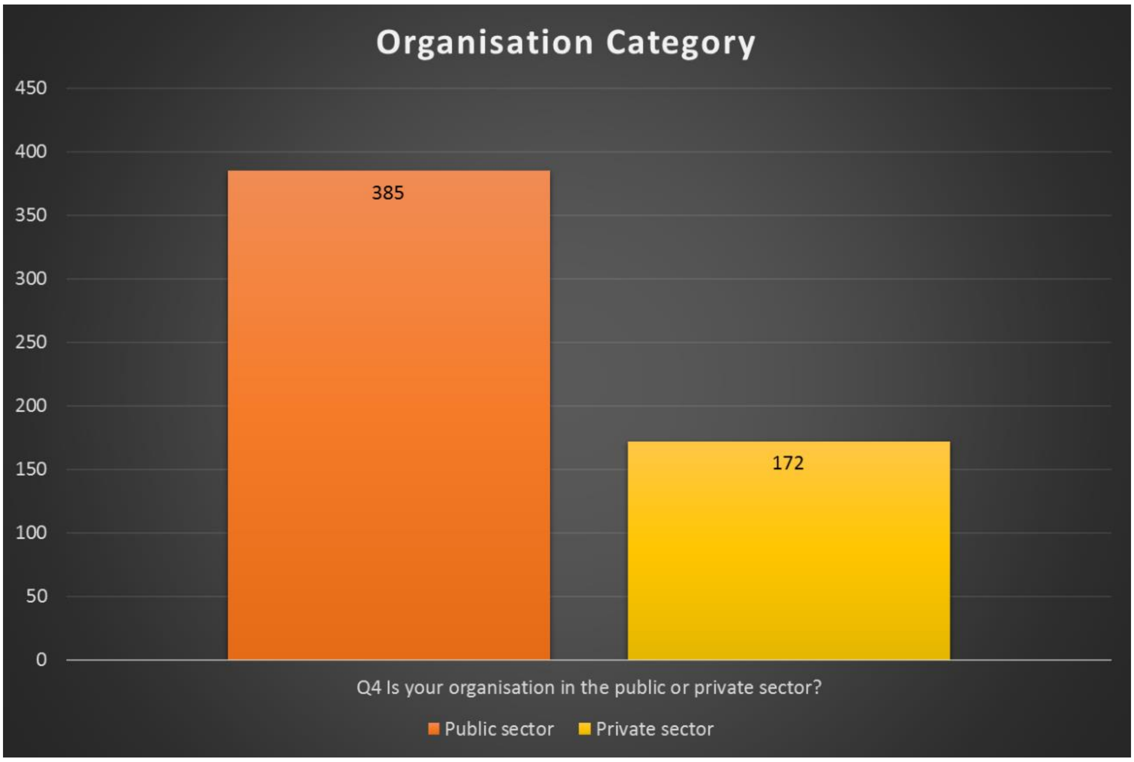


Figure 5. 6 Organisation Category

Table 5.1 summarises the demographic profiles of the respondents, including the gender, education status, occupations and organisation category. As seen from the table below, the majority of respondents are teaching staff (21.2%), students (20.1%) and researchers (16.5%). The remaining respondents are generally doing IT-related jobs as IT consultants, IT staff, etc.

Table 5.1. Survey demographic profiles

Characteristics	Response Options	Frequency	Percent	Valid Percent
Gender	Male	242	43.4	43.4
	Female	315	56.6	56.6
Education	Bachelor Degree	223	40.0	40.0
	Master Degree	145	26.0	26.0
	Doctorate (PhD)	73	13.1	13.1
	Others	116	20.8	20.8
Occupations	IT Staff	44	7.9	7.9
	Researcher	92	16.5	16.5
	Teaching Staff	118	21.2	21.2
	Student	112	20.1	20.1
	IT architect	14	2.5	2.5
	IT consultant	5	.9	.9
	IT manager	18	3.2	3.2
	Business analyst	7	1.3	1.3
	Chief Information Officer (CIO)	11	2.0	2.0
	Developer	23	4.1	4.1
	Enterprise architect	18	3.2	3.2
	Project manager	20	3.6	3.6
	Tester	24	4.3	4.3
	Other	51	9.2	9.2
	Total	557	100.0	100.0
Organisation Category	Public sector	385	69.1	69.1
	Private sector	172	30.9	30.9

5.4.2 Cloud Adoption Descriptive Statistics

This section covers cloud adoption by participants, including pricing model, service model as well as the deployment model they are using.

Figure 5.7 indicates that 208 participants are using “subscription” pricing model, which means they pay a fixed price based on a subscription period. Of the total number of participants, 184 selected “pay for resources” pricing model that they pay based on the amount of storage and bandwidth utilised. “Pay-as-you-go” pricing model means fixed price per unit of use and there are 103 participants selected this one. Free versions and free trial versions of cloud computing are also very popular, with over 200 participants selecting these options. Participants may use “pay for resources” in their organisations and free cloud service at home (e.g. Apple iCloud).

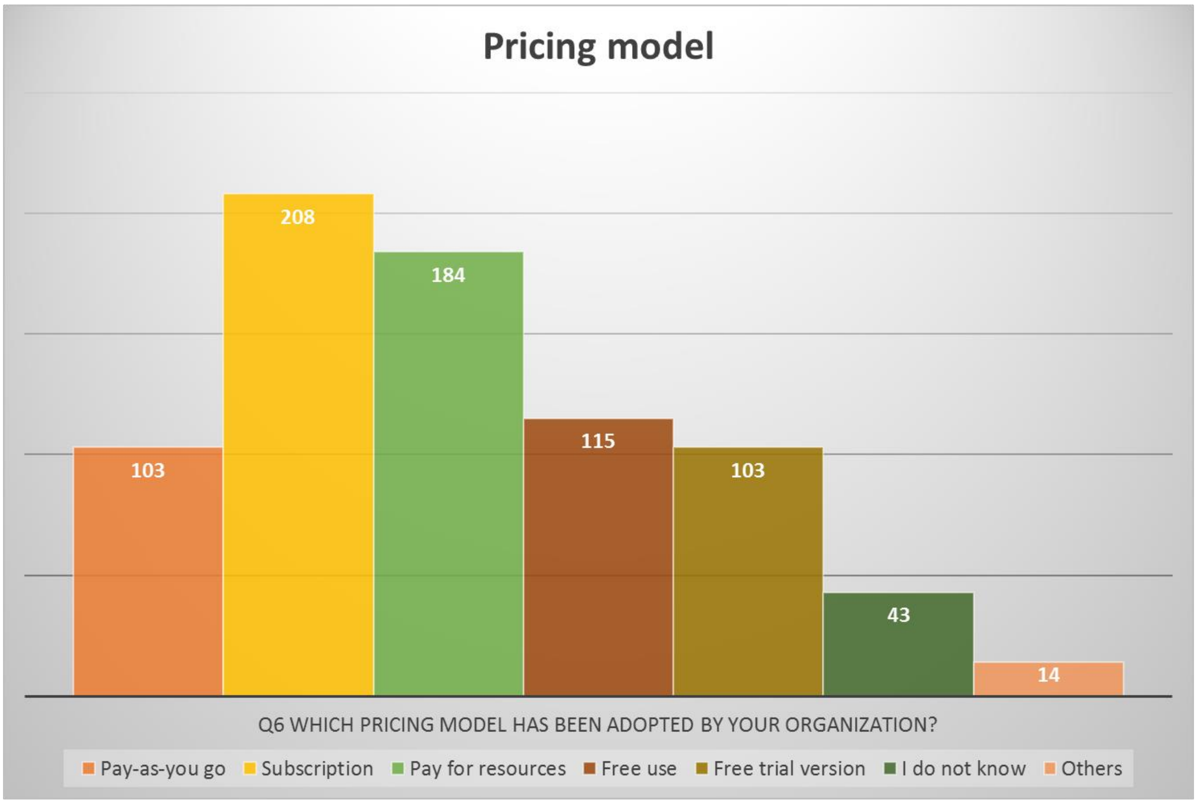


Figure 5.7. Pricing model

Figure 5.8 shows which cloud service model is adopted in participants’ organisations. The majority of participants selected Platform as a Service (PaaS) model. As discussed in section 2.3.2, in this model, cloud suppliers deal with the infrastructure and platforms that run the applications, but the cloud client has control over the deployment of applications, configurations and setting. The total numbers of participants who chose Infrastructure as a service (IaaS) and Software as a service (SaaS) are almost equal. In IaaS, cloud vendor oversee and control fundamental cloud infrastructure, yet cloud users can convey and run arbitrary software, which can incorporate operating systems and applications. In the SaaS model, the cloud providers manage the infrastructure and platforms that run the applications, and cloud users have access to software and the database.

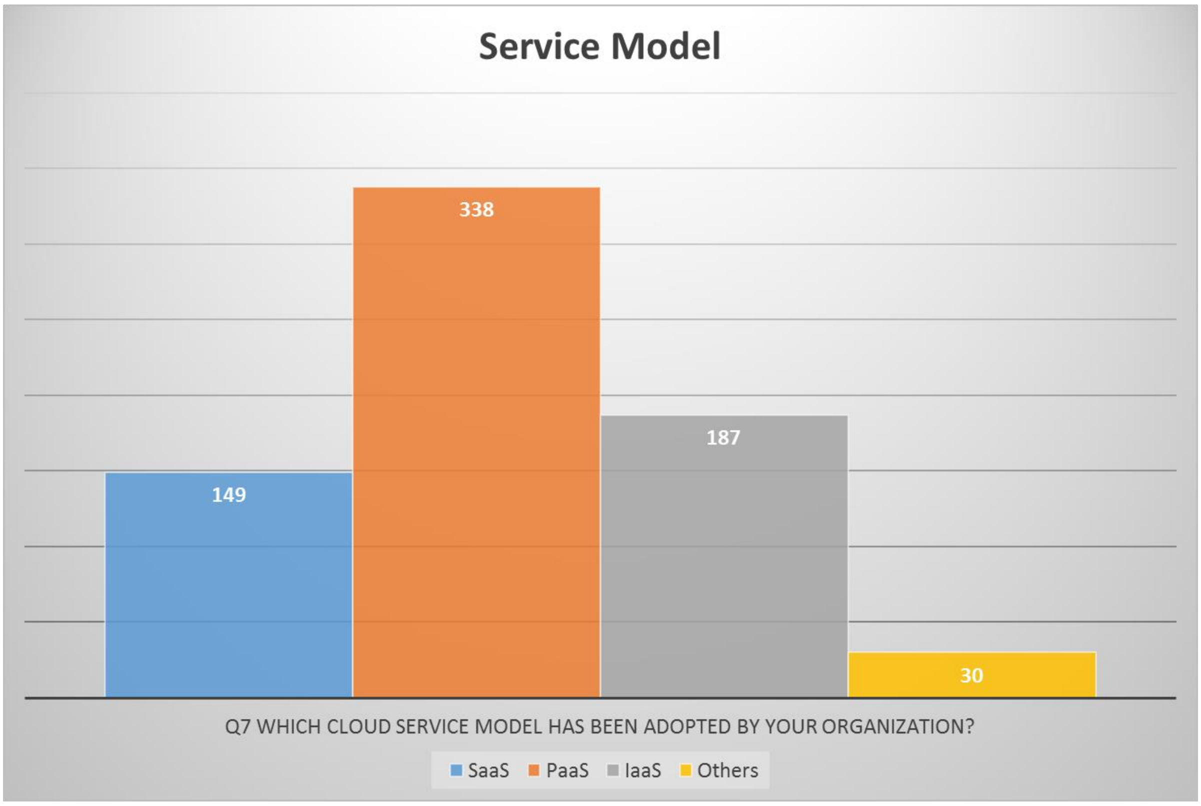


Figure 5.8. Service model

Figure 5.9 indicates the cloud deployment model that has been adopted by participants' organisations. Public cloud has the most users (39.9%) according to the online survey. As discussed in section 2.3.3, in this deployment model, the cloud infrastructure is provided to the public for open use. Approximately 32% of participants are using community cloud followed by private cloud (11.7%). In community cloud, a specific community from corporations who have shared concerns provides the cloud infrastructure for exclusive use. On the other hand, private cloud means that the cloud infrastructure is provided for exclusive use by a single organisation. Lastly, approximately 11% of participants mentioned hybrid cloud that means the cloud infrastructure is a combination of two or more different cloud infrastructures (private, community or public).

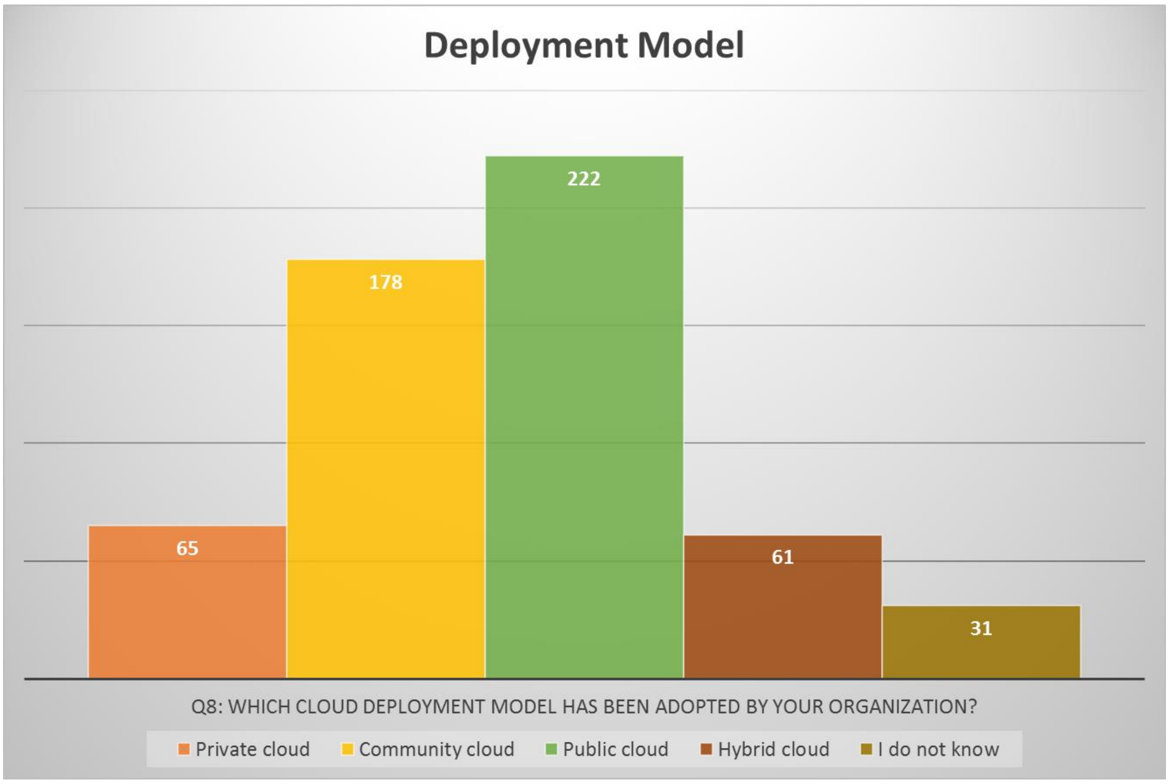


Figure 5.9. Deployment model

5.4.3 Cloud Governance Descriptive Statistics

Cloud governance refers to the application of specific policies or principles to the use of cloud computing services. As discussed in Chapter 4 and indicated in Figure 5.1, cloud governance contains the following factors: process, policy, risk management and resource management. This section is focused on the descriptive statistics from the online survey related to cloud governance.

As indicated in Figure 5.10, the majority of respondents (70.7%) believe that it is necessary to identify the cloud governance processes before moving to the cloud. The governance processes include, but not are limited to establishing assumptions, regulations and standards; identifying, analysing and prioritizing risks; identifying and selecting policies, laws, regulations, and contracts, etc. These sub-factors will then be tested in section 5.6 by applying Exploratory Factor Analysis to narrow down the scope before creating the final model.

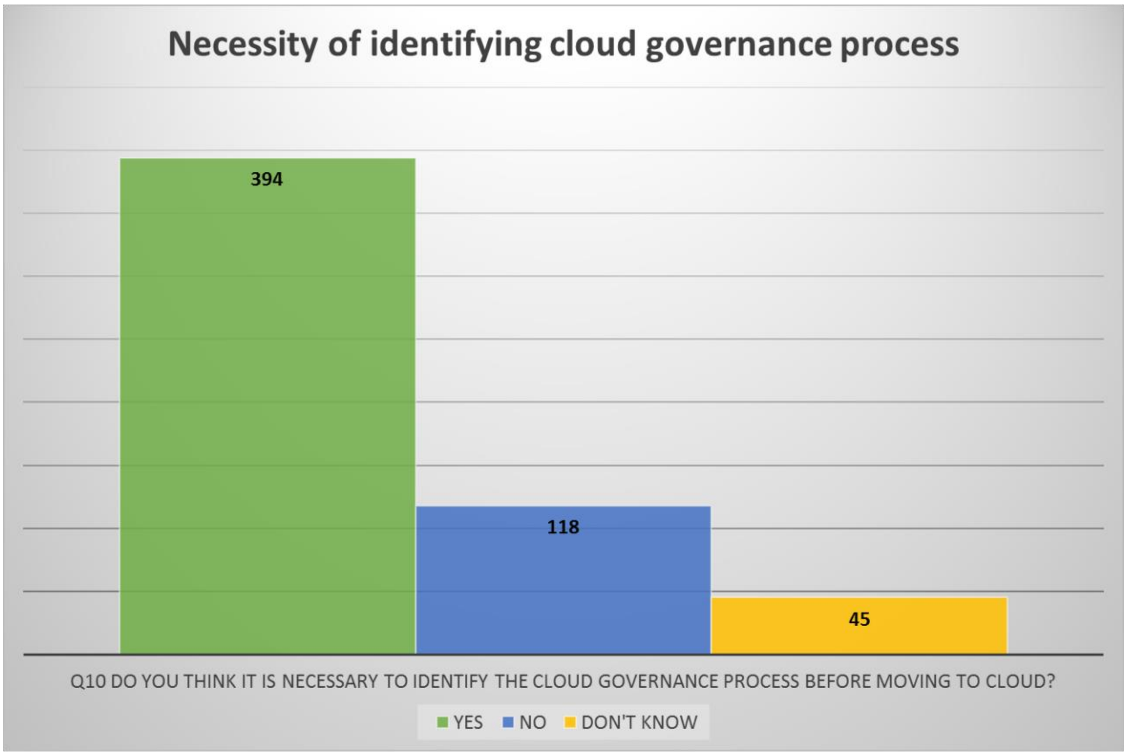


Figure 5.10. Necessity of identifying cloud governance process

Figure 5.11 reveals the data security concerns when sharing data with others. Participants were asked if they have shared the IT service log-in credentials with colleagues or friends; unsurprisingly, the majority have given the log-in passcode to others to use. Approximately 41.5% of participants have shared it once or twice; followed by 33.2% of participants who share their passcode occasionally. Only 15.7% of participants have never shared their passcodes.

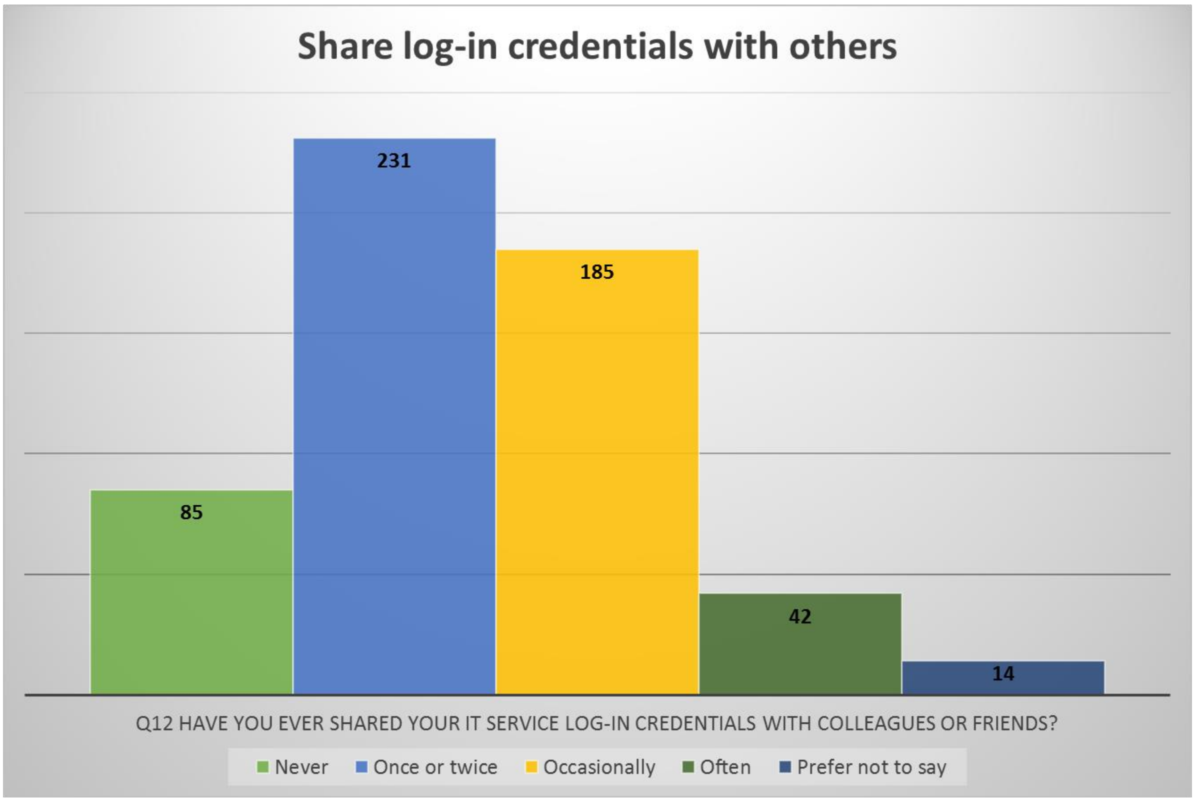


Figure 5.11. Share log-in credentials with others

The next figure summarises the concerns that cloud users have when moving to cloud. As seen in Figure 5.12, the top three concerns from participants are security and data protection, location of data, and privacy agreement and service level agreement. There are 313 participants who believe that security and data protection are the most important concerns regarding cloud adoption. As discussed in section 4.2.2, many interviewees also mentioned that data security should be taken into consideration when adopting cloud technology.

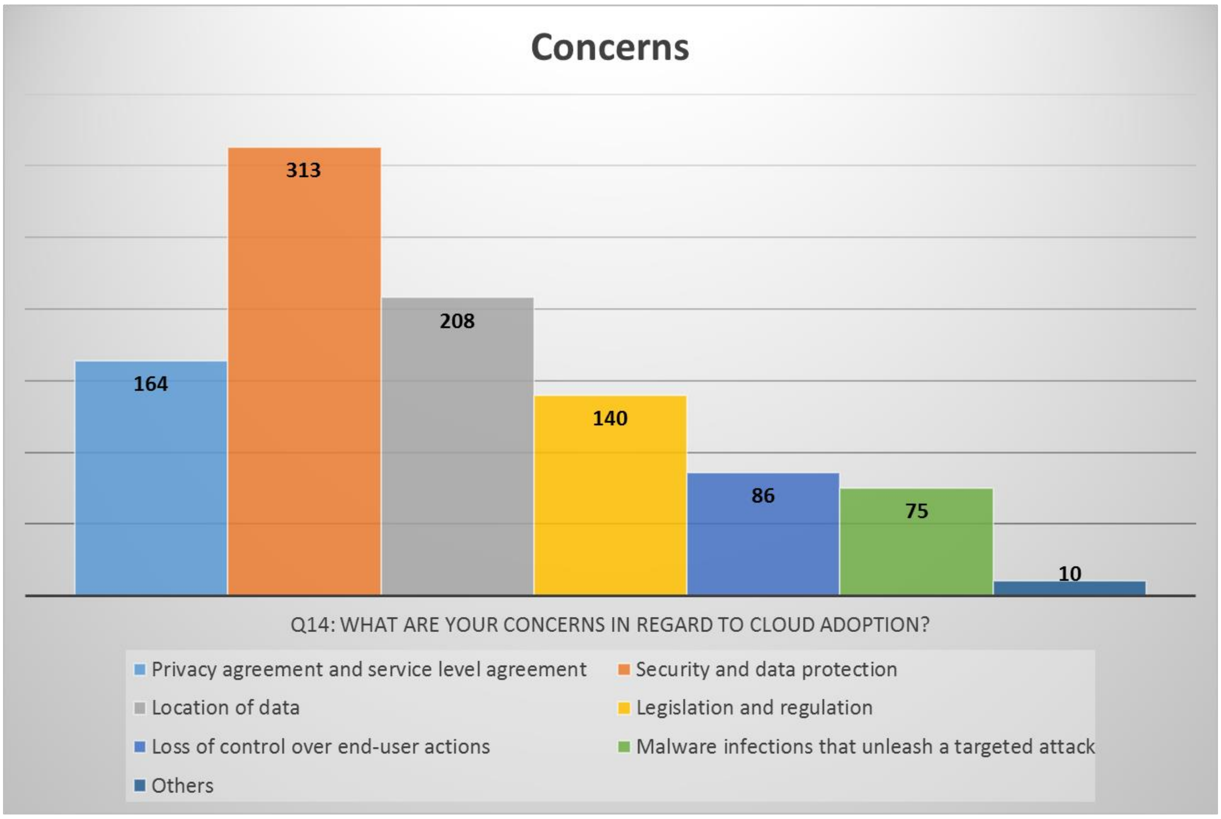


Figure 5.12. Concerns regarding cloud adoption

Compared with traditional IT resource management, there are some new challenges that organisations have to face when adopting cloud. For instance, as indicated in Figure 5.13, 308 participants believe that the lack of experience is one of the biggest challenges their organisation has encountered. The cost of resource management and the lack of comprehensive understanding of cloud resource management are in second and third place respectively in terms of resource management difficulties. Last, but of significance, some participants believe that the importance of cloud resource management has been overlooked.

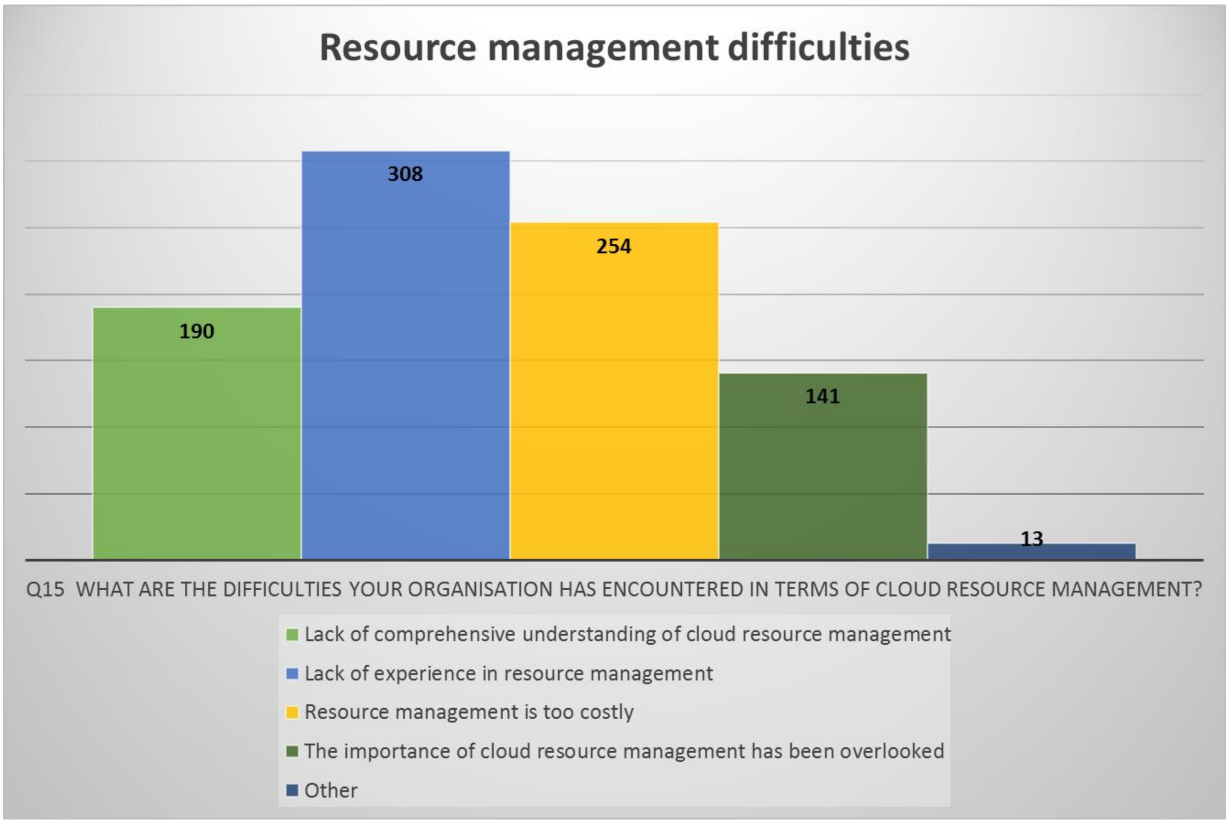


Figure 5.13. Resource management difficulties

Hence, if resource management is difficult, who should take that responsibility? Figure 5.14 below indicates the participants' opinions about the responsibilities of service providers and cloud users. According to the bar chart, most participants believe that the cloud user is responsible for resource allocation and data backup. The option "Both of them" is ranked second, many participants believe that both cloud user and service provider are responsible for resource management. Cloud providers usually have their own backup datacentre and the cloud products usually have backup solutions for customers as well, so from author's perspective, both cloud provider and cloud user are responsible for resource allocation and data backup.

