

Cloud Computing: Developing a Cost Estimation Model for Customers

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1 Introduction

'Being on the cloud exposes you to a different reality,' said an IT manager in a large enterprise. Reading this quote is different than hearing it from this manager. Cloud computing has become an essential ingredient in the digital transformation of businesses. The industry and academic reports widely discuss the merits of cloud computing. For example, it moves the burden of provisioning capital IT investments to the cloud provider's side rather than the customer's (Grossman, 2009). Hence, the management and maintenance costs of those resources no longer form a source of irritation to the cloud customer. Most importantly, the cloud computing concept offers cost reductions to its beneficiaries by exploiting the benefits of economies of scale (Foster et al., 2008; Kashef & Altmann, 2012).

However, this opening sentence has been said with a big sigh. Absolute benefits should not be taken for granted out of the clouds. Some studies proved that in particular cases, no significant cost savings were achieved through the cloud compared to the in-house developments. As well, different challenges are reported, such as security, lack of skilled resources, legal compliance, availability, and data privacy (Rastogi & Aggarwal, 2022; Sasubilli & R, 2021). Moreover, cloud computing might represent a critical change to cloud customers' business models (Singh, Banyal, and Sharma: 2019). Gaining the benefits of cloud computing while dealing with its challenges and adjusting to the new changes it imposes significantly put the cost estimation of cloud solutions in question (Duncan, 2018; Sharma et al., 2020).

Cloud computing has been tremendously evolving in the last decade. The National Institute of Standards and Technology (NIST) provided the most adopted cloud computing definition, according to google scholar, with more than 19000 citations(Choudhary & Vithayathil, 2013; Martens et al., 2012; Sahandi et al., 2013; Walterbusch et al., 2013). It defines cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction" (Mell et al., 2011:2).

Further, cloud computing can be classified, with regard to deployment in organizations, into four types; public clouds, private clouds, hybrid clouds, and community clouds (Lian et al., 2014; Sahandi et al., 2013). A public cloud is a service offered by third parties using the internet (Jayeola et al., 2022). A private cloud denotes that one company solely owns and uses a private cloud. Sometimes, a third party can manage the private cloud (Jayeola et al., 2022). Some organizations tend to host their sensitive data and applications in private clouds while utilizing the advantages of public clouds for non-critical business processes. This scenario denotes a hybrid cloud (Jayeola et al., 2022). A final deployment model is the community cloud, where a group of organizations with shared interests use and manage the cloud services (Meghana et al., 2013).

From another perspective, and despite becoming a business necessity, cloud computing was remarked as a rapidly evolving technology that still lacks some critical foundations (Bildosola et al., 2015). On the one hand, Worldwide end-user spending on public cloud services was forecasted to reach \$332.3 billion in 2021 (Gartner, 2021). On the other hand, it has not been easy to treat cloud computing as a ubiquitous technology due to different challenges such as security and legal compliance (Sasubilli & R, 2021). Moreover, according to Bildosola et al. (2015), there are no criteria or guidelines to help cloud customers get a complete picture of what is required from them before going to the cloud.

Cloud computing is usually marketed as it reduces technology infrastructure costs and improves accessibility. Companies switching to the clouds are promised significant cost savings (Jayeola et al., 2022). These promises cannot be denied but should not be misleading. In some cases, cloud services cost more than expected in terms of the initial investment, continuous maintenance, plus other hidden costs (Zimmerman, 2014). A study even reported that more than 70% of companies that moved to the cloud were unaware of unanticipated costs following adoption. Transparency of the service provider, need for continuous maintenance costs, and lack of cloud expertise play a role in unpredicted costs and implementation problems (Duncan, 2018; McCafferty, 2015; Sharma et al., 2020).

Generally, cost estimation is a well-established research area. There are various cost estimation models but mostly related to software development. However, in cloud computing, a company approaches a service provider to utilize a hosted service. In such a case, the costs that the beneficiary company needs to consider are vital to have a holistic approach to the benefit of the cloud service. According to Assunção et al. (2015), cost estimation is a primary step before transferring data to the cloud that should not be described as a “trivial task” (Assunção et al., 2015). The lack of coherent tools to analyze the costs of the clouds for cloud users would result in a weak foundation for risk assessment and cost optimization endeavors.

From an academic perspective, the business and organizational aspects of cloud computing are under-researched. According to a study published in 2016, only 6% of cloud computing research targeted the economic dimensions of cloud computing. In addition, 8 % addressed organizational dimensions. There is a general shortage of cloud publications in business journals (Bayramusta & Nasir, 2016). Simultaneously, new technologies change the nature of work in an organization, call for adaptations in organizational structures and impose misalignment risks within the organizational activities (Barley & Kunda, 2001). Hence, the ultimate question of the impact of introducing cloud computing to a company comes down to how it can affect the actual and ongoing aspects of IT processes: how cloud computing is imposing changes to existing practices, processes, and routines. This question is potentially much more complex than cost-benefit analysis research can answer. Cloud computing research needs to blend into organizations with their complex networks, cultures, and corporate histories. This means that research targeting cloud costs would be enhanced by studying the actual interactions of organizational entities (business units) operating

on a cloud project to build a cloud-enabled IT architecture. What are the business processes of provisioning a cloud service? Does cloud computing impose changes to other areas other than the IT department too? Eventually, it comes down to the question of ‘what is really going on in corporations when they move to the cloud?’ and ‘how is that being translated into the total costs’.

This research aims to develop a cost estimation model for cloud services from the cloud consumer perspective. A cost estimation model for cloud services would help cloud users estimate key performance indicators and financial ratios, such as returns on investment (ROI). Further, developing a total cost of ownership analysis is a significant determinant in assessing the readiness of a firm’s adoption of cloud computing. Thus, this dissertation provides essential aid to the digital transformation projects for almost any organization operating in the current globally volatile economy and ever-changing technological sphere. Moreover, the output of this project bridges the gap between the IT department and other internal and external stakeholders of cloud adoption projects. Using the comprehensive cost estimation model provided at the end of this dissertation will make the cloud costs, the digital transformation processes, and the communication among all affected parties less cloudy, i.e., well-informed and not vague.

This dissertation starts by identifying cloud computing along with its components and classifications in chapter 2. This chapter also explains the economics of cloud computing. Chapter 3 discusses theoretical foundations, including the total cost of ownership and transaction cost theory. Chapter 4 focuses on the cost estimation of cloud computing and covers the previous literature applying TCO to cloud computing. The research gap, as well as the methodology, is presented in sections 5 and 6, respectively. Chapter 7 reports the findings and discussion, while chapter 8 concludes the main contributions of this dissertation project.

2 Cloud Computing

Research has recently opted for comprehending cloud computing by articulating its definition, components, and classifications. It has been agreed in the literature a decade ago that the concept behind cloud computing is not novel (Marston et al., 2011; Wei & Blake, 2010) since it aims at using computing as a utility that a third party provides; in the same way electricity and water are used at homes (Buyya et al., 2008; Grossman, 2009; Nayak et al., 2018). However, there has been confusion about what exactly cloud computing is (Weinhardt et al., 2009). Moreover, some researchers argue that cloud computing is built on the previous grid computing concepts. For example, (Foster et al., 2008) argued that cloud computing evolved from grid computing, while the latter acts as the “backbone” for cloud services. However, this has been refuted by some researchers stating that the grid computing did not go beyond the research area and all the applications were externally financed; no operational business models were developed for it (Armbrust et al., 2010a; Buyya et al., 2008; Youseff et al., 2008). Grid computing could be defined as a computing paradigm that provides sharing, selecting, and aggregating a wide variety of

geographically distributed resources owned by different organizations (Foster et al., 2008). It was primarily considered a revolutionary computing model. Nevertheless, as stated earlier, it lacks sustainability as it depends on third-party funds.

This section will go as follows. First, the definitions of cloud computing will be targeted. Then, the different deployment models are explained. Finally, the enabling technologies, as well as the cloud players, are demonstrated.

2.1 Cloud Computing Definition

According to (Armbrust et al., 2010a), cloud computing denotes “both the applications delivered as services over the Internet and the hardware and systems software in the data centers that provide those services.” Unlike standard cloud computing definitions, Youseff et al. (2008) considered cloud computing as “a new computing paradigm that allows users to temporary utilize computing infrastructure over the network, supplied as a service by the cloud provider at possibly one or more levels of abstraction.”

One of the most adopted cloud computing definitions is the one provided by the National Institute of Standards and Technology (NIST). It defines cloud computing as “*a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction*” (Choudhary & Vithayathil, 2013; Jayeola et al., 2022; Martens et al., 2012; Mell et al., 2011; Sahandi et al., 2013; Walterbusch et al., 2013).

(Buyya et al., 2008) stressed the virtualization aspect of cloud computing. They proposed that “*A Cloud is a type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation; between the service provider and consumers.*”

Towards grasping the concept of cloud computing, cloud computing can be dissected according to the various services delivered by vendors. Further, Youseff et al. (2008) viewed cloud systems in five ordered layers: cloud application layer, cloud software environment layer, cloud software infrastructure layer, software kernel, and hardware and firmware (Böhm et al., 2011; Youseff et al., 2008). In this order, using the concept of SOA, they demonstrated that each layer could be composed of the layers underlying it. For example, cloud applications can be formulated using services from the software environment layer or infrastructure layer. At the same time, services can be used from the same layer; e.g., a payroll application may use an existing accounting application (Grossman, 2009).

Cloud Computing Service Delivery Models

The most famous delivery model classification available in academia is dissecting cloud services into software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) (Jayeola et al., 2022; Marston et al., 2011; Rastogi & Aggarwal, 2022). According to the NIST definition (Mell et al., 2011):

- Cloud Software as a Service (SaaS) denotes a service in which the cloud users utilize cloud applications running on a cloud infrastructure on the service provider side. The cloud user can access those applications via client interfaces such as web browsers. The cloud user has no authority in managing or controlling the underlying cloud infrastructure.
- Cloud Platform as a Service (PaaS) enables the consumer to deploy their applications created using programming tools and languages supported by the provider. The user can utilize operating system support and software development frameworks. The user has control over the deployed applications and, in some cases, the configurations of the application-hosting environment. However, the service provider exclusively manages the underlying cloud infrastructure, including network, servers, operating systems, and storage.
- Cloud Infrastructure as a Service (IaaS) provides the cloud user with the capability to provision processing, storage, networks, and other fundamental computing resources. The cloud user can deploy and run software resources, including operating systems and various applications. The cloud user can control operating systems, storage, and deployed applications. However, the service provider merely manages the underlying cloud infrastructure while empowering the cloud user with limited control over selecting networking components (e.g., host firewalls).

Figure 1 exhibits the service deployment models while mapping the customer's responsibility versus the vendor's.

Party	IaaS	PaaS	SaaS	Description of the layer
Cloud customer	Secure application usage			The cloud customers are responsible for secure usage of the application.
	User specifics			User-specific settings or configurations of used applications.
	Application	Application		Offered software solutions.
	Software security	Software security		Mechanisms to increase the security of provided applications.
	Administration and support	Administration and support		Administration of the software as well as receipt and handling of support inquiries from the cloud customer.
	Operating system	Operating system	Operating system	Basic software for operation of the application.
	Runtime environment	Runtime environment	Runtime environment	The runtime environment carries out applications for which the runtime environment is suitable.
	Database	Database	Database	Software for the management and structuring of data.
	Platform security	Platform security	Platform security	Mechanisms to increase the security of provided platforms.
	Administration and support	Administration and support	Administration and support	Administration of the provided platform as well as receipt and handling of support inquiries from the cloud customer.
Virtual machines	Virtual machines		Virtual representation of computer resources like, for example, servers or CPUs.	
Cloud provider	Virtualization	Virtualization		Mechanisms for the creation and management of virtual machines.
	Computing	Computing		Components to process data in the cloud service.
	Storage	Storage		Mechanisms for the storage of data.
	Network	Network		Mechanisms for the transfer of data.
	Infrastructure security	Infrastructure security		Mechanisms to increase the security of provided resources.
	Administration and support	Administration and support		Administration of the provided infrastructure as well as receipt and handling of support inquiries from the cloud customer.
	Hardware			The physical hardware for operation of the cloud service.
	Premises, housing and equipment			The physical set-up of the cloud service.
	Network			Physical connectivity of the data center.
	Data center security			Mechanisms to increase the security of the data center, including parties responsible for the housing, with security staff and physical security systems.

Key:

	Cloud customer		IaaS core business
	SaaS core business		Full stack provider or sub-provider
	PaaS core business		

Figure 1: Illustration of the different layers of the cloud service stack (Sunyaev, 2020: 213)

Cloud Computing Deployment Models

Cloud computing can be classified with regard to deployment in organizations. This classification would result in four types of clouds; public clouds, private clouds, hybrid clouds, and community clouds (Jayeola et al., 2022; Lian et al., 2014; Sahandi et al., 2013). A public cloud is a type of service offered by third parties using the internet. It provides a cost-effective solution for its customers since no upfront investments are needed. A customer pays for the service according to the pricing strategy followed by the provider (Grossman, 2009; Hofmann & Woods, 2010). A private cloud denotes the case in which the cloud is solely dedicated and owned by one company.

In some cases, a third party can manage the private cloud. Private clouds offer many of the advantages delivered by their public counterparts, such as usage elasticity. However, organizations deploying private cloud will have to bear upfront costs (Grossman, 2009). Some organizations tend to host their critical data in private clouds while utilizing the advantages of public clouds for non-critical data; this is denoted as the hybrid cloud (Guha & Al-Dabass, 2010). A final

deployment model is a community cloud in which a group of organizations with shared interests use and manage the cloud services (Marston et al., 2011; Meghana et al., 2013).

Cloud Computing Enabling Technologies

Cloud computing is enabled mainly by three primary technologies; virtualization, multi-tenancy, and web services (Low et al., 2011). Virtualization is a concept that has been prevalent since the 1960s, and it is considered the foundation of cloud computing (Chaisiri et al., 2012; Rastogi & Aggarwal, 2022; Vaquero et al., 2009; Vouk, 2008). It refers to presenting an abstract imitating computing platform that behaves like an independent system while hiding the physical characteristics from the users. Using virtualization, the computing infrastructure is better utilized, which leads to reduced operational and upfront costs (Marston et al., 2011). Such cost reduction is enabled by providing companies with the capabilities of pooling computing resources from a cluster of servers and allocating and de-allocating resources to applications in an on-demand scalable fashion (Guha & Al-Dabass, 2010; Zhang et al., 2010). By accommodating various and diverse operating systems on the same hardware, machine visualization allows for dividing the computing power of a physical machine into many virtual machines. In cloud computing, virtualization encompasses server, storage, network, service/application, and client/desktop/application virtualization (Bayramusta & Nasir, 2016).

As for the second enabling technology multitenancy, it denotes sharing a single instance of service by multiple tenants. A tenant might refer to an individual end-user or a whole company with multiple users (Dhar, 2012; Marston et al., 2011; Mietzner et al., 2009). Finally, some academics refer to web services as a third enabling technology for cloud computing (Marston et al., 2011). However, other scholars refer to the concept on which web services are built, service-oriented architecture (SOA) (Guha & Al-Dabass, 2010; Vouk, 2008). The SOA concept represents a philosophy that facilitates the interoperability between web services where users call services of certain functionality at a defined quality and capacity target. Cloud applications use the concept of SOA to compose services that could be offered by other cloud providers (Vouk, 2008; Youseff et al., 2008). According to Tsai et al. (2010), SOA and cloud computing complement and support each other.

Cloud Players

The entities involved in the computing services are various. Three players can be associated with a single cloud service; the user, service level agreement (SLA) resource allocator, and the cloud provider (Buyya et al., 2008). The user is the entity that requests and utilizes the service (Böhm et al., 2011; Vaquero et al., 2009). The SLA locator acts as an intermediary between the user and provider. According to Buyya et al. (2008), the SLA locator uses various mechanisms to support its operations, such as service request examiner and admission control, pricing, accounting, virtual machine monitor, dispatcher, and service request monitor. Finally, the service provider is liable for the quality of service (QoS) and the data center, which comprises multiple physical machines

that provide resources to meet cloud users' demands. The service provider also is responsible for the virtual machines (VMs) as they can be dynamically used on a single physical machine to meet service requests. In addition, multiple VMs can simultaneously run various applications on a single physical machine since every VM is completely isolated from one another on the same physical machine (Böhm et al., 2011; Buyya et al., 2008; Chaisiri et al., 2012; Pal & Hui, 2012; Rastogi & Aggarwal, 2022).

Cloud Computing Business Models

Upon reviewing the literature, it was found that some researchers tried to articulate the business models of cloud computing. The dilemma resides in the fact that cloud computing services commercially exist before attempting to frame them in explicit business models. This section will state some of the studies that tackled business models.