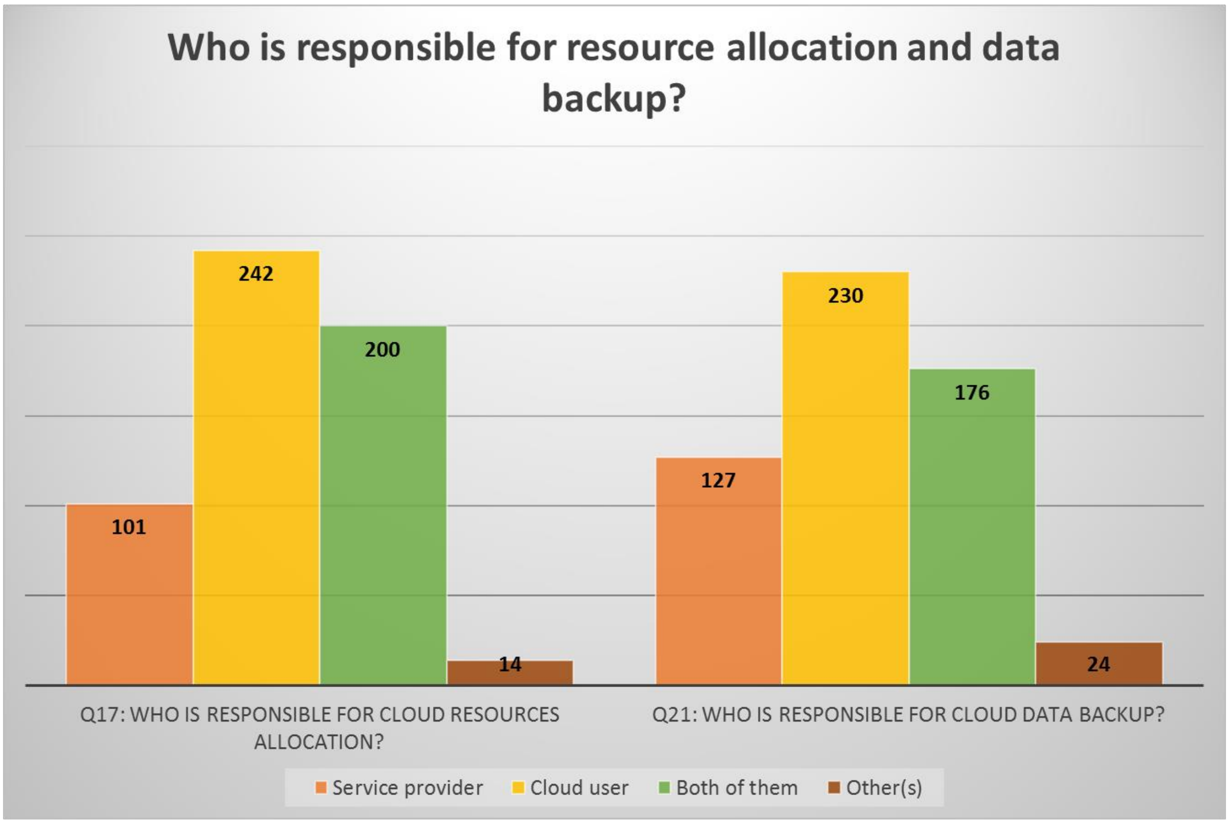


Figure 5.14. Resource allocation and data backup

5.4.4 Operations Management Descriptive Statistics

Cloud computing operations management involves designing and controlling daily operations in the cloud computing area. As discussed in chapter 4 and indicated in Figure 5.1, cloud operations management involves: data management, energy consumption, capacity management and virtualization. This section is focused on the descriptive statistics from the online survey in relation to cloud computing operations management.

Data management is one of the most significant activities in the management of daily operations. As indicated in Figure 5.15, the majority participants (69.5%) claim that their department would upload critical data to the cloud; however, only 278 participants (49.9%) believe their organisations have a disaster recovery plan for data management. Thus, it is essential to raise their awareness of the significance of having a disaster recovery plan for crucial data.

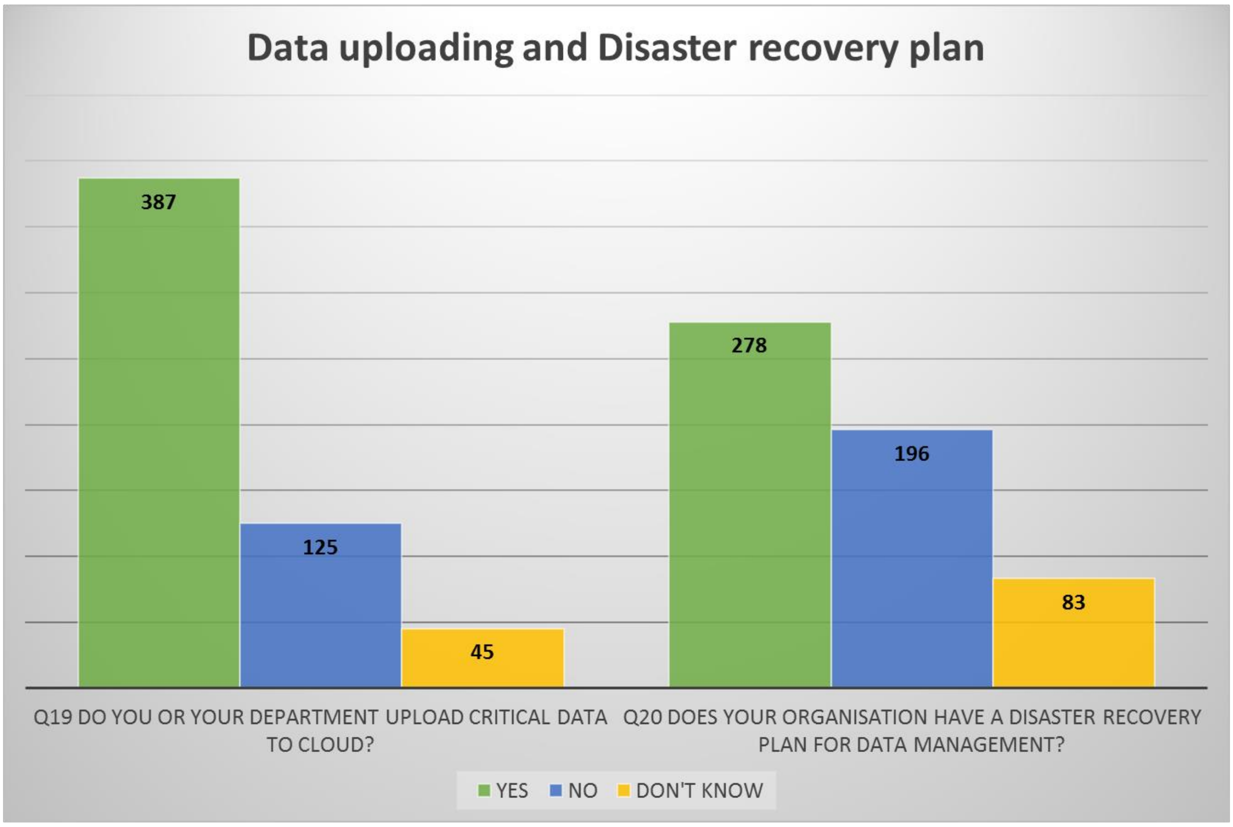


Figure 5.15. Data uploading and disaster recovery plan

Another aspect of operation management is energy consumption. When the participants were asked if their organisation implements relevant measures in order to achieve efficient energy management and energy conservation for the cloud operation, most of them said ‘yes’ which is a heartening result (Figure 5.16). However, 59.8% of participants believe that at present the effect of energy-efficiency and cost saving is not that obvious. Thus, there is still a long way to go to improve the management of energy consumption.

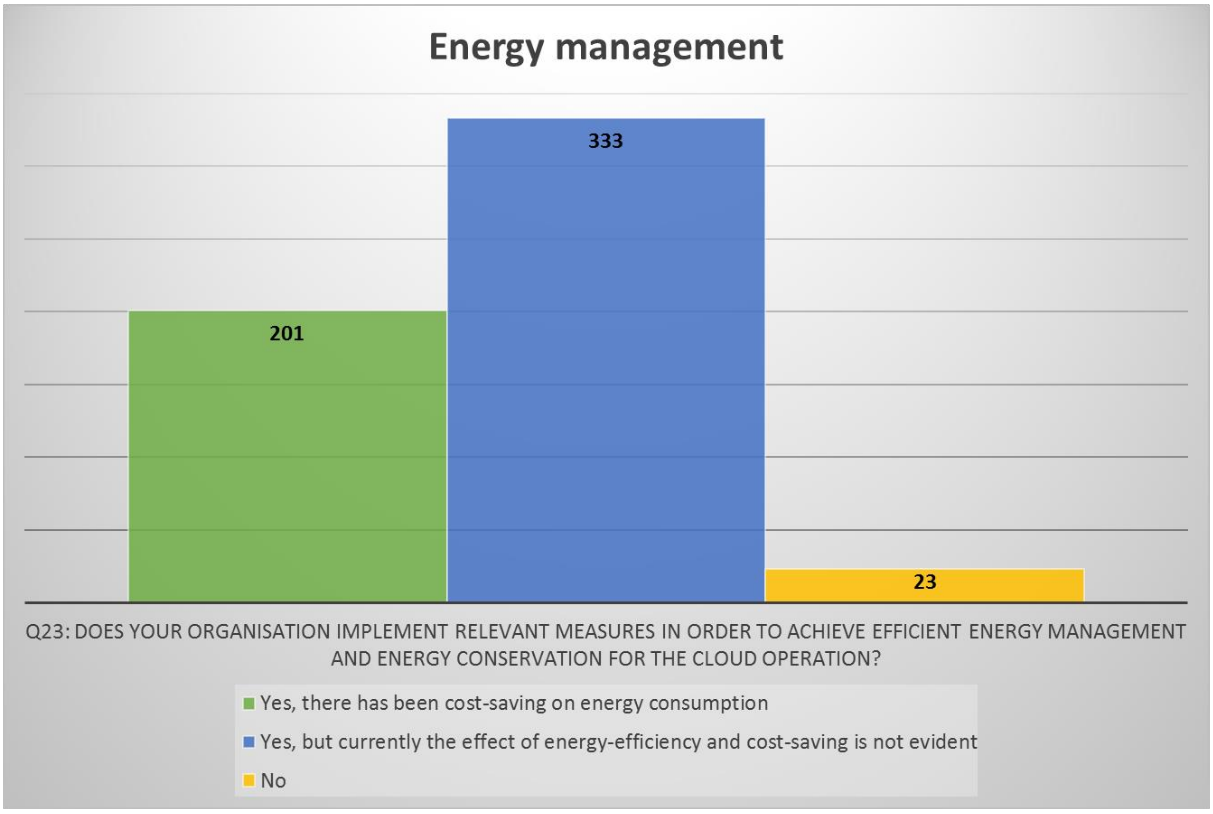


Figure 5.16. Energy management

One way of reducing consumption of energy is to upgrade current high-energy-consumption equipment. As indicated in Figure 5.17, approximately 95% of participants agree that upgrading high-energy-consumption equipment is essential. For instance, upgrading buildings' lighting systems to LED, implementing automatic controls for lighting, and using renewable energy, are all efficient ways of saving energy.

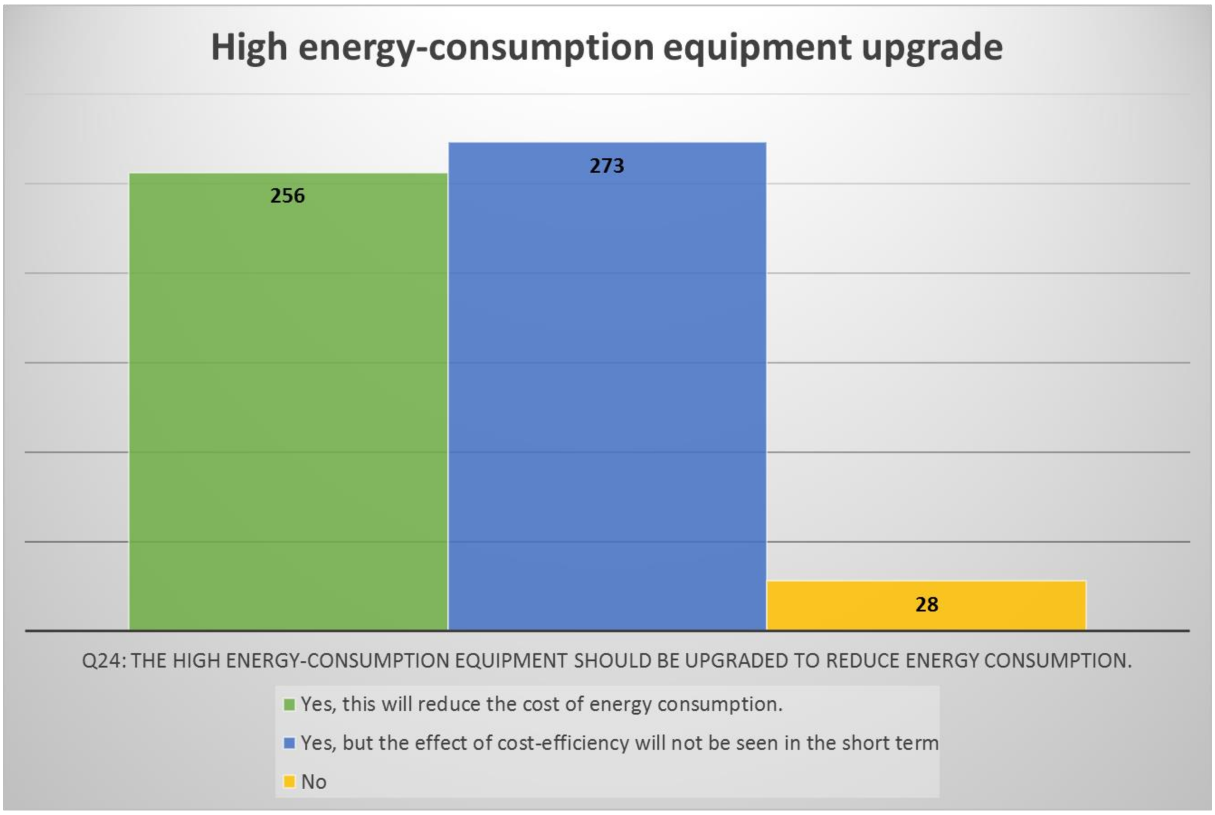


Figure 5.17. High energy-consumption equipment upgrade

Energy monitoring is also essential. Although the majority participants agree that it is necessary to monitor the energy consumption (Figure 5.18), many are concerned about the cost involved when monitoring energy. Monitoring solutions such as upgrading energy metering system, developing and managing energy metering and monitoring system can be time consuming and costly. Therefore, energy administration is required to improve the efficiency of energy monitoring.

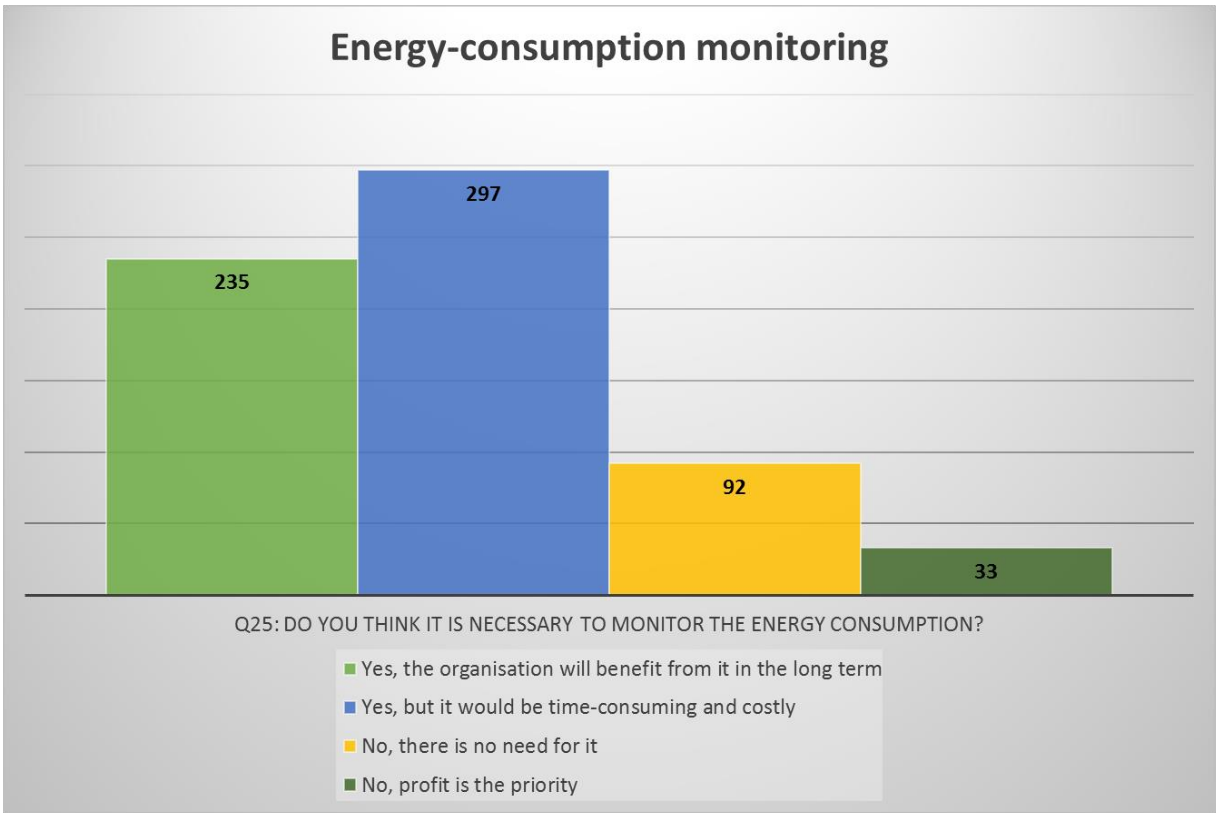


Figure 5.18. Energy monitoring

In regard to energy consumption by cloud computing, approximately 50% of participants believe that the cloud servers consume more energy, while 25% of participants agree that the cooling infrastructure of the server room should be taken into consideration.

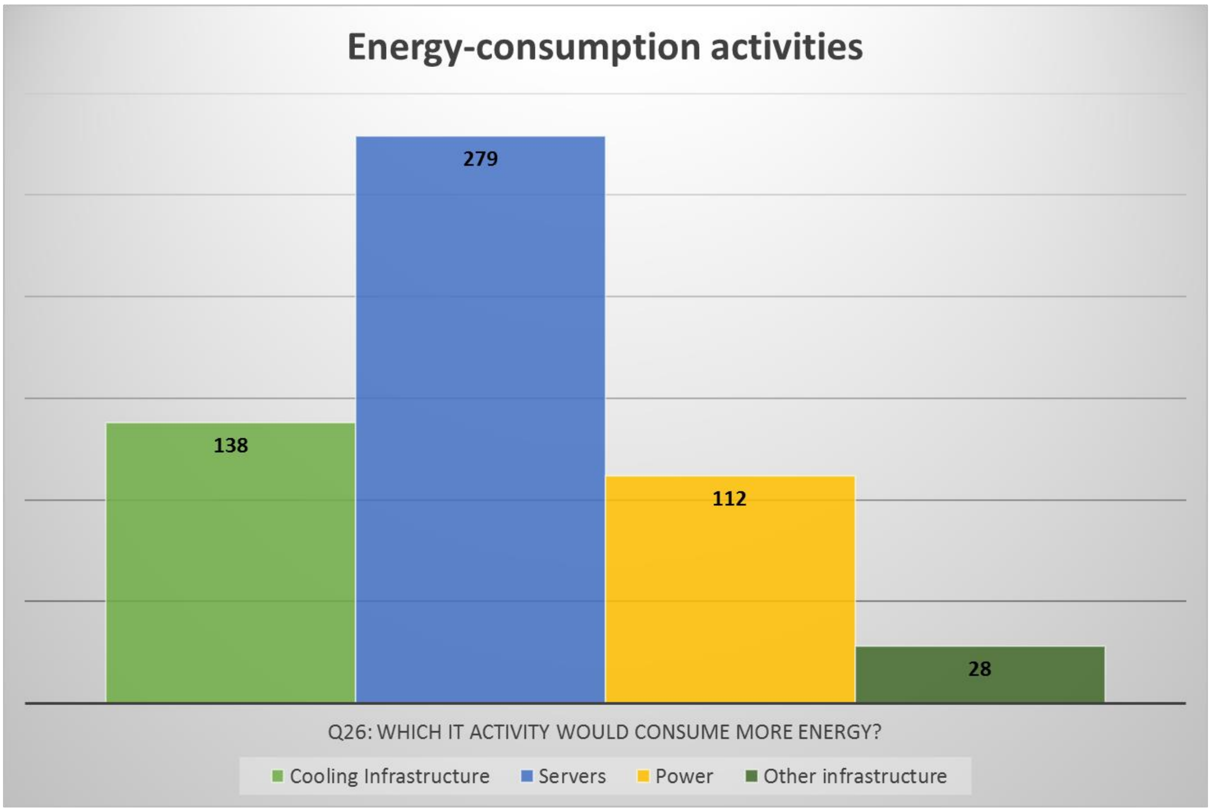


Figure 5.19. Energy-consumption activities

Another aspect of operations management is network capacity. According to China Internet Network Information Centre (CNNIC), in the third quarter of 2017, the average download speed for fixed broadband users was 16.6 Mbit/s and the average download speed for mobile broadband users accessing the Internet via 4G network was 15.4 Mbit/s ("The 41st Statistical Report on Internet Development in China," 2018). As demonstrated in Figure 5.20, 284 of the 557 participants (51%) believe that the network capacity is sufficient for cloud computing, while 36.3% disagree.

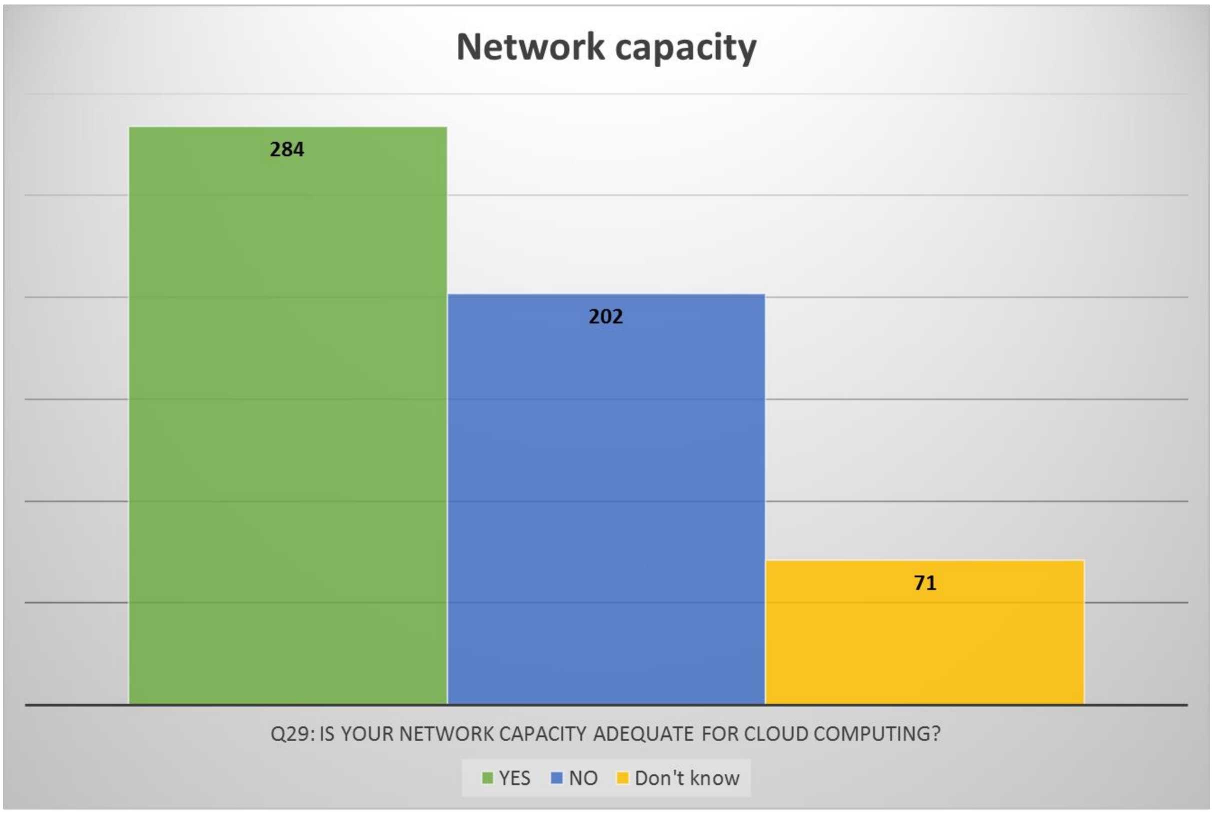


Figure 5.20. Network capacity

The final aspect of operations management in this research is virtualization. Virtualization is one of the key components of cloud computing which can provide computing and storage services (Xing & Zhan, 2012). According to Figure 5.21, operating system virtualization sits at the top, followed by server virtualization, then hardware virtualization and storage virtualization.

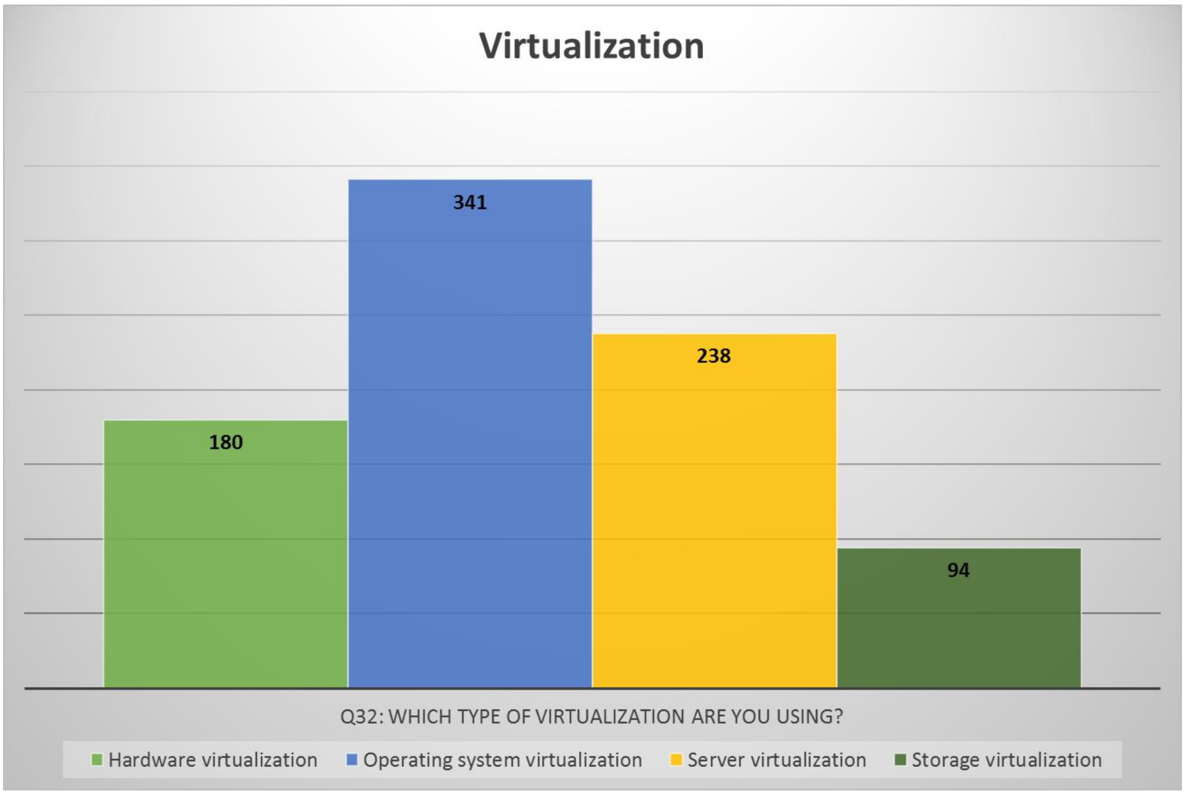


Figure 5.21. Virtualization

5.4.5 Sustainability Descriptive Statistics

Cloud computing sustainability means the cloud technology is designed, manufactured, managed and used in a way that can effectively minimize the negative impacts on the environment, and ensure sustainable development. As discussed in chapter 4 and indicated in Figure 5.1, cloud computing sustainability comprises the following factors: social, economic and environment. This section focuses on the descriptive statistics from the online survey related to cloud computing sustainability.

As discussed in section 2.6.1, all of the originations and individuals should take the social responsibility in order to maintain a balance between the economy and the ecosystems. Unfortunately, the awareness of social responsibility is remaining unsatisfactory. As indicated in Figure 5.22 below, most participants suggest that profit is more important and they would ignore the social responsibility when necessary. Moreover, fewer participants believe that fulfilling social responsibility can improve the organization's development and competitiveness. That is why social responsibility should be brought to the forefront and included in the final model of this research.

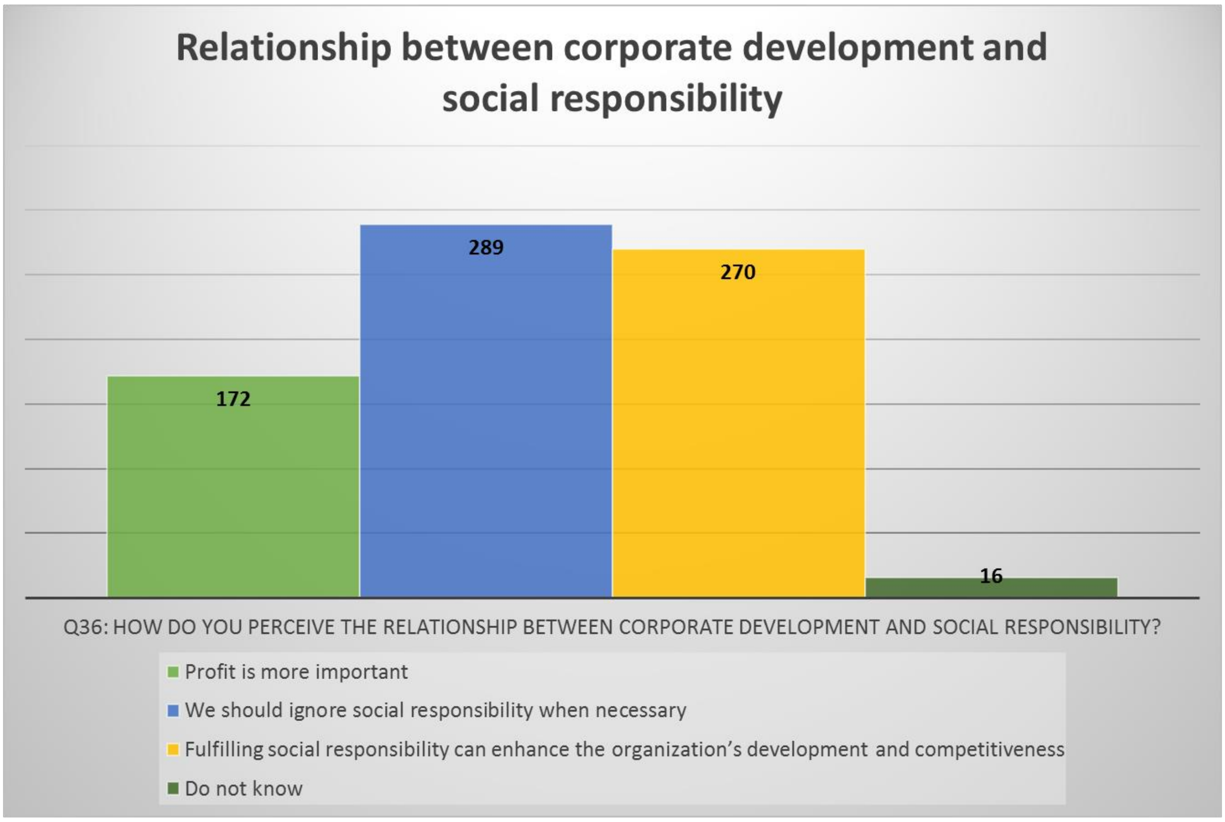


Figure 5.22. Corporate development and social responsibility

As discussed in Section 2.8, cloud computing is now widely used in education. From the Figure 5.23 below, it also confirms that cloud computing will bring benefits to education. In the online survey, 357 out of 557 participants (64.1%) hold a relatively positive opinion on the educational benefits of cloud computing. However, 27.1% participants disagree with that. Cloud computing can have several negative impacts on education. For instance, cloud computing relies on the internet; so, if the connection is lost, learning material cannot be delivered. Moreover, not all applications are running in the cloud.

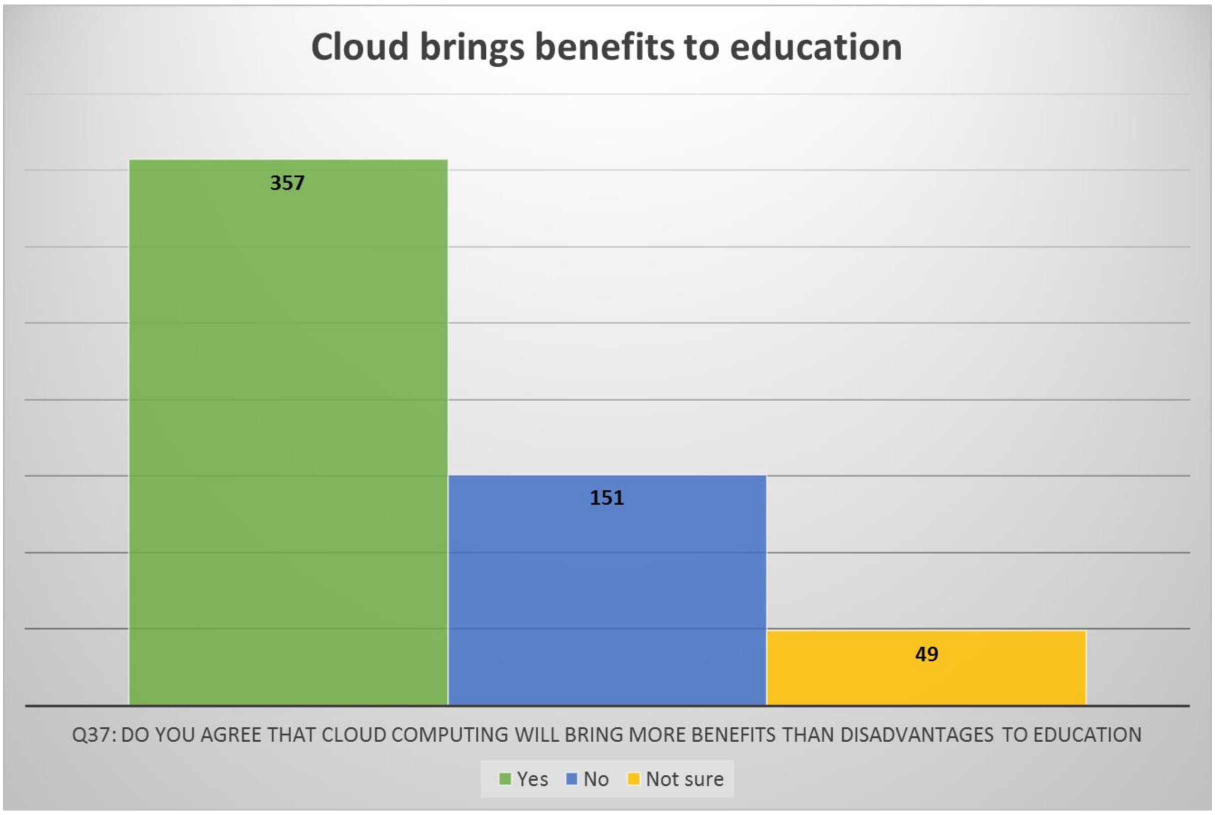


Figure 5.23. Educational benefits

If an organization can integrate environmental, economic and social responsibility into its business operations, a sustainable brand is created successfully. Implementing sustainability practices can improve firm performance and enhance brand value (V Kumar & Christodoulopoulou, 2014). This is also confirmed by the online survey. As indicated in Figure 5.24, nearly 65% of participants agree that sustainable operation activities would help a company to develop a better brand image.

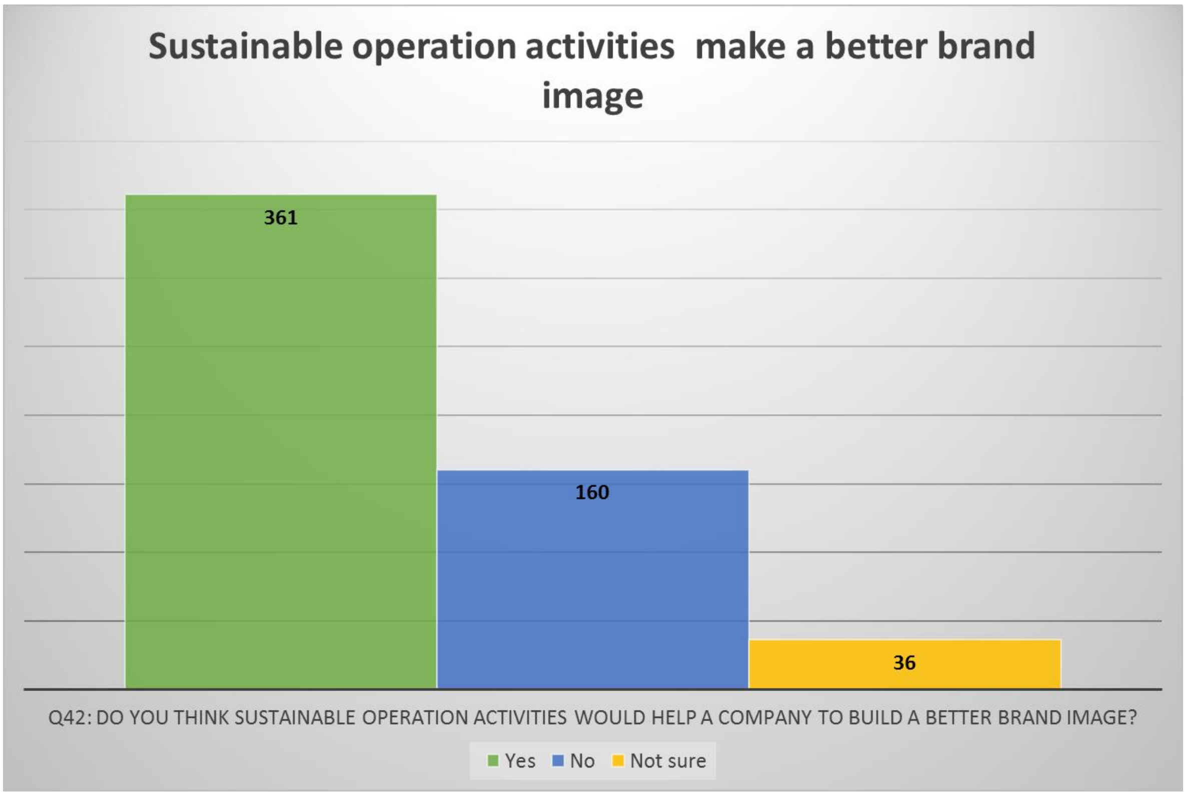


Figure 5.24. Sustainable operation with brand image

In order to ensure the successful implementation of cloud computing, organizations should establish a collaborative relationship with the cloud provider. Over 90% of participants believe that their organizations have a close or average relationship with cloud vendors (Figure 5.25).

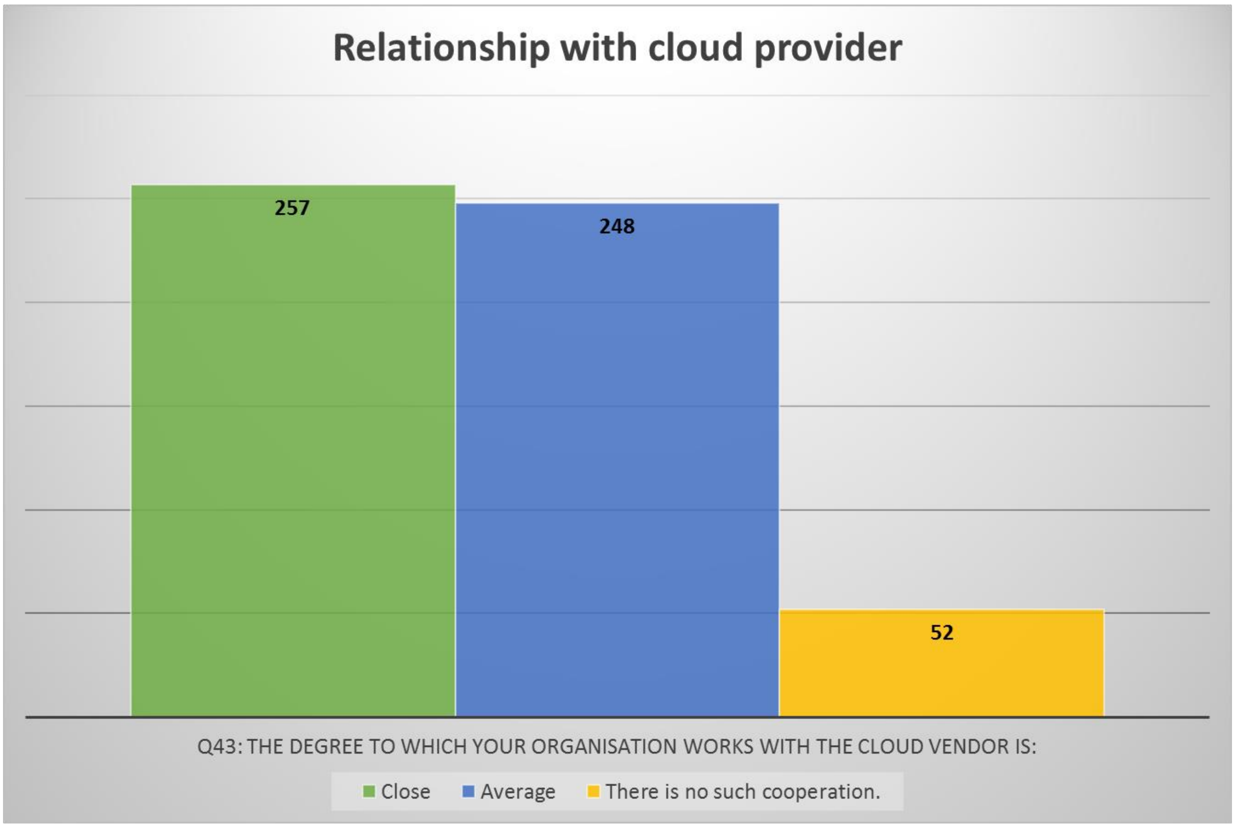


Figure 5.25. Relationship with cloud provider

When asked how they would deal with the development strategies, policies and regulations in terms of cloud development, 34.5% participants would include them in the development strategy; 47.2% participants would consider them occasionally while only 13.8% would pay no attention to them (Figure 5.26).

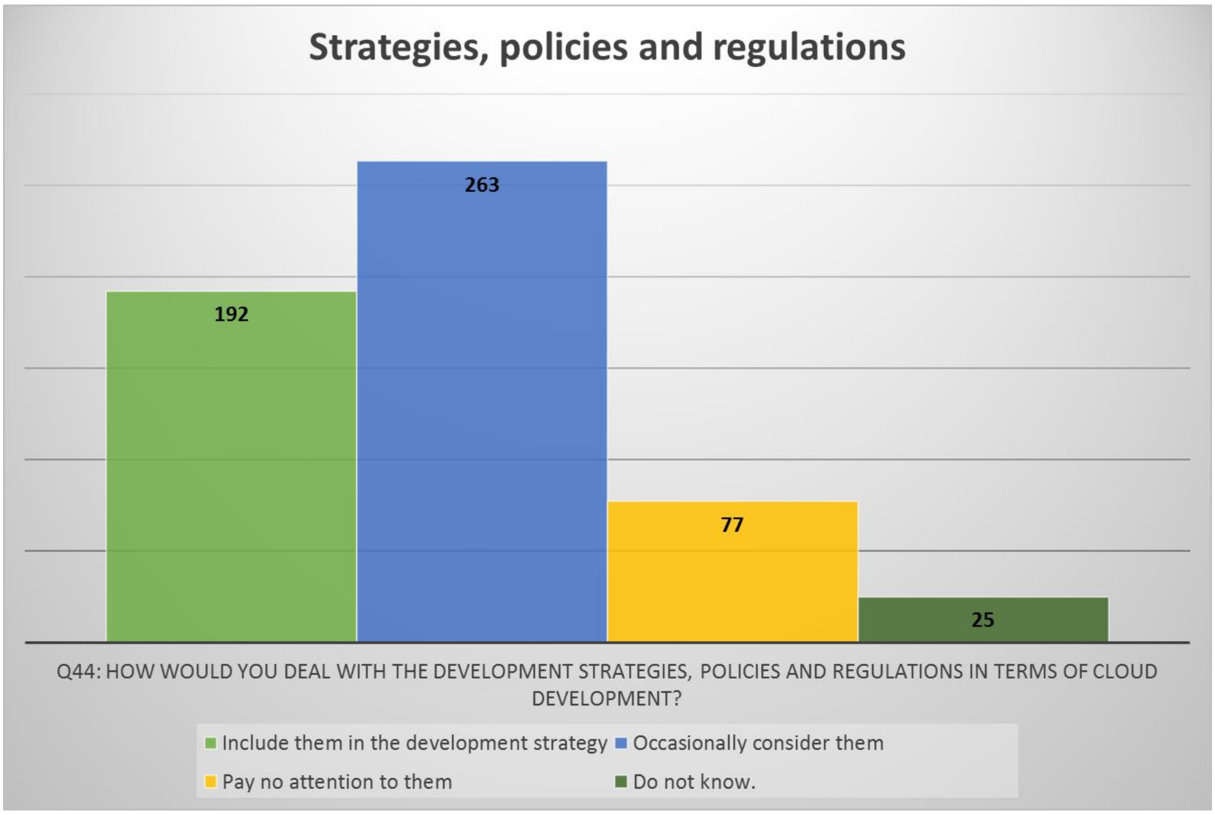


Figure 5.26. Strategies, policies and regulations

5.5 Online survey data analysis

This section is concerned mainly with the theoretical background information of the factor analysis; also, the processes of data preparation and factor analysis will be briefly discussed in this section.

5.5.1 Data preparation

Data cleansing is the process of preparing the data set for analysis. It is necessary to undertake the process of cleaning data before it is analysed. Certain tasks need to be performed in this step depending on the purpose of the research in order to fully prepare data for analysis. One of the most important issues concerns missing values. There are many reasons why there could be missing values in the data set. For example, participants may forget to answer an item or they simply want to withdraw during the process. This online survey received 709 responses in total, but many were incomplete due to missing values. After the data cleaning process, 557 responses remained, giving a valid data set.

5.5.2 Factor analysis

Besides the main factors, there are a number of sub-factors extracted from the literature review which are correlated to the main factors and that need to be tested. In order to reduce the number of sub-factors and identify the most significant sub-factors, factor analysis is utilised in this section.

Factor analysis is a data reduction technique whereby a large number of variables can be summarised into a more meaningful, smaller set of factors (Allen, 2014, p. 213). Factor analysis can also be used to identify interrelationships between variables in a data set. It takes a large set of variables and searches for a way the data might be reduced utilizing a smaller set of factors or components. Factor analysis does this by searching for groups among the inter-correlations of a set of variables (Pallant, 2016, p. 182).

5.5.2.1 Assumption testing

Several criteria should be met before conducting a factor analysis.

Independence. All participants should not participate more than once in the research, and should not influence other participants (Allen, 2014). Since the IP addresses of the participants in this survey are all different, it meets the requirements of independence.

Sample Size. Generally speaking, the correlation coefficients among the variables are less reliable in small sample (Pallant, 2016). There should be at least five participants per variable for factor analysis (Allen, 2014; Coakes, 2011). A minimum of 100 participants is required for a reliable factor analysis (Allen, 2014). Coakes (2011) suggests that sample sizes of 200+ are preferable. According to Comrey and Lee (1992) and Maccallum et al. (1999), if the sample size is less than 200, it is inadequate for factor analysis. It is acceptable if the sample size is around 300. It is adequate if the sample size is above 500 and excellent if more than 1000. Thus, the desired sample size for factor analysis in this research is 500. For the survey conducted in this research, 557 valid responses were returned.

Normality. Factor analysis is robust to assumptions of normality. However, if each variable is approximately normally distributed, the solution will be improved (Allen, 2014; Coakes, 2011).

Linearity. Factor analysis is based on the analysis of correlations; thus, there should be linear relationships among different variables (Allen, 2014; Coakes, 2011).

5.5.2.2 Descriptive Analysis

Kaiser-Meyer-Olkin (KMO) test measures the extent to which data is suitable for factor analysis. The test measures the sampling adequacy for each variable in the model and for the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. The lower the proportion, the more suited the data is to factor analysis. H. Kaiser (1974) allocated the following values to the results:

- 0.00 to 0.49 unacceptable.
- 0.50 to 0.59 miserable.
- 0.60 to 0.69 mediocre.
- 0.70 to 0.79 middling.
- 0.80 to 0.89 meritorious.
- 0.90 to 1.00 marvellous.

KMO returns values between 0 and 1. KMO values between 0.8 and 1 indicate the sampling is adequate. KMO values less than 0.6 indicate the sampling is not adequate and that remedial action should be taken. KMO Values close to zero means that there are large partial correlations compared to the sum of correlations. In other words, there are widespread correlations which are a large problem for factor analysis.

Bartlett's test of sphericity also indicates how suitable the data are for factor analysis. If Bartlett's Test is significant (sig < 0.05), the data is suitable. However if it is a non-significant (sig > 0.05), the Bartlett's test suggests the data is not acceptable for factor analysis (Allen, 2014).

5.5.2.3 Factor extraction

Factor extraction is used to determine the smallest number of factors that can be used to best represent the interrelationship among the set of variables. There are many approaches available for factor extraction as explained below:

- **Principal Components Analysis (PCA).** One of the most commonly-used approaches for factor extraction is Principal Components Analysis (PCA) (Pallant, 2016). PCA is utilised to arrive at a reduced set of components. This method seeks the set of components which can represent all the common and unique variance in a variable set (Allen, 2014).
- **Correlation Matrix**. The correlation matrix table represents the bivariate correlation between each pair of variables in the analyses. If several correlations in the correlation

matrix are above 0.3, the data set is suitable for factor analysis (Allen, 2014; Coakes, 2011).

- **Scree Plot**. This method was proposed by Cattell (1966). In his paper, Cattell (1966) proposed the scree plot as a way of determining the number of useful factors to retain. The aim is to apply this plot to identify the point where the decrease in eigenvalues starts to suddenly level off. The scree plot is a graph of the initial eigenvalues reported in the total variance explained table. It is another tool that can be utilised to decide how many factors should be interpreted (Allen, 2014).
- **Eigenvalue**. According to H. F. Kaiser (1960), the eigenvalue should be greater than one. If an eigenvalue is less than one, it implies that the scores on the component would have negative reliability (Cliff, 1988). The Eigenvalues-Greater-Than-One rule is one of the primary methods for extraction, for determining the number of components. However, using the Eigenvalues-Greater-Than-One rule is only one indication of how many factors to retain. Many techniques are available to address this challenging problem. Some of the better known methods are the scree test (Cattell, 1966) and parallel analysis (Horn, 1965).

In this research, the themes and the main factors related to each theme have been defined based on the literature review and analysis of interview data as indicated in Figure 5.1 at the beginning of this chapter. The aim of this chapter is to identify all the sub-factors which are correlated to the main factors by analysing the online survey data. Therefore, the factor analysis is undertaken several times based on each main factor, and each time only the questions related to that particular main factor are involved in the analysis.

The author applied the Eigenvalues-Greater-Than-One rule first, and one factor was obtained most of the time. However, the factor loadings of others were relatively high as well. Thus, after reconsideration and discussion with the supervisor, the author decided to use the “Fixed number of factors” function and the number of factors to extract was established as two, as indicated in Figure 5.27 below.

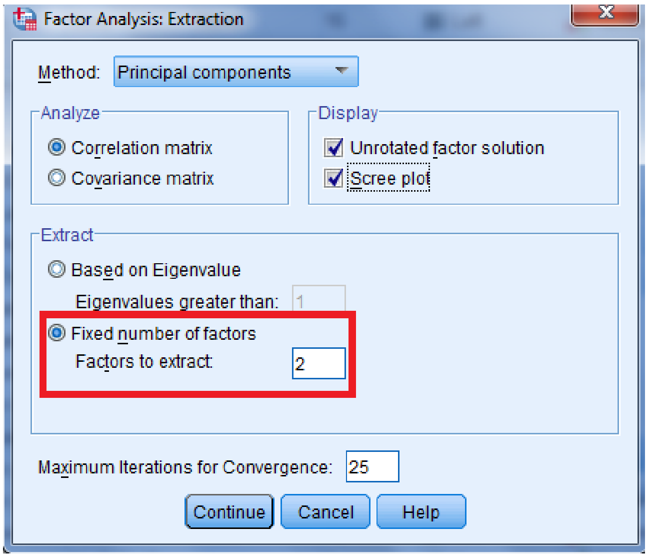


Figure 5.27. Factor extraction method in SPSS Version 22

5.5.2.4 Factor rotation

Once the number of factors has been resolved, the next stage is to attempt to interpret them. To assist with this procedure, the factors are rotated. This presents the pattern of loadings in a way that is easier to interpret. The most commonly used rotational approach in IBM SPSS is the Varimax method, which endeavours to minimise the number of variables that have high loadings on each factor (Allen, 2014; Coakes, 2011; Pallant, 2016).

5.5.2.5 Identification of factors

The last stage of factor analysis includes deciding on the number of factors to interpret and then labelling them. The number of factors to be interpreted largely depends on the reason for the analysis (Coakes, 2011). In the present study, the purpose is to reduce the number of sub-factors in order to create the final model. In this research, each factor has two or three sub-factors.

5.5.2.6 Summary of factor analysis

In this research, the process of factor analysis is summarized as:

1) Descriptive Analysis
   - KMO > 0.6
   - Bartlett's Test of Sphericity is significant (sig < 0.05)
2) Factor extraction
   - Principal Components Analysis (PCA)
   - Correlation Matrix > 0.3

- Scree Plot
- Fixed number of factors = 2

3) Factor rotation method
   - Varimax method

5.6 Exploratory Factor Analysis

The last section discusses the methods and techniques that can be applied to the online survey data analysis. This section presents various types of factor analysis and the reason why exploratory factor analysis is selected in this research.

Factor analysis is "a collection of methods used to examine how underlying constructs influence the responses on a number of measured variables". There are two main types of factor analysis: exploratory and confirmatory (DeCoster, 1998).

Exploratory factor analysis (EFA) is "performed routinely to study the latent factors that underlie scores on a larger number of measured variables or items", and applied in the development of assessment instruments (Courtney & Gordon, 2013; Ruscio & Roche, 2012, p. 282). EFA endeavours to identify the nature of the constructs influencing a set of responses (DeCoster, 1998). According to Suhr (2006, p. 1), the EFA could be described as an "orderly simplification of interrelated measures". EFA is utilised to obtain the potential factors from a set of variables without imposing a preconceived structure on the outcome. Therefore, the underlying factor structure is identified by applying EFA (Suhr, 2006).

Confirmatory factor analysis (CFA) determines whether "a specified set of constructs is influencing responses in a predicted way" (DeCoster, 1998, p. 1). CFA is a statistical technique that can be utilised to verify the factor structure of a set of observed variables. According to Suhr (2006), CFA enables the researcher to examine the assumption that the observed variables have a connection with their underlying latent constructs. The researcher presumes the existence of a relationship between them, and then tests the hypothesis statistically (Suhr, 2006).

In this research, the main factors are generated from the literature review and interviews in order to create the model. The purpose of the online survey is to refine the model by adding sub-factors to it, and these sub-factors are extracted from the online survey data. EFA can identify factors based on data collected from the survey and can maximise the amount of variance explained (Suhr, 2006). Thus, EFA is considered to be more appropriate than CFA in this research because the latter does not show how well the items load on the non-hypothesized factors (Kelloway, 1995). The software that will be utilised to perform EFA in this research is IBM SPSS version 22. The next section presents the results of the exploratory factor analysis.

5.7 Results of online survey data analysis

Based on the discussion above, this section presents the results of the online survey data analysis. As indicated in Figure 5.1, there are three main themes in this research: cloud governance, operation management and sustainability. Each theme contains a set of factors. However, the sub-factors related to each main factor have yet to be determined. Thus, this section will analyse the data collected from the online survey and generate the sub-factors by using exploratory factor analysis (EFA) via IBM SPSS version 22.

As been mentioned in Section 5.3, 709 responses were received, of which 557 (78.6%) were valid. However, there were 51 participants selected "others" when asked about their occupations (Table 5.1). This research is focused on academic, student and IT professional groups' perspectives; thus, the final number of responses that suitable for factor analysis is 506.

When performing the factor analysis, the 506 participants are divided into three groups based on their occupations: academics, students, or IT professionals. Each group is analysed separately and the results are compared for each main factor. Table 5.2 shows the number of participants in each group.

Table 5.2. Participant groups

Group Name	**Number of Participants**
Academic Group	140
Student Group	112
IT professional group	254
Total	506

5.7.1 Theme 1: Cloud Governance

The first theme, Cloud Governance, contains four main factors: process, resource, policy and risk management.

5.7.1.1 Factor 1: Process

In this section, variables related to process will be tested in order to extract sub-factors. Data from three groups (academics, students and IT professionals) will be analysed separately and the results will be compared to see if different groups share the same opinion.

5.7.1.1.1 Group 1: Academics Group

Table 5.3 below indicates the factor loadings, KMO and scree plot results for the academics group on “Process”.
The Component Matrix (variables and factor loadings) indicates how each of the individual items performs in terms of forming that component. The first column has seventeen items and the second column shows the component loadings (factor loadings). The component loadings explain how strong the relationship is between the item and the component in the solution. The numbers in second column explain the correlation of the item with the component. For instance, the first item ‘Identifying controls’ loads 0.72 on the first extracted component, but lodes 0.252 on the section component, which means this item contribute more to the first component. Overall, the factor loadings highlighted in green means these items load or correlate very highly on the first component; blue ones are correlate highly on the second extracted component.

According to H. Kaiser (1974), KMO value should be greater than 0.6, and sig. value should less than 0.05 in Bartlett’s Test. In Table 5.3, the academics group is significant as it is less than 0.05 and the KOM value is 0.923. It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

In the scree plot, the component number is from one to seventeen on the X-axis, which means there are seventeen variables to test. On the Y-axis, the numbers are the eigenvalues. The eigenvalues are plotted from left to right in the scree plot diagram. The number of components that are above what is known as the scree, or where the plot tends to not drop much, are retained. As can be seen in the diagram, eigenvalue two to seventeen taper off very gradually, but there is a big drop from component one to component two. Thus, according to the scree plot, it can be interpreted that the component one should be retained as it tends to no longer change very much. However, as discussed in section 5.5.3.3, the eigenvalue is only one indication of the number of factors that should be retained. As the factor loadings from the Component Matrix are relatively high, two components will be extracted as shown in Table 5.2.

Table 5. 3 Factor loadings, KMO and scree plot for academics group on "Process"

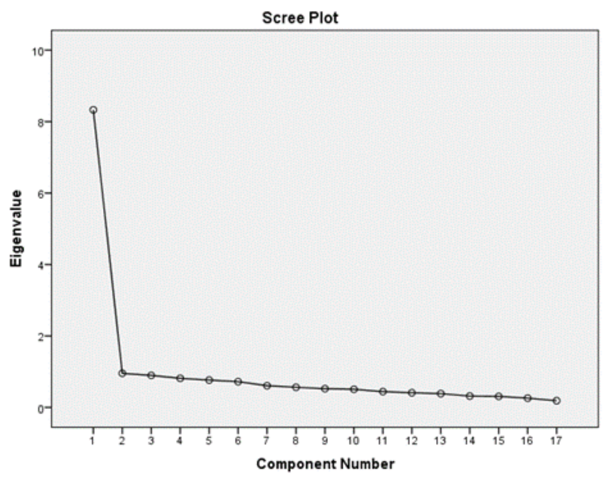
Theme 1: Cloud Governance
Main Factor 1: Process
Group 1: Academics Group

Variables for Academics group	Factor loadings 1	Factor loadings 2
(F) Identifying controls	.720	.252
(L) Selecting policies, laws, regulations, and contracts	.711	.245
(N) Setting future compliance state	.707	.231
(D) Identifying risk	.665	.320
(P) Maintaining compliance	.664	.300
(H) Planning and scheduling implementation	.647	.343
(J) Operating controls	.607	.385
(M) Assessing current compliance state	.589	.413
(B) Establishing a vision	.538	.413
(A) Establishing assumptions	.270	.729
(K) Identifying policies, laws, regulations, and contracts	.183	.720
(C) Establishing regulations and standards	.273	.687
(G) Analysing controls	.365	.652
(Q) Auditing compliance	.489	.644
(O) Creating compliance plan	.343	.588
(I) Tracking and reporting risks and controls	.510	.581
(E) Analysing and prioritizing risks	.487	.515

KMO and Bartlett's Test, and Scree Plot

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.923
Bartlett's Test of Sphericity	Approx. Chi-Square	1222.7 15
	df	136
	Sig.	.000



Based on the discussion above, Table 5.4 indicates the factor labels of sub-factors for process (academics group). The first label is "Analysing critical risk" and the second one is "Establishing governance regulations". Later, the result from academics group will be compared with those from the student group and the IT professional group in section 5.7.1.1.4.