Currently, the market of the cloud represents a very dynamic business where providers, as well as beneficiaries, increase rapidly. However, the lack of appropriate business models that satisfy the long-term requirements has exemplified a significant problem (Weinhardt et al., 2009). It is relatively vague how much payment providers should ask for which feature/service. Also, it has been unclear how providers may sustain their business upon providing clouds. Further, the business models addressing IT service and provisioning of resources have dramatically changed over recent years. Having one-time license fees and licensing models tied to individual users or machines is no longer the only model or the most dominant one. There is much movement towards flat rates and free or low-cost online applications. Accordingly, new models have been needed to describe how to generate revenues and how to calculate and compare costs (Schubert & Jeffery, 2012).

Weinhardt et al. (2009) provided ontology for cloud business models. The ontology is divided according to the three delivery models; infrastructure, platform, and application. The infrastructure business models have two categories: storage capabilities and computing power. The pricing for those business models is mainly pay-per-use or based on subscription. At the platform layer, two business models are distinguished. First, development platforms represent a business model that allows developers to write their applications and upload their code to the cloud while granting scalability. Second, business platforms are a business model that enables the development, deployment, and management of tailored business applications. The last layer is the application layer which entails two business models; software as a service and on-demand web services. Figure 2 explains those business models provided by Weinhardt et al. (2009), gives examples for each model, and clarifies the relationship between them. The models on top can encapsulate functionalities from the layers beneath by aggregating and extending service components.

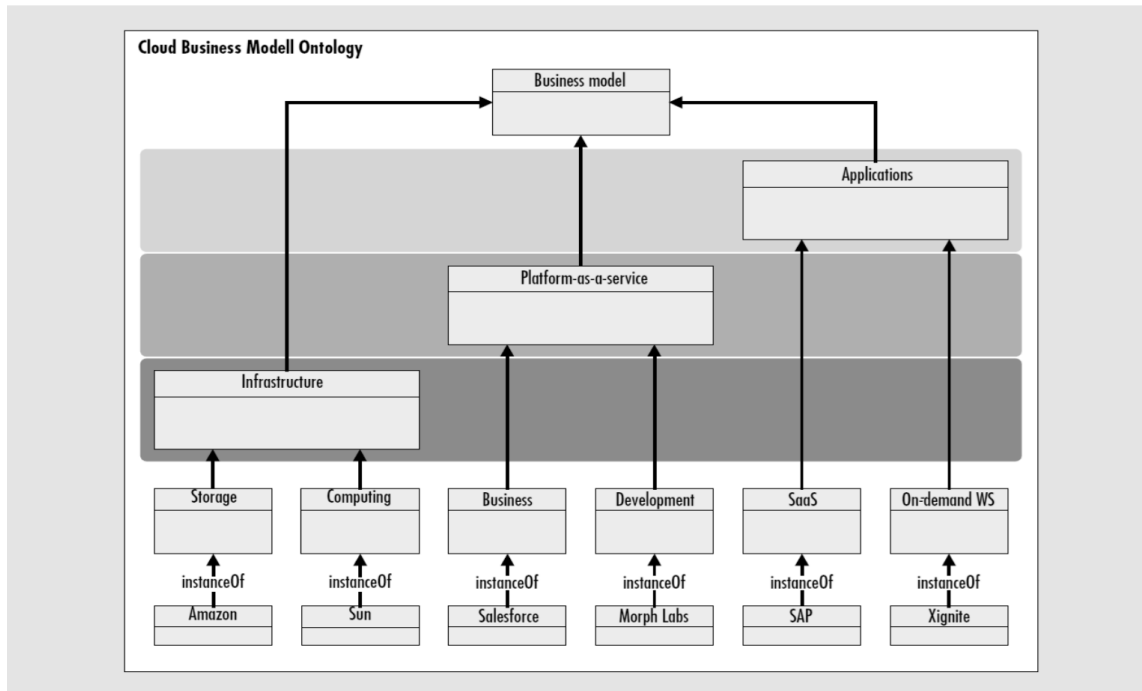


Figure 2: Cloud computing business models proposed by Weinhardt et al. (2009).

2.2 Cloud computing versus Outsourcing

The buy-or-make decisions have interested the IT industry for a long time. A close look at cloud computing may trigger the following question, how different is cloud computing from outsourcing models. Böhm et al. (2011) agreed that cloud computing could be viewed as an evolution in the development of outsourcing models. However, cloud computing takes a more holistic view. It directs the focus from a merely technological standpoint to a broader comprehension of the business needs such as reliability, availability, economies of scale, and flexibility. In other words, cloud services aim at meeting those business challenges (Böhm et al., 2011). From an economic point of view, cloud computing and IT outsourcing share some similarities. These similarities imply that the IT outsourcing knowledge base can be extended to serve the understanding of cloud computing with its emerging differences (Martens & Teuteberg, 2011). Clemons & Chen (2011) clearly stated that cloud computing is an advanced form of outsourcing. Most of what applies to IT outsourcing applies to the cloud.

The main difference between classical outsourcing and cloud computing is the following. Clouds are more service-oriented, while outsourcing focuses more on a single provider. In other words, the classical value chain of outsourcing has broken up in the clouds. Cloud providers can offer their customers new flexibilities with new services and business models. As well, clouds allow modifying existing services without significant investments.

Clouds can be viewed from two main sides. First, infrastructure is offered as a service. Second, new platforms emerged, integrating the offerings of hardware and software as a service. These

platforms allow the creation of new single and composed services. From a value chain point of view, these platforms can be viewed as a marketplace where various cloud services are integrated. Also, the as-a-service concept allows the mixing of on-premise and cloud services and the mixing of pure cloud applications (Böhm et al., 2011).

2.3 Cloud Computing Economics

One of the distinguishing aspects of cloud computing is how different the articulation of its services' supply and demand is. Cloud computing enables high scalability; companies can promptly respond to their variations in demand via provisioning and de-provisioning of cloud resources (H. Li et al., 2009). This scalability allows cloud users to utilize infinite cloud resources to keep up with load surges while eliminating the burden of planning ahead for provisioning. It also enables cloud users to pay only for the computing resources they utilize on a short-term basis. The computing industry has been moving toward the cloud, motivated by economies of scale; large data centers can deploy computational resources at significantly lower costs (Pal & Hui, 2012; H. Li et al., 2009).

Some researchers have discussed the pricing of cloud services. Pricing models for cloud services are generally pay-per-use or subscription-based (Weinhardt et al., 2009). Harmon et al. (2009) discussed that the IT industry has been moving from product-centric to service-centric business models facilitated by cloud computing. Pricing services is much more complex than pricing products. The authors argued that the pricing of the IT services should be value-based rather than cost-based.

Moreover, Chaisiri et al. (2012) studied the pricing of IaaS providers and claimed that the reservation plan promises lower prices than the on-demand plans. However, a cloud consumer following the reservation plan will be at risk of under/over-provisioning problems caused by demand uncertainty. Table 1 shows the pricing models offered by various cloud providers. Finally, Pal & Hui (2012) developed inter-organizational economic models for pricing cloud services by applying the game theory approach. They concluded that there is Nash equilibrium in some QoS-driven pricing models.

Company/Product	Service type	Pricing Model
Amazon EC2, S3, SimpleDB, SQS, FPS, DevPay	Computing, Storage, Database, Payment, Billing	Pay-per-use
Appian Anywhere	Business Process Management	Pay-per-use
Box.net	Storage	Pay-per-use
FlexiScale	Infrastructure	Pay-per-use
Google App Engine	Infrastructure, Web Applications	Pay-per-use
Gmail Drive	Storage, Email	free* / Pay-per-use
MuxCloud	Data Processing (Video): uses Amazon's EC2	Pay-per-use
Nirvanix	Storage	Pay-per-use
Network.com	Infrastructure	Pay-per-use
OpSource	Billing	Subscription
Process Maker Live	Business Process Management	Pay-per-use
Salesforce.com	Platform	Pay-per-use
MS SkyDrive	Storage	free*
SmugMug	Data Sharing (Photo)	Subscription
Strikeiron	Web Services	Subscription/ Pay-per-use
XDrive	Storage	Subscription
XCalibre	Infrastructure	Subscription
Zimory.com	Marketplace	Dynamic pricing
* free up to a limited contingent, e. g. 5 GB or 7 GB		

Table 1: Pricing model offered by various cloud providers (Weinhardt et al., 2009)

2.4 Challenges of Cloud Computing

Although cloud computing offers attractive advantages, it still encompasses challenges (Sun, 2020). For example, due to the nature of cloud computing, its services are usually provided remotely, especially in the public cloud deployment model. This might cause cloud users to suffer from latency and bandwidth problems. In addition, some issues can arise when multiple customers share one piece of hardware. For instance, it was stated that a user's application can compromise other users' applications sharing the same system. Muhleman et al. (2012) also explained that customers have to tolerate a level of access control and privacy to the cloud provider, which highlights the sensitivity of service level agreements (SLA), contract terms, and security control. This section explains more of the cloud computing challenges.

Business Continuity and Service Availability: as assured by cloud vendors' marketing initiatives, cloud users expect cloud services to be highly available. However, such high availability is not guaranteed (Sun, 2020). For example, Amazon Simple Storage Service (S3) experienced a 6-8 hours outage on 20/07/2008. Also, Gmail was unavailable for 1.5 hours on 11/08/2008 (Armbrust et al., 2010a). Those outages of the two famous cloud vendors were due to technical problems. However, non-technical reasons can still dominate, such as being subject to regulatory actions or going out of business. Recently, in the last months of the year 2021, AWS experienced three significant outages affecting many companies, including McDonald's, Toyota, and Disney (Jeans, 2022).

Data Lock-in and interoperability: Data lock-in is viewed as an advantage for cloud providers. However, data lock-in is one obstacle that hinders cloud computing adoption for cloud users. Cloud users cannot seamlessly move their data from one service provider to another because, among other reasons, cloud providers speak different languages (Hofmann & Woods, 2010). Accordingly, if a service provider goes out of business, its customers' data might be lost. According to Armbrust et al. (2010), one of the solutions to this dilemma is to standardize the APIs so that services and data can be deployed across multiple providers to minimize the harm of the failure of a single provider.

Data Transfer: the cost of transferring large data volumes over the internet might be very high, especially in data-intensive applications. This cost incorporates money and time (Noor et al., 2018).

Security: one of the significant issues of cloud computing is that having data accessible by third parties highlights security and regulatory concerns (Rastogi & Aggarwal, 2022). Security as responsibility is divided among the cloud provider (liable for physical security), cloud user (liable for application-level security), and sometimes third-party vendors that the users hire for security-sensitive configurations.

The increase of security concerns of the cloud asks for extra efforts in evaluating the IT risks and IT processes. These extra efforts result in more hassle for the planning, monitoring, and evaluation processes because a new party is part of the process now, the vendor. Thus, cloud customers must exert more effort to ensure compliance (Rastogi & Aggarwal, 2022; Varghese & Buyya, 2018).

IT service management of the cloud: Managing IT services offered by an IT department is crucial to any organization and formulates the ITSM processes. A company planning to integrate cloud solutions into existing IT architecture should anticipate changes in its ITSM. Depending on the extent of cloud used in the company, these changes can be 'fundamental,' e.g., aligning IT and business strategy and increasing the transparency and quality of IT processes and services (Erek et al., 2014).

Due to the interest of many organizations in cloud computing, they would be confronted with changes in the IT service management (ITSM) processes. Most cloud customers adopt cloud

services along with their existing in-house IT applications. In other words, cloud customers partially use the cloud to source their IT services (Erek et al., 2014).

Erek et al. (2014) reported that ITIL processes could be adapted to cloud computing services. The authors highlighted that some processes would require changes within the five phases of the ITIL service life cycle. Such changes question how this can be translated into costs/ cost factors. Considering only the initial costs of cloud adoption is the most trivial thing companies can do.

Moreover, cloud computing imposes a new risk to the IT organization represented in service disintermediation (O'Loughlin, 2016) or shadow-IT (Erek et al., 2014). This risk happens when the IT organization cannot cope with the vast publicly available cloud services in the cloud market places. Service consumers anticipate higher value from the cloud broker or the cloud provider than the value offered by the IT organization. So, they buy services directly without returning to the IT organization. This calls for some actions by the IT organization to maintain concrete governance of the services adopted and utilized by service consumers. For example, an IT organization has to be more responsive, agile, and flexible when it comes to providing services. Further, the IT organization can act as the service broker by providing a clear service catalog or marketplace for the different business units. These actions call for changes in the ITSM practices that were familiar to the IT organization before cloud introduction to the company (O'Loughlin, 2016).

3 Theoretical Foundation

This chapter explains the two main theories applied in this research. First, the researcher explains the total cost of ownership theory (TCO) with its origins and application in the information technology field. Second, the transaction cost theory (TCT) is explained.

3.1 The Total Cost of Ownership

TCO Origins

According to (L. Ellram, 1993), TCO is a concept that stresses understanding the cost of dealing with a supplier, which is by far not only the price. Multiple researchers have sought to classify the cost factors impeded in the TCO. For example, L. Ellram (1994) showed that it is crucial to analyze the internal, external, and administrative costs. Earlier, the same author suggested another classification; pre-transaction, transaction, and post-transaction costs(L. Ellram, 1993). Further, a detailed classification recommended six categories to analyze TCO: management, delivery, service, communications, price, and quality (L. M. Ellram & Siferd, 1993). McKeen & Smith (2010) identified four strategies to handle the TCO implementation. Since TCO is a costly concept itself, the first strategy is to use it in critical matters. The second strategy is more related to the governance of the TCO initiative. A TCO office is recommended to take ownership of the TCO-related activities, which will be a hub for standards, methodologies, and expertise. The third strategy is to count for the timing in which TCO data will be gathered. According to the authors,

TCO data is to be solicited at different stages throughout the lifecycle of the IT application. The last strategy is to acquire TCO management tools to handle TCO data, track different cost types and provide reporting functionality.

Classically the importance of the TCO concept is common sense. It is mainstream that companies should account for all the costs associated with their sourcing decisions. However, the dilemma resides in the application of the concept. For example, the number of cost factors tied to TCO is remarkable. Further, some costs are difficult to isolate for the application in question, such as network charges (McKeen & Smith, 2010).

TCO for IT

Information technology costs represent a significant portion of the overall operational budget. Although TCO is not an innovative concept- it is based on lifecycle cost analysis and full cost accounting-it was first applied to IT by Gartner in 1987. TCO aims to view the IT costs holistically by encompassing the direct and indirect cost factors (McKeen & Smith, 2010). According to (McKeen & Smith, 2010), the TCO concept has been studied in several IT areas such as desktop/workstations, ERP systems, system software, and total IT investment. So the concept has primarily been used to address the actual costs associated with provisioning and managing an IT component in the organization. It incorporates capital and operating costs throughout the life cycle of the application in question (H. Li et al., 2009). McKeen & Smith (2010) highlighted four challenges faced by IT managers which make TCO irreplaceable. The first challenge is to effectively manage IT costs. IT managers are always expected to stream a high demand for IT services within condensed costs. The second challenge comes when supporting business cases. Sometimes, it is difficult for the managers to comprehend the total cost effect imposed by a new business initiative. The third challenge is to explain the IT charges to the business functions. The fourth challenge faced by IT managers is to have the cost transparency that helps justify technology strategies.

David et al. (2002) categorized the IT total cost of ownership factors into acquisition costs, control costs, and operation costs (Table 2). The control costs aim at lowering IT costs through streamlining operations via centralization and standardization.

Table 2 Categories of IT TCO Factors (David et al., 2002: 103).

<i>TCO Category</i>	Acquisition Costs	Control	Operations
<i>Cost Factor</i>	<ul style="list-style-type: none"> • Hardware • Software 	<ul style="list-style-type: none"> • Implementation and maintenance of centralization • Implementation and maintenance of 	<ul style="list-style-type: none"> • support • evaluation • installation/upgrades • training • downtime

		<ul style="list-style-type: none"> • standardization 	<ul style="list-style-type: none"> • futz • auditing • viruses • power consumption
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Based on a focus group of IT managers, the TCO can focus on the cost factors demonstrated in **Table 3**.

<i>Cost Category</i>	One-time (start-up) costs	Ongoing (lifetime) and enhancement costs	Ancillary costs	One-time (end-of-life) costs
<i>Cost Factor</i>	<ul style="list-style-type: none"> • end-user computer hardware purchase costs • software license purchase costs • hardware and software implementation/d deployment costs • operations infrastructure costs • network hardware and software costs • server hardware and software costs • testing costs • technology training costs of users and IT personnel 	<ul style="list-style-type: none"> • hardware warranties and maintenance costs • software license tracking costs • operations infrastructure costs • infrastructure (floor space) costs • cost for electricity and cooling • network hardware and software costs • server hardware and software costs • backup and recovery process costs • cost to upgrade or scalability • costs incurred to integrate with other applications • audit costs • insurance costs 	<ul style="list-style-type: none"> • IT personnel costs • “C” level management contribution • costs associated with failure or outage • diminished performance incidents (e.g., users having to wait) • costs of security breaches (e.g., loss of reputation and recovery costs) 	<ul style="list-style-type: none"> • replacement costs • migration costs • decommissioning costs

Table 3: Costs that could be included in a TCO formula (McKeen & Smith, 2010: 631).

outsourcer to exploit economies of scale. Another efficiency-based reason is that outsourcing IS services allows for more concentration on core business processes. Cost efficiency also results from decreasing or removing fixed costs of huge technology investments. The second motivation, political motivation, is, for example, having difficulties in managing IS activities due to inadequate IS departments.

The first motivation highlighted by Aubert et al. (1996), efficiency-based, applies perfectly to cloud computing. Reasons such as economies of scale and pooling of demand are prevailing in the cloud computing justification writings ((Foster et al., 2008; Kashef & Altmann, 2012; H. Li et al., 2009; Pal & Hui, 2012). Further, the point of decreasing or removing fixed costs directly points to the Capex / Opex argument raised -or facilitated- by the cloud (Grossman, 2009).

The coming chapter discusses the cost estimation of cloud computing, whereas section 4.3 gives more details on the TCE of cloud computing.

4 Cost Estimation of Cloud Computing

Cloud computing is usually marketed by the cost advantages that it brings to the organization. This chapter reviews the state-of-the-art of cloud computing cost estimation. Then, the literature on how both total cost of ownership (TCO) and Transaction cost Theory apply to cloud computing is discussed. Finally, the expected output is reported in a form of a knowledge base.

4.1 State of The Art

The literature is primarily rich in the field of software cost estimation models. This area of research has been active since the 1970s resulting in many models and improvements of models to cope with the changes associated with the software development field. **Table 4** provides a sample of the most prominent cost estimation models.

Model	Year
SDC (Systems Development Corp.)	1965
TRW Wolverton	1974
Putnam SLIM (<i>Software Lifecycle Management</i>)	1976
Boeing Black	1977
Doty	1977
IBM-FSD (IBM Federal Systems Division)	1977
RCA Price S	1977
Walston-Felix	1977
IBM function points	1979
Bailey-Basili Meta-Model	1981
Cocoma (Constructive Cost Model)	1981
SoftCost-R	1981
Estimacs	1983
Jensen/SEER (<i>Software Evaluation and Estimation of Resources</i>)	1983
SPQR (<i>Software Productivity Quality and Reliability</i>)/Checkpoint	1985

Table 4: Prominent software estimation models (Boehm & Valerdi, 2008)

However, those models are meant for developing software. What if the software is already built and is released as a utility (cloud-based)? How will the costs be estimated? Barbosa & Charão (2012) stressed the need to revise established models such as COCOMO II in the context of cloud computing. Also, according to Li & Keung (2010), COCOMO II cannot conclude cost estimation for an SOA application development.

The problem arises from the fact that cloud-based solutions are –in many cases- composable: a service is composed of other services. Further, cloud services are developed based on service-oriented architecture philosophy (SOA). They are viewed as loosely coupled services in which technical details are hidden and are not technology-specific. This means that the implementation of a service is independent of programming language and platforms. Therefore, a single application could include different development strategies and development processes. As a result, COCOMO II is not sufficient to justify the customer-centric cost estimation for SOA-based applications despite being a model that incorporates a considerable number of coefficients (Z. Li & Keung, 2010). It is more of a developers' / providers' -perspective.

From the customer perspective, services are reused, not developed for each customer. COCOMO II model supports two kinds of reused components, black-box, and white-box. Black box components can be reused without making any changes in it or knowing the complete code. White-box components must be amended or integrated with other components before reusing them. Alike, there are black-box services and white-box services within the service-oriented architecture. However, there is a significant difference between code-level reuse and service-level reuse (Z. Li & Keung, 2010). The following paragraphs review the related work in this area.

Singer et al. (2010) presented a linear programming model that helps estimate the costs of replacing in-house IT infrastructure with hosted infrastructure. The authors attempted to validate the model by applying it to estimate the cost of replacing in-house systems with cloud resources from Amazon EC2. The model investigates the number of virtual machine instances required to handle a particular load by identifying the usage in the in-house servers over a representative period. That usage includes load, RAM, storage, and network usage. Accordingly, the authors presented a function consisting of three components; a. the total cost of reserving instances throughout the planning period; b. the total cost of using reserved instances; c. the total cost of using on-demand instances.

Further, Klems et al. (2009) developed a valuation framework that provides a guide to determining the benefits of cloud computing. The main components of their framework are business domain, objectives, demand behavior, and technical requirements. However, according to the authors, their framework is generic and does not provide specific cost valuation methods. In 2014, Lian et al. studied cost as one of the technological factors affecting cloud adoption in hospitals. Their study empirically proved that cost is the most significant factor in cloud computing adoption (Lian et al., 2014)

From another perspective, Truong & Dustdar (2010) demonstrated a service for estimating, monitoring, and analyzing the costs associated with using scientific cloud applications. They mainly depended on execution time, input data transfer costs, output data transfer costs, CPU

instance/hour costs, and storage/month costs. However, the service offered by authors is limited to scientific applications for small scientific groups.

Also, (Strebel & Stage, 2010) proposed an economic decision model for deployment using hybrid clouds and focused on IaaS only. The authors presented cost formulas, an optimization model, and a regression model. The authors' main conclusion was that cloud computing is suitable for high storage requirements. However, they reported that cost-effectiveness negatively affects the number of virtualized applications because internal servers can be utilized more effectively. The authors included the following cost factors for IaaS resources:

- Cost of a virtual machine CPU hour.
- Cost of time contingent.
- Cost of cloud storage.
- Internet bandwidth cost.
- Cost of inbound data transfer.
- Cost of outbound data transfer.

Further, the emergence of cloud computing services implies changes in the IT departments of the beneficiary companies and how they operate. In their paper, Choudhary & Vithayathil (2013) examined how the dependence on cloud-based IT services affects how the IT department is organizationally structured. They discussed the scenario in which the IT department acts as an intermediary between the cloud vendor and the service-consuming organizational unit. The authors considered the quality of the internal services delivered by the IT departments as an essential determinant of the value of the IT service to the firm. This paper concluded that the IT department should be organized as a cost center when it utilizes infrastructure cloud services (IaaS). When it comes to deploying higher value-added services such as enterprise applications or business intelligence solutions- i.e., SaaS, a profit-center organizational structure is recommended. They reasoned that to the following. Vendors of SaaS, such as enterprise applications, enjoy higher pricing power than those who offer commodity services such as e-mail, storage, and backup. Accordingly, the profit-center organizational structure for SaaS would generate higher benefits for the firm.

Addressing existing established cost models, Barbosa & Charão (2012) studied the impact of the pay-as-you-go pricing model on the software development models such as COCOMO II and other aspects related to requirement engineering and benchmarking. They concluded that established models such as COCOMO II need to be revised to help avoid mindless consumption of resources, which would lead to reduced profits.

Some studies focused on studying the costs of the IaaS service type. For example, Chaisiri et al. (2012) proposed an optimal cloud resource provisioning (OCRP) algorithm that minimizes the total cost of provisioning resources in a given period. Also, Lampe et al. (2012) studied the problem of cloud-oriented workload distribution and introduced an optimization approach for cost-

efficient workload distribution in infrastructure clouds. Finally, (Han et al., 2014) checked the costs of IaaS service from the vendor perspective. They suggested an adaptive scaling algorithm that minimizes the costs of cloud IaaS by discovering the bottlenecks in a class of multi-tier applications.

Martens & Teuteberg (2012) view the decision to move to the cloud as a cost versus risk decision. They developed a mathematical model to quantify costs and risks associated with cloud adoption. The advantage of this model is that the authors tried to build it on a solid theoretical basis. A considerable drawback in the cloud literature is the weakness of the theoretical foundation of the published papers. However, being a mathematical model raises the question of the model’s actual usability by the customers. Most importantly, the significance of the factors they included in the model needs to be tested.

4.2 Cloud Computing TCO

The total cost of ownership provides companies with a comprehensive overview of the cost factors, enabling better decision-making. Applying the TCO approach to cloud computing is vital for cloud beneficiaries to avoid vague estimations of the added values and account for indirect and lifetime-spanned costs. Various industries proved that comparing cloud services to in-house developments lowers the total cost of ownership (Cegielski et al., 2012). On the other hand, some studies demonstrated that, in particular cases, companies did not achieve significant cost savings through the cloud compared to in-house developments (Singer et al., 2010; West, 2010). Accordingly, the TCO of cloud computing is complex (Vouk, 2008).

Moreover, the TCO of clouds should not be limited to hard numbers. For better accuracy, companies should count for –among other things- database and application licenses. Since cloud services are usually charged by usage or by the number of users, the licensing structure would entail some differences. Companies approaching cloud adoption overlook this point sometimes.

Table 5 demonstrates the studies handling costing in cloud computing with a TCO approach.

Article	service type	Deployment Model	Customer/ Vendor	Methodology	Cost Factors/Types/ Determinants
Fisher, 2018	Not defined	Not defined	Customer	Using a case study, this paper compares Cloud versus On-Premise Computing.	Subscription, Deployment consulting, annual maintenance, Seld reliant IT costs.

(Jain & Hazra, 2019)	Not defined	Hybrid Cloud	Customer	developing a model of ideal customer behavior when deciding on how much cloud-based computational load to adopt versus internal purchased servers	Customer Demand, Price
(Kawatra & Kumar, 2017)	Not defined	Not defined	Customer	Case study of a lab setup.	<p>a. Upfront costs : Technical readiness, Implementation, Integration, Training, configuration, organizational Change</p> <p>b. Recurring costs: Subscription, Change management, Vendor management, cloud coordination, risk mitigation, downsize/upsized.</p> <p>c. Termination costs</p>
(Rosati et al., 2019)	SaaS based on IaaS and PaaS	Public cloud	vendor	A case study discussing the impact of right-scaling on the cost modeling for migration decision-making and price setting of cloud services	Price Migration and implementation
Aggarwal and McCabe, 2009	SaaS	Public cloud	Customer	The study is a white paper by a consulting and market research firm. It used the TCO approach to conduct a four-year study to compare cloud applications with on-premise applications.	<p>a. evaluation and selection.</p> <p>b. application subscription costs.</p> <p>c. Initial and ongoing training costs.</p>
Klems et al., 2009	IaaS	not defined	Customer	A framework was developed as a guide for determining the value of cloud computing. However, according to the authors, their framework is generic and does not provide	business domain, objectives, demand behavior, and technical requirements

				specific cost valuation methods.	
Singer et al., 2010	IaaS	public cloud	Customer	The authors presented a linear programming model estimating the costs of replacing in-house IT infrastructure with hosted infrastructure. The model was validated by applying it to cloud resources from Amazon EC2. The model investigates the number of virtual machine instances required to handle a specific load by identifying the usage in the in-house servers over a representative period.	load curve, RAM, storage, and network usage
Truong and Dustdar, 2010	SaaS	Public cloud	Customer	The authors demonstrated a service for estimating, monitoring, and analyzing the costs of using scientific cloud applications.	execution time, costs for input data transfer, Costs for output data transfer, the cost for CPU instance/hour, and cost for storage/month
Martens et al., 2012	IaaS, PaaS, SaaS	the model intentionally disregarded the different between deployment models	Customer	The TCO approach was applied to cloud computing. The use of the TCO approach helps in identifying the hidden and indirect costs associated with cloud computing. The authors identified cost types involved with the cloud and interpreted them into cost factors.	a. Strategic Decision and Selection of Cloud Services, b. Evaluation and Selection of a vendor, c. Service Charge IaaS/PaaS/SaaS, d. Implementation, Configuration, Integration and Migration, e. Support, f. Initial and permanent training, g. Maintenance and Modification, h. System Failure, i. Backsourcing or Discarding

Strebel and Stage, 2010	IaaS	Hybrid Cloud	Customer	the authors proposed an economic decision model for deployment using hybrid clouds and focused on IaaS only. The authors presented cost formulas, an optimization model, and a regression model.	a. Cost of a virtual machine CPU hour. b. Cost of time contingent. c. Cost of cloud storage. d. Internet bandwidth cost. e. Cost of inbound data transfer. f. cost of outbound data transfer.
(Ellman et al., 2018)	IaaS	Public Cloud	Customer	This paper proposed a costing model on a data set that was derived from a data center workload by calculating the cost of service provision from two cloud providers.	Compute cost, Cost of persistent Storage, IP Address Price, Support Cost
Lian et al., 2014	IaaS		Vendor	Utilizing the TCO approach, the authors developed a method to provide the cloud vendor with a solid approach to analyzing the economic efficiency of operating the cloud.	a. server. b. software. c. facilities. d. support and maintenance. e. network. f. power. g. cooling. h. real-estate.

Table 5: studies targeting costs of cloud computing

H. Li et al. (2009) developed a cost analysis method utilizing the TCO approach for cloud computing. This method aimed to provide the cloud vendor with a solid strategy to analyze the economic efficiency of operating the cloud. According to the authors, the elastic nature of the cloud restricts the use of common cost analysis techniques for cloud services. This restriction is due to the difficulty of attaining accurate data of every cost item of the always-changing cloud. Li et al. considered eight cost items for the cloud TCO; server, software, facilities, support and maintenance, network, power, cooling, and real estate. The advantage of this method is that it took virtualization and elasticity into consideration. Cloud is primarily built using the virtualization concept, and cloud vendors package arbitrary cloud applications as sets of virtual machines (Nayak et al., 2018). Accordingly, the unit of measure in the cloud environment is not the physical server but the virtual machines. As for elasticity, the changing demand of cloud users needs to be considered in the cost analysis. That is why, in their method, Li et al. used the utilization cost as a subset of TCO.

In 2009, Hurwitz associates (a consulting and market research firm) used the TCO approach to conduct a four-year study to compare cloud applications with on-premise applications (Aggarwal & McCabe, 2009; Muhleman et al., 2012). According to the authors, a solution won't need

significant replacements of its components for four years. The authors used two sides of systems for the comparison; NetSuite SaaS solution for the cloud side and Microsoft Dynamics GP and CRM for the on-premise side. The study demonstrated that cloud-based solutions save 50% compared to the on-premise ones. The TCO calculation model used by this study encompassed the following components (Aggarwal & McCabe, 2009):

1. Evaluation and Selection.
 - 1.1. Solution evaluation & analysis.
 - 1.2. Vendor review and SLA analysis (as applicable).
2. IT Infrastructure hardware, software, and support (primarily required for the on-premise solution; these are included in the subscription costs for cloud solutions).
 - 2.1. Server and storage hardware and maintenance.
 - 2.2. Operating system, database, security, backup software, and maintenance.
 - 2.3. Administrative IT costs for systems and database.
3. Application subscription costs OR application license costs.
 - 3.1. ERP and CRM application subscription or license cost.
 - 3.2. Application maintenance.
4. Application solution deployment costs.
 - 4.1. Detailed design.
 - 4.2. Configuration and deployment.
5. Initial and ongoing training costs.
 - 5.1. User training.

Martens et al. (2012) presented a mathematical model for calculating the total cost of ownership (TCO) for cloud computing. The use of the TCO approach helps in identifying the hidden and the indirect costs associated with cloud computing. The authors described some cost types that customers need to consider in calculating cloud computing costs. They interpreted those cost types as then to cost factors. The main cost types are:

1. Strategic Decision, Selection of Cloud Computing Services, and Cloud Types
2. Evaluation and Selection of Service Provider
3. Service Charge IaaS
4. Service Charge PaaS
5. Service Charge SaaS
6. Implementation, Configuration, Integration, and Migration
7. Support
8. Initial and permanent training
9. Maintenance and Modification
10. System Failure
11. Backsourcing or Discarding
12. Administrative training.

4.3 Transaction Cost Theory Application on The Cloud

Transaction cost economics (TCE) principally perceives that transactions must be ‘governed, designed and carried out’. TCE is used as a theoretical background in studying various economic fields such as transfer pricing, corporate finance, vertical integration, long-term commercial contracting, and other formal and informal contracting relations (Shelanski & Klein, 1995). TCE argues that contracts are typically incomplete, which results in asymmetric information between the contracting parties. Accordingly, the contracting parties or the trading partners choose from alternative governance setups in a way that protects their interests at the lowest possible cost relations (Shelanski & Klein, 1995).