Table 5.4. Factor labels of sub-factors for Process (Academics group)

Variables for Academics group	Factor Label	
	1	2
(F) Identifying controls (L) Selecting policies, laws, regulations, and contracts (N) Setting future compliance state (D) Identifying risk (P) Maintaining compliance (H) Planning and scheduling implementation (J) Operating controls (M) Assessing current compliance state (B) Establishing a vision	**Analysing critical risk**	
(A) Establishing assumptions (K) Identifying policies, laws, regulations, and contracts (C) Establishing regulations and standards (G) Analysing controls (Q) Auditing compliance (O) Creating compliance plan (I) Tracking and reporting risks and controls (E) Analysing and prioritizing risks		**Establishing governance regulations**

5.7.1.1.2 Group 2: Student Group

Table 5.5 below indicates the factor loadings, KMO and Bartlett's Test, and scree plot results for student group on "Process". The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's Test, the student group is significant as the value in Bartlett's Test is less than 0.05 and the KMO value is 0.924 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.5. Factor loadings, KMO and scree plot for student group on "Process"

Theme 1: Cloud Governance Main Factor 1: Process Group 2: Student Group			
Variables for Student group	**Factor loadings**		**KMO and Bartlett's Test, and Scree Plot**
	1	2	
(M) Assessing current compliance state	.830	.117	**KMO and Bartlett's Test** Kaiser-Meyer-Olkin Measure of Sampling Adequacy. .924
(O) Creating compliance plan	.736	.300	
(D) Identifying risk	.721	.329	
(K) Identifying policies, laws, regulations, and contracts	.700	.414	

(Q) Auditing compliance	.690	.378
(H) Planning and scheduling implementation	.574	.495
(F) Identifying controls	.574	.439
(J) Operating controls	.527	.461
(A) Establishing assumptions	.513	.486
(C) Establishing regulations and standards	.152	.835
(L) Selecting policies, laws, regulations, and contracts	.337	.724
(N) Setting future compliance state	.225	.706
(E) Analysing and prioritizing risks	.455	.673
(G) Analysing controls	.409	.647
(P) Maintaining compliance	.447	.596
(I) Tracking and reporting risks and controls	.392	.583
(B) Establishing a vision	.447	.449

Bartlett's Test of Sphericity	Approx. Chi-Square	1128.766
	df	136
	Sig.	.000

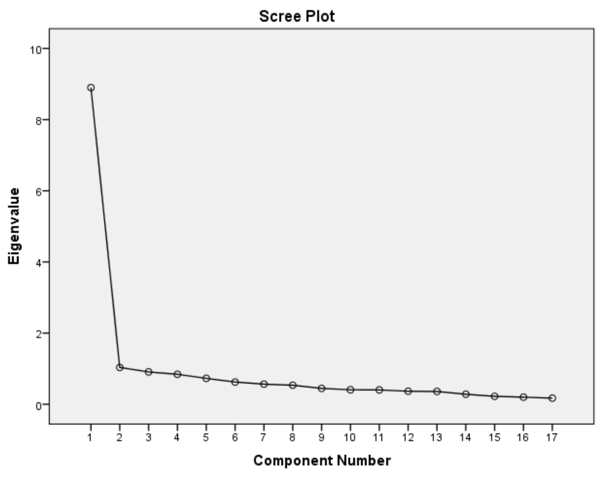


Table 5.6 lists the factor labels of sub-factors for process (student group). The first label is “Assessing and auditing compliance plan” and the second label is “Establishing governance regulations”. The result from student group will be compared with those of the academics group and the IT professional group in section 5.7.1.1.4.

Table 5.6. Factor labels of sub-factors for Process (Academics group)

Variables for Student group	Factor Label 1	Factor Label 2
(M) Assessing current compliance state	**Assessing and auditing compliance plan**	
(O) Creating compliance plan		
(D) Identifying risk		
(K) Identifying policies, laws, regulations, and contracts		
(Q) Auditing compliance		
(H) Planning and scheduling implementation		
(F) Identifying controls		
(J) Operating controls		
(A) Establishing assumptions		
(C) Establishing regulations and standards		**Establishing governance regulations**
(L) Selecting policies, laws, regulations, and contracts		
(N) Setting future compliance state		
(E) Analysing and prioritizing risks		

(G) Analysing controls (P) Maintaining compliance (I) Tracking and reporting risks and controls (B) Establishing a vision		

5.7.1.1.3 Group 3: IT professional group

Table 5.7 illustrates the factor loadings, KMO and Bartlett's Test, and scree plot results for the IT professional group on "Process". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's Test, the IT professional group is significant as the value in Bartlett's Test is less than 0.05 and the KMO value is 0.938 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.7. Factor loadings, KMO and scree plot for IT professional group on "Process"

Theme 1: Cloud Governance Main Factor 1: Process Group 3: IT professional group			
Variables for IT professional group	**Factor loadings**		**KMO and Bartlett's Test, and Scree Plot**
	1	2	
(Q) Auditing compliance	.778	.217	
(J) Operating controls	.690	.249	
(I) Tracking and reporting risks and controls	.672	.280	
(B) Establishing a vision	.639	.291	
(A) Establishing assumptions	.603	.300	
(P) Maintaining compliance	.596	.319	
(H) Planning and scheduling implementation	.584	.396	
(C) Establishing regulations and standards	.527	.477	
(E) Analysing and prioritizing risks	.248	.766	
(M) Assessing current compliance state	.189	.762	
(N) Setting future compliance state	.304	.685	
(L) Selecting policies, laws, regulations, and contracts	.341	.648	
(F) Identifying controls	.341	.619	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.938
Bartlett's Test of Sphericity	Approx. Chi-Square	2100.898
	df	136
	Sig.	.000

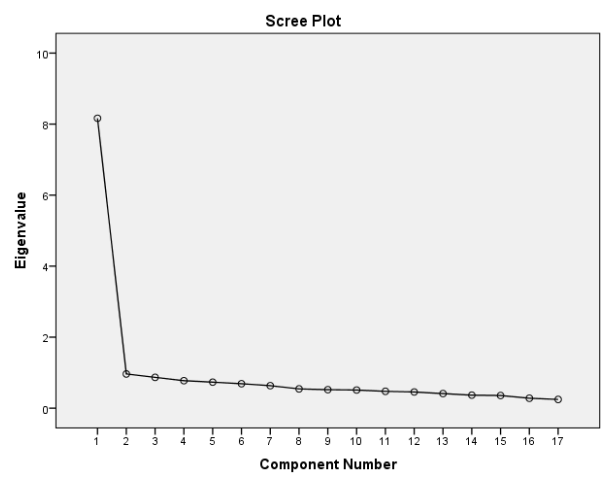
(D) Identifying risk	.451	.594	
(O) Creating compliance plan	.505	.548	
(K) Identifying policies, laws, regulations, and contracts	.501	.544	
(G) Analysing controls	.470	.512	

Table 5.8 shows the factor labels of sub-factors for process (IT professional group). The first label is "Assessing and auditing compliance plan" and the second label is "Analysing critical risk". The result from the IT professional group will be compared with those of the academics group and the student group in section 5.7.1.1.4.

Table 5.8. Factor labels of sub-factors for Process (IT professional group)

Variables for IT professional group	**Factor Label**	
	1	**2**
(Q) Auditing compliance (J) Operating controls (I) Tracking and reporting risks and controls (B) Establishing a vision (A) Establishing assumptions (P) Maintaining compliance (H) Planning and scheduling implementation (C) Establishing regulations and standards	**Assessing and auditing compliance plan**	
(E) Analysing and prioritizing risks (M) Assessing current compliance state (N) Setting future compliance state (L) Selecting policies, laws, regulations, and contracts (F) Identifying controls (D) Identifying risk (O) Creating compliance plan (K) Identifying policies, laws, regulations, and contracts (G) Analysing controls		**Analysing critical risk**

5.7.1.1.4 Summary of sub-factors for Process

Table 5.9 indicates the sub-factors provided by each group. It seems that "Analysing critical risk", "Establishing governance regulations" and "Assessing and auditing compliance plan" are equally important; thus, these sub-factors related to process are included in the final model as shown in Figure 5.28.

Table 5.9. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Analysing critical risk	Establishing governance regulations
Student Group	Assessing and auditing compliance plan	Establishing governance regulations
IT professional group	Assessing and auditing compliance plan	Analysing critical risk

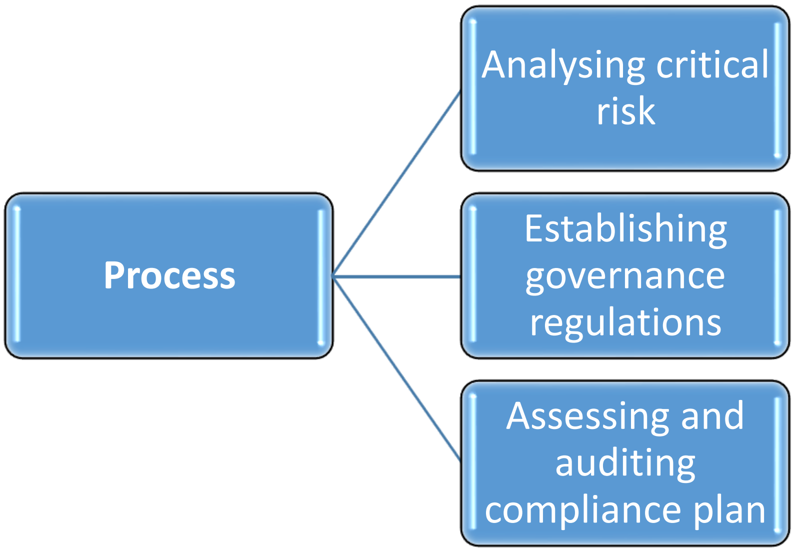


Figure 5.28. Sub-factors of "Process"

5.7.1.2 Factor 2: Policy

In this section, variables related to Policy will be tested in order to extract sub-factors. Data from different groups (academic, students and IT professionals) will be analysed separately and the results will be compared to ascertain whether different groups share the same opinion.

5.7.1.2.1 Group 1: Academics Group

Table 5.10 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for academics group on "Policy". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett's Test is less than 0.05 and the KMO value is 0.761 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.10. Factor loadings, KMO and scree plot for academics group on "Policy"

Theme 1: Cloud Governance Main Factor 2: Policy Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
(B) It is necessary to include 'Policy' factor in the cloud governance	.859	.110
(D) Storage content in cloud	.734	.289
(C) Cloud authorization	.158	.938
(A) Cloud governance strategies	.558	.567

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	111.125
	df	6
	Sig.	.000

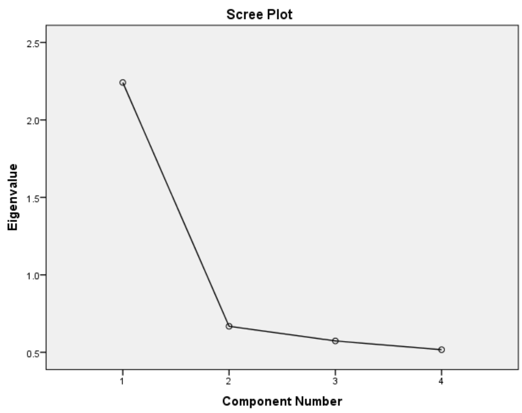


Table 5.11 explains the factor labels of sub-factors for process (academics group). The first label is "Storage content" and the second label is "Governance strategies". The result from the academics group will be compared with those of the IT professional group and student group in section 5.7.1.2.4.

Table 5.11. Factor labels of sub-factors for Policy (academics group)

Variables for academics group	**Factor Label**	
	1	**2**

(B) It is necessary to include 'Policy' factor in the cloud governance (D) Storage content in cloud	**Storage content**	
(C) Cloud authorization (A) Cloud governance strategies		**Governance strategies**

5.7.1.2.2 Group 2: Student Group

Table 5.12 show the factor loadings, KMO and Bartlett's test, and scree plot results for student group on "Policy". The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's Test, the student group is significant as the value in Bartlett's Test is less than 0.05 and the KMO value is 0.776 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.12. Factor loadings, KMO and scree plot for student group on "Policy"

Theme 1: Cloud Governance
Main Factor 2: Policy
Group 2: Student Group

Variables for Student group	**Factor loadings**	
	1	**2**
(B) It is necessary to include 'Policy' factor in the cloud governance	.865	.094
(A) Cloud governance strategies	.764	.358
(C) Cloud authorization	.640	.476
(D) Storage content in cloud	.210	.939

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.776
Bartlett's Test of Sphericity	Approx. Chi-Square	116.963
	df	6
	Sig.	.000

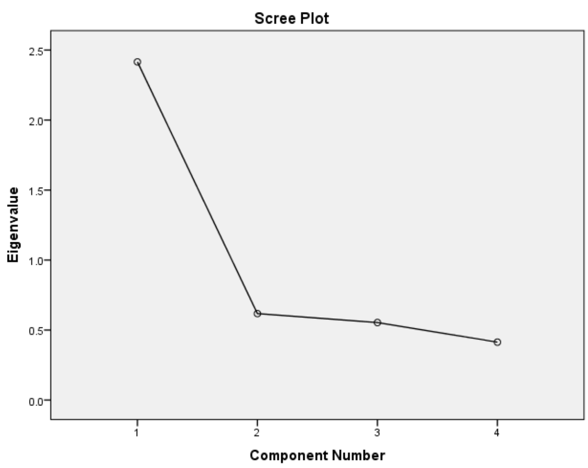


Table 5.13 explains the factor labels of sub-factors for policy (student group). The first label is "Governance strategies" and the second label is "Storage content". The result from student

group will be compared with IT the professionals group and the academics group in section 5.7.1.2.4.

Table 5.13. Factor labels of sub-factors for Policy (student group)

Variables for Student group	Factor Label	
	1	2
(B) It is necessary to include 'Policy' factor in the cloud governance (A) Cloud governance strategies (C) Cloud authorization	**Governance strategies**	
(D) Storage content in cloud		**Storage content**

5.7.1.2.3 Group 3: IT professional group

Table 5.14 indicates the factor loadings, KMO and Bartlett's test, and scree plot results for IT professional group on "Policy". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the IT professional group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.761 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.14. Factor loadings, KMO and scree plot for IT professional group on "Policy"

Theme 1: Cloud Governance Main Factor 2: Policy Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
(A) Cloud governance strategies	.865	.148
(B) It is necessary to include 'Policy' factor in the cloud governance	.728	.328
(C) Cloud authorization	.144	.905
(D) Storage content in cloud	.424	.656

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	189.366
	df	6
	Sig.	.000

Table 5.15 shows the factor labels of sub-factors for policy (IT professional group). The first label is "Governance strategies" and the second label is "Storage content". The result from the IT professional group will be compared with those of the student group and the academics group in section 5.7.1.2.4.

Table 5.15. Factor labels of sub-factors for policy (IT professional group)

Variables for IT professional group	Factor Label	
	1	2
(A) Cloud governance strategies (B) It is necessary to include 'Policy' factor in the cloud governance	**Governance strategies**	
(C) Cloud authorization (D) Storage content in cloud		**Storage content**

5.7.1.2.4 Summary of sub-factors for Policy

Table 5.16 indicates the sub-factors provided by each group. As can be seen, "Governance strategies" and "Storage content" are equally important; thus, these two sub-factors related to policy are included in the final model as shown in Figure 5.29.

Table 5.16. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Storage content	Governance strategies
Student Group	Governance strategies	Storage content
IT professional group	Governance strategies	Storage content

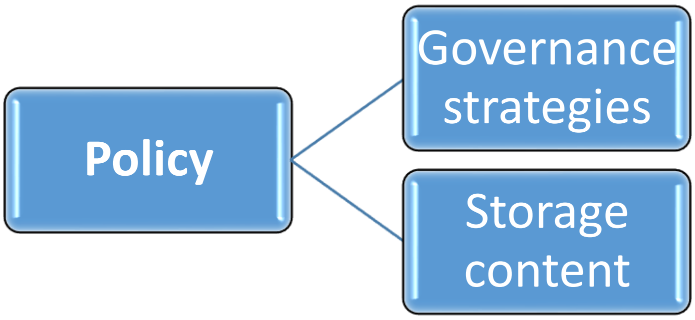


Figure 5.29. Sub-factors of "Policy"

5.7.1.3 Factor 3: Risk Management

In this section, variables related to Risk Management are tested in order to extract sub-factors. Data from different group (academic, students and IT professionals) will be analysed separately and the results will be compared to see if different groups share the same opinion.

5.7.1.3.1 Group 1: Academics Group

Table 5.17 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for academics group on "Risk Management". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.76 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.17. Factor loadings, KMO and scree plot for academics group on "Risk Management"

Theme 1: Cloud Governance Main Factor 3: Risk Management Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
(B) Cloud activities regulation	.836	.175
(D) Risk warning and tracking system	.818	.174
(C) Risk assessment system	.033	.902
(E) It is necessary to include the 'risk management' factor in the cloud governance.	.395	.647
(A) Security	.466	.525

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.760
Bartlett's Test of Sphericity	Approx. Chi-Square	142.102
	df	10
	Sig.	.000

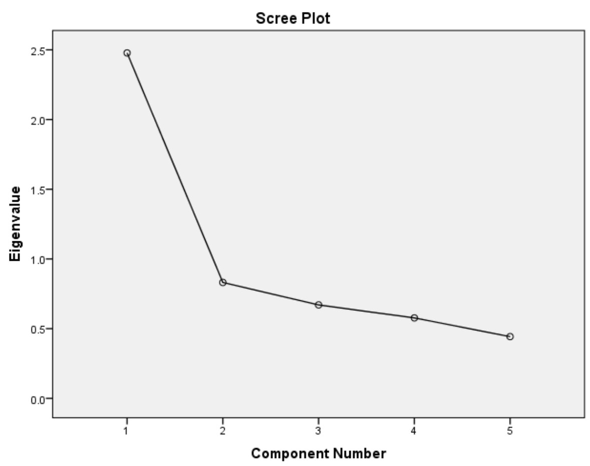


Table 5.18 explains the factor labels of sub-factors for Risk Management (academics group). The first label is "Activities regulation" and the second label is "Assess Risks". The result from academics group will be compared with those of the IT professional group and the student group in section 5.7.1.3.4.

Table 5.18. Factor labels of sub-factors for Risk Management (academics group)

Variables for academics group	Factor Label	
	1	2
(B) Cloud activities regulation (D) Risk warning and tracking system	**Activities regulation**	
(C) Risk assessment system (E) It is necessary to include the 'risk management' factor in the cloud governance. (A) Security		**Assess Risks**

5.7.1.3.2 Group 2: Student Group

Table 5.19 shows the factor loadings, KMO and Bartlett's test, and scree plot results for student group on "Risk Management". The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's test, the student group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.744 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.19. Factor loadings, KMO and scree plot for student group on "Risk Management"

Theme 1: Cloud Governance Main Factor 3: Risk Management Group 2: Student Group		
Variables for Student group	**Factor loadings**	
	1	**2**
(C) Risk assessment system	.915	.068
(A) Security	.780	.346
(E) It is necessary to include the 'risk management' factor in the cloud governance.	.566	.442
(B) Cloud activities regulation	.181	.865
(D) Risk warning and tracking system	.223	.809

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.744
Bartlett's Test of Sphericity	Approx. Chi-Square	159.540
	df	10
	Sig.	.000

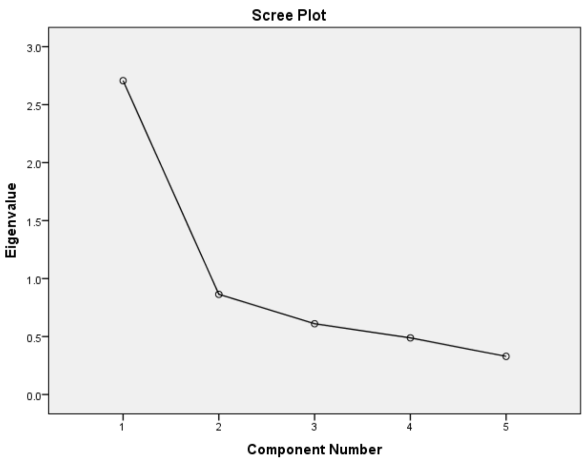


Table 5.20 shows the factor labels of sub-factors for Risk Management (student group). The first label is named "Assess Risks" and the second label is "Activities regulation". The result from the student group will be compared with those of the IT professional group and the academics group in section 5.7.1.3.4.

Table 5.20. Factor labels of sub-factors for Risk Management (student group)

Variables for Student group	**Factor Label**	
	1	**2**
(C) Risk assessment system (A) Security (E) It is necessary to include the 'risk management' factor in the cloud governance.	**Assess Risks**	
(B) Cloud activities regulation (D) Risk warning and tracking system		**Activities regulation**

5.7.1.3.3 Group 3: IT professional group

Table 5.21 lists the factor loadings, KMO and Bartlett's test, and scree plot results for the IT professional group on “Risk Management”. The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the IT professional group is significant as the value derived from Bartlett’s test is less than 0.05 and the KMO value is 0.812 (above 0.6). This confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.21. Factor loadings, KMO and scree plot for IT professional group on “Risk Management”

Theme 1: Cloud Governance
Main Factor 3: Risk Management
Group 3: IT professional group

Variables for IT professional group	Factor loadings	
	1	2
(B) Cloud activities regulation	.859	.129
(D) Risk warning and tracking system	.707	.303
(A) Security	.663	.382
(E) It is necessary to include the ‘risk management’ factor in the cloud governance.	.205	.864
(C) Risk assessment system	.315	.802

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.812
Bartlett's Test of Sphericity	Approx. Chi-Square	338.142
	df	10
	Sig.	.000

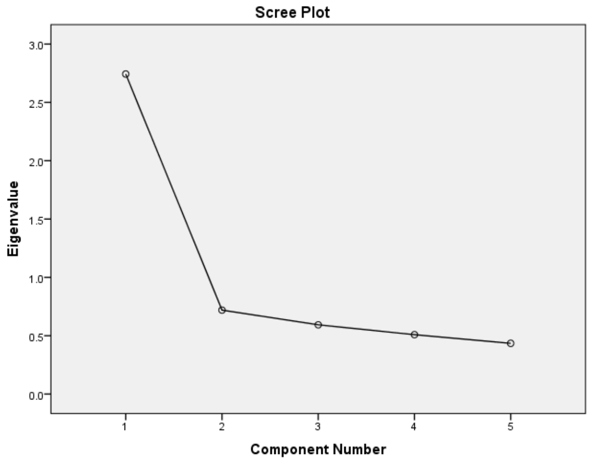


Table 5.22 shows the factor labels of sub-factors for Risk Management (IT professional group). The first label is “Activities regulation” and the second label is “Assess Risks”. The result from the IT professional group will be compared with those from the student group and the academics group in section 5.7.1.3.4.

Table 5.22. Factor labels of sub-factors for Risk Management (IT professional group)

Variables for IT professional group	Factor Label	
	1	2
(B) Cloud activities regulation (D) Risk warning and tracking system (A) Security	**Activities regulation**	
(E) It is necessary to include the 'risk management' factor in the cloud governance. (C) Risk assessment system		**Assess Risks**

5.7.1.3.4 Summary of sub-factors for Risk Management

Table 5.23 indicates the sub-factors provided by each group. As can be seen that "Activities regulation" and "Assess Risks" are equally important; thus, these two sub-factors related to risk management are included in the final model as shown in Figure 5.30.

Table 5. 23 Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Activities regulation	Assess Risks
Student Group	Assess Risks	Activities regulation
IT professional group	Activities regulation	Assess Risks

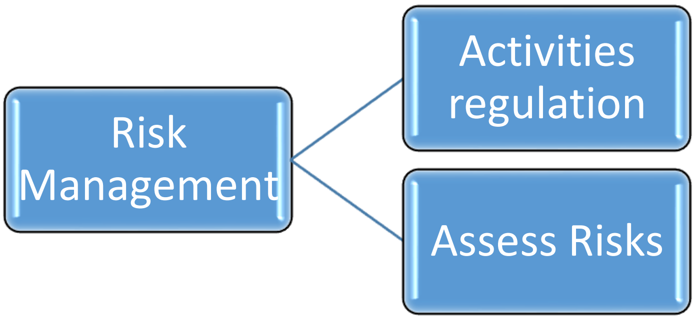


Figure 5.30. Sub-factors of "Risk Management"

5.7.1.4 Factor 4: Resource management

In this section, variables related to resource management will be tested in order to extract sub-factors. Data from three different groups (academic, students and IT professionals) will be analysed separately and the results will be compared to see if the different groups share the same opinion.

5.7.1.4.1 Group 1: Academics Group

Table 5.24 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for academics group on "Resource management". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.794 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.24. Factor loadings, KMO and scree plot for academics group on "Resource management"

Theme 1: Cloud Governance Main Factor 4: Resource management Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
Monitoring resource availability	.838	.211
Resource Regulation	.815	.225
It is necessary to include the 'resource management' factor in the cloud governance	.555	.503
Resource and scalability limits	.173	.860
Quality of service (QoS)	.277	.728

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	176.145
	df	10
	Sig.	.000

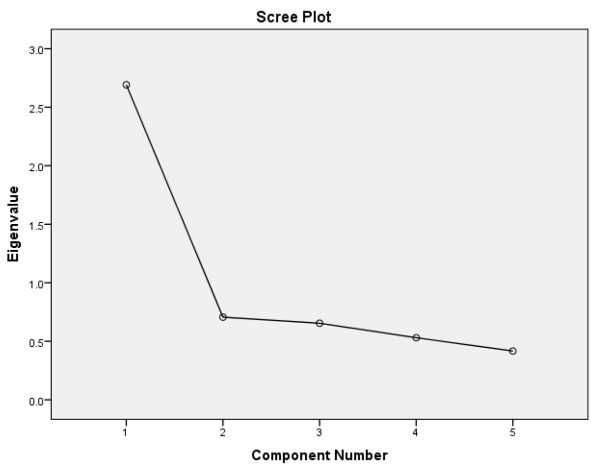


Table 5.25 indicates the factor labels of sub-factors for Resource Management (academics group). The first label is "Resource Control" and the second label is "Resource limits". The result from the academics group will be compared with those of the IT professional group and the student group in section 5.7.1.4.4.

Table 5.25. Factor labels of sub-factors for Resource Management (academics group)

Variables for academics group	Factor Label	
	1	2
Monitoring resource availability Resource Regulation It is necessary to include the 'resource management' factor in the cloud governance	Resource Control	
Resource and scalability limits Quality of service (QoS)		Resource limits

5.7.1.4.2 Group 2: Student Group

Table 5.26 show the factor loadings, KMO and Bartlett's test, and scree plot results for student group on "Resource Management". The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's test, the student group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.747 (above 0.6). This confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.26. Factor loadings, KMO and scree plot for student group on "Resource Management"

Theme 1: Cloud Governance Main Factor 4: Resource Management Group 2: Student Group		
Variables for Student group	Factor loadings	
	1	2
Monitoring resource availability	.917	.098
Resource Regulation	.776	.386
It is necessary to include the 'resource management' factor in the cloud governance	.697	.433
Resource and scalability limits	.206	.878
Quality of service (QoS)	.263	.764

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.747
Bartlett's Test of Sphericity	Approx. Chi-Square	208.216
	df	10
	Sig.	.000

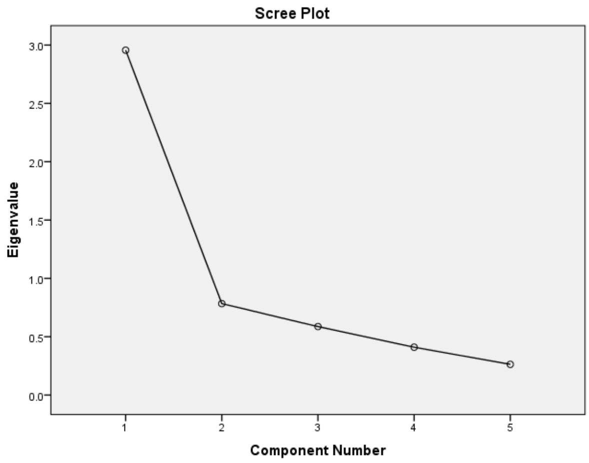


Table 5.27 explains the factor labels of sub-factors for Resource Management (student group). The first label is "Resource Control" and the second label is "Resource limits". The result from the student group will be compared with those of the IT professional group and the academics group in section 5.7.1.4.4.

Table 5.27. Factor labels of sub-factors for Resource Management (student group)

Variables for Student group	Factor Label	
	1	2
Monitoring resource availability Resource Regulation It is necessary to include the 'resource management' factor in the cloud governance	**Resource Control**	
Resource and scalability limits Quality of service (QoS)		**Resource limits**

5.7.1.4.3 Group 3: IT professional group

Table 5.28 show the factor loadings, KMO and Bartlett's test, and scree plot results for IT professional group on "Resource Management". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the IT professional group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.814 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.28. Factor loadings, KMO and scree plot for IT professional group on "Resource Management"

Theme 1: Cloud Governance Main Factor 4: Resource Management Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
Quality of service (QoS)	.806	.206
Resource and scalability limits	.778	.207
It is necessary to include the 'resource management' factor in the cloud governance	.557	.514
Monitoring resource availability	.149	.863
Resource Regulation	.317	.739

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.814
Bartlett's Test of Sphericity	Approx. Chi-Square	295.153
	df	10
	Sig.	.000

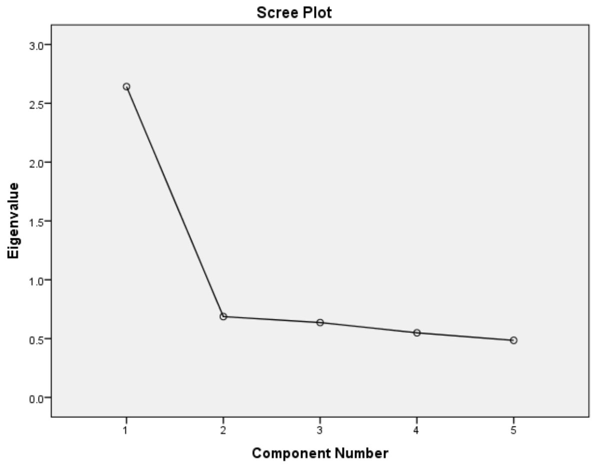


Table 5.29 shows the factor labels of sub-factors for Resource Management (IT professional group). The first label is "Resource limits" and the second label is "Resource Control". The result from the IT professional group will be compared with those of the student group and the academics group in section 5.7.1.4.4.

Table 5.29. Factor labels of sub-factors for Resource Management (IT professional group)

Variables for IT professional group	**Factor Label**	
	1	**2**
Quality of service (QoS) Resource and scalability limits It is necessary to include the 'resource management' factor in the cloud governance	**Resource limits**	
Monitoring resource availability Resource Regulation		**Resource Control**

5.7.1.4.4 Summary of sub-factors for Resource Management

Table 5.30 presents the sub-factors provided by each group. As can be seen, "Resource Control" and "Resource limits" are equally important; thus, these two sub-factors related to Resource Management are included in the final model as shown in Figure 5.31.

Table 5.30. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Resource Control	Resource limits
Student Group	Resource Control	Resource limits
IT professional group	Resource limits	Resource Control

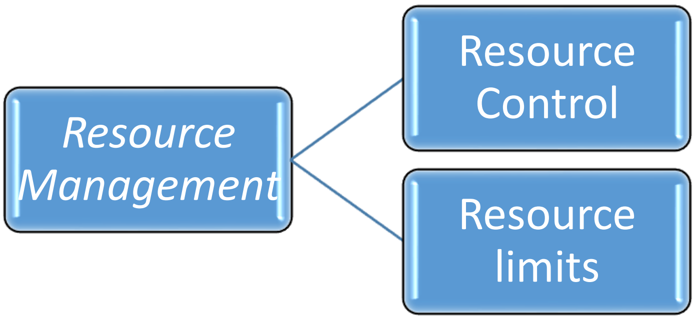


Figure 5.31. Sub-factors of "Resource Management"

5.7.2 Theme 2: Operations Management

The second theme is Operations Management, which consists of four main factors: data management, energy consumption, capacity management and virtualization as indicated in Figure 5.1. However, as the data management and energy consumption concepts are too broad, the scope of these two factors has been narrowed down by combining them together to a more specific factor: Energy-efficient data management. Hence, the sub-factors related to data management and energy consumption will be analyzed together as indicated in section 5.7.2.1.

5.7.2.1 Factor 1: Energy-efficient data management

In this section, variables related to the data management and energy consumption will be evaluated in order to obtain sub-factors. Data from three groups (academics, students and IT professionals) will be analysed separately and the results will be compared to ascertain whether different groups share the same opinion.

5.7.2.1.1 Group 1: Academics Group

Table 5.31 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for the academics group on "energy-efficient data management". The factor loadings in the component matrix indicate that two factors are obtained. In the KMO and Bartlett's test, the academics group is significant as the value obtained by Bartlett's test is less than 0.05 and the KMO value is 0.757 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.31. Factor loadings, KMO and scree plot for academics group on "Energy-efficient data management"

Theme 2: Operations Management Main Factor 1: Energy-efficient data management Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
Cloud technology will reduce energy consumption.	.810	.230
Authorization and identity should be specified in data management operations.	.809	.280
It is necessary to include the 'data management' factor in operations management.	.763	.176
It is necessary to include the 'energy consumption' factor in operations management	.733	.235
The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution.	.205	.886
Cloud technology is now more secure than before in terms of data protection.	.307	.838

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.757
Bartlett's Test of Sphericity	Approx. Chi-Square	342.671
	df	15
	Sig.	.000

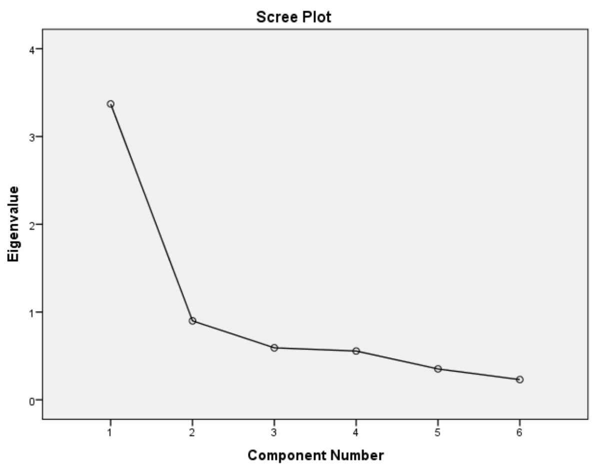


Table 5.32 indicates the factor labels of sub-factors for energy-efficient data management (academics group). The first label is "Authentication and Authorization" and the second label

is “Energy Optimization”. The result from the academics group will be compared with the IT professional group and student group in section 5.7.2.1.4.

Table 5.32. Factor labels of sub-factors for energy-efficient data management (academics group)

Variables for academics group	Factor Label 1	Factor Label 2
Cloud technology will reduce energy consumption. Authorization and identity should be specified in data management operations. It is necessary to include the ‘data management’ factor in operations management. It is necessary to include the ‘energy consumption’ factor in operations management	**Authentication and Authorization**	
The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution. Cloud technology is now more secure than before in terms of data protection.		**Energy Optimization**

5.7.2.1.2 Group 2: Student Group

Table 5.33 show the factor loadings, KMO and Bartlett's test, and scree plot results for student group on “energy-efficient data management”. The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's test, the student group is significant as the value in Bartlett’s test is less than 0.05 and the KMO value is 0.795 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.33. Factor loadings, KMO and scree plot for student group on “energy-efficient data management”

Theme 2: Operations Management Main Factor 1: Energy-efficient data management Group 2: Student Group		
Variables for Student group	**Factor loadings 1**	**Factor loadings 2**
It is necessary to include the ‘energy consumption’ factor in operations management	.835	.085
Authorization and identity should be specified in data management operations.	.819	.353
It is necessary to include the ‘data management’ factor in operations management.	.798	.289
Cloud technology will reduce energy consumption.	.783	.386
The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution.	.246	.863

Cloud technology is now more secure than before in terms of data protection.	.246	.842

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.795
Bartlett's Test of Sphericity	Approx. Chi-Square	347.383
	df	15
	Sig.	.000

Table 5.34 explains the factor labels of sub-factors for Energy-efficient data management (student group). The first label is “Authentication and Authorization” and the second label is “Energy Optimization”. The result from the student group will be compared with the IT professional group and academics group in section 5.7.2.1.4.

Table 5.34. Factor labels of sub-factors for energy-efficient data management (student group)

Variables for Student group	Factor Label 1	Factor Label 2
It is necessary to include the ‘energy consumption’ factor in operations management	**Authentication and Authorization**	
Authorization and identity should be specified in data management operations.		
It is necessary to include the ‘data management’ factor in operations management.		
Cloud technology will reduce energy consumption.		
The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution.		**Energy Optimization**
Cloud technology is now more secure than before in terms of data protection.		

5.7.2.1.3 Group 3: IT professional group

Table 5.35 indicates the factor loadings, KMO and Bartlett's test, and scree plot results for the IT professional group on “Energy-efficient data management”. The factor loadings in the component matrix indicate that two factors are obtained. The KMO and Bartlett's test indicate that the IT professional group is significant as the value in Bartlett’s test is less than 0.05 and the KMO value is 0.732 (above 0.6). This confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.35. Factor loadings, KMO and scree plot for IT professional group on "energy-efficient data management"

Theme 2: Operations Management Main Factor 1: Energy-efficient data management Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
Cloud technology is now more secure than before in terms of data protection.	.860	.099
The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution.	.813	.199
It is necessary to include the 'energy consumption' factor in operations management	.635	.358
It is necessary to include the 'data management' factor in operations management.	.567	.463
Authorization and identity should be specified in data management operations.	.221	.906
Cloud technology will reduce energy consumption.	.215	.901

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.732
Bartlett's Test of Sphericity	Approx. Chi-Square	653.748
	df	15
	Sig.	.000

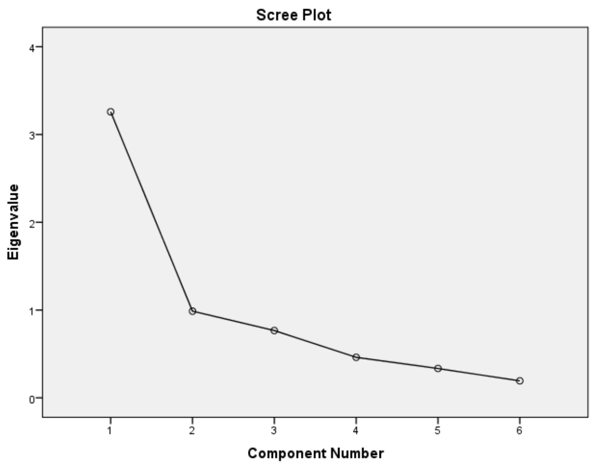


Table 5.36 shows the factor labels of sub-factors for energy-efficient data management (IT professional group). The first label is "Energy Optimization" and the second label is "Authentication and Authorization". The results from IT professional group will be compared with the student group and academics group in section 5.7.2.1.4.

Table 5.36. Factor labels of sub-factors for energy-efficient data management (IT professional group)

Variables for IT professional group	**Factor Label**	
	1	**2**

Cloud technology is now more secure than before in terms of data protection. The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution. It is necessary to include the 'energy consumption' factor in operations management It is necessary to include the 'data management' factor in operations management.	**Energy Optimization**	
Authorization and identity should be specified in data management operations. Cloud technology will reduce energy consumption.		**Authentication and Authorization**

5.7.2.1.4 Summary of sub-factors for Energy-Efficient Data Management

Table 5.37 indicates the sub-factors provided by each group. As can be seen, "Authentication and Authorization" and "Energy Optimization" are equally important; thus, these two sub-factors related to Energy-Efficient Data Management are included in the final model as shown in Figure 5.32.

Table 5.37. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Authentication and Authorization	Energy Optimization
Student Group	Authentication and Authorization	Energy Optimization
IT professional group	Energy Optimization	Authentication and Authorization

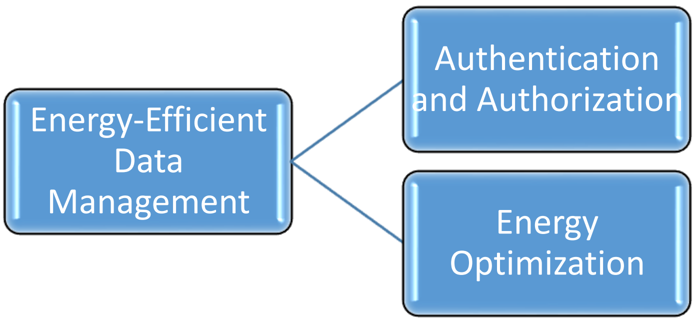


Figure 5. 32 Sub-factors of "Energy-Efficient Data Management"

5.7.2.2 Factor 2: Capacity Management

In this section, variables related to the Capacity Management will be evaluated in order to obtain sub-factors. Data from three groups (academic, students and IT professionals) will be analysed separately and the results will be compared to determine whether different groups share the same opinion.

5.7.2.2.1 Group 1: Academics Group

Table 5.38 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for the academics group on "Capacity Management". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.761 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.38. Factor loadings, KMO and scree plot for academics group on "Capacity Management"

Theme 2: Operations Management
Main Factor 2: Capacity Management
Group 1: Academics Group

Variables for academics group	Factor loadings	
	1	2
(C) Load balancing	.850	.058
(A) Flexibility and scalability	.772	.300
(E) It is necessary to include 'capacity management' factor in operations management	.652	.311
(D) Bandwidth	.127	.888
(B) Capacity allocation	.330	.800

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.761
Bartlett's Test of Sphericity	Approx. Chi-Square	174.828
	df	10
	Sig.	.000

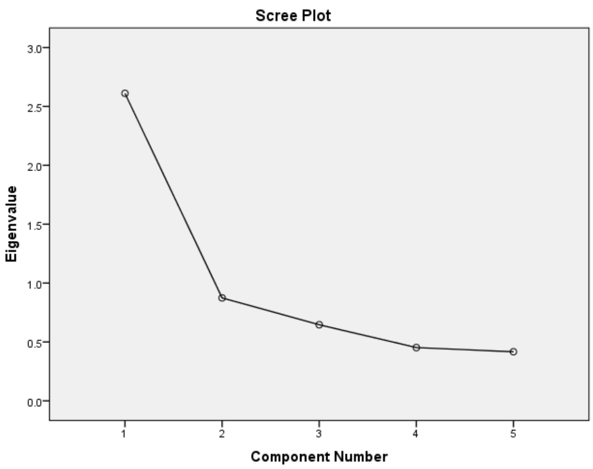


Table 5.39 indicates the factor labels of sub-factors for Capacity Management (academics group). The first label is "Scalability" and the second label is "Bandwidth and capacity control". The result from academics group will be compared with the IT professional group and student group in section 5.7.2.2.4.

Table 5.39. Factor labels of sub-factors for Capacity Management (academics group)

Variables for academics group	Factor Label	
	1	2
(C) Load balancing (A) Flexibility and scalability (E) It is necessary to include ‘capacity management’ factor in operations management	Scalability	
(D) Bandwidth (B) Capacity allocation		Bandwidth and capacity control

5.7.2.2.2 Group 2: Student Group

Table 5.40 shows the factor loadings, KMO and Bartlett's test, and scree plot results for the student group on “Capacity Management”. The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's test, the student group is significant as the value in Bartlett’s test is less than 0.05 and the KMO value is 0.721 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.40. Factor loadings, KMO and scree plot for student group on “Capacity Management”

Theme 2: Operations Management Main Factor 2: Capacity Management Group 2: Student Group		
Variables for Student group	Factor loadings	
	1	2
(C) Load balancing	.872	.123
(A) Flexibility and scalability	.850	.194
(E) It is necessary to include ‘capacity management’ factor in operations management	.681	.379
(B) Capacity allocation	.207	.877
(D) Bandwidth	.204	.844

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.721
Bartlett's Test of Sphericity	Approx. Chi-Square	180.861
	df	10
	Sig.	.000

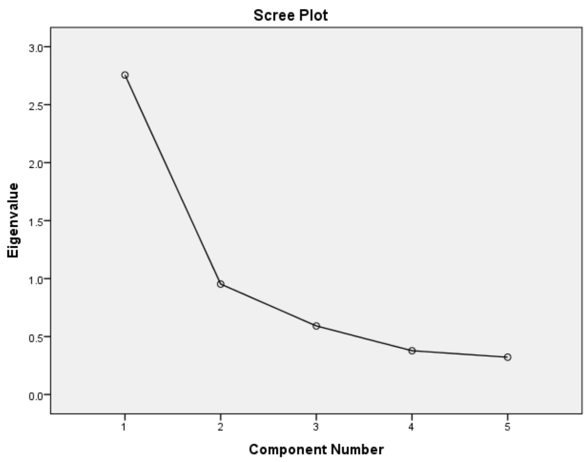


Table 5.41 lists the labels of sub-factors for Capacity Management (student group). The first label is “Scalability” and the second label is “Bandwidth and capacity control”. The result from the student group will be compared with those of the IT professional group and academics group in section 5.7.2.2.4.

Table 5.41. Factor labels of sub-factors for Capacity Management (student group)

Variables for Student group	Factor Label	
	1	2
(C) Load balancing (A) Flexibility and scalability (E) It is necessary to include ‘capacity management’ factor in operations management	**Scalability**	
(B) Capacity allocation (D) Bandwidth		**Bandwidth and capacity control**

5.7.2.2.3 Group 3: IT professional group

Table 5.42 indicates the factor loadings, KMO and Bartlett's test, and scree plot results for IT the professionals group on “Capacity Management”. The factor loadings in the component matrix indicate that two factors are obtained. In the KMO and Bartlett's test, the IT professional group is significant as the value obtained by Bartlett’s test is less than 0.05 and the KMO value is 0.816 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.42. Factor loadings, KMO and scree plot for IT professional group on “Capacity Management”

Theme 2: Operations Management Main Factor 2: Capacity Management Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
(A) Flexibility and scalability	.800	.140
(E) It is necessary to include 'capacity management' factor in operations management	.721	.272
(C) Load balancing	.711	.332
(D) Bandwidth	.221	.825
(B) Capacity allocation	.265	.775

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.816
Bartlett's Test of Sphericity	Approx. Chi-Square	270.694
	df	10
	Sig.	.000

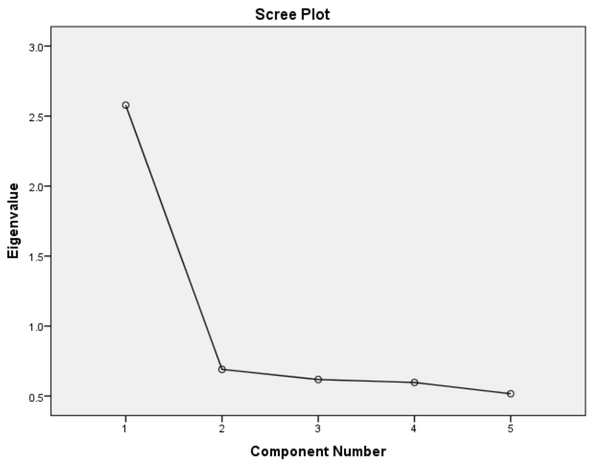


Table 5.43 shows the factor labels of sub-factors for Capacity Management (IT professional group). The first label is "Scalability" and the second label is "Bandwidth and capacity control". The result from the IT professional group will be compared with those of the student group and academics group in section 5.7.2.2.4.

Table 5.43. Factor labels of sub-factors for Capacity Management (IT professional group)

Variables for IT professional group	**Factor Label**	
	1	**2**
(A) Flexibility and scalability (E) It is necessary to include 'capacity management' factor in operations management (C) Load balancing	**Scalability**	
(D) Bandwidth (B) Capacity allocation		**Bandwidth and capacity control**

5.7.2.2.4 Summary of sub-factors for Capacity Management

Table 5.44 presents the sub-factors provided by each group. As can be seen, "Bandwidth and capacity control" and "Scalability" are equally important; thus, these two sub-factors related to Capacity Management are included in the final model as shown in Figure 5.33.

Table 5.44. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Bandwidth and capacity control	Scalability
Student Group	Scalability	Bandwidth and capacity control
IT professional group	Scalability	Bandwidth and capacity control

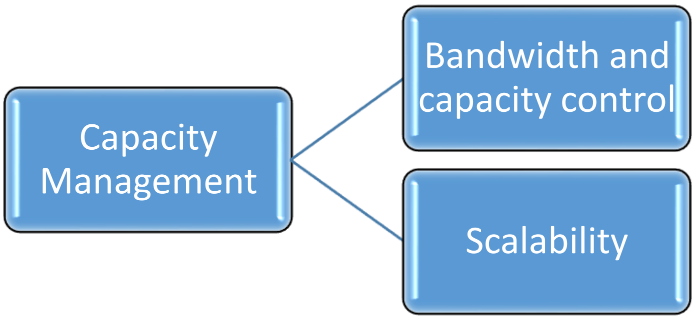


Figure 5.33. Sub-factors of "Capacity Management"

5.7.2.3 Factor 3: Virtualization

In this section, the variables related to Virtualization will be evaluated in order to obtain sub-factors. Data from three different groups (academic, students and IT professionals) will be analysed separately and the results will be compared to see if these groups share the same opinion.

5.7.2.3.1 Group 1: Academics Group

Table 5.45 below shows the factor loadings, KMO and Bartlett's test, and scree plot results for the academics group on "Virtualization". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.938 (above 0.6). This confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.45. Factor loadings, KMO and scree plot for academics group on "Virtualization"

Theme 2: Operations Management Main Factor 3: Virtualization Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
(H) Provides safe backup	.749	.204
(A) Decreases hardware costs	.717	.305
(C) Decreases maintenance costs	.697	.356
(L) It is necessary to include the 'virtualization' factor in operations management	.683	.246
(B) Decreases license costs	.648	.410
(K) Has positive effects on the environment	.229	.771
(G) Reduces redundancy	.179	.724
(F) Provides better security	.432	.637
(D) Offers better performance	.352	.625
(E) Improves scalability	.360	.621
(J) Simplifies deployment	.524	.557
(I) Simplifies development	.506	.527

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.938
Bartlett's Test of Sphericity	Approx. Chi-Square	730.142
	df	66
	Sig.	.000

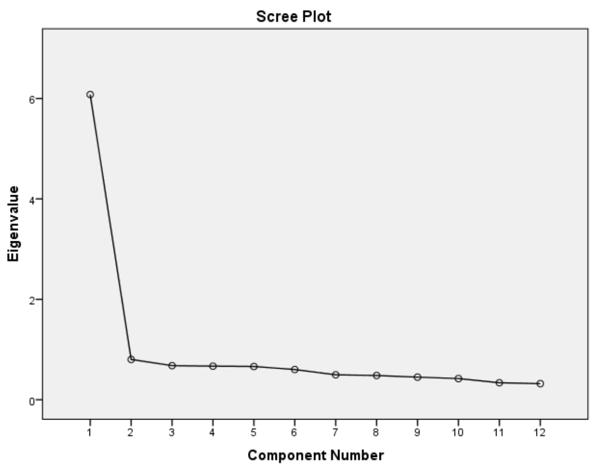


Table 5.39 indicates the factor labels of sub-factors for Virtualization (academics group). The first label is "Economise on hardware, software and maintenance" and the second label is "Better performance". The result from academics group will be compared with that for the IT professional group and student group in section 5.7.2.3.4.

Table 5.46. Factor labels of sub-factors for Virtualization (academics group)

Variables for academics group	Factor Label	
	1	2
(H) Provides safe backup (A) Decreases hardware costs (C) Decreases maintenance costs (L) It is necessary to include the 'virtualization' factor in operations management (B) Decreases license costs	**Economise on hardware, software and maintenance**	
(K) Has positive effects on the environment (G) Reduces redundancy (F) Provides better security (D) Offers better performance (E) Improves scalability (J) Simplifies deployment (I) Simplifies development		**Better performance**

5.7.2.3.2 Group 2: Student Group

Table 5.47 shows the factor loadings, KMO and Bartlett's test, and scree plot results for the student group on "Virtualization". The factor loadings in the component matrix indicate that two factors are extracted. In KMO and Bartlett's test, the student group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.89 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.47. Factor loadings, KMO and scree plot for student group on "Virtualization"

Theme 2: Operations Management Main Factor 3: Virtualization Group 2: Student Group		
Variables for Student group	Factor loadings	
	1	2
(D) Offers better performance	.905	.088
(I) Simplifies development	.724	.316
(L) It is necessary to include the 'virtualization' factor in operations management	.679	.449
(B) Decreases license costs	.593	.449
(A) Decreases hardware costs	.561	.551
(J) Simplifies deployment	.510	.484
(C) Decreases maintenance costs	.131	.830

(K) Has positive effects on the environment	.261	.802
(E) Improves scalability	.466	.646
(G) Reduces redundancy	.413	.599
(F) Provides better security	.516	.538
(H) Provides safe backup	.482	.482

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.890
Bartlett's Test of Sphericity	Approx. Chi-Square	740.304
	df	66
	Sig.	.000

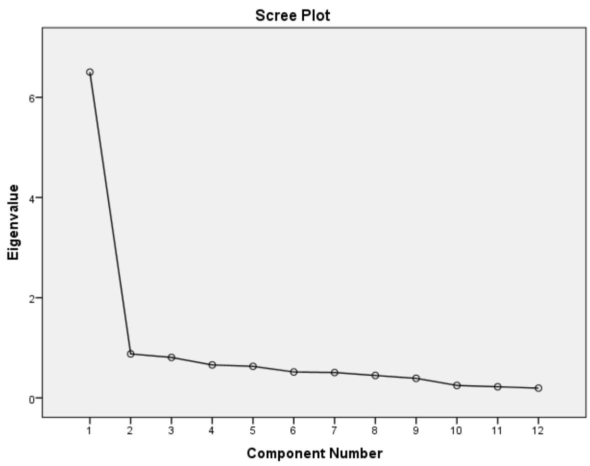


Table 5.48 explains the factor labels of sub-factors for Virtualization (student group). The first label is “Better performance” and the second label is “Economise on hardware, software and maintenance”. The result from the student group will be compared with IT professional group and academics group in section 5.7.2.3.4.

Table 5.48. Factor labels of sub-factors for Virtualization (student group)

Variables for Student group	Factor Label 1	Factor Label 2
(D) Offers better performance	Better performance	
(I) Simplifies development		
(L) It is necessary to include the ‘virtualization’ factor in operations management		
(B) Decreases license costs		
(A) Decreases hardware costs		
(J) Simplifies deployment		
(C) Decreases maintenance costs		Economise on hardware, software and maintenance
(K) Has positive effects on the environment		
(E) Improves scalability		
(G) Reduces redundancy		
(F) Provides better security		

(H) Provides safe backup		

5.7.2.3.3 Group 3: IT professional group

Table 5.49 indicates the factor loadings, KMO and Bartlett's test, and scree plot results for the IT professional group for "Virtualization". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the IT professional group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.936 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5. 49 Factor loadings, KMO and scree plot for IT professional group on "Virtualization"

Theme 2: Operations Management Main Factor 3: Virtualization Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
(D) Offers better performance	.775	.178
(L) It is necessary to include the 'virtualization' factor in operations management	.773	.261
(E) Improves scalability	.760	.270
(F) Provides better security	.716	.288
(K) Has positive effects on the environment	.699	.326
(C) Decreases maintenance costs	.589	.486
(G) Reduces redundancy	.510	.497
(I) Simplifies development	.154	.806
(A) Decreases hardware costs	.185	.776
(H) Provides safe backup	.357	.641
(B) Decreases license costs	.449	.620
(J) Simplifies deployment	.388	.595

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.936
Bartlett's Test of Sphericity	Approx. Chi-Square	1437.075
	df	66
	Sig.	.000

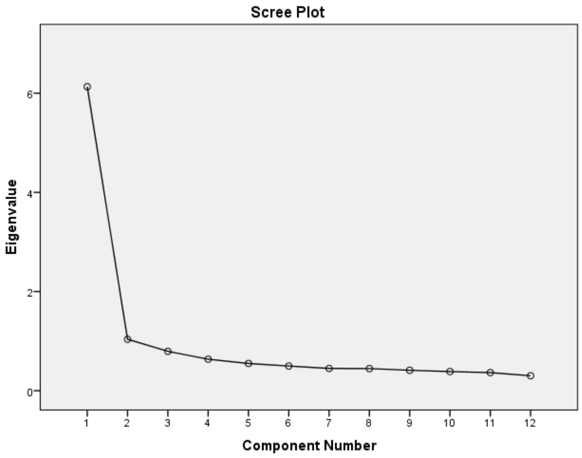


Table 5.50 shows the factor labels of sub-factors for Virtualization (IT professional group). The first label is summarised as “Better performance” and the second label is “Economise on hardware, software and maintenance”. The result from IT professional group will be compared with student group and academics group in section 5.7.2.3.4.

Table 5.50. Factor labels of sub-factors for Virtualization (IT professional group)

Variables for IT professional group	Factor Label 1	Factor Label 2
(D) Offers better performance	**Better performance**	
(L) It is necessary to include the ‘virtualization’ factor in operations management		
(E) Improves scalability		
(F) Provides better security		
(K) Has positive effects on the environment		
(C) Decreases maintenance costs		
(G) Reduces redundancy		
(I) Simplifies development		**Economise on hardware, software and maintenance**
(A) Decreases hardware costs		
(H) Provides safe backup		
(B) Decreases license costs		
(J) Simplifies deployment		

5.7.2.3.4 Summary of sub-factors for Virtualization

Table 5.51 presents the sub-factors provided by each group. As can be seen, “Economise on hardware, software and maintenance” and “Better performance” are equally important; thus, these two sub-factors related to Virtualization are included in the final model as shown in Figure 5.34.

Table 5.51. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Economise on hardware, software and maintenance	Better performance
Student Group	Better performance	Economise on hardware, software and maintenance
IT professional group	Better performance	Economise on hardware, software and maintenance

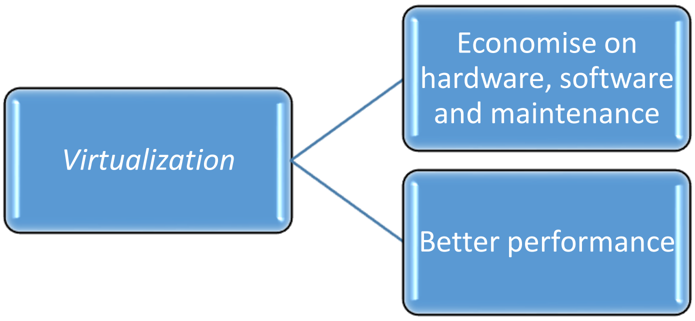


Figure 5.34. Sub-factors of "Virtualization"

5.7.3 Theme 3: Sustainability

The third theme is Sustainability, which contains three main factors: Social Responsibility, Economy, and Environment as indicated in Figure 5.1.

5.7.3.1 Factor 1: Social Responsibility

In this section, variables related to the Social Responsibility factor will be evaluated in order to obtain sub-factors. Data from different groups (academic, students and IT professionals) will be analysed separately and the results will be compared to determine whether different groups share the same opinion.

5.7.3.1.1 Group 1: Academics Group

Table 5.52 below lists the factor loadings, KMO and Bartlett's test, and scree plot results for academics group on "Social Responsibility". The factor loadings in the component matrix indicate that two factors are obtained. In the KMO and Bartlett's test, the academics group is significant as the value in Bartlett's test is less than 0.05 and the KMO value is 0.756 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.52. Factor loadings, KMO and scree plot for academics group on "Social Responsibility"

Theme 3: Sustainability
Main Factor 1: Social Responsibility
Group 1: Academics Group

Variables for academics group	Factor loadings	
	1	2
Lack of support from professional organizations	.862	.206
Lack of Corporation Social Responsibility (CSR) awareness	.814	.288
Budget constraints	.168	.882
Not required by headquarters	.352	.740

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.756
Bartlett's Test of Sphericity	Approx. Chi-Square	129.735
	df	6
	Sig.	.000

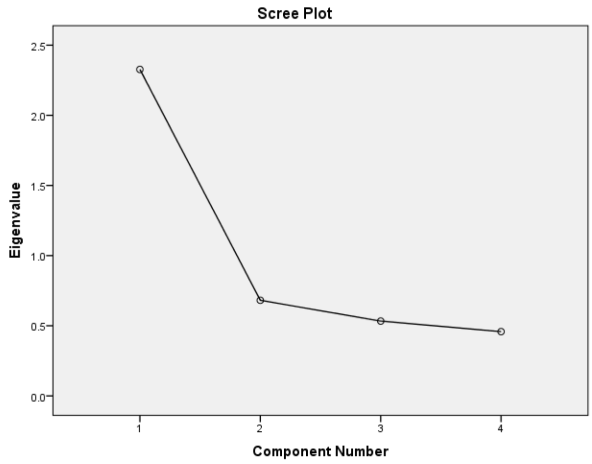


Table 5.53 indicates the factor labels of sub-factors for Social Responsibility (academics group). The first label is "CSR awareness" and the second label is "Budget constrains". The result from academics group will be compared with the IT professional group and student group in section 5.7.3.1.4.