As highlighted earlier, some of the IS outsourcing assumptions and writings can apply to cloud computing. Aubert et al. (1996) dissected the motivation behind outsourcing decisions into two categories: efficiency-based and politically driven. Efficiency-based motivation revolves around cost efficiency. This cost efficiency is attributed to the pooling of demands that allows the outsourcer to exploit economies of scale. Another efficiency-based reason is that outsourcing IS services allows for more concentration on core business processes. Cost efficiency also results from decreasing or removing fixed costs of huge technology investments. Since economies of scale and pooling of demand are prevailing in the cloud computing justification writings (Foster et al., 2008; Kashef & Altmann, 2012; H. Li et al., 2009; Pal & Hui, 2012), the efficiency-based motivation highlighted by Aubert et al. (1996), applies perfectly to cloud computing. Further, the point of decreasing or removing fixed costs mentioned by Aubert et al. (1996) directly points to the Capex / Opex argument raised -or facilitated- by the cloud (Grossman, 2009).

Martens & Teuteberg (2012) applied TCT to cloud computing. Yigitbasioglu (2014: 203) also stated that TCE is a "powerful theoretical framework" for studying cloud computing economics.

As explained in section 3.2, the transaction cost theory helps organizations identify the boundaries of their governance by discussing the transaction costs. These transaction costs refer to the costs linked with managing the transaction while monitoring and controlling it (Nuseibeh, 2011; Shelanski & Klein, 1995). Cloud computing offers its customers competitive prices and cost savings. However, cloud computing entails high transaction costs. Transaction costs include managing and negotiating contracts, which are – along with service level agreements- a tricky part of cloud adoption decisions.

But transaction cost theory digs more profound than that. Two of the dimensions describing transactions are asset specificity and uncertainty. Cloud asset specificity refers to the ability of cloud customers to switch from one cloud vendor to another in a smooth manner. Previous research has highlighted this switching as a challenge. Further, asset specificity increases transaction costs and thus hinders the customers’ cloud adoption decisions to avoid data lock-in problems. Cloud vendors lack standards, which do not allow customers to migrate easily. The other dimension

describing the transaction, uncertainty, is hypothesized as a discouragement of cloud adoption (Nuseibeh, 2011).

The science of contract

Throughout the 20th century, economics has primarily focused on choice. However, complex economic setups need the science of contract besides the science of choice.

One of the most famous transactions in economic history is the make-or-buy decision. This transaction includes many asymmetrical conditions- information, risk, legal expertise, and others. These conditions make a transaction, a make-or-buy decision, more complex (Williamson, 2002).

Cloud customers face this transaction frequently. Should we buy our own server? Or just easily have it as a service? Should we build our own data center or buy it as-a-service from a cloud vendor? It is even still confusing. Are we buying or leasing or building?

Are we buying a server on the cloud provider side? Or are we just buying the right to use it? Should we build our applications on a rented server from the cloud provider?

One other big question here is, what is a transaction in a cloud computing setup? From the economic background, the make-or-buy decision is a transaction. So the decision to go for the cloud is the transaction. However, the transaction does not end in cloud computing once we decide and sign the contract. Transactions occur every time we use the contracted instance because governance and monitoring are needed every time a cloud instance is used. Or, to be more precise, a transaction also happens due to the scalability option of the cloud. Thus, a transaction occurs each time an instance is used or is shut down.

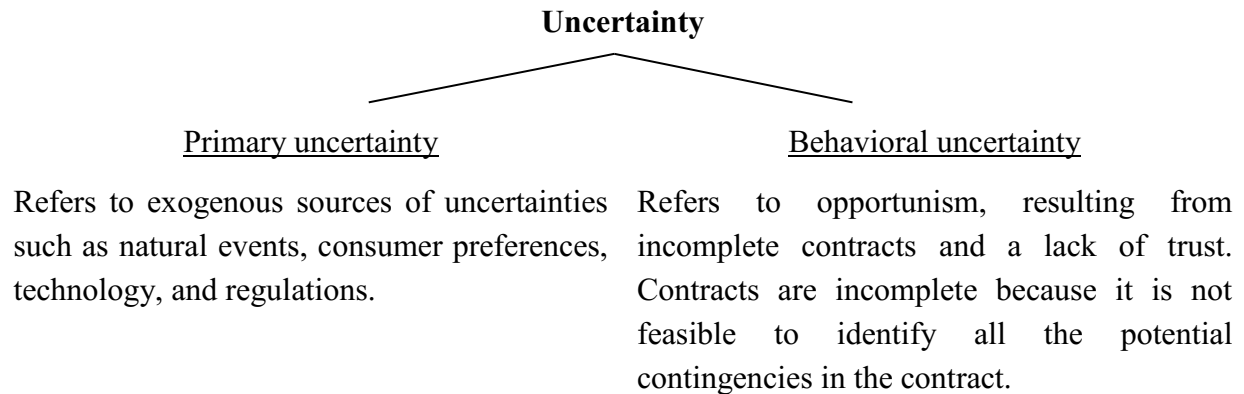
IT outsourcing literature has frequently used transaction cost theory. Contrarily, only a few papers have used it to study cloud computing adoption (Benlian, 2009; Benlian et al., 2009; Yigitbasioglu, 2014). Transaction costs relate to the time and effort to reach, negotiate, contract, and maintain a relationship with vendors or customers (Yigitbasioglu, 2014). According to TCE, higher transaction costs direct organizations to vertical integration, which means deciding to make rather than to buy.

Transaction costs relate to the time and effort to reach, negotiate, *contract*, and maintain a relationship with vendors or customers (Yigitbasioglu, 2014). Throughout the 20th century, economics has primarily focused on choice. The science of choice would guide an organization in studying its decision as it has the right to choose freely from the open market. The science of choice puts the cloud customer in an open position where they can freely choose a cloud service from a market of many cloud vendors. This is how the cloud is marketed by vendors and perceived by customers: as an easy choice with different advantages and a couple-of-hour adoption process. However, the real adoption cases showed that the science of choice is insufficient to govern the cloud setup. Cloud is a complex economic setup that needs a more complex contract. Accordingly, the science of contract is inevitable for a cloud scenario.

Cloud computing contracts have three crucial dimensions for the cloud customer. The first dimension is performance, represented in the service level agreement. It should tackle uptime, support time, and response time of the service; in other words, availability of the service. The performance also includes service reliability and network stability. The second contract dimension is security. This dimension should manage data ownership and access. Contracts should identify how the vendor is penalized in incidents of security breaches. The third dimension is legal recourse. Contracts should include clauses about the right to report a legal claim and collect evidence (Clemons & Chen, 2011).

However, vendors usually ensure that the clauses of contracts are in their favor. Most SLAs allow the vendor to prevent the client from getting access to his data at any time. Contracts should explicitly tackle disaster recovery and service failure penalties. In some cloud contracts, security is not guaranteed, or the vendor is not plainly held responsible. Contracts should also govern where data stand after service termination. As for the legal recourse, it is, to some extent, a hectic process to claim compensation for cloud outages. Another part of legal recourse is the choice of the court that should handle a dispute between the vendor and the customer. Cloud contracts usually grant the cloud vendor this right of court choice (Clemons & Chen, 2011).

Williamson (1985), as cited in (Yigitbasioglu, 2014), has defined two types of uncertainties as to the following.



Yigitbasioglu (2014) sees that asset specificity is not essential when analyzing cloud computing because:

- Asset specificity is irrelevant for IaaS because IaaS have low switching costs.
- Asset specificity is only relevant in SaaS if customization is in place.

Where does cloud "legally" stand? It might be an overstatement to ask, is "cloud computing legal?". The legal aspect of cloud computing includes two areas. (1) The 'contract' represents the relationship between the customer and the vendor. Here, the subject of the contract is the hosted service. (2) Data residency and privacy laws.

Contract as the first area of the cloud legal aspect is a knotty point. The legal compliance of organizations using the cloud might be at risk at any point in time. This is because the contract with the cloud vendor might be tricky, and the vendor might add clauses allowing the use of end-user data without charge. As well, the cloud service, as the subject matter of the contract, is a very unpredictable evolving technology (Yigitbasioglu, 2014). Thus, the contract negotiation and the SLA need special attention from cloud customers.

Data residency means where the data is stored. The cloud customer can be operating in country X, the vendor in country Y, and the data center in country Z. The laws in most countries prohibit data storage outside the country's borders (Rastogi & Aggarwal, 2022). For example, the central bank in Egypt does not allow the banks to have their customer data stored outside Egypt. As well, the vendor in country Y does not know – and is not willing to tackle – the laws in country X, the country of the customer.

Most importantly, if a problem arises in the data center in country Z, litigation is a problematic issue. Which laws should be applied in which country? Laws of country X, Y, or Z? According to an article titled (“Data Residency – Do You Know Where Your Data Resides?” 2020), 74% of cloud computing providers do not comply with the EU data residency laws. Another critical question is which party should be liable for the legal expertise? And is the law community competent enough for such volatile technology?

Yigitbasioglu (2014) concluded that the cloud is perceived to be of high-security risk because of its perceived legislative uncertainty. The legislation around cloud computing is still evolving. Organizations might decide to be in the safe area and adopt cloud services from domestic vendors to ensure they comply with the domestic law (Yigitbasioglu, 2014).

Security is concerned with confidentiality, integrity, and availability of the system. Cloud computing offers its clients security advantages as well as disadvantages. On the one hand, large cloud computing providers such as Google and Amazon are expected to afford higher IT security than other organizations. Data centers at the cloud provider side are more likely to be protected than a regular organization's IT infrastructure. This protection is because prominent cloud vendors invest heavily in their IT architecture to maintain their clients' trust. Moreover, many large cloud providers mirror the data in scattered data centers around the world.

On the other hand, cloud computing is highly based on virtualization (Nayak et al., 2018), which increases the possibility that more than one client accesses the same physical server when using their dedicated virtual machines. Cloud vendors might also be asked to reveal information to their governments by law, which affects the confidentiality of the clients' data. This confidentiality violation may result in hefty penalties by laws in the client's county, apart from reputational harm (Rastogi & Aggarwal, 2022).

Availability of the system is also an essential pillar of security. Nowadays, organizations depend heavily on their information systems. Unavailable cloud services can severely disrupt daily

operations, resulting in financial loss and harming the business's reputation. The cloud service might be unavailable because of connectivity problems. For example, Australia has special weather conditions that expose it to internet outages. This unavailability can be because the network provider or the cloud provider faces connectivity problems. For example, Microsoft Azure was unavailable for 22 hours in 2009 and 8 hours in 2013. Amazon also experienced such an incident in 2011.

Availability is also at risk when systems are susceptible to Denial of Service DDoS attacks or malicious software. These DDoS attacks affected the availability of affected companies (Rastogi & Aggarwal, 2022). As a result, cloud customers might be more encouraged to adopt hybrid solutions and put only non-critical applications on the cloud (Yigitbasioglu, 2014).

Vendor opportunism in the cloud

Opportunism puts cloud contracts under three types of risks. (1) "shirking and deliberate underperformance." Cloud vendors might cause a slowdown and blame it on the network by under-investing in essential capabilities. (2) "Poaching and theft of intellectual property." (3)"opportunistic re-pricing, client lock-in, and vendor lock-in." Behavioral uncertainty in terms of perceived vendor opportunism is positively related to perceived security risk ((Yigitbasioglu, 2014:197).

4.4 Expected Output: Knowledge Base

Different aspects must be comprehended when considering the variables that constitute the cost of cloud computing. A cloud customer standing at the point of decision-making of service adoption has to have a full view of the various activities of the total cost of ownership and the multiple stages of the service lifecycle. An incomplete picture of the variables results in uninformed decisions, which put the company at risk of incurring unexpected costs.

As a means of classification, TCO activities introduced by Ellram and Siferd (1993) are adopted in Table 6 to digest the various cost variables in the literature (L. M. Ellram & Siferd, 1993).

Table 6: Cloud cost elements in the literature (classified based on TCO categories)

	Service Model		
	SaaS	IaaS	PaaS
Management	<ul style="list-style-type: none"> Strategic Decision and Selection of Cloud Services (Aggarwal and McCabe, 2009, Martens et al., 2012) 		
Delivery	<ul style="list-style-type: none"> Implementation, Configuration, Integration, and Migration ((Kawatra & Kumar, 2017; Martens et al., 2012) <ul style="list-style-type: none"> Support (Martens et al., 2012) Initial training (Aggarwal & McCabe, 2009; Kawatra & Kumar, 2017; Martens et al., 2012) 		
Quality	<ul style="list-style-type: none"> Backsourcing or Discarding (Martens et al., 2012). <ul style="list-style-type: none"> System Failure (Martens et al., 2012). 		
Price	<ul style="list-style-type: none"> Service Charge (Aggarwal and McCabe; 2009, Martens et al., 2012) Execution time (Truong and Dustdar, 2010). Costs for input data transfer (Truong and Dustdar, 2010). Costs for output data transfer (Truong and Dustdar, 2010) CPU instance/hour (Truong and Dustdar, 2010) storage/month (Truong and Dustdar, 2010) 	<ul style="list-style-type: none"> Service Charge (Martens et al., 2012) Load curve (Singer et al., 2010) RAM(Singer et al., 2010) Storage and network usage (Singer et al., 2010; Strebel and Stage, 2010) Cost of virtual machine CPU hour (Strebel and Stage, 2010). Cost of time contingent (Strebel and Stage, 2010). Internet bandwidth cost (Strebel and Stage, 2010). Cost of inbound data transfer (Strebel and Stage, 2010). Cost of outbound data transfer (Strebel and Stage, 2010). 	<ul style="list-style-type: none"> Service Charge (Martens et al., 2012)
Service	<ul style="list-style-type: none"> Maintenance and Modification (Martens et al., 2012) <ul style="list-style-type: none"> Permanent training (Aggarwal and McCabe, 2009; Martens et al., 2012). 		
Communication	<ul style="list-style-type: none"> Evaluation and Selection of the vendor (Aggarwal and McCabe, 2009; Martens et al., 2012) 		

5 Research Gap

In the digital transformation journey of companies, cloud computing is an essential ingredient. The benefits promised by cloud computing have been widely cited in the literature. As well, different challenges are reported, such as security, lack of skilled resources, legal compliance, availability, and data privacy (Sasubilli & R, 2021). Moreover, cloud computing might represent a critical change to cloud customers' business models (Singh et al., 2019). Gaining the benefits, while dealing with the challenges and adjusting to new changes, significantly put the cost estimation of cloud solutions in question (Duncan, 2018; Sharma et al., 2020).

From another perspective, cloud customers are asked to engage with cloud vendors strategically, which, similar to any outsourcing project, includes information asymmetry (Hanafizadeh & Zararavasan, 2020). Such asymmetry is present since cloud customers tend to have deficient control over the data and the business processes affected by the cloud solution (Ayaburi et al., 2020).

Upon reviewing the literature, it was remarked that cloud computing is an emerging technology that still lacks some essential foundations (Bildosola et al., 2015). On the one hand, worldwide end-user spending on public cloud services was forecasted to reach \$332.3 billion in 2021 (Gartner, 2021). On the other hand, it has been difficult to treat cloud computing as a ubiquitous technology due to different challenges such as security and legal compliance (Sasubilli & R, 2021). Moreover, According to Bildosola et al. (2015), there are no criteria or guidelines to help cloud customers get a complete picture of what is required from them before going to the cloud.

Cloud vendors usually market that cloud computing reduces the costs of technology infrastructure. They promise companies switching to cloud computing significant cost savings (Jayeola et al., 2022). These promises cannot be denied but should not be misleading. In some cases, cloud services cost more than expected in terms of the initial investment, continuous maintenance, plus other hidden costs (Zimmerman, 2014). A survey conducted on 250 IT managers reported that more than 70% of companies that moved to the cloud were unaware of unanticipated costs following adoption. Transparency of the service provider, need for continuous maintenance costs, and lack of cloud expertise play a role in unpredicted costs and implementation problems (Duncan, 2018; McCafferty, 2015; Sharma et al., 2020).

Moreover, customers find difficulty in comparing cloud services due to the increasing competition between cloud providers. As per reviewing existing literature on cloud computing, some papers focused on cloud computing definitions and classifications, while others differentiated between cloud computing and grid computing. Further, many articles discussed the potential of cloud services and addressed the technicalities of this evolving technology, such as security issues and resource provisioning optimization (Cayirci & de Oliveira, 2018; Duncan, 2018; Nayak et al., 2018; Noor et al., 2018; Sun, 2020; van der Werff et al., 2019; Varghese & Buyya, 2018). Costing issues were targeted by a few studies, as mentioned earlier (Choudhary & Vithayathil, 2013). For

example, Martens et al. (2012) applied the TCO approach to cloud computing. Also, Ding et al. (2018) presented a cloud cost management system to monitor customers' public cloud environment automatically and track the changes in cloud resource efficiency and cost-saving. According to Assunção et al. (2015), estimating the costs of relocating data to the cloud, assigning virtual machines, and running analytics is indispensable. The authors indicated that this is a primary task that should not be treated trivially. Additionally, it was highlighted that although some best practices are available, tools targeting cost estimation from the customer perspective are needed. Thus, it is imperative but difficult to evaluate the real costs associated with switching to the cloud since individual calculators offered by service providers do not account for the full aspects involved in moving to the cloud.