Table 5.53. Factor labels of sub-factors for Social Responsibility (academics group)

Variables for academics group	Factor Label	
	1	2
Lack of support from professional organizations Lack of Corporation Social Responsibility (CSR) awareness	**CSR awareness**	
Budget constraints Not required by headquarters		**Budget constrains**

5.7.3.1.2 Group 2: Student Group

Table 5.54 below indicates the factor loadings, KMO and Bartlett's test, and scree plot results for the student group on “Social Responsibility”. The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the student group is significant as the value derived from Bartlett’s test is less than 0.05 and the KMO value is 0.744 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.54. Factor loadings, KMO and scree plot for Student group on “Social Responsibility”

Theme 3: Sustainability Main Factor 1: Social Responsibility Group 2: Student Group		
Variables for Student group	**Factor loadings**	
	1	**2**
Budget constraints	.864	.221
Not required by headquarters	.817	.300
Lack of Corporation Social Responsibility (CSR) awareness	.232	.849
Lack of support from professional organizations	.281	.822

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.744
Bartlett's Test of Sphericity	Approx. Chi-Square	118.126
	df	6
	Sig.	.000

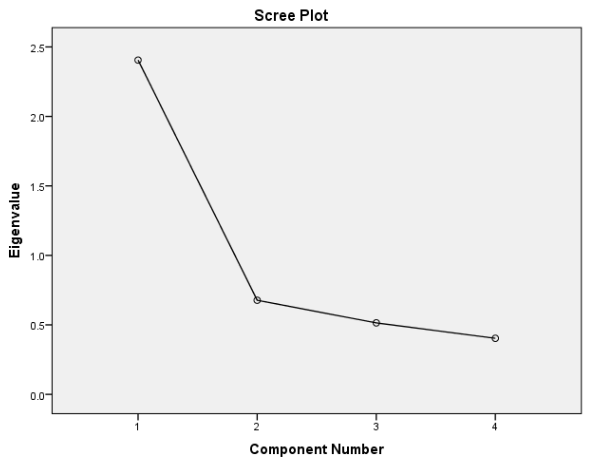


Table 5.55 presents the factor labels of sub-factors for Social Responsibility (Student Group). The first label is “Budget constraints” and the second label is “CSR awareness”. The result from the student group will be compared with that of the h IT professional group and academics group in section 5.7.3.1.4.

Table 5.55. Factor labels of sub-factors for Social Responsibility (Student Group)

Variables for Student Group	Factor Label	
	1	2
Budget constraints Not required by headquarters	**Budget constrains**	
Lack of Corporation Social Responsibility (CSR) awareness Not required by headquarters		**CSR awareness**

5.7.3.1.3 Group 3: IT professional group

Table 5.56 below presents the factor loadings, KMO and Bartlett's test, and scree plot results for IT professional group on "Social Responsibility". The factor loadings in the component matrix indicate that two factors have been obtained. In KMO and Bartlett's test, the IT professional group is significant as the value derived by Bartlett's test is less than 0.05 and the KMO value is 0.746 (above 0.6). This confirms that the variables are significantly correlated. Thus, the data set from this group is suitable for factor analysis.

Table 5.56. Factor loadings, KMO and scree plot for IT professional group on "Social Responsibility"

Theme 3: Sustainability Main Factor 1: Social Responsibility Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
Lack of support from professional organizations	.835	.204
Not required by headquarters	.813	.251
Lack of Corporation Social Responsibility (CSR) awareness	.150	.892
Budget constraints	.360	.750

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.746
Bartlett's Test of Sphericity	Approx. Chi-Square	216.796
	df	6
	Sig.	.000

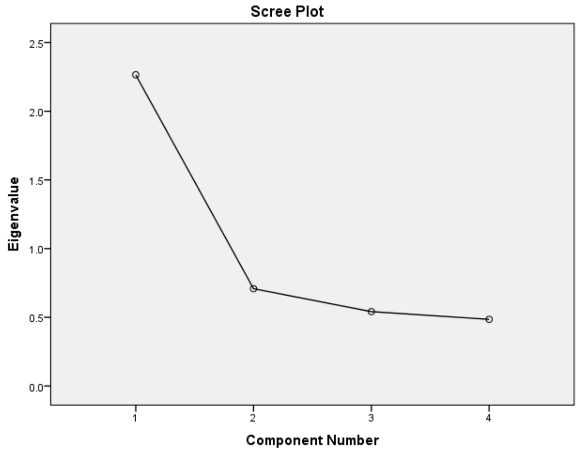


Table 5.57 shows the factor labels for the Social Responsibility sub-factors (IT professional group). The first label is “Lack of support” and the second is “CSR awareness”. The result from the IT professional group will be compared with those of the student group and academics group in section 5.7.3.1.4.

Table 5.57. Factor labels of sub-factors for Social Responsibility (IT professional group)

Variables for IT professional group	Factor Label	
	1	2
Lack of support from professional organizations Not required by headquarters	**Lack of support**	
Lack of Corporation Social Responsibility (CSR) awareness Budget constraints		**CSR awareness**

5.7.3.1.4 Summary of sub-factors for Social Responsibility

Table 5.58 lists the sub-factors provided by each group. As can be seen, “CSR awareness” and “Budget constraints” are repeated multiple times in the table; thus, these two sub-factors related to Social Responsibility are included in the final model as shown in Figure 5.35.

Table 5.58. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	CSR awareness	Budget constrains
Student Group	Budget constrains	CSR awareness
IT professional group	Lack of support	CSR awareness

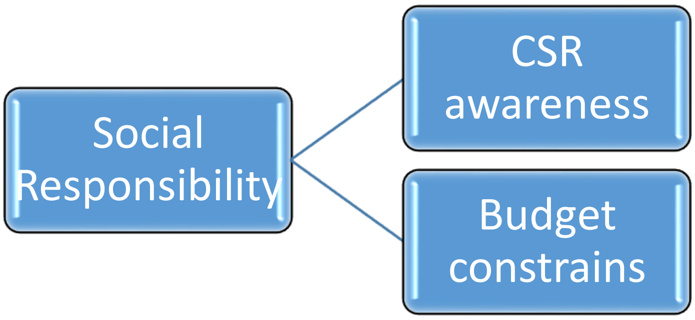


Figure 5.35. Sub-factors of "Social Responsibility"

5.7.3.2 Factor 2: Economy

Due to the design issue, online survey questions related to "Economy" did not require responses using the 5-point Likert scale. Therefore, instead of using SPSS factor analysis, frequency analysis was applied to determine the sub-factors related to Economy.

As indicated in Figure 5.36 below, when the participants are asked if they believe that sustainable operation activities would help a company to build a better brand image, the majority agree. Specifically, 65% from the Academics Group, 76% from the Student Group and 63.4% from the IT professional group agree that sustainable operations produce a better brand image. Subsequently, this would contribute to the economic development of the organisation. Therefore, "Sustainable Operation Activities" would be one of the sub-factors for Economy.

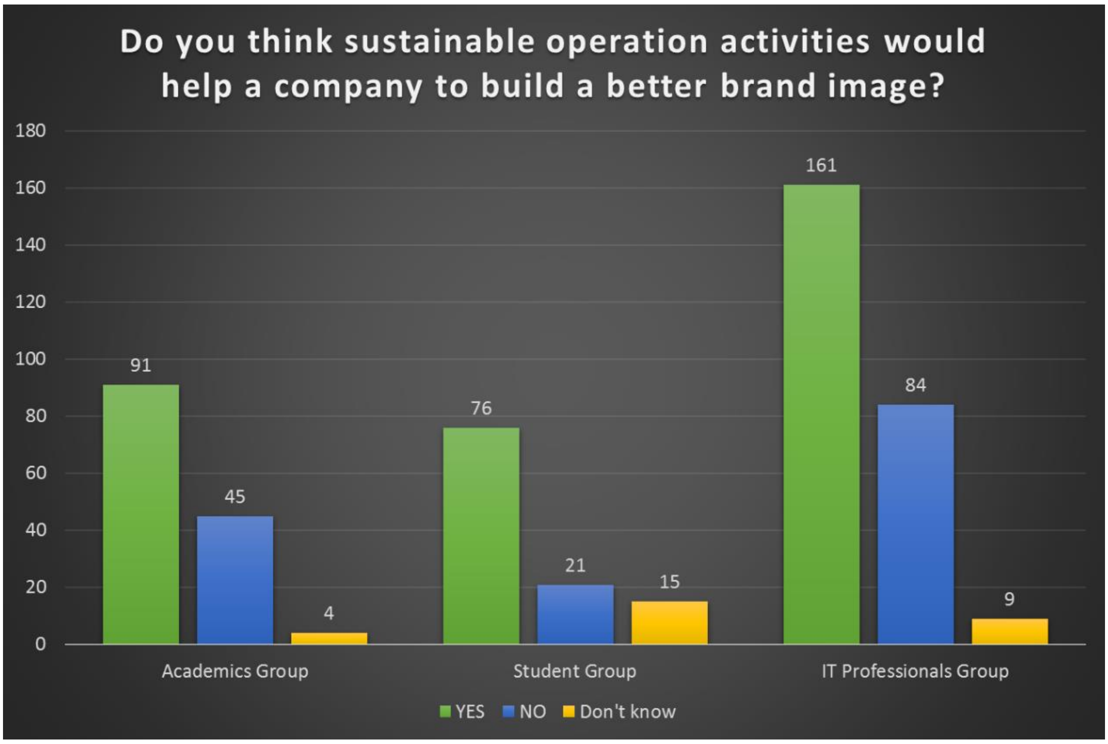


Figure 5.36. Correlation between sustainable operation activities and a better brand image

As shown in Figure 5.37, when the participants are asked how they deal with the development strategies and regulations in terms of cloud development, the majority of participants occasionally consider them (Academics Group: 48.6%; Student Group: 45.5%; IT professional group: 49.6%) or may even include them in their development strategy (Academics Group: 32.1%; Student Group: 37.5%; IT professional group: 33.9%). Only a few would pay no attention to them (Academics Group: 17.9%; Student Group: 10.7%; IT professional group: 14.6%). Therefore, "Cloud Development Strategies and Regulations" along with "Sustainable Operation Activities" from Figure 5.36 can be considered as sub-factors for Economy as shown in Figure 5.38.

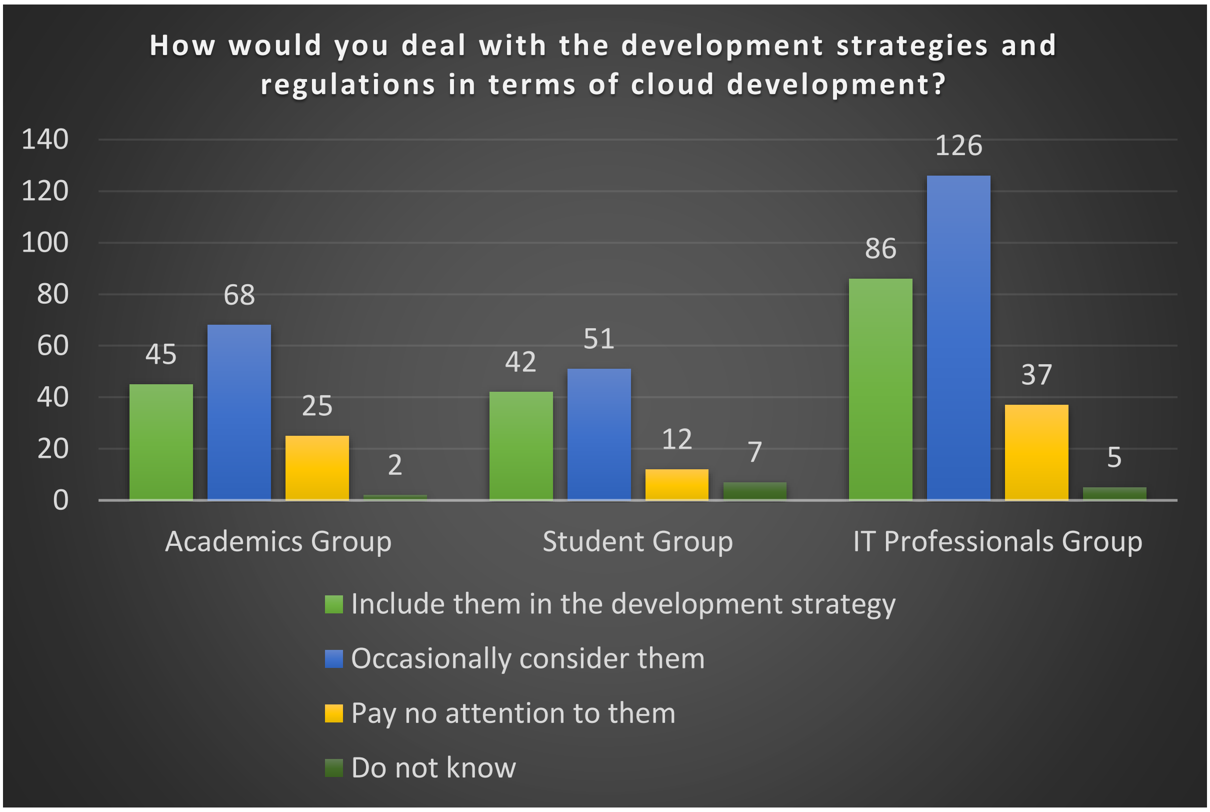


Figure 5.37. Cloud development strategies and regulations

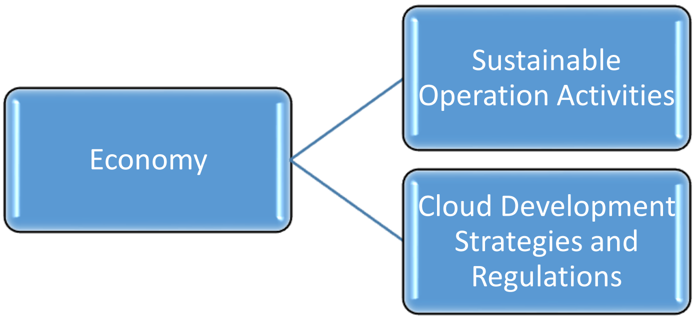


Figure 5.38. Sub-factors of "Economy"

5.7.3.3 Factor 3: Environment

In this section, variables related to the Environment are evaluated in order to obtain sub-factors. Data from three groups (academic, students and IT professionals) will be analysed separately and the results will be compared to determine whether different groups share the same opinion.

5.7.3.3.1 Group 1: Academics Group

Table 5.59 below indicates the Factor loadings, KMO and Bartlett's test, and scree plot results for the academics group on "Environment". The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the academics group is significant as the value in Bartlett’s test is less than 0.05 and the KMO value is 0.764 (above 0.6). It confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.59. Factor loadings, KMO and scree plot for academics group on “Environment”

Theme 3: Sustainability Main Factor 3: Environment Group 1: Academics Group		
Variables for academics group	**Factor loadings**	
	1	**2**
Cloud produces less e-waste.	.877	.172
Cloud is a “greener” computing alternative.	.782	.301
Cloud computing will reduce the carbon footprint.	.166	.932
Cloud is energy saving.	.513	.655

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.764
Bartlett's Test of Sphericity	Approx. Chi-Square	151.481
	df	6
	Sig.	.000

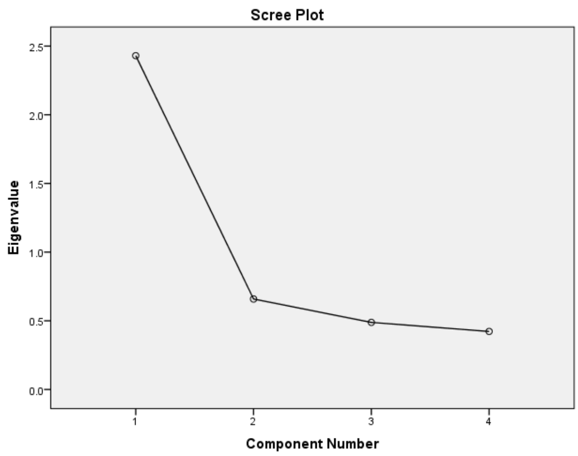


Table 5.60 shows the factor labels of the sub-factors for Environment (academics group). The first label is “Reduce e-waste” and the second label is “Reduce carbon footprint”. The result from the academics group are compared with the IT professional group and student group in section 5.7.3.3.4.

Table 5.60. Factor labels of sub-factors for Environment (academics group)

Variables for academics group	Factor Label	
	1	2
Cloud produces less e-waste. Cloud is a "greener" computing alternative.	**Reduce e-waste**	
Cloud computing will reduce the carbon footprint. Cloud is energy saving.		**Reduce carbon footprint**

5.7.3.3.2 Group 2: Student Group

Table 5.61 below indicates the results of the Factor loadings, KMO and Bartlett's test, and scree plot for the Student Group in regard to "Environment". From the factor loadings in the component matrix, two factors are obtained. In KMO and Bartlett's test, the Student Group is significant as the value obtained by Bartlett's test is less than 0.05 and the KMO value is 0.758 (above 0.6). This confirms that the variables are significantly correlated. Thus, data set from this group is suitable for factor analysis.

Table 5.61. Factor loadings, KMO and scree plot for Student Group on "Environment"

Theme 3: Sustainability
Main Factor 3: Environment
Group 2: Student Group

Variables for Student Group	Factor loadings	
	1	2
Cloud is energy saving.	.919	.117
Cloud computing will reduce the carbon footprint.	.757	.413
Cloud is a "greener" computing alternative.	.149	.936
Cloud produces less e-waste.	.535	.643

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.758
Bartlett's Test of Sphericity	Approx. Chi-Square	140.042
	df	6
	Sig.	.000

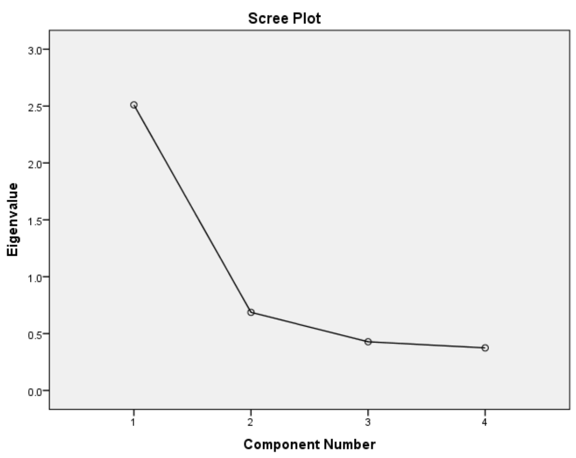


Table 5.62 indicates the factor labels of sub-factors for Environment (Student Group). The first label is “Reduce carbon footprint” and the second label is “Reduce e-waste”. The results from student group will be compared with those of the IT professional group and academics group in section 5.7.3.3.4.

Table 5.62. Factor labels of sub-factors for Environment (Student Group)

Variables for Student Group	Factor Label	
	1	2
Cloud is energy saving. Cloud computing will reduce the carbon footprint.	**Reduce carbon footprint**	
Cloud is a “greener” computing alternative. Cloud produces less e-waste.		**Reduce e-waste**

5.7.3.3.3 Group 3: IT professional group

Table 5.63 below shows the results for Factor loadings, KMO and Bartlett's test, and scree plot for the IT professional group on “Environment”. The factor loadings in the component matrix indicate that two factors are obtained. In KMO and Bartlett's test, the IT professional group is significant as the value in Bartlett’s test is less than 0.05 and the KMO value is 0.758 (above 0.6). It confirms that the variables are significantly correlated. Thus, the data set for this group is suitable for factor analysis.

Table 5.63. Factor loadings, KMO and scree plot for IT professional group on “Environment”

Theme 3: Sustainability Main Factor 3: Environment Group 3: IT professional group		
Variables for IT professional group	**Factor loadings**	
	1	**2**
Cloud produces less e-waste.	.898	.155
Cloud is energy saving.	.771	.344
Cloud computing will reduce the carbon footprint.	.185	.931
Cloud is a “greener” computing alternative.	.508	.561

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.758
Bartlett's Test of Sphericity	Approx. Chi-Square	263.640
	df	6
	Sig.	.000

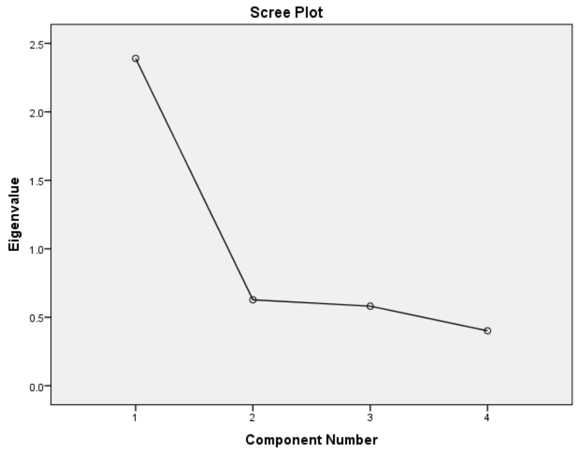


Table 5.64 shows the factor labels of the sub-factors for Environment (IT professional group). The first label is summarised as "Reduce e-waste" and the second label is "Reduce carbon footprint". The results obtained from the IT professional group are compared with the student group and academics group in section 5.7.3.3.4.

Table 5.64. Factor labels of sub-factors for Environment (IT professional group)

Variables for IT professional group	Factor Label	
	1	2
Cloud produces less e-waste. Cloud is energy saving.	**Reduce e-waste**	
Cloud computing will reduce the carbon footprint. Cloud is a "greener" computing alternative.		**Reduce carbon footprint**

5.7.3.3.4 Summary of sub-factors for Environment

Table 5.65 depicts the sub-factors provided by each group. As can be seen that "Reduce e-waste" and "Reduce carbon footprint" are repeated multiple times in the table; thus, these two sub-factors related to Environment are included in the final model as shown in Figure 5.39.

Table 5.65. Comparison of sub-factors in different groups

Group Name	Sub-Factor 1	Sub-Factor 2
Academics Group	Reduce e-waste	Reduce carbon footprint
Student Group	Reduce carbon footprint	Reduce e-waste
IT professional group	Reduce e-waste	Reduce carbon footprint

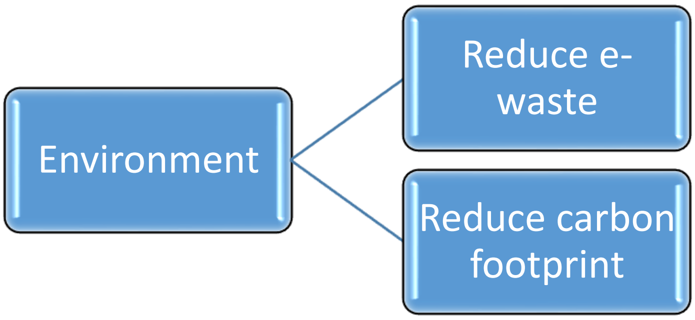


Figure 5.39. Sub-factors of "Environment"

5.8: Chapter summary

In conclusion, the purpose of this chapter is to refine the model and determine the sub-factors of each factor in order to create the final sustainable cloud computing model for the higher education sector in China. In order to identify the sub-factors for the final model, factor analysis is applied in this research. Factor analysis is a dimension-reduction method the aim of which is to reduce a certain number of variables or items to a smaller number of factors or components. In other words, the factor analysis is about obtaining all of the values, determining the number of components to extract or retain, and examining the loading in order to name extracted components. As the themes and main factors are defined in the literature review chapter and interview chapter, this chapter adds the sub-factors to each main factor as indicated in Figure 5.40 which is the concept map of sub-factors for the new sustainable cloud computing model. All the new elements are presented in the green, yellow and purple squares.

In Theme 1, Cloud Governance, the first factor 'Process' contains three sub-factors, which are: analysing critical risk, establishing governance regulations, and assessing and auditing compliance plan. The second factor, 'Policy', has two sub-factors: governance strategies and storage content. Factor 3 'Risk Management' refers to the regulation of activities and assessment of risks. Factor 4 'Resource management' contains resource control and resource limits. In Theme 2, Operations Management, the first factor 'Energy-efficient data management' contains two sub-factors, which are authentication and authorization, and energy optimization. The second factor 'Virtualization' means economise on hardware, software and maintenance, and better performance. The third factor, 'Capacity', refers to bandwidth and capacity control, and scalability. In Theme 3, Sustainability, the first factor 'Social Responsibility' contains two sub-factors, which are CSR awareness and budget constraints.

The second factor ‘Economy’ refers to sustainable operation activities, and cloud development strategies and regulations. The last factor, ‘Environment’, means reduction of e-waste and carbon footprint. This concept map provides guidelines for the creation of the final version of the new sustainable cloud computing model.

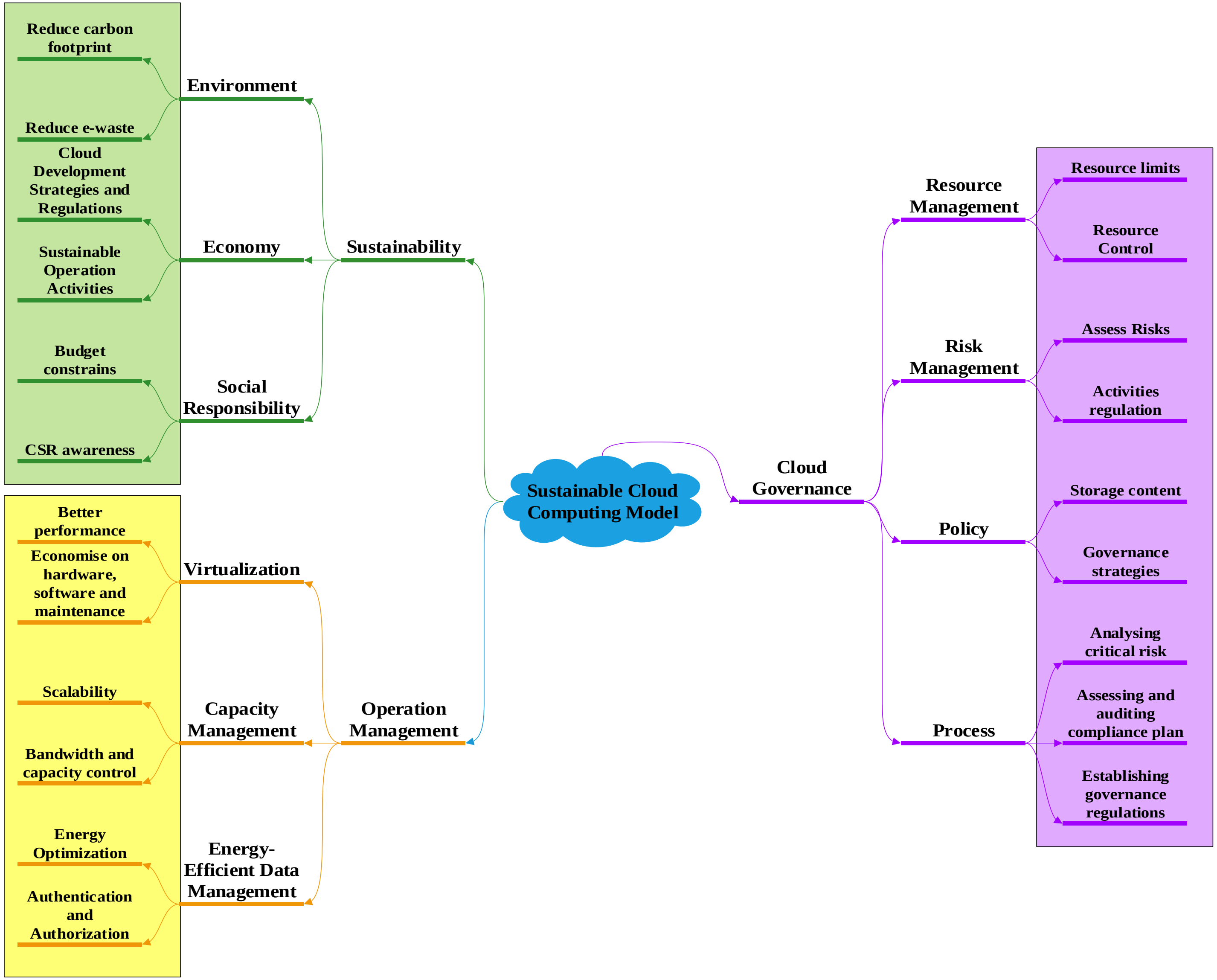


Figure 5.40. Concept map of sub-factors for the New Sustainable Cloud Computing Model

The online survey analysis provides valuable information informing the final model for this research. Now the sub-factors for each main factor are determined and the final version of the New Sustainable Cloud Computing Model is presented in Figure 5.41 below.