From another perspective, cost estimation models for software development are various. However, those models cannot be applied to cloud services because they incorporate different cost determinants. Also, the concept of cloud computing looks very similar to outsourcing, which raises the question of using existing costing scenarios such as ERP costing or IT portfolio management principles. However, as explained earlier, the value chain of classical outsourcing is different from the cloud computing value chain. This difference implies that existing cost factors from software development or outsourced business applications cannot be adopted on cloud services as is (Barbosa & Charão, 2012; Böhm et al., 2011). Accordingly, the main aim of this research is to develop a model to estimate the costs of cloud computing services.

Being more focused, this research studies the cost from the customer's perspective, not the vendors' perspective. On the one hand, the costs associated with cloud services are a significant factor in the cloud adoption decision. On the other hand, studying costs from the vendors' side could help determine the pricing strategy (Nayak et al., 2018). However, Harmon et al. (2009) indicated that cost-based pricing creates short-term values for the service provider and, thus, vendors should focus more on customer value-based pricing.

The importance of this research is two folds. From the academic perspective, developing a model for cost estimation of different cloud services would demonstrate the various factors affecting cost estimation in cloud services and shed light on the challenges associated with meeting those factors. From the business perspective, this research offers a comprehensive aid for companies in their digital transformation journey by estimating the cost of moving to the cloud.

Cost estimation is vital for any enterprise consuming IT services. It is crucial to determine the IT costs that the enterprise needs to afford to, among other reasons, make rational decisions about the worthiness of such technology. Simultaneously, IT is continuously emerging, resulting in new computing models such as cloud computing, which is commercially existent by large. Determining the total cost of a cloud computing service should help the company decide whether to move to the cloud or use traditional in-house systems. The lack of a cloud cost estimation model would

direct the companies to rely on assumptions for calculating the cloud costs, which would lead to vague results and risky decisions.

According to a study published in 2016, only 6% of cloud computing research targeted the economic dimensions of cloud computing. In addition, 8 % addressed organizational dimensions. In general, there is a shortage of cloud publications in business journals (Bayramusta & Nasir, 2016). Such a shortage implies that the business aspect of cloud computing has not yet reached the maturity level. Simultaneously, new technologies change the nature of work in an organization, call for adaptations in organizational structures and impose misalignment risks within the organizational activities (Barley & Kunda, 2001). Hence, the ultimate question of the impact of introducing cloud computing to a company comes down to how it can affect the actual and ongoing aspects of IT processes: how cloud computing is imposing changes to existing practices, processes, and routines. This question is potentially much more complex than cost-benefit analysis research can answer. Cloud computing research needs to blend into organizations with their complex networks, cultures, and corporate histories. This means that research targeting cloud costs would be enhanced by studying the actual interactions of organizational entities (business units) operating on a cloud project to build a cloud-enabled IT architecture. What are the business processes of provisioning a cloud service? Does cloud computing impose changes to other areas other than the IT department too? Ultimately, it comes down to the question of ‘what is really going on in corporations when they move to the cloud?’ and ‘how is that being translated into the total costs’

Accordingly, the main research question targeted in this study is:

RQ: Based on the total cost of ownership approach, what costs should a customer estimate when running a cloud service?

Answering this question, the main aim of this dissertation project is to estimate the running costs of cloud computing. The coming ‘Scope’ section provides focused details on that aim.

5.1 Scope

Unit of analysis

The unit of analysis is the cloud service, which makes it flexible, modular, and valuable to be used on different service levels and with various organizations.

Armbrust et al. (2010) refused the distinction among the cloud service models (IaaS, PaaS, and SaaS). They reasoned this to the lack of tangible differences among those service models. They illustrated that platform-as-a-service and infrastructure-as-a-service have more commonalities than differences. This dissertation project sees that such classification is not vital in the transaction cost analysis and the total cost estimation in the cloud transformation journey. The explored cost areas are applicable in IaaS, PaaS, and SaaS.

Which decision are we supporting?

We are focusing on the costs. Delta, the difference between benefits and costs, can come later. First, it is essential to ensure we are getting the costs right. At this point, it is presumed that the services have already been moved to the cloud, but their costs are unclear. There are mainly two types of delta:

- *Set up costs and benefits*
- *Savings: Costs if this was hosted internally- **running costs***

This Model focuses on running costs. Table 7 explains the model’s premises.

What the model is NOT covering	What the model IS covering
Hybrid Clouds; Private Clouds	Public Clouds
Costs for adopting Cloud Computing	Costs for running Cloud Computing
Cost-Benefit Analysis (CBA)	
Delta of total on-premise costs vs. total cloud computing costs	
Delta of running costs in-house vs. running costs in the cloud	
Mathematical equations for cost estimation	A model for the dimensions to use to estimate the costs of cloud solutions.
Management Model	Measurement Model

Table 7: Model Premises

6 Methodology

This dissertation employs a design science approach to develop a cost estimation model to investigate the estimated costs of running cloud services from the customer perspective. This research invades a relatively raw area that lacks theories and models explaining the interaction among its actors. The area referenced here is cloud computing, while the interaction is among cloud services and cloud customers. This research aims at theorizing an artifact. Then this artifact is tested to ensure its validity. The design science research approach guides this process of theorizing and testing while using expert interviews and case studies.

This chapter explains those research methods in detail and how they were utilized to answer the research question and fulfill the main aim of this dissertation project. The following section describes the motive behind using the design science approach. Then, the empirical work section depicts the expert interviews and case studies performed in this research project.

6.1 Design Science Approach

The main distinction between information technology and information systems as disciplines is that the information systems field views the context of the organization and people with the technology. Thus, information systems (IS) research has to target this interaction of business strategy, IT strategy, organizational structure, and IS architecture. In the design science approach pioneered by Hevner et al. (2004), artifacts are built to solve information systems problems. Three cycles here are identified: The design cycle, rigor cycle, and relevance cycle. In the rigor cycle, the existing theoretical foundation and the existing knowledge have to be well searched to contribute to the designed artifact. In the relevance cycle, the need for the research outcome is identified; how relevant the potential result is to the environment. So, both the knowledge base and the environment are input into the research process and the artifact. At the same time, when the artifact is developed, its contribution back to the knowledge base is vital, and how the artifact is built into fulfilling the business need.

More technical disciplines such as computer science have applied design science research. However, IS research called for design science research to increase the effectiveness and usefulness of IT solutions in solving actual business problems (A. Hevner & Chatterjee, 2010). Since Information systems is a multidisciplinary field in the essence that it applies theories from different backgrounds, such as computer science and economics, it can be interpreted that Information Systems as a research field belong more to the applied research paradigm (Peffer et al., 2007). This interpretation calls for research that designs rigorous solutions to identified information systems problems, research that is not merely descriptive or explanatory (Peffer et al., 2007).

Design is “the act of creating an explicitly applicable solution to a problem” (Peffer et al., 2007:47). Design science can be described fundamentally as a problem-solving paradigm. It aims

at innovation creation that explains the ideas, practices, technical capabilities, and products. Such a creation should increase the effectiveness and efficiency of the analysis, design, implementation, and use of information systems (A. Hevner & Chatterjee, 2010).

Hevner et al. (2004) provided seven guidelines to conduct, control, and present design science research in a manner that makes it relevant in both research and practice communities, Table 8. Design science concentrates on designing and creating artifacts that have a use in real life. In the information systems discipline, design science offers a helpful way of addressing the gap of relevancy that academic research suffers. While behavioral science is more appropriate for studying existing and evolving phenomena, design science is more suitable for complicated organizational problems that require novel solutions.

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems
Guideline 3: Design Evaluation	A design artifact's utility, quality, and efficacy must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide transparent and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available process means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Research must be presented effectively to both technology-oriented as well as management-oriented audiences.

Table 8: Design-Science research guidelines (Hevner et al., 2004:83)

According to Hevner (2007), any design research project should include three design science research cycles; relevance, design, and rigor, see Figure 3. The ‘relevance cycle’ bridges the gap between the research project and the contextual environment. As for the core ‘design science’, it repeats itself between building and evaluating the design artifact and processes of the research. The ‘rigor cycle’ links design-science activities to the existing scientific foundations, known as the knowledge base.

Building the knowledge base included reviewing the available literature on this topic and finding a solid theoretical background to act as a base for the model. The available literature is reported in chapter 4, describing the previous studies on cloud-computing cost estimation models. Table 5, also in chapter 4, summarizes the studies handling this area. Framing the knowledge base makes this research more rigorous. The following subsection explains the kernel theories that further contributed to building the knowledge base.

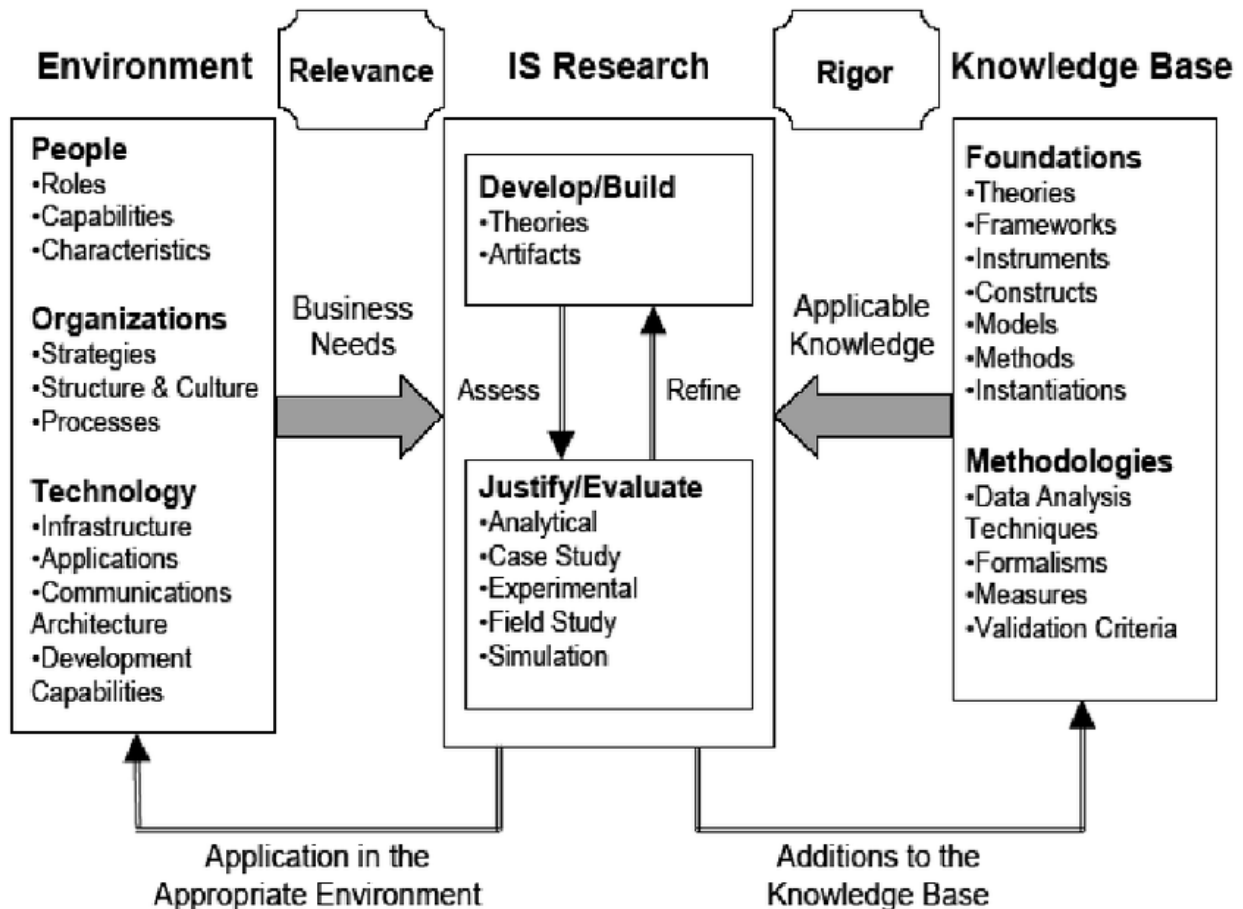


Figure 3: Information Systems Research Framework (A. R. Hevner et al., 2004)

Kernel Theories

To build the cost estimation model, this dissertation used transaction costs theory and the total cost of ownership approach. These acted as kernel theories to ground the model. Chapter 3 described the rationale behind using those theories. Nevertheless, it is essential to mention some other intentionally excluded theories. For example, some researchers that viewed my work kindly suggested using the activity-based costing (ABC) theory. Being relevant to the topic of this project, ABC is excellent for allocating overhead costs. Thus, it will be beneficial and recommended to the cloud customers to use ABC to guide their cloud cost allocation. However, the focus of this project is to calculate the running costs. After calculating those costs, the company can use ABC to allocate them to the different business departments. Cost allocation was reported in the findings as one of the main challenges that frustrate the IT and the accounting/ finance departments. This frustration increases the running costs. But developing an artifact allocating cloud costs -using ABC- is beyond this project's scope.

Further, reviewing the state-of-art, some researchers applied other theories too to cloud computing, such as resource dependency theory and diffusion of innovation theory (e.g. (Nuseibeh, 2011)). However, these theories study the propensity of the organization to adopt cloud computing. This dissertation assumes that the decision is already made to go for the cloud. We aim to explore the running costs of the cloud since its advantages have become a business necessity. Further, some research applied other economic theories on cloud computing, such as game theory and market equilibrium (Anselmi et al., 2017; Dong et al., 2017; Pal & Hui, 2012). However, such research focused on price competition (e.g. (Chaisiri et al., 2012)) and more vendor-side interactions (e.g., between IaaS and PaaS). This dissertation explores the running costs that a cloud customer incurs beyond the price. Those running costs were not apparent in previous cloud TCO research. Considering the pricing only had shown to be misleading and incomprehensive of the total cost of ownership.

Thus, out of an ocean of theoretical foundations in operations research, accounting, and economics, we chose the following approaches as kernel theories for building our artifact:

- Transaction Cost Economics
- Total Cost of Ownership

Guideline 7 of (A. R. Hevner et al., 2004) indicates that design-science research must be communicated effectively. The model was presented in a design science course with two prestigious design science scholars and many Ph.D. researchers in the final stage.

As mentioned previously, this research project employs expert interviews and case studies under the umbrella of design science research. While the empirical work is explained in the next section in detail, Figure 4 demonstrates this empirical work based on the research framework by (A. R. Hevner et al., 2004). Figure 5 further shows the research approach.