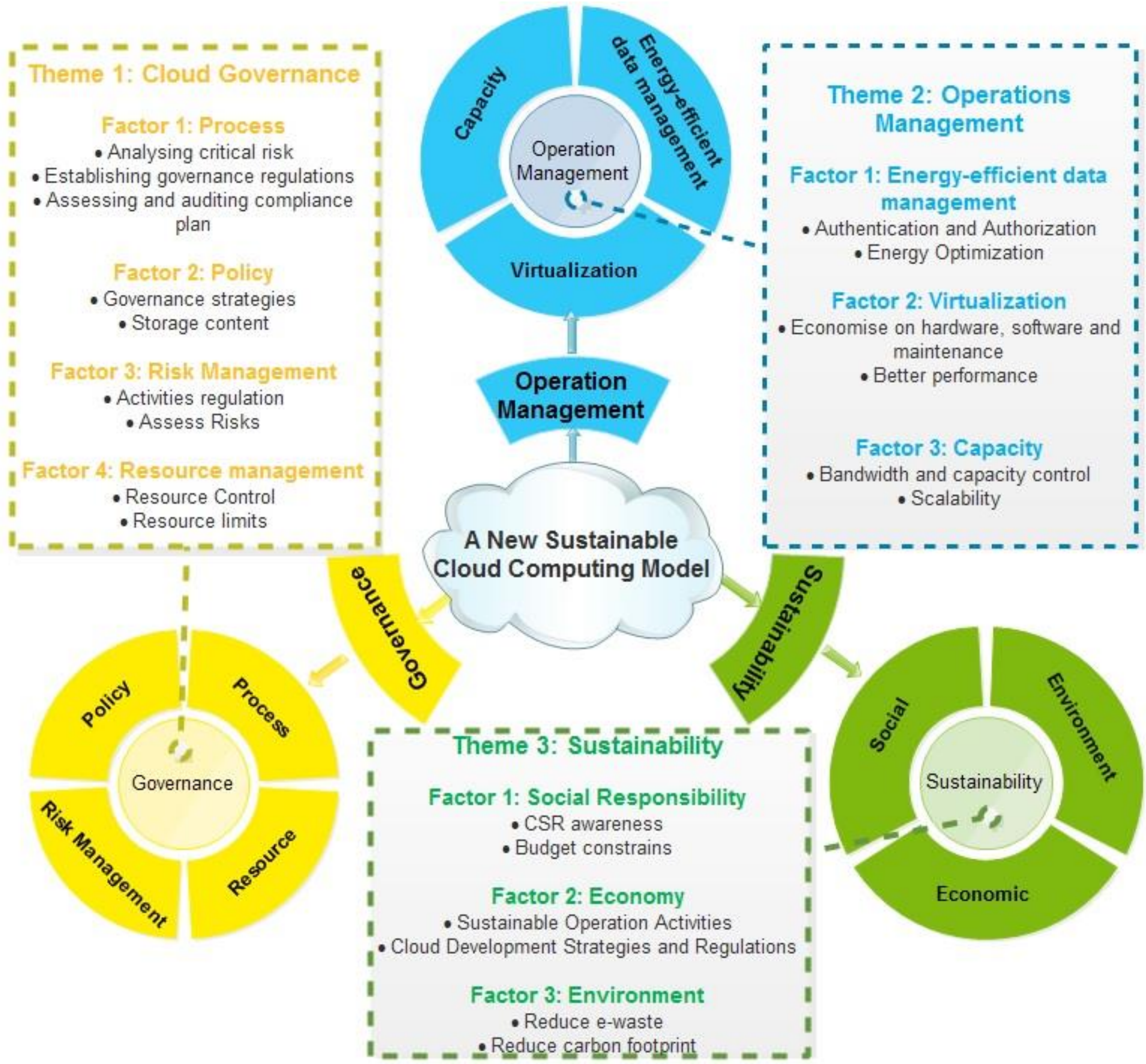


Figure 5.41. Final Version of the New Sustainable Cloud Computing Model

The next chapter concludes this research thesis. The final model will be discussed, the limitations of this research are acknowledged, and recommendations are made for avenues available for future research.

Chapter 6: Research Findings and Conclusion

6.1 Introduction

In the previous chapter, the quantitative data collected form the online survey was analysed using IBM SPSS Statistics software (version 22). The sub-factors for the main factors are extracted via factor analysis to form the final sustainable cloud computing model for the higher education sector in China.

This chapter presents the findings and outcomes of this research. It begins with a summary of the research. The purpose, process and the outcome of this research will be briefly discussed. The conclusion from the data analysis is also presented in this chapter, including the evolution of the new sustainable cloud computing model for higher education sector in China, and the explanation of each component in that model. This chapter also answers both the primary and secondary research questions. This is followed by a discussion of the research limitations and recommendations. Lastly, the significance and future research opportunities, as well as the chapter summary, are presented at the end of this chapter.

6.2 Summary of Research

This section provides a brief summary of this research, including the purpose, processes, logic and outcome of this doctoral dissertation.

Cloud computing is recognized as one of the significant IT megatrends now and in the future. Bottlenecks currently exist at governmental levels. Thorough standards and protocols are required to remove barriers to ensure good and responsible management. In addition to inconsistent standards, other bottlenecks include issues with promotion and trust, stability of cloud service, illegitimate use of cloud computing, construction and maintenance of cloud infrastructure. However, it is believed that cloud computing will shift the economic landscape of information and communication technologies (Chen, Li, & Chen, 2011).

As the largest developing country, China plays a significant role in the international environmental governance. China has established a set of domestic environmental governance norms to meet the 2030 Sustainable Development Goals. China has also established an inter-ministerial coordination mechanism for implementing the Sustainable Development Agenda composed of 43 government departments (Zhu, 2017). Moreover, China is continuously participating in international environmental governance, promoting the treaties on environmental protection at the international and regional levels (Qin & Fang, 2018).

The **purpose** of the research is the reason why it is conducted (Collis & Hussey, 2009). The purpose of this study is to develop a new sustainable cloud computing model for the higher education sector in China using a mixed research method. It is hoped that the outcome of this research can integrate the different aspects of cloud computing and guide further research in this area.

The research **process** is related to the way that the research data was collected and analysed. The process of this research is summarized as Figure 6.1 which contains the literature review, interviews and online survey. As discussed in chapter 2, this research begins with a comprehensive literature review in order to identify the current research gap. Various research works related to cloud computing, particularly in regard to cloud government, cloud sustainability and cloud performance have been reviewed. The outcome of the literature review was the initial sustainable cloud computing model as shown in Figure 2.35. After that, it was necessary to validate the initial model. Therefore, the second stage was to conduct the interviews. Chapter 4 gives the details of the interview analysis and results. In that chapter, interview preparation, interviewees and organization descriptions, data transcription, data coding and results analysis were presented. Interview phase offered the qualitative data to researcher by direct interacting with participants. NVivo (Version 11) was utilised in that phase to perform the thematic analysis. The total number of interviews that have been conducted in that phase was twenty-five. Participants were from three different universities located in three cities. Each interview took approximately 30 minutes. The results from the interviews are presented in Figure 4.17, which was a refined model based on the analysis of interviews data. Several new components were added or updated in that refined model. The final phase in terms of data analysis was the online survey. The refined model has three main themes and each theme has three to four factors. However, as discussed in chapter 5, most of these main factors have sub-factors, so the scope of the refined model should be more comprehensive. That was why the online survey phase was applied. In the online survey phase, quantity data was generated and sufficient variables correlated to each main factor were tested. The purpose of online survey was to enhance the sustainable cloud computing model by attaching sub-factors to the model, and the sub-factors were extracted from the online survey data. A professional translator from the National Accreditation Authority for Translators and Interpreters (NAATI) translated the online questionnaire from English to Chinese language. Responses of open-ended questions in the online survey were not analysed, as the response rate of those questions was low, it was not necessary to translate those responses from Chinese to English. Therefore, the online survey was available in two languages, and participants were able to switch easily from one language to another by clicking the language option button. Human Research Ethics Committee of Curtin University reviewed the questionnaire in order to issue the ethic approval. After that, the questionnaire was uploaded to the Qualtrics Online Survey Platform. The hyperlink for this online survey was disseminated to potential respondents via many channels, one of which was the social network. In total, 709 responses were received, of which 557 were valid. IBM SPSS Statistics 22 was utilised to analyse online survey data. These sub-factors were tested in section 5.6 using Exploratory Factor Analysis to narrow down the number of factors to be used for the final model presented in Figure 5.41.

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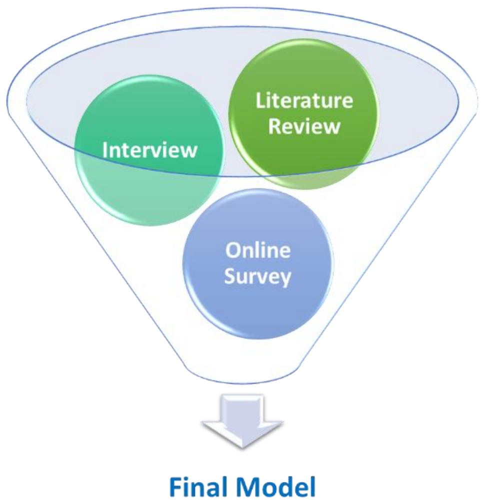


Figure 6.1. Process of this research

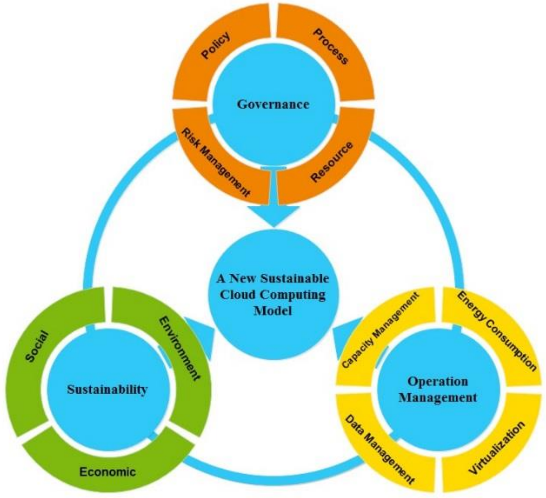
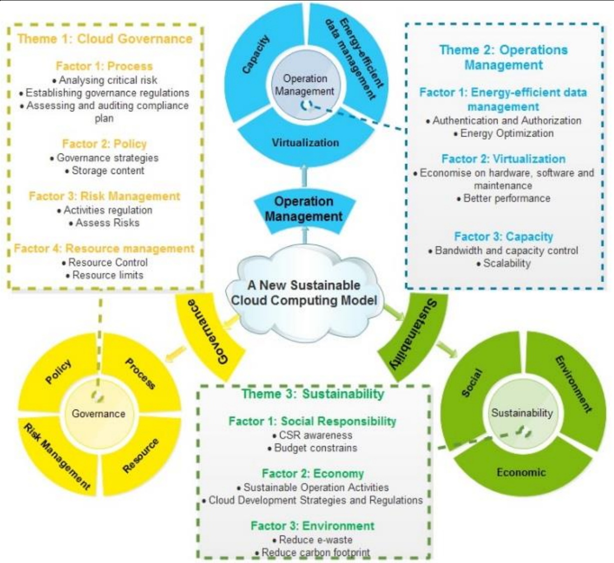
Logic of the research was discussed in Chapter 3. Whether the research logic works from the general to the specific, or vice versa, is worthy of consideration. As indicated in section 3.6, the approach selected for this research is deductive; in other words, it works from the general to the specific.

The **Outcome** of this research is a new sustainable cloud computing model which can be applied to universities in China. Details of this new model are discussed in section 6.3. It is hoped that this model will assist Chinese universities or organizations to transition smoothly to the cloud. For those universities that are already using cloud technology, this model offers valuable information to improve their current cloud implementation strategy. Moreover, organizations and universities in other countries could also adopt this cloud model with certain modifications.

6.3 Conclusion from the Data Analysis

This section concludes the major findings from the data analysis. As mentioned earlier, this research involved a literature review, interviews and online survey prior to creating the final model. After each step, new elements were added or updated. Table 6.1 below shows the evolution of the new sustainable cloud computing model. This section briefly discusses the final model, including the main themes, factors and sub-factors.

Table 6.1. Evolution of the new sustainable cloud computing model in this research

<table>
<tr><th colspan="3">Evolvement of the new sustainable cloud computing model in this research</th></tr>
<tr><th>Version 1</th><th>Version 2</th><th>Version 3 (Final Version)</th></tr>
<tr><td>Initial model (generated from literature review) (Figure 2.35)</td><td>Refined model (based on the interview analysis) (Figure 4.17)</td><td>Final Version of the New Sustainable Cloud Computing Model (based on the online survey data analysis) (Figure 5.41)</td></tr>
<tr><td>
</td><td>
</td><td>
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</table>

6.3.1: Theme 1 Cloud Governance

Cloud Governance refers to defining appropriate, realistic, and relevant policies around managing and overseeing cloud resources, to track and enforce the policies at runtime when applications are running. As discussed in section 2.4, cloud governance is an extension of IT governance. Cloud policies need to be established formally to address the extraordinary challenges and changes posed by cloud adoption (Raj, 2013).

Factor 1: Process

Process in terms of cloud governance refers to the different phases of cloud technology adoption. For instance, Raj (2013) believes the cloud governance process should include a cloud evaluation phase, governance definition phase, development of a relationship with providers, cloud governance execution phase, and operational and review phase. The purpose of identifying cloud processes or phases is to ensure the smooth implementation of cloud computing and to avoid potential risks.

- Analyzing critical risk

  At this stage, the critical risks are identified and analysed and the solution to the risks will be proposed in Factor 3 Risk Management. Critical risks include data security and regulatory, technology, operational, vendor and financial risks (Gadia, 2018). Data security and regulatory risk refer to the loss, leakage, or unavailability of data. Technology risk is related to constantly evolving technologies but lack of standardization in how they integrate into existing information systems. Operational risk can be associated with the execution of daily operations and the IT services that the organisation relies upon. Vendor risk comes from association or communication with cloud providers. Financial risk refers to going over budget or losing revenue because of cloud computing implementation. Therefore, these potential risks should be analysed if the higher education sectors in China considers adopting cloud technology.
- Establishing governance regulations

  Universities in China should establish governance regulations that include standards, templates and best practices in order to ensure that cloud users follow the regulations and avoid risks.
- Assessing and auditing the compliance plan

Regarding the compliance plan, the first thing to do is to assess the current compliance statement, and then make necessary changes to meet the requirements.

Factor 2: Policy

Cloud computing demands a consideration of the gap between policy and technology (Jaeger et al., 2008). During the design and development stage, it is important to establish rules and policies that clearly specify how the various services participating in a cloud are going to be monitored and managed (Raj, 2013; Yoo, 2011). Well-defined and well-enforced policies are necessary to ensure the robustness and trustworthiness of cloud-based applications.

- Governance strategies

  The governance strategies include understanding motivations (e.g. cost savings), defining strategic targets (e.g. IaaS, PaaS, SaaS), identifying impacts to stakeholders (e.g. users experience), choosing cloud locations (e.g. public, private), planning strategic milestones (e.g. implementation plan) and designing strategic measures (e.g. assessment on cloud assets).
- Storage content

  The storage content should be regulated. Universities should clearly establish what content can be uploaded to cloud and what is forbidden for both security reason and copyright reasons.

Factor 3: Risk Management

While cloud computing offers numerous advantages, at the same time it presents several risks to cloud users, and these risks need to be managed properly. Well-managed organizations should understand and overcome dangers to better utilise their cloud computing resources.

- Activities regulation

  Universities should regulate some of the cloud activities. For instance, cloud users should not have access to online gaming websites on campus. IT service login credentials should not be shared with colleagues or friends.
- Assess Risks

As mentioned earlier, critical risks include data security and regulatory, technology, operational, vendor and financial risks. Universities should have adequate data protection and regulatory compliance programs to offset data security and regulatory risks. As for the technology risk, universities should train individuals and encourage the adoption of cloud technology. In order to avoid the operational risk, universities need to monitor the operation status regularly. For the vendor risk, universities should take a long-term strategic view to manage their relationships with cloud service providers. To overcome the financial risk, responsibility for budgeting, tracking, and managing cloud costs needs to be clarified before implementation.

Factor 4: Resource management

According to (Mell & Grance, 2009), computing resources include networks, servers, storage, applications, and services. A cloud can be formed through the federation of distributed and decentralized IT resources. The visibility level decreases and, hence, controllability becomes a major issue (Raj, 2013). To cope with the challenge, it is of paramount importance to develop efficient and flexible resource management strategies (Zhao & Li, 2013).

- Resource Control
  Universities need to monitor resource availability (e.g. 24/7 access to online journal database), and to establish proper resource regulations to meet the requirements.
- Resource limits
  The resources limits should also be clarified. When monitoring cloud assets, IT departments should identify the resource limits such as CPU core usage and memory usage to ensure the accessibility during peak hours.

6.3.2: Theme 2 Operations Management

The management of cloud computing operations is the process of monitoring resources that support application program performance in cloud environments. This theme contains three factors: energy-efficient data management, virtualization and capacity management. One of the important purposes of operations management is to provide IT administrators with the ability to monitor the operation status and to identify a poor user experience quickly.

Factor 1: Energy-efficient data management

Vikas Kumar and Vidhyalakshmi (2012, p. 470) reported that cloud computing at present is responsible for almost 2% of the world's energy consumption, and the data centre energy footprint is enormous with energy consumption being approximately more than 600 billion kilowatts per hour. That is why energy efficiency is one of major challenges in terms of performance management. In daily operations, universities should manage the cloud data as well as the energy consumption.

- Authentication and Authorization

  Data management is primarily concerned with the data protection and privacy regulations; therefore, authentication and authorization are necessary. Authentication verifies the identity of the cloud user, while authorization decides if the user have permission to access a resource.
- Energy Optimization

  This includes energy efficiency, renewable energy, and energy monitoring and administration.

Factor 2: Virtualization

Virtualization includes virtual computer hardware platforms, storage devices, and computer network resources. For instance, virtualization can be utilised to create virtual environments and the applications can run on the virtual machine. Virtualization is one of the key components of cloud computing which can provide computing and storage services (Xing & Zhan, 2012).

- Economise on hardware, software and maintenance

  Universities should run a cost benefit analysis to determine whether virtualization is necessary. Virtualization would reduce expenditure on hardware, software and maintenance as all the resources are online and can be shared among the network.
- Better performance

  Virtualization is like a resource pool, where cloud resources can be accessed easily and additional data storage or computing power are available, which would lead to better performance. Universities should use performance indicators to measure the benefits of virtualization.

Factor 3: Capacity

The goal of the capacity management process is to ensure that cost-justifiable IT capacity, in all areas of IT, always exists and is matched to the current and future agreed-upon needs of the business, in a timely manner (Sabharwal & Wali, 2013). One of the technical challenges facing cloud computing is to effectively manage cloud capacity in response to the increased demand for changes in clouds, as computing customers can now provision and de-provision virtual machines more frequently (Y. Jiang et al., 2012).

- Bandwidth and capacity control

  One challenge worth attention is that the size of data keeps increasing (Gai et al., 2015). Network congestion is a critical issue which affects the performance of the entire network system (Gai, Qiu, & Zhao, 2016). This can also lead to great network latency (Keke et al., 2016; H.-M. Sun et al., 2011). Thus, sufficient network bandwidth is a crucial requirement for current cloud computing deployments (H. Jiang & Sun, 2017). Universities should have a bandwidth and capacity control strategy to ensure accessibility to cloud assets.
- Scalability

  Scalability is the ability to handle growing or shrinking resources to meet demands from cloud users satisfactorily. For instance, during the semester break, less computing power would be required in universities, and the capacity can be decreased as needed.

6.3.3: Theme 3 Sustainability

Sustainable business approaches help to generate profits by improving business practices, without having any negative impact on the global or local environment (Vikas Kumar & Vidhyalakshmi, 2012). There are three aspects of sustainability in this section: which are social, economic and environment.

Factor 1: Social Responsibility

According to Issa et al. (2010), the social factor is relevant to the transformation of organisations who are implementing the cloud computing technology, as it incorporates consumer awareness and attitudes, as well as individual practices of utilizing services on the cloud.

- CSR awareness

  Corporate social responsibility (CSR) is a self-regulating business model, and universities need to be aware that they should be accountable to society.

- Budget constraints

  As discussed in Chapter 5, one of the most significant reasons that organisation cannot fulfil their social responsibility is the budget constraints. It requires support from both government and school management in order to overcome the budget concerns.

Factor 2: Economy

When computing operations are migrated to the cloud, one significant advantage is the cost savings achieved due to the decrease in staffing expenses, and reduction in cloud services and their applications.

- Sustainable Operation Activities

  This is related to long-term development in terms of cloud computing implementation and utilisation. Daily operation activities should meet the sustainable goals.

- Cloud Development Strategies and Regulations

  Cloud development guidelines and regulations are essential to achieve economic goals. Different milestones should be identified in the strategic plan and universities should apply cost benefit analysis to ensure that economic benefits are achievable.

Factor 3: Environment

The implementation of Cloud Computing for ICT operations reduces the expense of operations as well as the pollution emission to the environment (Vikas Kumar & Vidhyalakshmi, 2012; Uchechukwu et al., 2014).

- Reduce e-waste

  Many universities have become increasingly aware of the environmental issues raised by the disposal of electronic waste (e-waste). One way to solve this is to have regular e-waste collection on campus, and then reuse or recycle electronic materials.

- Reduce carbon footprint

  Universities should have environmental reporting to ensure the energy and environmental performance. Environmental awareness would facilitate behavioural changes in order to reduce carbon footprint.

6.4 Answering the research questions

As stated in section 3.3, the main research question is:

- *What are the factors pertaining to governance, sustainability and performance management that should be taken into consideration when developing the new sustainable cloud computing model for the higher education sector in China?*

As indicated in Figure 6.2, the final version of the new sustainable cloud computing model contains three main themes, and each theme has three to four factors, then each factor is correlated with several sub-factors.

The first theme is Cloud Governance. Factor 1 is process, which contains three sub-factors: analysing critical risk, establishing governance regulations, and assessing and auditing compliance plan. Factor 2 is policy, which contains two sub-factors: governance strategies and storage content. Factor 3 is risk management, and the sub-factors are activities regulation and assess risks. Factor 4 is resource management, and it contains resource control and resource limits.

The second theme is Operations Management. Factor 1 is energy-efficient data management, which contains two sub-factors: authentication and authorization, and energy optimization. Factor 2 is virtualization and it has two sub-factors: economise on hardware, software and maintenance, and better performance. Factor 3 is capacity, which contains bandwidth and capacity control, and scalability.

The third theme is Sustainability. Factor 1 is social responsibility, which contains two sub-factors: CSR awareness and budget constraints. Factor 2 is economy, including sustainable operation activities, and cloud development strategies and regulations. Factor 3 is environment, and the sub-factors are reduction of e-waste and reduction of carbon footprint.

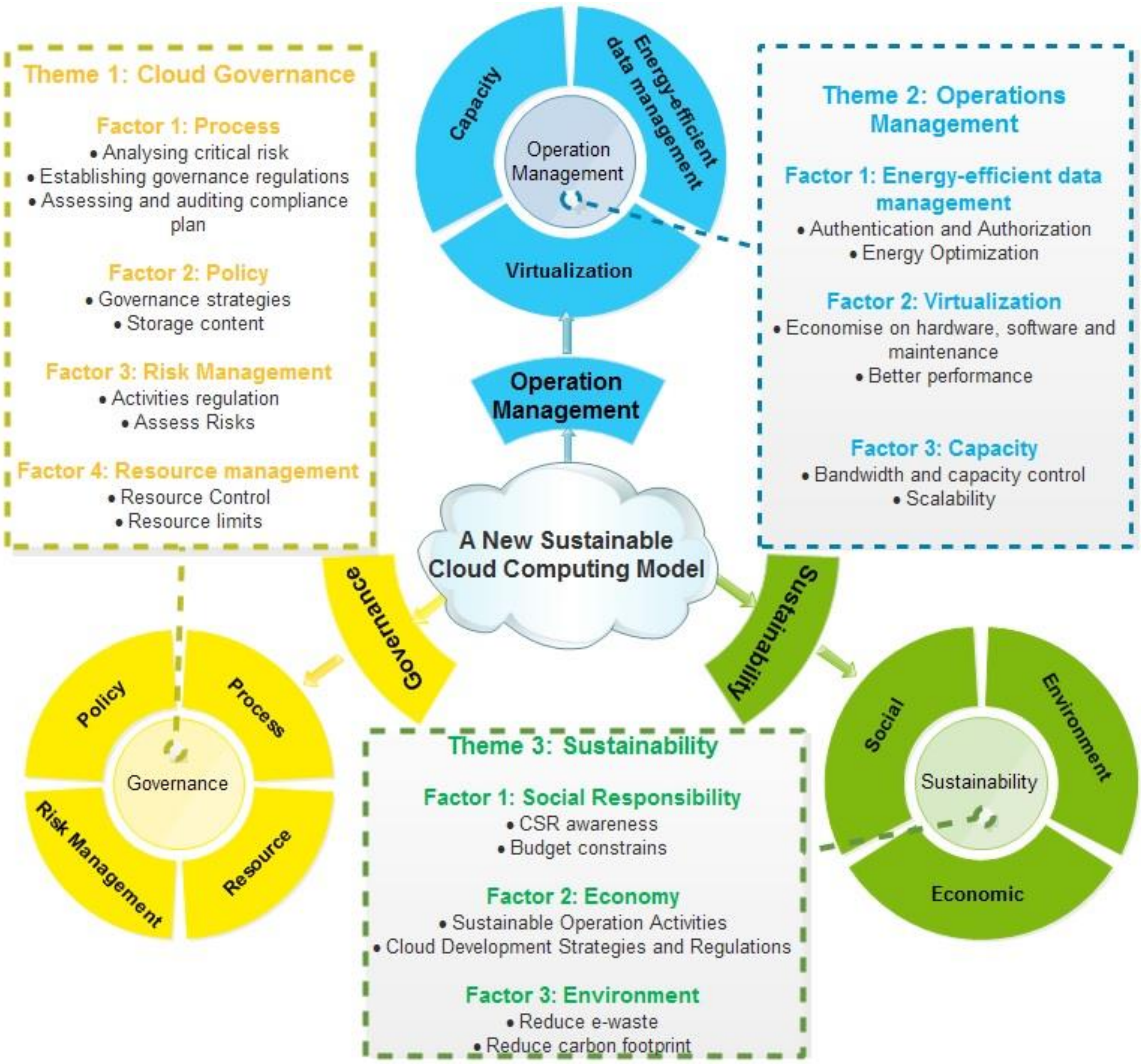

Figure 6.2. Final Version of the New Sustainable Cloud Computing Model

The secondary research questions for this research are:

- *What are the perceptions and attitudes of students, academic staff and IT department personnel towards the new sustainable cloud computing model in Chinese universities?*

As discussed in Chapter 4, all of the interviewees gave feedback for the initial model, although some amendments were required. Overall, students, academic staff and IT department personnel who were interviewed were satisfied with the new sustainable cloud computing model.

In chapter 5, data collected from the online survey were separated into three different groups based on participants' occupations. Group 1 was Academics Group, group 2 was Student Group and group 3 was IT professional group. The results of factor analysis for different groups were compared and showed that opinions from different groups were very similar. Then, based on their feedback, the final model was developed. Therefore, it can be concluded that students, academic staff and IT department personnel have positive attitudes towards the new sustainable cloud computing model, and the final model has been improved based on their perceptions and feedback.

- *What are the relationships among governance, sustainability and performance management?*

One of the questions from online survey was directly related to the relationships among governance, sustainability and performance management (performance management has been renamed as operations management after Chapter 4). In the online survey, 48.3% of participants believed that cloud governance has a positive impact on operations management, and 49.4% of participants agreed that cloud governance has a positive impact on sustainability. Therefore, when developing the final model for this research, the author considered drawing multiple communication networks among those main themes to illustrate the positive impact of cloud governance on sustainability and operations management. However, this would add complexity to the diagram, making it harder to understand. Besides, the 'positive impact' does not mean it should in the dominant position. To be more specific, the author believes that these main themes reinforce and complement each other. For instance, the operations management would also have impacts on sustainability performance. Therefore, none of them is in a dominant position, and they should be treated equally. After discussion with the supervisor, the author decided to draw the themes individually, instead of creating multiple communication networks among them. The final model is shown in Figure 6.2.

To sum up, governance, sustainability and operations management all play significant roles in terms of the development of sustainable cloud computing, and they should be treated as equally important.

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6.5 Research limitations and recommendations

This research offers significant contributions in terms of sustainable cloud computing development from both theoretical and practical perspectives; however, it has several limitations.

Firstly, the author originally planned to gather online survey data from 30 selected Chinese universities. However, due to a low response rate and time limitation, the author had to expand the scope in order to obtain enough feedback. Therefore, although the occupations of the participants are known, it is impossible to identify which university they were from in the online survey. Besides, demographic data for the online survey was collected and analyzed in Chapter 5. However, demographic data for those 25 interviewees was not collected. This is considered as one of the limitations of this research.

Secondly, the questionnaire had several limitations. Some questions which do not affect the final model (Question 9, 20, 21, 28, 31, 33, 45-48) were analysed but the results were invalid, therefore in the future these questions will be examined to confirm the validity. Moreover, as mentioned in section 5.7.3.2, due to the design issue, questions related to "Economy" in the online survey did not apply the 5-point Likert scale. Therefore, instead of using SPSS (version 22) factor analysis, frequency analysis was applied in order to determine the sub-factors related to Economy. It would be better if the factor analysis could have been applied in that section.

6.6 Significance and Future Research

Chinese organizations are encouraged to be responsible in the management of their IT infrastructure that includes the adoption of cloud computing. The new cloud computing model is likely to be received in China given the sustaining efficiencies that organizations will experience. Organizations in China will find out about the sustainable new cloud computing model via publications and presentations at industry events and conferences. Some publications are already available and future publications will focus on the adoption of this new sustainable cloud computing model. Moreover, the final model will be available to some of the participants in China and they can disseminate the model in their profession and workplace. As stated in chapter 3.2, it is anticipated that this research has both theoretical significance and practical significance. Theoretical significance refers to the exploration of new knowledge and the expansion of the existing knowledge on a certain topic. Practical significance refers to the empirical impact that the results of this research has in real life. From a theoretical stance, the goal of this research is to explain how to adopt cloud computing technology while protecting the environment. It explores this topic from the angles of governance, performance management and sustainability. Moreover, the outcome of this study can contribute to future studies on the sustainable development of cloud computing in China. From a practical perspective, the main aim of this study was to identify a set of key factors that would assist the successful implementation of a new sustainable cloud computing model in the higher education sector in China. The outcome of this research would benefit cloud users, service providers, professionals and other stakeholders who want to contribute to the sustainable development of cloud computing. Moreover, the final model could also benefit students, IT staff and academic staff in various universities in China. The outcome of this research can integrate the different aspects of cloud computing and can guide further research on this topic. To sum up, the research contributions include:

Theoretical Significance

- Detailed description of and new perspective on cloud computing adoption.
- The governance, sustainability and performance management of cloud computing will be explained and summarized
- The proposed model aims to provide a broader view of the cloud technology by combining all these three elements together.

Technical Significance

- The outcome of this research is a new cloud computing model which can be applied to universities in China.
- The new cloud computing model will be developed to support a great number of potential cloud users.

Compared to existing models, this new model requires the cooperation from policy makers, researchers, cloud users and providers, because both management and technical requirements are included in this model. Software engineering is not mentioned in this research and that will be a future research direction.

This final model has the potential to be applied to other countries or other sectors. It is anticipated that this model will encourage Chinese universities or organizations to move to the cloud. For those universities who are already using the cloud technology, this model will also provide some valuable information to improve their cloud strategy. Furthermore, with certain modifications, this cloud model could be adapted for other organizations and universities in other countries.

6.7 Chapter summary

This is the final chapter of this research thesis. The research findings and final thoughts were presented in this chapter. Section 6.2 discussed the purpose, process and the outcome of this research. In section 6.3, a figure showing the evolution of the new sustainable cloud computing model for higher education sector in China was presented, followed by a brief description and explanation of the final model, including all the main themes, factors and sub-factors. After that, both primary research question and secondary research questions were answered and the final model was presented in that section, followed by a discussion of research limitations and recommendations. Towards the end of the chapter, the significance and future research opportunities were presented.