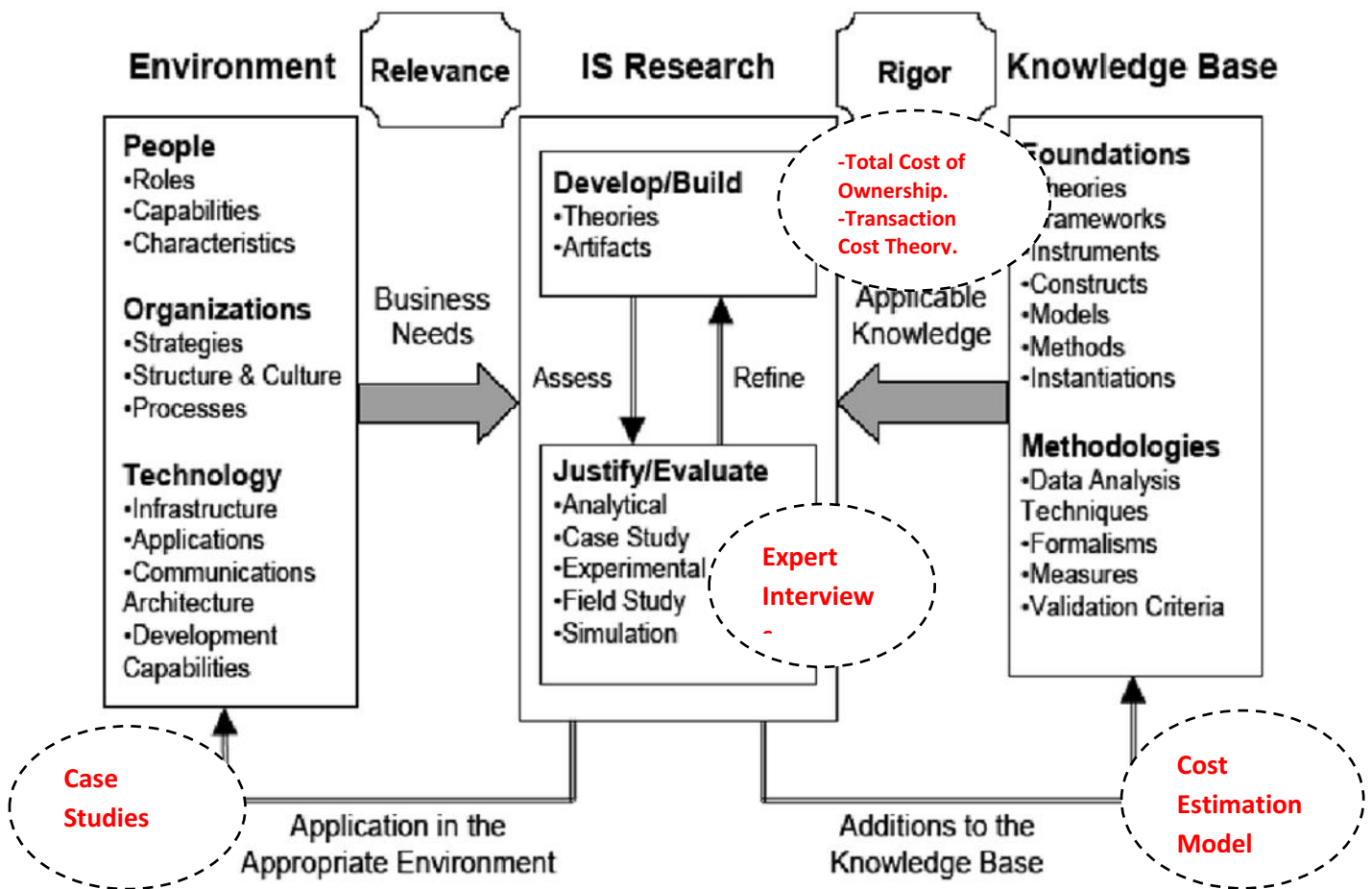


Figure 4: Empirical Work guided by (A. R. Hevner et al., 2004)

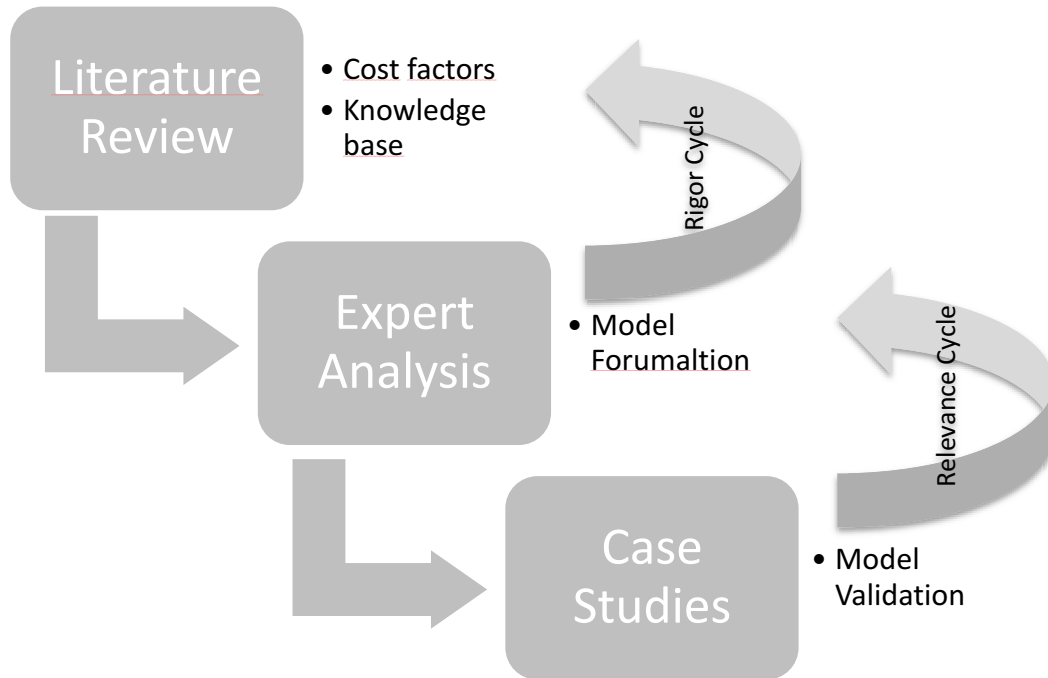


Figure 5: Research Approach

6.2 Empirical Work

This section explains first the expert interviews, which helped build the 1st version of the cloud-computing cost estimation model. Then, the case studies used to validate the model are explained from a methodological point of view.

6.2.1 Expert Interviews: Model Building

Blumberg et al. (2014) stated that qualitative research methods are best suited when the research contributions to the researched topic are modest. In cloud-computing cost estimation, the established theories/ models are scarce. A knowledge base is needed to build a model where prior IS research is investigated to study the related models, frameworks, and/or theories available in the literature. The IS literature is vital for building a solid knowledge base and other disciplines related to the research topic, such as operations research and cost accounting. Such a step helps provide the raw material for building a preliminary base for the expert interviews.

These expert interviews are one of the first steps in the empirical work of this research. Experts in cloud computing were intended to be mainly from the vendor side. Designing the interview questions was an extremely challenging process. The challenge was in the expected bias of the vendors toward the technology they sell. This research attempts to uncover the hidden costs and efforts that the customer must incur when adopting the cloud. Experts from the vendor side want to highlight the benefits and not discuss the costs and efforts. This intention is understandable

because the cloud is perceived as a cost saver. But 50% savings are much more different than 35% savings. And here, the role of research and academia is of utmost importance; to take no sides and help all sides have an honest view of the object under study.

The researcher prepared a thorough description of the topic and research questions to overcome this challenge. An emphasis was essential, in the introduction, on the cost savings offered by the cloud. As well, the vagueness - experienced by the customers in estimating those cost savings - was demonstrated by proof from previous research. Furthermore, to guarantee useful and unbiased answers, questions were formulated in ways asking for suggestions, enhancements, and best practices. Direct questions, such as “what are the hidden costs of the cloud?” did not find sufficient answers in the pilot testing.

The output of the interviews with the vendor was challenging. The answers were cautious. Whenever a vendor highlights a cost factor, he immediately supports it with sentences like, ‘*but this is in very rare cases*’ or ‘*but we as the vendor, we make sure the customers do not go through such pain.*’ Thus, the researcher decided that both customer and independent opinions are vital for the results. Accordingly, the researcher included consultancy and customer-side experts in the expert interviews phase.

The interview guide divided the questions into categories according to the main research questions. Those categories included: change management questions, IT service management questions, business process reengineering questions, and total cost of ownership questions. Such categories helped to fully view the changes and costs associated with the cloud when pursued by the customer.

It is worth considering that the overlapping between the categories is inevitable. For example, the researcher viewed change management at first as any change that will happen in the organization, including business process reengineering. On the contrary, after many readings, change management turned out to be a human-resources terminology incorporating preparing people and departmental roles for a change. As such, IT service management frameworks have a change-management-related process. This process, however, depicts the requests exchanged between-IT organizations and business units for the sake of changing services. Finally, it is foreseeable that the total cost of ownership should embrace the costs incurred by the other constructs; IT service management, business process reengineering, and change management. Thus, designing the questions was sensitive to this overlapping. The researcher made sure not to overcome an aspect while accounting for questions redundancy.

Questions significantly affect collected answers. If a question is ill-framed, the answer is well misleading. To make sure the answers were valid for the main aim of the research, multiple aids supported formulating the questions. First, the adoption frameworks of two of the most prominent four cloud vendors were used as guides, which helped stand on the same ground as the respondents. Further, this gave insights on adoption and post-adoption activities and emphasized that the main aim of this research, TCO and BPR practices of the cloud, is not isolated from real-life practices.

Quotes were adopted in some questions when the interviewer was affiliated with the framework's vendor. For example, extracts from Oracle adoption principles (OCAP) (Oracle, 2016) were beneficial when directing the questions to a cloud presales employee at Oracle. Such quotes helped accept the questions' ideas and provide cohesive answers.

The second helpful aid for formulating the questions was cloud consultants' white papers. Last but not least, research on the interaction of cloud services and IT service management frameworks was a vital aid. Such research helped formulate the questions associated with the service management area because it showed expected changes caused by cloud services on ITIL practices. As well, change management resources, such as the guide of change management models and techniques (Cameron & Green, 2019), supplied the essential ingredients for a comprehensive set of questions in that area. While the questions asked to the cloud computing experts aimed at building a preliminary model, case studies were to validate that model. The following subsection explains the steps performed to test the interview questions.

Testing Interview Questions

After preparing the questions of the interview guide, the researcher performed testing for the questions. This testing was vital to ensure the reliability and validity of the questions, which helped identify vagueness in the questions and clarify them. The researcher tested the questions with a representative from the vendor side who had experience with cloud services. Her title is SAP Cloud (Success Factors) implementer. She used to work for an SAP partner.

The tester suggested two things besides discussing amendments to the questions to make them more precise and more understandable. First, the tester claimed that it would be easier to send the interview guide to the interviewee first via email. The tester believed that this would help the interviewees give more accurate results. In addition, the questions were tested using voice calls since most of the interviews were to be done in this manner. For that, sending the interview questions first will help avoid any misunderstanding of the questions. Second, the tester commented that the questions were too many. Experts from the vendor side, who are account managers in some cases, would not tolerate giving so much time to answer those questions. As a result, the researcher decided to send the questions only when asked in order not to demotivate the potential interviewees from participating in the expert analysis. Essentially, the questions were used only as a guide as it is not a survey where every question must be answered.

Justification for Expert Interviews Sampling

The researcher conducted a 360-degree industry view analysis through expert interviews. Experts from the vendor, customer, and consultant sides were interviewed. The main criterion for selecting a consultancy-side expert is having particular interest and experience in cloud computing projects. The criteria for the vendor-side experts is to have direct interaction with total cost estimations for cloud customers. As for the customer-side experts, it was essential to have direct experience with cloud adoption projects and a current cloud computing related job.

Twenty-one (21) experts were contacted for interviews. A total number of thirteen (13) agreed to participate in the study; five (5) consultancy-side, four (4) customer-side, and four (4) vendor-side experts. This number was sufficient because we reached a point where more interviews did not add something new to the findings. Table 9 depicts some of the main characteristics of the interviewed experts.

The interviews with the vendor-side experts formed a significant challenge for the researcher. One reason for that is that the vendor experts are very shy about highlighting a cost issue that might affect the cost-saving image of the cloud. In addition, the marketing-trained minds of the vendor experts kept twisting the facts and extracting benefits from each drawback. For example, one of the major concerns of the IT department members is that upon the adoption of the cloud, downsizing is unavoidable. In such an instant, the experts consume a valuable amount of time explaining the opportunities to utilize the downsized employees in the HR and marketing departments. Thus, the 360 view through interviewing customers and consultants was vital to get non-biased results.

The researcher recorded interviews after obtaining the necessary permissions. Then, a speech recognition software transcribed the recorded interviews. The researcher reviewed the transcripts manually for adjustments. Finally, the researcher utilized text mining to extract and report findings.

Table 9: highlights of interviewed experts' characteristics

	Characteristic	Frequency
Consultancy-side experts	More than 25 years of experience in IT consultancy, with a current focus on cloud computing	3
	More than seven years of experience in IT consultancy/ cloud computing	1
	Author of a best-selling cloud computing book.	1
	Holder of Ph.D. in cloud computing economics.	1
	Named by wired.com as one of the top 10 Cloud Influencers (Ellis, 2012)	1
Vendor-side experts	Account manager in a top-two cloud-computing vendor, according to Forbes (Evans, n.d.).	3
	Presales consultant in a top-ten cloud-computing vendor, according to Forbes (Evans, n.d.).	1
Customers-side experts	Cloud manager in a 100,000 employees multinational	2
	Middle-level cloud roles	2

6.2.2 Case studies: Model Validation

The output of the expert interviews was a preliminary cost estimation model. This model was to be tested for validation through case studies. Four case studies were done, as will be shortly explained. To ensure the quality of the case studies, Yin (2009) suggested four tests in Table 10.

Quality Test	Case study Tactic	Phase in which tactic occurs
Construct validity	<ul style="list-style-type: none"> • Use multiple sources of evidence • Establish a chain of evidence 	Data collection
	<ul style="list-style-type: none"> • Have key informants review the draft case study report 	Composition
Internal Validity	<ul style="list-style-type: none"> • Do pattern-matching • Do explanation-building • Address rival explanations • Use logic models 	Data Analysis
External Validity	<ul style="list-style-type: none"> • Use theory in single-case studies • Use replication logic in multiple-case studies 	Research design
Reliability	<ul style="list-style-type: none"> • Use case study protocol • Develop a case study database 	Data collection

Table 10: Quality Tests for case study research (Yin, 2009)

In this research project, three of these tests were employed, namely:

1. **Construct Validity:** this relates to establishing correct operational measures for the studied concept (Rowley, 2002). This test links data collection questions and measures them to research questions and propositions. To test construct validity, I pursued the following tactics. (a) I used multiple sources of evidence, i.e., triangulation. Data were collected through interviews, documents of cost analysis, and internet-available sources of the company's cloud portfolio. (b) I sent an executive summary of the case study findings to the interviewed top manager of the studies company.
2. **External validity:** I used multiple case studies to test for external validity. External validity is concerned with the generalizability of the case study findings. This generalizability is analytical, not statistical. The output of the expert interviews hypothesized a template with

which the case study output was compared. According to (Rowley, 2002), if two or more case studies support the hypothesized template, the generalization can be claimed.

3. **Reliability:** to test the reliability of the case study, we documented each step of the case study. Interviews were recorded. Also, documents and other sources collected were kept in the case study database.

Justification for Case study Sampling

The needed sample for the case studies should have been companies that adopted cloud computing services. The companies should have different sizes to enable testing the applicability of the model initially developed using the output of the expert interviews. The international variety of companies participating in the case studies is crucial to avoid cultural and contextual bias. More than fourteen (14) companies were contacted, reaching for the IT top management and/or the public relations department. I also asked the customer-side experts to get permission from their companies to make a case study. I went through my professional connections to recommend some companies. Moreover, I asked the vendor's side experts if they could establish a connection between me and some contacts of their clients.

Finally, I managed to convince four (4) companies that meet the sample criteria needed for this research. Table 11 describes the companies' characteristics, data collected for the case studies, and the number of interviews conducted with the company's IT representative.

Table 11: case studies description.

	Company Characteristics	Data Collected	No. of Interviews
Case Study A	2000 employees, operating in 10 countries. Uses SaaS, PaaS and IaaS services.	Interviews with IT Top Management and internal documents	3
Case Study B	Canadian Startup heavily dependent on cloud computing	Interview with COO; online resources	1
Case Study C	9000 employees, uses a cloud-first strategy and has customers spread over 40 countries.	Interviews with IT Top Management; internal and online documents	2
Case Study D	A medium-sized governmental entity based in Germany.	Interview with an IT leader; online resources	1

Analysis

Having qualitative data that are based on interviews mainly in the expert analysis and partially in the case studies, coding was key to data analysis (Gorden, 1998). I applied open coding (Khandkar, 2009) where comparisons were constantly sought. I labeled relevant words, phrases, sentences and actions from the interviews' transcripts. Those codes have indicated actions, activities and processes that were relevant to the research aim. The relevancy here was decided upon when something was mentioned repeatedly, when it was surprisingly refuting an accepted belief, when it resembled some of the literature review findings, or when it matched the kernel theories used in this research.

Since cloud computing has a different value chain than traditional outsourcing scenarios, it calls for a special handling of its costs. While having used TCO and TCT as kernel theories to establish the rigor of the cost model, these theories were used also in categorizing the codes and building the relationships among the codes. Thus, this research I adopted the TCO Cost activities proposed by Ellram and Siferd (1993) from the supply chain discipline to serve as an initial theoretical idea in naming the categories. Then the cost areas emerged under the initial TCO areas. Finally, I used transaction cost theories to establish and validate relationships among cost areas, and to enhance the conceptualization and theorization stages.

It is worth noting that while TCO principles proposed by Ellram and Siferd (1993) are advantageous in the fashion of being comprehensive and not time-specific, the word 'Ownership' is critical because it incompatible with the as-a-service understanding of cloud computing.

7 Findings and Discussion

As mentioned in the methodology chapter, this dissertation project is two parts: expert interviews and case studies. The expert interviews were executed to build a preliminary cloud-computing cost estimation model for cloud customers. The case studies worked then as a means to test the model. In section 7.1, the findings of the expert interviews are reported and discussed in the form of the TCO cost categories. Then, separate figures for each case illustrate the case studies' findings in section 7.2. Finally, section 7.3 discusses and compares the case studies.

7.1 Expert Interviews Findings and Discussion

This section presents and discusses the findings of the expert interviews conducted to investigate customer-centric cost areas of cloud computing.

Total Cost of Ownership

Studying the cost estimation of running cloud computing is inevitable for an informed adoption decision. One can argue that the cost factors are similar to any typical IT system, for example, ERP. One needs to eliminate the infrastructure costs and will get the required results of the cloud cost estimation. Expert 4 refuted that by stating that although this might be true in ideal cases, that is not usually the case in practice. He explained that the problem is that cost estimation of the cloud sounds simple, but it is not necessarily so. For example, with ERP, there are different versions, different API layers, different modules, and all those sources of consideration. ERP operates even in the same suite-product from the same vendor. Contrarily, one operates differently in a cloud model (Expert 4).

As mentioned in section 3.1, cost factors contributing to TCO calculation for IT initiatives can have various categorizations. David et al. (2002) used the following categories: acquisition costs, control, and Operations. Mceen and Smith (2010) used other categories; One-time (start-up) costs, ongoing (lifetime) and enhancement costs, Ancillary costs, and one-time (end-of-life) costs. Although IT outsourcing decisions use these categorizations, the value chain of cloud computing is different. Clouds are more service-oriented, while outsourcing focuses more on a single provider. In other words, the classical value chain of outsourcing has broken up in the clouds. Cloud providers can offer their customers new flexibilities with new services and business models. Cloud computing also allows modifying existing services without engaging in significant investments (Boehm et al., 2011).

Because of this value chain difference, cloud computing calls for different categorizations for cost factors. Thus, this research adopts the purchasing activities contributing to TCO introduced by Ellram and Siferd (1993). Although the word 'purchasing' here is critical since it is incompatible with the as-a-service model, these activities are pretty comprehensive. Those TCO activities also do not depend on the time dimension, which is beneficial because cloud services represent ongoing

consumption and long-term relationships with vendors. The activities- denoted here as cost categories- are management, delivery, service, communications, price, and quality. Figure 6 represents the cost areas that evolved under the cost categories throughout the coding and analysis of the expert interviews. The coming subsections explain those cost areas in detail.

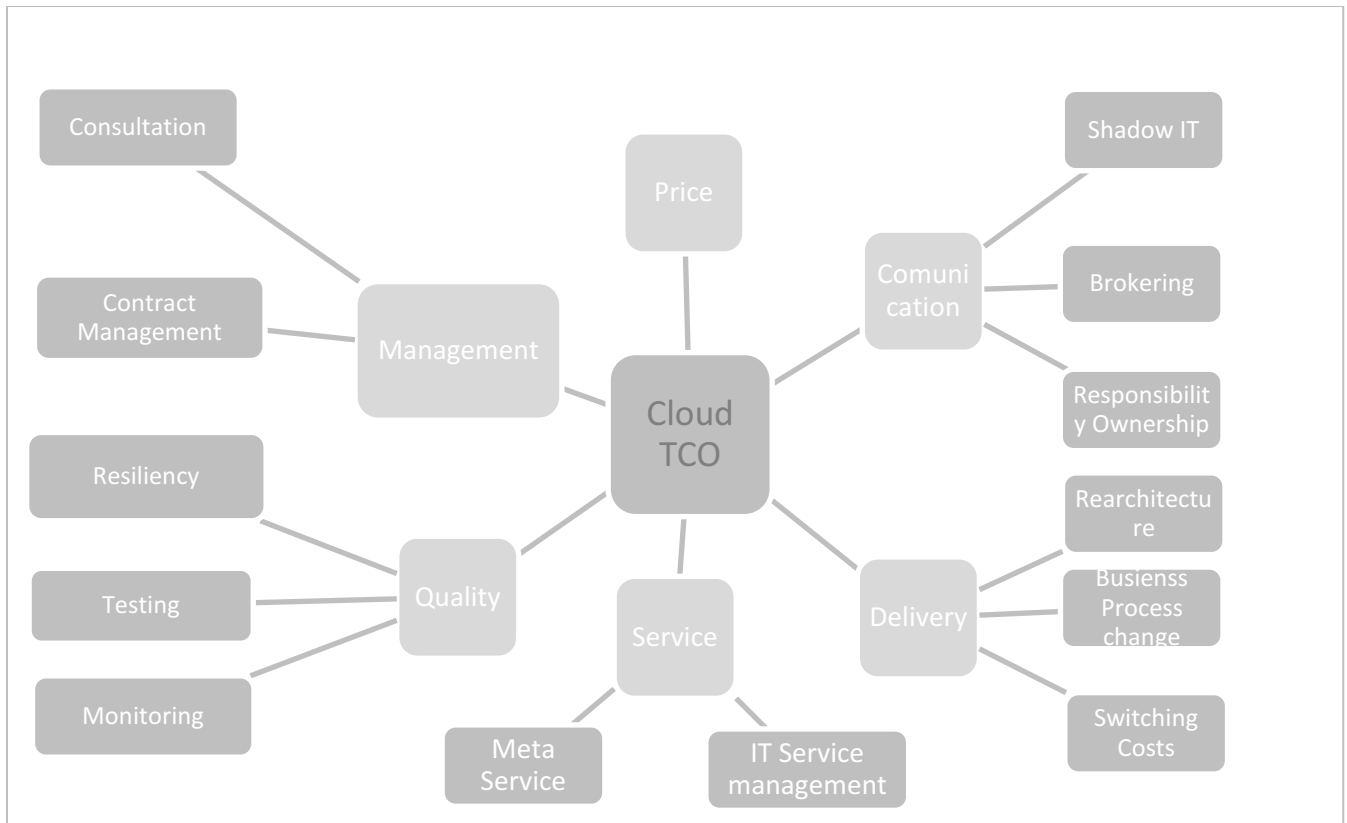


Figure 6: Cost areas that evolved via expert interviews

7.1.1 Cost Category 1: Delivery

“Going to the cloud requires that every part of the organization be more mature or more of, you know, it requires some more skills across the entire organization” stated Expert 6. Further, Expert 4 explained, ‘In fact, some companies should not move to the cloud because they are just so immature in their process that is just going to cost a lot of money and put their business at risk.’ Thus, the adoption of cloud services imposes **business process change** that demonstrates itself in **business process reengineering** and **change management**. Another important ingredient of Delivery costs is **Rearchitecture**. Not only do processes and employees change when a company

moves to the cloud, but also the company's IT architecture, which incurs costs for customizations and adjustments.

7.1.1.1 Re-architecture

Buying a cloud service is more than a lift and shift task. It entails costs in the areas of re-architecture and business process change. Re-architecting has two-sided implications. On the one hand, automating auto-scaling and shutting down development environments is significantly costly. On the other hand, this automation or preparation helps companies save many costs. In other words, if a company just does some lifts and shifts, it becomes quite challenging and may result in higher costs than anticipated for its services (Expert 5).

According to Expert 3, the highest cost is re-architecting the application to be cloud-native. This re-architecture applies when a company has an application on its infrastructure and a decision is in place to move it to the cloud. The cost here is not associated with picking up the application and moving it. Instead, it relates to preparing the application to be able to seize the advantages of the cloud. If the company wants to be able to scale on-demand, it will probably have to rebuild the cloud application. That re-architecting and all that expense is a significant amount, as hinted by Expert 3.

In return, re-architecture costs time too. According to Expert 4, *'clients we have seen have taken 18 months or 12 months beforehand to actually get all of this work done before they're ready to actually go live to implementation and sign the contract'*.

Application re-architecture as a cost factor incorporates understanding how the application will grow and shrink. It calls for new systems and a level of consultancy at the beginning because one needs to ensure the application can do that scaling. Nevertheless, on an ongoing basis, there is a need to understand capacity and ensure that it is at its cheapest level and available when required. As time goes on, it becomes evident that a company will need to increase capacity and sometimes decrease it. Therefore, according to Expert 3, one solution is a marketplace or an exchange where a cloud customer can buy and sell capacity depending on the changing day-to-day needs. Expert 1 stated that the best way is not to upscale and downscale manually. Instead, cloud customers should invest in load balancers.

Expert 4 agreed with the point of preparing the application. He stated that most organizations do not have a clean dataset. This data cleansing is a prerequisite to migration to ensure robustness and sound structuring, which, in return, can be a source of unhappy surprises when overlooked.

Prerequisites for migration are various. The cloud journey does not take off with signing the contract. Before that, along with contract negotiations, several angles ask for excessive efforts. Examples include new processes, new configurations, new taxonomies, new data structures, and many other architectural issues. The major mistake organizations make is ignoring all that until they are ready to go live. In that case, they must do it in a hurry, which almost goes wrong (Expert

4; Expert 7). This came in agreement with Expert 2, who stated, “*I have definitely encountered people who say, I have moved my application to cloud How come is it not resilient and automatically scalable? Well, you have to design and alter your application to take advantage of the cloud characteristics that enable those things. Just putting it on the cloud environment does not magically make it scalable or resilient*”.

7.1.1.2 Business Process Change

The operation of any organization consists of a group of processes. The IT department is concerned with and responsible for many processes. Each process has tasks, roles, and responsibilities. Sometimes, a process is in place just to control other processes, such as processes of service management frameworks. Each time a company adopts a new system, some processes are affected. It is not only a matter of moving infrastructure or software to the cloud that will solve the problem. But also, a company needs to put effort into redesigning its business process, aligning organizational structure and job roles, and rethinking well-established frameworks (Expert 4; Expert 7; Expert 6). This section discusses those activities of business process reengineering triggered by cloud adoption. This discussion entails two subsections, business process reengineering, and change management.

a. Business process reengineering

‘In fact, some companies should not move to the cloud because they are just so immature in their processes that is just going to cost a lot of money and put their business at risk,’ stated Expert 4, based on his consultancy experience with cloud adoption projects. According to him, cloud customers hugely underestimate how vital and complicated it is to reengineer business processes. This reengineering includes both IT and non-IT processes.

a.1. IT processes

The information technology (IT) department faces many reengineering requirements in its business processes when the cloud becomes part of its architecture. This reengineering can range from introducing new processes, deleting some, and amending other existing ones. Starting with the existing ones to be amended, Expert 5 from the customer-side reported that the work style and project management practices are different under the umbrella of cloud computing. A more agile work style is needed instead of the classical waterfall. As well, the follow-up processes and the testing processes need reengineering. Moreover, the IT department has to change the processes for interacting with developers. The reason for such change is that cloud computing requires developers more than administrators, and developers have different ways of working together.

Although essential for the success of the cloud project, such change in existing processes is not as straightforward as it seems. One of the most famous processes that change is the ‘ordering a server’ process. Despite being constantly referred to as one of the merits of cloud computing, a cloud customer can get servers, or services, up and running quickly, but things can go wrong fast, and

many costs can be generated very rapidly. According to Expert 5, some accounts generated thousands of Euros in a few days because of this process.

From another perspective, cloud computing introduces other completely new processes to the company. According to Expert 1, *'You need to do other stuff. You need to define which software will be installed, how many services, the testing, and automatic testing. So once you finished your code, you need to submit it to a gate repo, then Jenkins, for example, or a CI tool will pull this code, test it, automatically in the cloud spinning up servers and testing code, and then give you feedback. So this is all are things that we did not use before'*. Expert 4 added that cloud customers should add some other processes to manage the Cloud environment. Examples cover escalation processes and lines of contact, and customer support processes.

Finally, some processes are no longer required. They must be eliminated from the organization and communicated to everybody that those things are no longer undertaken. For example, in helpdesk procedures where users might contact the help desk looking for assistance or guidance, a cloud customer might no longer have an internal helpdesk it is now externally based (Expert 9; Expert 10).

a.2. Non-IT processes

Besides the reengineering of IT processes, some processes are cross-functional. This subsection discusses two areas that require business process reengineering due to the adoption of cloud computing.

Finance and Accounting processes

The finance and accounting business units are involved in comparing the costs of the cloud adoption decision. One extremely more-challenging business process for these business units is cost allocation (Expert 2, Expert 5, Expert 7). A company deals with different pricing options and styles from the vendor. For example, a vendor can charge the first 5 Terabytes of storage at a particular cost, but the second 5 Terabytes would affect the total storage cost. Also, if a customer uses two Terabytes, it has a different calculation. How can the finance department split the costs across the various business units? Each business unit has its consumption, and the accounting people cannot just evenly divide these costs. According to expert 5, *'All these small bits and pieces which actually made the challenge of really dividing this total cost. We get a bill at the end of the month for all these services and all these business units, and we have to work with the financial department to split this across so that each business unit will really reflect their real costs plus their all operational costs and so on.'*

Another critical point that is bothering the finance and accounting department is taxation. Expert 5 from the customer side explained that his company's business units could be spread in Switzerland, the USA, and parts of Asia, while cloud resources are in the USA. Although all business units get a collective bill from the vendor, each country has different tax regulations.

Thus, the IT and finance departments struggle to find and maybe automate a solution for that challenging issue.

Procurement and Supply Chain Processes

A cloud customer needs specific documentation and new business process design and/or reengineering. As an example of new business process design and reengineering, cloud computing introduces the need to sit down with supply-chain employees and design a new process for evaluating cloud providers. A supply chain department employee should engage in providing periodic reviews with the service providers (Expert 6).

Traditionally, suppose a company buys a server and puts it in the data center. In that case, the supply chain department does not expect the responsibility to investigate the performance of this server every quarter. Instead, their role ends when the purchase process is complete, then the IT department is in charge (Expert 6).

Non-traditionally, in cloud computing, if a company rents a service in the cloud, there is the cloud provider and the cloud service agreement in place. A good supply-chain department should have an employee in charge of reviewing how the contract is going, how the service is going, whether the SLAs are met, etc. According to Expert 6, this person might be the category manager for IT services. His role might include meeting up with the service provider and the IT people and evaluating the vendor performance per the contract and SLA's terms and what changes are required.

This new supply chain involvement shows a new type of relationship. This relationship is far beyond merely offering training to the IT employees for the new cloud service. Instead, people from the IT department, supply chain department, and vendor representatives engage on a much longer-term basis in managing and controlling the performance of the cloud service (Expert 6).

Expert 4 also referred to this involvement of the supply chain and IT business units. He highlighted that cloud adoption is not merely an IT issue. It is a business issue where the steering committee or the project board must include procurement, among other parties. However, this does not happen very often. Many companies hurry to move quickly and do not necessarily get the best benefit from it. This quick adoption made many organizations unhappy with their cloud providers. The vendors also play a role in this hurry as they market that a company can move to the cloud in a couple of hours. Referring to Expert 4, this is true if we are not discussing successful adoption. If a company is seeking successful adoption, it is a deliberate process with a lot of pre-work.

The customer side also supported the involvement of supply chain and/or procurement departments (Expert 7). However, in some companies, this is not currently happening. According to one of the Expert 5, despite the need for the controlling rule from the supply chain people, sometimes heads of end-user business units are responsible for ordering the services themselves. They are responsible if they incur unneeded costs for not using the cloud wisely. *'It is working so*

far. I mean, it may sound strange, but it is working. There is no strict approval process so far because the cloud account itself costs nothing' stated Expert 5 according to his company.

b. Change Management

Cloud computing is different from using on-premise IT infrastructure in the sense that employees within and outside the IT department have to be familiar with what a cloud service means, how it functions, how it is different, etcetera. Thus, the second aspect of business process change is the highly under-estimated change management costs (Expert 4).

According to the vendor side, the training offers that accompany the cloud service adoption cover those change management aspects (Expert 10; Expert 9; Expert 8; Expert 13). This claim raises the following questions. How comprehensive are those training offers? How much support will the cloud customer get versus how much support is needed? Expert 10, a vendor-side expert, stated that a cloud vendor takes care of that with its customers and proposes a timeframe with the required training. For example, according to him, *'there is a training for one month, I think, to be certified on how to develop using the tools of azure, be an admin for this platform, be familiar with the layout or the interface, integrate with the on-prem and make the hybrid options, customize your platform and customize your interface, apply policies with your users'*

However, it might not be that simple (Expert 6, Expert 2, Expert 7, Expert 5). Cloud is opening a new branch of training that is important for the IT industry. Expert 10 stated, after further questioning, that his company, one of the top 3 cloud providers in the world, provides many certifications; some are free, and the rest are paid. It is not one training or certificate for the cloud for one timeframe. There are many timeframes, certifications, and training types paid and non-paid.

This training assortment leads to another question that the consultancy-side experts raised, train who for what? The traditional IT department has many employees who manage hardware and other infrastructure components. Does a cloud customer want to retrain them? Do they want to be retrained? Also, are there enough new jobs for them? (Expert 4, Expert 6, Expert 2). For example, vendor-side Expert 10 stated that the IT workforce would be reduced with the cloud and thus can be used in other business units. Consultancy-side experts noted that this is not realistic. From one side, it is difficult to train an infrastructure caliber for a cloud management position. Moreover, such calibers might leave the organization and work for other competitor companies. Also, if the organization decides to fire them, this has its costs (Expert 4, Expert 6).