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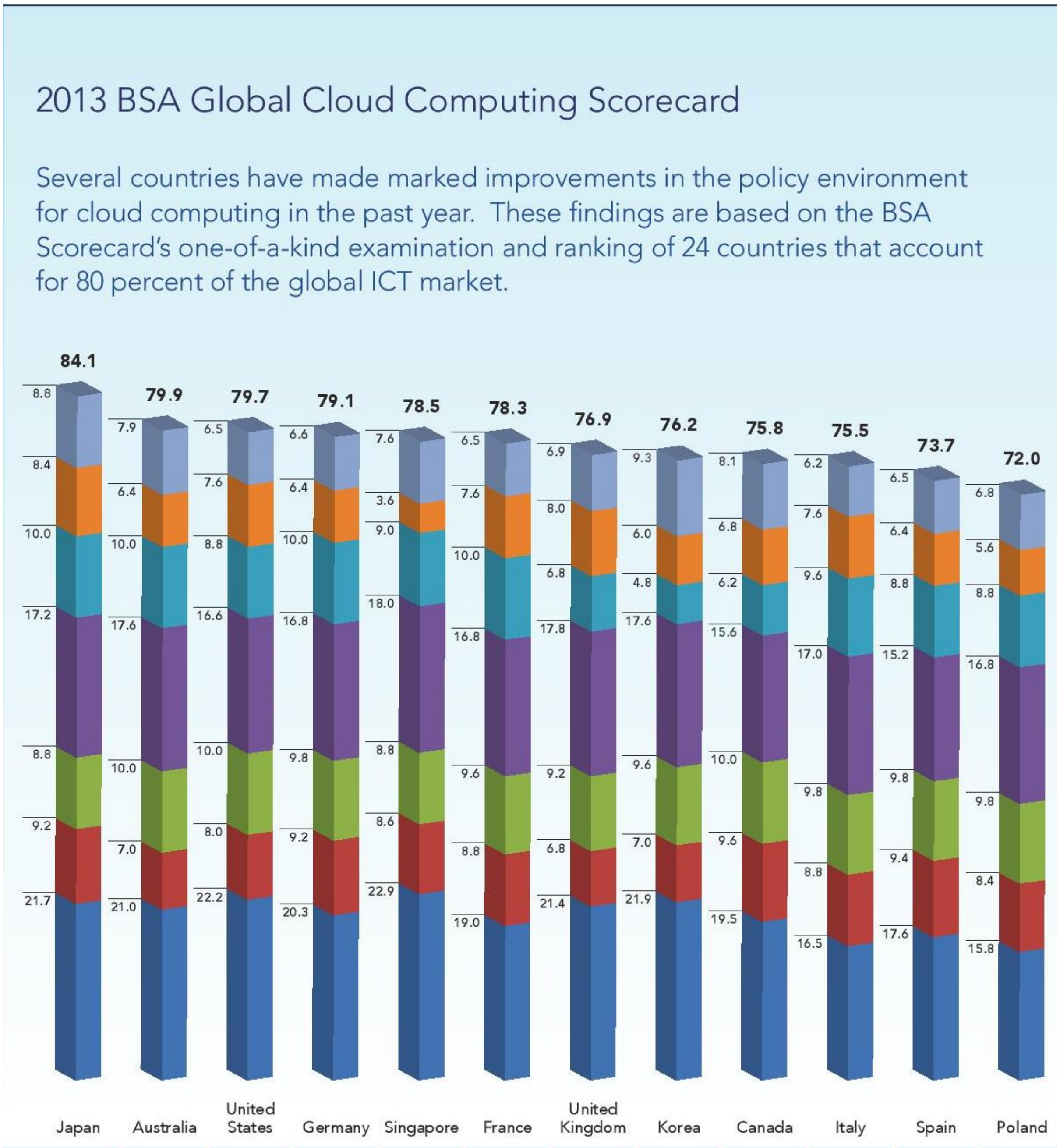
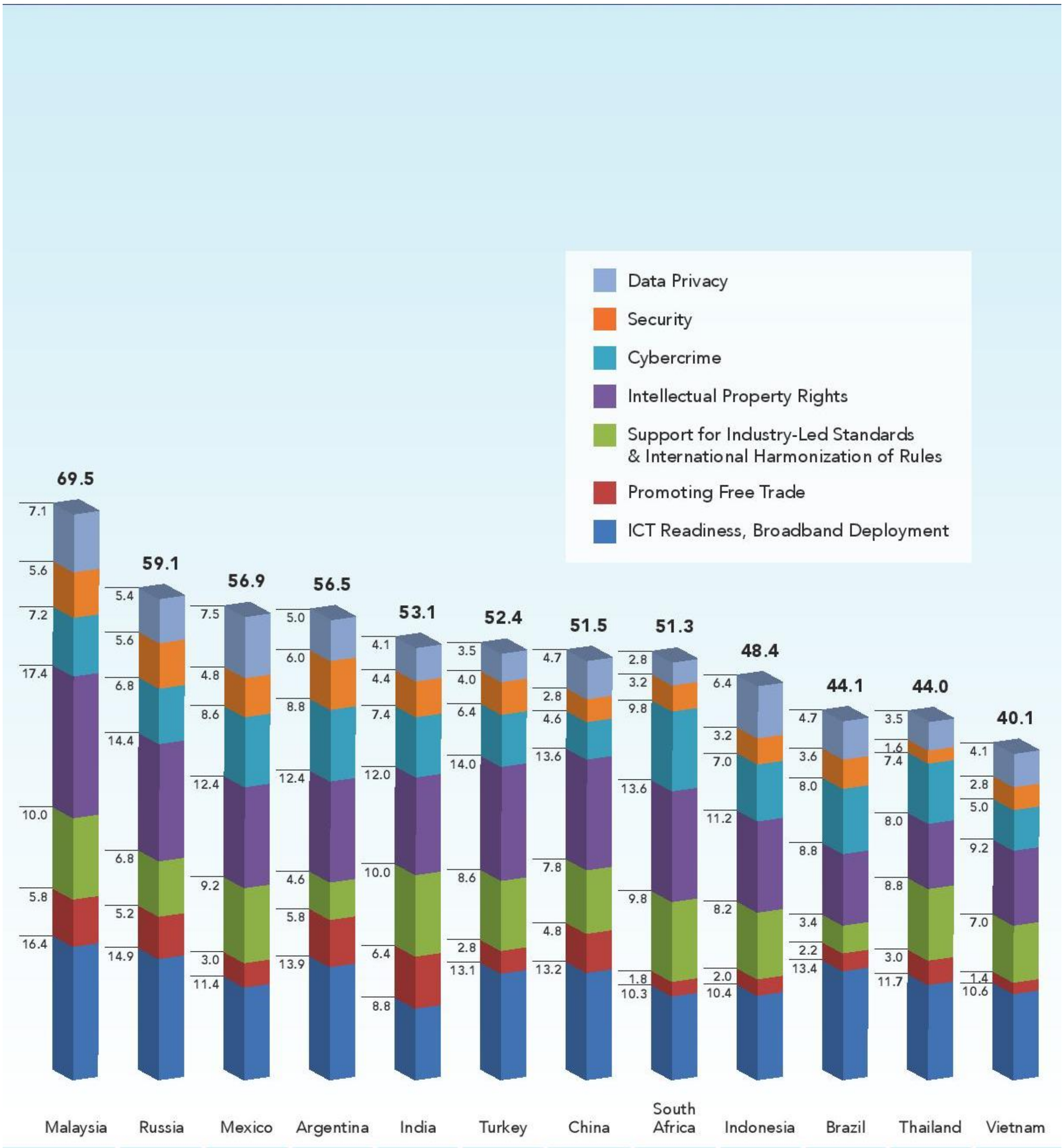
Appendices

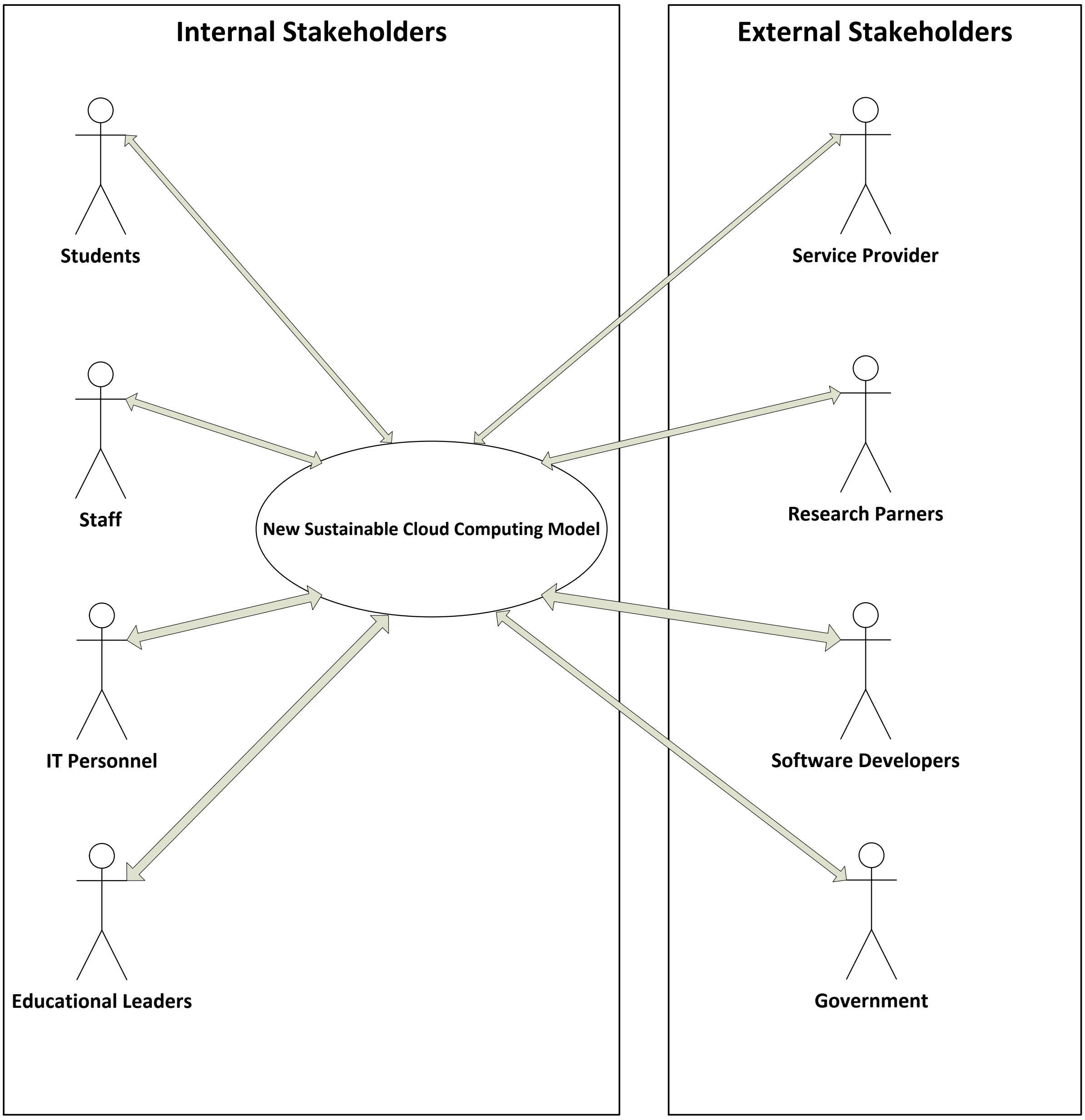
Appendix A: The 2013 BSA Global Cloud Computing Scorecard





(Source: http://cloudscorecard.bsa.org/2013/)

Appendix B: Internal Stakeholders and External Stakeholders



Appendix C: Sample size calculation for online survey

According to Bartlett, Kotrlik, and Higgins (2001), the sample size formula for categorical data is:

$$\underline{n}_0 = \frac{(\underline{t})^2 * (p)(q)}{(\underline{d})^2}$$

- t = value for selected alpha level of .025 in each tail = 1.96.
    - The alpha level .05 or .01 is mostly used in determining sample size in research studies (Ary, Jacobs, Sorensen, & Walker, 2013). The alpha level of .05 is chosen for this research, it indicates the level of risk the researcher is willing to take that true margin of error may exceed the acceptable margin of error. T-value for alpha level of .05 is 1.96 for sample sizes above 120 (Bartlett et al., 2001).
- (p)(q) = estimate of variance = .25.
    - Maximum possible proportion (.5) * 1- maximum possible proportion (.5) produces maximum possible sample size (Bartlett et al., 2001).
- d = acceptable margin of error for proportion being estimated = .05.
    - For categorical data, 5% margin of error is acceptable (Krejcie & Morgan, 1970).

Therefore, the sample n_o for this research will be at least 384.

$$\underline{n}_0 = \frac{(1.96)^2(.5)(.5)}{(.05)^2} = 384$$

Appendix D: Interview Questions

Cloud Background	**1**	Do you know cloud computing? Does your organization/department use cloud computing? And Why?
	2	Which cloud service model dose your organization/department use or plan to use: SaaS, PaaS, or IaaS?
	3	What kind of data would your organization/department upload to the cloud?
	4	What would you or your organization/department concern the most when moving to the cloud?
Governance	**5**	Does your organization/department have cloud computing governance strategies? And Why?
	6	What kind of cloud computing policies does your organization/department has?
	7	In a cloud computing governance lifecycle, what are the processes should be applied?
	8	How does your organization/department manage the cloud resource/cloud assets? And Why?
	9	What other elements/components could be added on to this cloud computing governance model besides resource, process and policy?
Sustainability	**10**	What are the social effects the cloud computing could have?
	11	What are the financial effects the cloud computing could have?
	12	What are the environmental effects the cloud computing could have?
	13	In your opinion, what dose sustainability mean? In addition, is there any cloud computing activities could enhance the sustainability performance in your organization/department?
Operation management	**14**	If your organization/department is currently using cloud computing, who is responsible for the performance management?
	15	If your organization/department is not currently using cloud computing, would you think performance management is important, and why?
	16	Data management: does your organization/department have backup data centre, or does the cloud vendor provide that? If not, why? What kind of data security methods the cloud vendor has? Who is responsible for data loss?
	17	Energy consumption: is that possible to figure out how much energy has been saved by using cloud-computing technology in your organization/department?

	18	Computing capacity management: when it would reach the maximum computing capacity of the information systems in your organization/department? And how your organization/department would solve this?
Daily Use	**19**	What kind of IT support would you need and why?
	20	What is your major? e.g. Computing science? Arts? (For students only)
	21	Do you use the university’s servers and do you need the access to the university’s servers during the semester break?
	22	What tasks do you wish to complete by using university's servers? E.g. daily learning; project; personal website/school site; Data Analysis; others.
Comments on current model	**23**	How to improve this proposed sustainable cloud-computing model from your perspective?

Appendix E: Participant Information Sheet

HREC Project Number:	10716
Project Title:	A new sustainable cloud computing model for the higher education sector in China
Principal Investigator:	Dr. Tomayess Issa Senior Lecturer, Curtin Business School (CBS)
Student researcher:	YUCHAO DUAN PhD Candidacy
Version Number:	1
Version Date:	09/JUL/2016

What is the Project About?

Cloud computing is considered a new frontier in the field of computing. Currently, there are several obstacles facing the adoption of cloud computing in China, namely: lack of standards; insufficient educational data and a disregard for environmental impacts. Therefore, to address these problems, this proposed model will apply the principles of governance, performance management and sustainability to the higher education sector in China. The proposed research aims to examine the impacts of sustainability, governance and performance management on the development of cloud computing for the higher education sector specifically in China. There will be 20 interviews to elicit the attitudes of the cloud users towards the initial model, based on the interviews feedback, the model will be optimized.

Who is doing the Research?

The project is being conducted by YUCHAO DUAN. The results of this research project will be used by YUCHAO DUAN to obtain a Doctor of Philosophy at Curtin University. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

We are looking for volunteers to take part in this one-hour interview to examine your attitudes towards various aspects from cloud computing, including sustainability, performance management, government and other aspects in order to refine the current sustainable cloud computing model. The study will take place at a mutually convenient location.

This research involves a series of questions in the form of an interview, which will take up to one hour to complete. This interview contains 23 questions. There will be no cost to you for taking part in this research and you will not be paid for taking part in this process.

Are there any benefits' to being in the research project?

We encourage you to participate in this research because this research will provide valuable insights to determine the essential characteristics of a cloud computing model for China. Your assistance in this research is greatly appreciated and is crucial for the success of its findings. We hope that the results of this research will allow us to develop a customised cloud computing model for Chinese Higher Education.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

There are no foreseeable risks from this research project. Apart from giving up your time, we do not expect that there will be any risks or inconveniences associated with taking part in this study. If you feel uncomfortable in answering certain questions, please feel free to disregard them.

Who will have access to my information?

The information collected in this research will be re-identifiable (coded). This means that the stored information will be re-identifiable which means we will remove identifying information on any data or sample and replace it with a code. Only the research team have access to the code to match your name or your organisation if it is necessary to do so. Any information we collect will be treated as confidential and used only in this project unless otherwise specified. The following people will have access to the information we collect in this research: the research team and the Curtin University Ethics Committee. Electronic data will be password-protected and hard copy data (including video or audio tapes) will be in locked storage. The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed/kept indefinitely (select one).You have the right to access, and request correction of, your information in accordance with relevant privacy laws. The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

We are not able to send you any results from this research as we do not collect any personal information to be able to contact you.

<u>Do I have to take part in the research project?</u>

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know if you want to stop so we can make sure you are aware of any thing that needs to be done so you can withdraw safely. If you choose not to take part or start and then stop the study, it will not affect your relationship with the University, staff or colleagues. If you chose to leave the study we will use any information collected unless you tell us not to.

<u>What happens next and who can I contact about the research?</u>

If you would like to obtain further information regarding this research, please contact the PhD candidacy: YUCHAO (KEVIN) DUAN, +61425019863, <u>yuchao.duan@curtin.edu.au</u>; or*<u>Tomayess.Issa@cbs.curtin.edu.au</u>(Phone: +61 8 9266 7682).*

If you decide to take part in this research we will ask you to sign the consent form. By signing it is telling us that you understand what you have read and what has been discussed. Signing the consent indicates that you agree to be in the research project and have your health information used as described. Please take your time and ask any questions you have before you decide what to do. You will be given a copy of this information and the consent form to keep.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number 10716). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Appendix F: Interview Consent Form

HREC Project Number:	10716
Project Title:	A new sustainable cloud computing model for the higher education sector in China
Principal Investigator:	Dr. Tomayess Issa Senior Lecturer, Curtin Business School (CBS)
Student researcher:	YUCHAO DUAN PhD Candidacy
Version Number:	1
Version Date:	09/JUL/2016

- I have read, the information statement version listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007).
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
Participant Signature	
Date	

<u>Declaration by researcher:</u> I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	
Researcher Signature	
Date	

Note: All parties signing the Consent Form must date their own signature.

<u>OPTIONAL CONSENT</u>

☐ I do	☐ I do not	consent to being audio-recorded

Appendix G: Online Questionnaire

Part 1: Personal information

1. What is your gender?

- Male
- Female

2. What is your highest qualification?

- Bachelor Degree
- Master Degree
- Doctorate (PhD)
- Other, please specify ___________

3.What is your current role?

- IT Staff
- Researcher
- Teaching Staff
- Student (Please go to Question 51)
- IT architect
- IT consultant
- IT manager
- Business analyst
- Chief Information Officer (CIO)
- Developer
- Enterprise architect
- Project manager
- Tester
- Other (Please specify)_______________________

4. Is your organisation in the public or private sector?

- Public sector
- Private sector

Part 2: Cloud adoption

5. At what stage is your organization regarding the adoption of cloud computing?

- Have no intention of adopting cloud
- Considering adoption in the near future
- Piloting cloud

- Adoption in process
- Have already adopted cloud
- Other (Please specify) ________________________

6. Which pricing model has been adopted by your organization? (*For cloud providers: Which model do you provide to your customer?)* (You can choose two or more options)

- ☐ Pay-as-you go (fixed price per unit of use)
- ☐ Subscription (fixed price based on a period of subscription)
- ☐ Pay for resources (based on amount of storage and bandwidth utilized)
- ☐ Free use
- ☐ Free trial version
- ☐ I do not know
- ☐ Other (Please specify) _________________________

7. Which cloud service model has been adopted by your organization? (*For cloud providers: Which model do you provide to your customer?)* (You can choose two or more options)

- ☐ Software as a service (SaaS)
- ☐ Platform as a Service (PaaS)
- ☐ Infrastructure as a service (IaaS)
- ☐ Other (Please Specify)___

8. Which cloud deployment model has been adopted by your organization? (*For cloud providers: Which model do you provide to your customer?)* (You can choose two or more options)

- ☐ Private cloud
- ☐ Community cloud
- ☐ Public cloud
- ☐ Hybrid cloud
- ☐ I do not know

Part 3: Cloud Governance (applying specific policies or principles to the use of cloud computing services)

9. Cloud Governance would have a positive impact on	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Operations management					
(B) Sustainability					

Factor 1: Process

10. Do you think it is necessary to identify the cloud governance process before moving to cloud?

- Yes
- No
- I do not know

11. How important to you are the following aspects of establishing cloud governance (A-C); assessing, monitoring, and controlling risk (D-J); and complying with directives (K-Q)?

	Not at all important	Slightly important	Important	Fairly important	Very important
(A) Establishing assumptions					
(B) Establishing a vision					
(C) Establishing regulations and standards					
(D) Identifying risk					
(E) Analysing and prioritizing risks					
(F) Identifying controls					
(G) Analysing controls					
(H) Planning and scheduling implementation					
(I) Tracking and reporting risks and controls					
(J) Operating controls					
(K) Identifying policies, laws, regulations, and contracts					
(L) Selecting policies, laws, regulations, and contracts					
(M) Assessing current compliance state					
(N) Setting future compliance state					
(O) Creating compliance plan					
(P) Maintaining compliance					
(Q) Auditing compliance					

Factor 2: Policy

12. Have you ever shared your IT service log-in credentials with colleagues or friends?

- Never
- Once or twice
- Occasionally
- Often
- Prefer not to say

13. Please indicate the extent to which you agree or disagree with the statements below regarding cloud policy.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Cloud computing governance strategies are essential before moving to cloud					
(B) It is necessary to include 'Policy' factor in the cloud governance					
(C) Use of cloud computing services for work purposes must be formally authorized by the IT Manager/CIO					
(D) The IT Manager/CIO decides what data may or may not be stored in the Cloud					

Factor 3: Risk management

14. What are your concerns in regard to cloud adoption? (You can choose two or more opinions)

- ☐ Privacy agreement and service level agreement
- ☐ Security and data protection
- ☐ Location of data
- ☐ Legislation and regulation
- ☐ Loss of control over end-user actions
- ☐ Malware infections that unleash a targeted attack
- ☐ Other(s) (Please specify) ________________________________

15. What are the difficulties your organisation has encountered in terms of cloud resource management? (You can choose more than one option)

- ☐ Lack of comprehensive understanding of cloud resource management
- ☐ Lack of experience in resource management
- ☐ Resource management is too costly
- ☐ The importance of cloud resource management has been overlooked
- ☐ Other(s) ________________________________

16. Please indicate the extent to which you agree or disagree with the statements below regarding cloud risk management.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Security is the most significant factor that should be considered before moving to cloud.					
(B) Cloud computing activities within an organization should be regulated by cloud computing policies.					
(C) Establishing a standard risk assessment system and risk warning system is necessary for establishing the framework for a risk management system.					

(D) Enacting relevant policies and establishing a risk warning and tracking system are possible means of handling potential risk.					
(E) It is necessary to include the ‘risk management’ factor in the cloud governance.					

Factor 4 Resource management

17. Who is responsible for cloud resources allocation?

- Service provider
- Cloud user
- Both of them
- Other(s) ___________________________

18. Please indicate the extent to which you agree or disagree with the statements below regarding cloud resource management.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Organizations should have regulations to manage the cloud resource.					
(B) Resource and scalability limits should be specified in cloud policy.					
(C) It is essential to monitor the availability of cloud resources.					
(D) The cloud service level agreement should contain quality of service (QoS) guarantees in order to satisfy timing or other conditions.					
(E) It is necessary to include the ‘resource management’ factor in the cloud governance					

Part 4: Operations Management (designing and controlling daily operations)

Factor 1: Data management

19. Do you or your department upload critical data to cloud?

- Yes
- No
- I do not know

20. Does your organisation have a disaster recovery plan for data management?

- Yes

- No
- I do not know

21. Who is responsible for cloud data backup?

- Service provider
- Cloud user
- Both of them
- Other(s) ________________________

22. Please indicate the extent to which you agree or disagree with the statements below regarding cloud data management.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Authorization and identity should be specified in data management operations.					
(B) Cloud technology is now more secure than before in terms of data protection.					
(C) It is necessary to include the 'data management' factor in operations management.					

Factor 2: Energy Consumption

23. Does your organisation implement relevant measures in order to achieve efficient energy management and energy conservation for the cloud operation?

- Yes, there has been cost-saving on energy consumption
- Yes, but currently the effect of energy-efficiency and cost-saving is not evident
- No

24. The high energy-consumption equipment should be updated to reduce energy consumption.

- Yes, this will reduce the cost of energy consumption.
- Yes, but the effect of cost-efficiency will not be seen in the short term
- No

25. Do you think it is necessary to monitor the energy consumption? *(You may choose more than one option)*

☐ Yes, the organisation will benefit from it in the long term.
☐ Yes, but it would be time-consuming and costly.
☐ No, there is no need for it.
☐ No, profit is the priority.

26. Which IT activity would consume more energy?

- Cooling Infrastructure
- Servers
- Power
- Other infrastructure

27. Please indicate the extent to which you agree or disagree with the statements below regarding energy consumption.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Cloud technology will reduce energy consumption.					
(B) The purpose of energy optimization is to minimise the energy consumption in order to save costs and reduce pollution.					
(C) It is necessary to include the 'energy consumption' factor in operations management					

Factor 3: Capacity Management

28. In the past three years, your data storage needs have:

- decreased dramatically
- decreased
- not changed
- increased
- increased dramatically

29. Is your network capacity adequate for cloud computing?

- Yes
- No
- I do not know

30. Please indicate the extent to which you agree or disagree with the statements below regarding capacity management.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Flexibility and scalability are the benefits of cloud computing in terms of capacity management.					
(B) Cloud computing can easily allocate resources for individual usage of a service (capacity allocation).					
(C) Cloud computing would achieve load balancing by distributing the workload evenly among the servers.					
(D) Bandwidth affects cloud computing using experience.					

(E) It is necessary to include 'capacity management' factor in operations management					

Factor 4: Virtualization

31. Which virtualization technologies does your organisation use? (You can choose more than one option)

- ☐ VMWare ESX Server
- ☐ VMWare Server
- ☐ VMWare Workstation
- ☐ Microsoft Hyper-V
- ☐ Microsoft Virtual Server
- ☐ Microsoft Virtual PC
- ☐ Other(s) please specify________________________________-

32. Which type of virtualization are you using? (You can choose more than one option)

- ☐ Hardware virtualization
- ☐ Operating system virtualization
- ☐ Server virtualization
- ☐ Storage virtualization

33. Which environments are you virtualizing? (You can choose more than one option)

- ☐ Development
- ☐ Production
- ☐ Testing
- ☐ Other(s) ______________________________

34. Please indicate the extent to which you agree or disagree with the statements below regarding virtualization.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Decreases hardware cosst					
(B) Decreases license costs					
(C) Decreases maintenance costs					
(D) Offers better performance					
(E) Improves scalability					
(F) Provides better security					
(G) Reduces redundancy					
(H) Provides safe backup					
(I) Simplifies development					
(J) Simplifies deployment					
(K) Has positive effects on the environment					
(L) It is necessary to include the 'virtualization' factor in operations management					

Part 5: Sustainability (ICT is designed, manufactured, managed and used in a way that minimizes environmental impact and meets the aims of sustainable development)

35. Please indicate the extent to which you agree or disagree with the statements below regarding cloud computing and sustainability

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
(A) Cloud computing would have positive effects on society, finance and environment					
(B) Cloud computing will improve organisations' sustainability performance					
(C) It is necessary to include 'social', 'economic' and 'environmental' factors in the sustainability theme.					

Factor 1: Social responsibility

36. How do you perceive the relationship between corporate development and social responsibility? (You may choose more than one option)

☐ Profit is more important.
☐ We should ignore social responsibility when necessary
☐ Fulfilling social responsibility can enhance the organization's development and competitiveness
☐ Do not know.

37. Do you agree that cloud computing will bring more benefits than disadvantages to education?

- Yes
- No
- Not sure

38. The major problems that your organisation has encountered when implementing cloud:

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
It takes a long time to become familiar with cloud computing					
Employees' lack of experience in working with cloud computing					
Organisation needs to provide more training for employees					

39. What are the positive impacts of cloud computing in education?

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Allows access to applications from anywhere					
Provides support for teaching and learning					
Software is free or pay per use					
24-hour access to infrastructure and content					
Provides access to business environment and advanced research					
Protects the environment by using green technologies					
Increases student awareness of new technologies					
Increases functional capabilities					
Enables offline usage with further synchronization opportunities					

40. What are the negative impacts of cloud computing in education?

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Not all applications run in cloud					
Risks related to data protection and security and accounts management					
Lack of organizational support					
Security and protection of sensitive data					
Lack of confidence					
Slow speed/lack of Internet can affect work practices					

41. What prevents organisations from fulfilling their social responsibilities?

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Lack of Corporation Social Responsibility (CSR) awareness					
Budget constraints					
Lack of support from professional organizations					
Not required by headquarters					
Other(s)					

Factor 2: Economy

42. Do you think sustainable operation activities would help a company to build a better brand image?

- Yes
- No

- I do not know.

43. The degree to which your organisation works with the cloud vendor is:

- Close
- Average
- There is no such cooperation.

44. How would you deal with the development strategies, policies and regulations in terms of cloud development?

- Include them in the development strategy
- Occasionally consider them
- Pay no attention to them
- Do not know.

45. Is your cloud provider a Chinese company?

- Yes
- If not, please specify the country in which the company is based

  ____

- Don’t know

46. If possible, do you prefer to purchase cloud products and services from local service providers?

- Yes
- No
- Makes no difference

47. How profitable is your cloud computing investment?

- Very profitable
- Profitable
- Breaking even
- Currently in loss
- Do not know

Factor 3: Environmental

48. How familiar are you with current environmental laws and regulations in relation to the IT industry?

- Very familiar
- Familiar
- Somewhat familiar
- Not familiar

49. Please indicate the extent to which you agree or disagree with the statements below regarding the environmental impacts of cloud computing

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Cloud computing will reduce the carbon footprint.					

Cloud is a “greener” computing alternative.					
Cloud is energy saving.					
Cloud produces less e-waste.					