According to customer-side Expert 7, there was a need for knowledge of the services they support. Thus, in Azure, for instance, they needed Azure training and certification. Moreover, security and architecture-related matters were vital to be well-understood in the cloud environment.

As a result, the matter is not only training. It is change management. Training in that sense is part of change management. Customer-side Expert 5 provided examples of the change management practices they had to deploy. He stated that his large multinational company incurred huge costs from offering the business units free of charge service just to enhance their buy-in for the new technology. Other change management costs include the cost of firings infrastructure resources and the costs of recruiting cloud positions.

New job positions emerge to fill some gaps in delivering the cloud. Expert 3 highlighted a shortage of architects who can design cloud applications. *'If you look at amazon web services, they have got a ridiculous number of products, like hundreds of products, and there are very few specialists out there who can design an application that brings in all of amazon products and makes the best of them'* (Expert 3). This shortage was supported by Expert 7, who stated that his company had to introduce new jobs such as Cloud Security Engineer, Cloud Architect, and Cloud Operations Support. Further, according to Expert 5, *'The vendor is usually giving you the price of the service without any kind of management whatsoever....Usually, the vendor would give you how much a database would cost over a one-year period with this and this like specs. But there is no database admin together with this. Still, you need someone; you need the team of developers to write this code so that you can actually move to the cloud. The cloud vendors do not operate their services, so they give you the service; they give you the database, which is already batched, and so on. But they do not have a database admin which administrates for you this database.'*

Another huge gap is present in understanding the costs associated with the cloud. There is a shortage of people who understand cloud capacity planning and cost savings. *'Amazon has these things called reserved instances, and if you buy reserved instances, it can save up to 50% on your cloud cost. But very few people know how and when to buy these and at what point they make good financial sense'* stated Expert 3. He further expected that before 2030, IT departments would have a *cloud financial officer*, a dedicated person assigned to ensure the cloud is delivered at the optimum price to meet capacity requirements (Expert 3).

Further, there was a need to change the work lifestyle or the project management method from the classical waterfall to a more agile style. Thus, the IT department organized agile management training for the leaders. Getting used to this new working style was also a challenge in itself (Expert 5). Changing project management style and introducing new processes incurs new costs to the company. These costs range from training costs to costs of new setups and equipment to familiarize the new agile management techniques. These efforts may target developers and top management (Expert 5).

Expert 3 suggested a systemized change in the IT department in, what he calls, *the broker model*. The IT department needs to act as a broker about cloud services. This broker model requires a tremendous change in the mindset of the IT top management, which entails the following:

- They need to realize that they need to give end-users some level of flexibility,

- They need to let end users access services on demand.
- They need to allow individual departments to own the budgets.
- They may need to produce a portal or a marketplace where end-users have the flexibility to choose the applications they need, and then the IT department's role now needs to be to add services to the marketplace.
- It is the IT department that needs to talk to multiple suppliers, negotiate contracts,
- They ensure that they are meeting certain levels of security and data protection, so end-users get flexibility. At the same time, the IT department has visibility and control of budgets, and they also have visibility of governance and security.

Another example of change management practices reported by expert 5, based on one of the companies he worked in, was that the cloud customer had to go through one year of internal marketing. They went through training the employees and doing some sandbox events and other sorts of events to get people to know the cloud, which has consumed some time. Simultaneously, they offered accounts free of charge for unlimited time for people to try. Different project managers and different teams liked the idea. The accounts were named playground accounts. Despite being offered for free, this generated a lot of costs. That was also the budget for getting people to try to get their hands dirty. After approximately six months, the company started to charge for the accounts.

However, other experts questioned this practice. Expert 3 had a different view from that approach for resistance to change. In the example of the last paragraph, the company of Expert 5 tried to encourage the business units to go for the cloud. However, Expert 3 believes that business units are enthusiastic about the cloud because it appears to them that they can get access to the resources they want quickly; they do not have to worry about the IT department. Instead, the most significant resistance to change is in IT departments because they have a lot to lose. They can lose control, and they can potentially lose full-time employees. On top of that, the IT department is also potentially losing control of security compliance governance.

Thus, and from a change management point of view, consultants highlighted the importance of developing a change management strategy. This strategy should include training, communication, personal development, mentoring and coaching, and all the workshops that need to be done from a communication point of view. Further job descriptions need to be written and validated. All of this needs to be planned out and made into an integrated set of activities, where the organization would lead a workforce to a particular place (Expert 4). It is important to view how the whole business is going to benefit rather than just how the IT department is going to benefit. Thus, change management, in this case, is a strategic matter. 'Strategic' here identifies business objectives and people roadmap rather than a mere technology roadmap (Expert 3).

But who should lead this change? IT or business units? According to Expert 3, the change needs to be led from the very top because this is an organizational change and is not just a question of

the IT department doing something new. Introducing the cloud to the company puts new responsibilities on business units, mainly when it comes to managing their business budgets. Meanwhile, *‘Just because an area's got a manager doesn't mean to say that the manager will be able to help their group of people move to a new way of working because that manager is also going through the change and will need to adapt’* (Expert 4).

Expert 4 added that the ideal situation is to hire an external consultant who has experience with cloud deployment projects to lead the change. IT people view change management the way ITIL defines it; it is merely about deleting and replacing some code with other code. Expert 1, at some point, stated that change *‘eventually require like more or less coding because you either have to write your own code or even maintain a current code.’* However, he refuted that -supporting Expert 4 opinion- it is *‘more than just training, it can be all the operations involved.’* According to Expert 4, Change Management here should not be an IT function. An external consultant can lead the change and work to identify within business units people who can internally lead and facilitate the change management activities.

All of this needs planning and takes time to gain the cloud benefits. Unfortunately, the vendors can not ask customers for such change management practices. A vendor will not tell a customer that it is more difficult because this means that the customer will slow down the decision-making process, which is not in the vendor's interest (Expert 4).

7.1.1.3 Switching Costs

One of the challenges widely cited about cloud computing is data lock-in. It refers to the customer's difficulty in switching from one provider to another. The reason behind that can be the different ontological backgrounds used by the vendors. Moving from one provider to another entails what is called switching costs. A cloud customer should consider how the data transfer from one environment to another (Expert 2). According to Expert 6 *‘In theory, getting the data should not be complicated and should not cost much unless the contract says if you need a copy of all your data extracted in a usable format to put it somewhere else we charge you. Some cloud providers might say that. They might say yes, we do offer an exit process in which we're giving you your data, but as a disincentive against switching, you are going to make you pay for it.’*

Switching costs depend on the complication of the application to be moved and the additional value targeted from such a move (Expert 2). If a cloud customer switches a simple website to the cloud, the switching will be easy and take a few hours. The costs here can be straightforward, such as different contract negotiations, licensing arrangements, and subscription models (Expert 4; Expert 6). However, a lot of developmental work is involved if the switch aims to absorb more cloud advantages, such as being more resilient and scalable. This work might take weeks, months, or years (Expert 3).

Expert 3 gave the following example for this application complication. If a cloud service operates on Amazon Web Services (AWS), it uses AWS images, APIs, virtual machines, and different

databases. It also uses proprietary technologies such as AWS Lambda. To move this service or application to Google, the cloud customer has to recode every single API code so that it would be compatible with the new provider. The cloud customer also has to recode some proprietary technologies. *‘Let’s say that I was using AWS dynamic database, but I would have to recode my application in google to take advantage of google database. And if that is a really complicated application of intensive virtual machines, tens of services, that can take months and months and months, especially when you consider all the testing required’* (Expert 3). As expected, Expert 8 from the vendor side also stated that they try to convince the customers to buy fully integrated solutions instead of single cloud services.

Expert 6 added *‘If you have a problem during the test, and then you need to fix the problems, and then you need to do a second test, and then you verify that things are okay, and then you switch. Well, during that extra period of time, you’ve consumed more resources.’*

Another aspect of switching costs complication relates to disruption to the organization with stuff that is still trying to find a pace for itself in the new cloud ocean. This disruption means that all the recommendations about preparing an organization for the cloud in terms of processes and structures must be revisited. It is also vital that the cloud customer’s staff has learned new technologies with the old cloud provider and now has to learn new ones. In other words, a substantial cost here is the loss of knowledge (Expert 4; Expert 6).

The more a company grows on the cloud, the harder it will be to switch. Cloud providers play it smart when it comes to this point. One of the main advantages of the cloud is scalability; a cloud customer can grow quickly and scale his resources whenever the business operations require. Thus, cloud providers offer desirable options to small companies and startups. Examples of that could be free subscriptions and free API gateways. As the startup grows, they buy more cloud resources and get attached more to the languages and standards of the vendor. At a certain point, it becomes difficult to switch to another vendor (Expert 1).

If switching is inevitable, the cloud customer might have to operate with both providers simultaneously until the operations with the new one are stable (Expert 1; Expert 6). Sometimes, earlier smart decisions can facilitate switching (Expert 2, Expert 6). These decisions require experience with the cloud, which is not guaranteed for all adopters. For example, Expert 1 hinted, *‘Sometimes it is easier like if you use something like docker. So everything is dockerized, and you have virtual machines. So everything will just be as simple as downloading the virtual machine from Amazon and just upholding it on Microsoft. So it also needs like some smart decisions that can be taken early’*.

Expert 7 indicated that the switching costs vary depending on the cloud service model. From his standpoint as a customer-side expert, he stated, *‘We do have several providers at the same time at IaaS level to be able to easily switch from one to another. The cost is associated only with the migration methodology you will use. For PaaS, it depends on what you use there; if it is*

proprietary technology, then you cannot exit at all. SaaS, you have to agree on the exit process before you sign-up the contract. We do have this in our standard assessment process before going cloud. Then this cost can be regulated contractually and will depend on vendors’.

7.1.2 Cost Category 2: Management

The findings under ‘Management’ as a cost category included contract management and consultations. The findings show that customers might be putting a mission-critical system under an unstudied contract. External legal expertise with cloud experience is required. Other areas within adoption require consulting too. The costs can include hiring a large consulting company to provide those different consulting needs. Otherwise, it can be by separate entities according to the area. It also depends on how the cloud customer can harmonize all the needed consulting aspects. It is not in favor of the customer to have different consultants working on islands and not integrate their efforts for the sake of the project.

7.1.2.1 Contract Management

Cloud customers are usually not ready for the contract management task. Contract management is one of the things that companies overlook, and it turns out to be a surprise (Expert 4). Cloud customers must negotiate contracts and build plans before engaging in a cloud initiative (Expert 7). To do so, they need to seek external expertise or hire someone with experience in cloud contracts to navigate the contracts' information asymmetry. In other words, the vendors will not show the points where the customers have possible disadvantages in contracts. Investing in understanding and negotiating the contract is crucial because it is hard to go back once you have a contract and arrangement in place that is of a three- or five-year time horizon (Expert 4).

This contract negotiation depends on the type of outsourcing at hand. If it is a public cloud, it's a pure sense, and it is almost impossible to get the providers to change their contracts. Customers do not have bargaining power in this case. Thus, a large organization might be putting a mission-critical system under that arrangement. That is why cloud customers must think it through carefully (Expert 4).

There is an information asymmetry between the customer and the vendor regarding hidden information and actions. As expected, the findings show information asymmetry between cloud customers and service providers. Addressing this information asymmetry seems to require the organization to mature. According to Expert 6, *“going to the cloud requires that every part of the organization be more mature or more of you know, it requires some more skills across the entire organization.”* Further, Expert 4 explained, *‘In fact, some companies should not move to the cloud because they are just so immature in their process that is just going to cost a lot of money and put their business at risk.’* Curiously, this information asymmetry seems particularly relevant in two internal departments besides IT: legal and procurement. The expert findings indicate that to negotiate a smooth transfer from on-premises to on-cloud computing and avoid adverse selection,

it is necessary to ensure that the legal and/or procurement departments have the needed expertise. Accordingly, a coordinated strategy for communication between the departments is essential. Sometimes it is inevitable to hire consultants in this regard (Expert 6; Expert 4).

Adverse Selection

The findings report two types of adverse selection: a selection of an inappropriate ‘vendor’ or the selection of inappropriate ‘terms’ for the transaction itself. Expert 4 argued that “... *make sure that the contract is signed as good clauses around the data protection up, business continuity of privacy components of it. A lot of cloud contracts are written by the cloud providers of their very favorable to the providers. So the onus is on the customer to really make sure that their interests are actually protected and forcing the company, the providers, to give some guarantees and warranties that that protection is going to be there.*”

The required cloud-related expertise is challenging to find or under-addressed in the legal and procurement departments (Expert 4). Without such expertise or coordinated communication between departments, the cloud customer could agree to suboptimal legal or financial terms. After signing the contract, the cloud customer’s negotiation power is far less, according to Expert 7.

The second major problem suggested by the agency theory is that of moral hazard. In engaging a cloud vendor’s service, the principal ‘loses control’ over their data to a certain, potentially considerable, extent (Ayaburi et al. 2020). Since the cloud customer (the principal) cannot observe the actions of the cloud vendor (the agent) directly, it can only rely on the agent’s word concerning its performance - unless it finds a way to address this issue. The data confirms the existence of this issue. Expert 3 stated ‘*So, essentially if you're using a company like amazon web services or google or Microsoft or anyone else to a large degree, you are trusting that the pricing of the invoice they are giving you is accurate. And I would say at the moment most enterprises are relying a lot on that trust*’.

The continuous contract management cost factor is also required to account for non-functional but crucial requirements, such as ensuring compliance with data residency requirements or other data protection, privacy, and security requirements (Expert 2). Expert 6 further hinted that the cloud customer and vendor could seek insurance to mitigate some risk of putting the data on the cloud. However, others noted that negotiating such a clause into the agreement would be pretty tricky. For example, Expert 4 stated, ‘*good luck in trying to negotiate those things in a lot of contracts*’). An alternative would be third-party insurance, but while protecting the cloud customer from losses, it is difficult to realign the vendor’s incentives. Even third-party insurance services do not seem to have had success in this context (Expert 3).

Continuous contract management costs also entail costs that come in addressing the information asymmetry between the cloud customer and the vendor before the agreement is concluded. These

'knowledge gain costs' are necessary to ensure that the customer does not select a low-quality agent or terms for the transaction. As mentioned in other sections, Experts suggest that a specific instantiation of these costs may include hiring legal consultants or ensuring effective communication between the affected departments (e.g., legal and procurement, as mentioned in the 'business process change' cost area).

IT departments have been dealing with contracts before the introduction of cloud computing, e.g., in ERP licenses. However, cloud computing imposes different contexts that now require other competencies. According to Expert 2, *'So, is that a new job? No. It is a job that needs somewhat different knowledge'*. That was also supported by Expert 6; *'But it's a completely different job.'*

The usage of cloud computing adds a rather unique flavor to the problem. While cloud computing is similar to outsourcing an internal IT activity, it is critical to continuously review the vendor for compliance with the contract terms and SLA and even ensure that these terms match the customer's interests. This continuous review might require significant investments adding to the total costs. Further, due to the nature of the service, it becomes vital to evaluate and select new terms for the agreement (Expert 6). This nature makes continuous contract management an important cost area, which is influenced by the transaction frequency dimension of the TCT explained in section 3.2.

For instance, while on-premises computing would require addressing the issue of data residency only at the time of setting up the infrastructure, the usage of a cloud vendor's services requires this issue to be checked frequently (Expert 6).

Digging more into the issue of data residency, TCT handles three dimensions: uncertainty, asset specificity, and frequency. Uncertainty of a transaction includes two types, behavioral and primary (Yigitbasioglu, 2014). Primary uncertainty is more relevant here as it relates to uncontrolled actions such as government regulations according to the transaction cost theory. Since data in the cloud might be crossing oceans, a primary uncertainty emerges in the form of legal compliance. Compliance can be defined as the enforcement of rules and the implementation of policies defined in the regulations. Legal compliance is one of the most critical non-functional requirements in the IT industry (Yimam & Fernandez, 2016). An important question here is, is the cloud customer violating the domestic laws when the cloud vendor centralizes its cloud resources in certain limited spots around the world?

According to expert 6, *"most companies don't know. They have no idea..... and their legal office may never have considered that issue"*. Further, Experts 6 and 4 agreed that legal departments on the cloud-customer side lack the calibers to work on cloud legal issues. This lack of caliber is challenging because cloud legislation is evolving steadily (Yigitbasioglu, 2014). Thus, cloud customers might benefit from a long-term external legal consultancy to mitigate the legal compliance risk.

Figure 7 demonstrates the cloud agency-driven issues and the cost areas incurred by the cloud customer. The left side of the figure links the cost areas to transaction cost theory. This figure is a part of a paper (see details in Appendix 10.2 **Fehler! Verweisquelle konnte nicht gefunden werden.**) that exclusively targets cloud computing contracts as a part of this dissertation project.

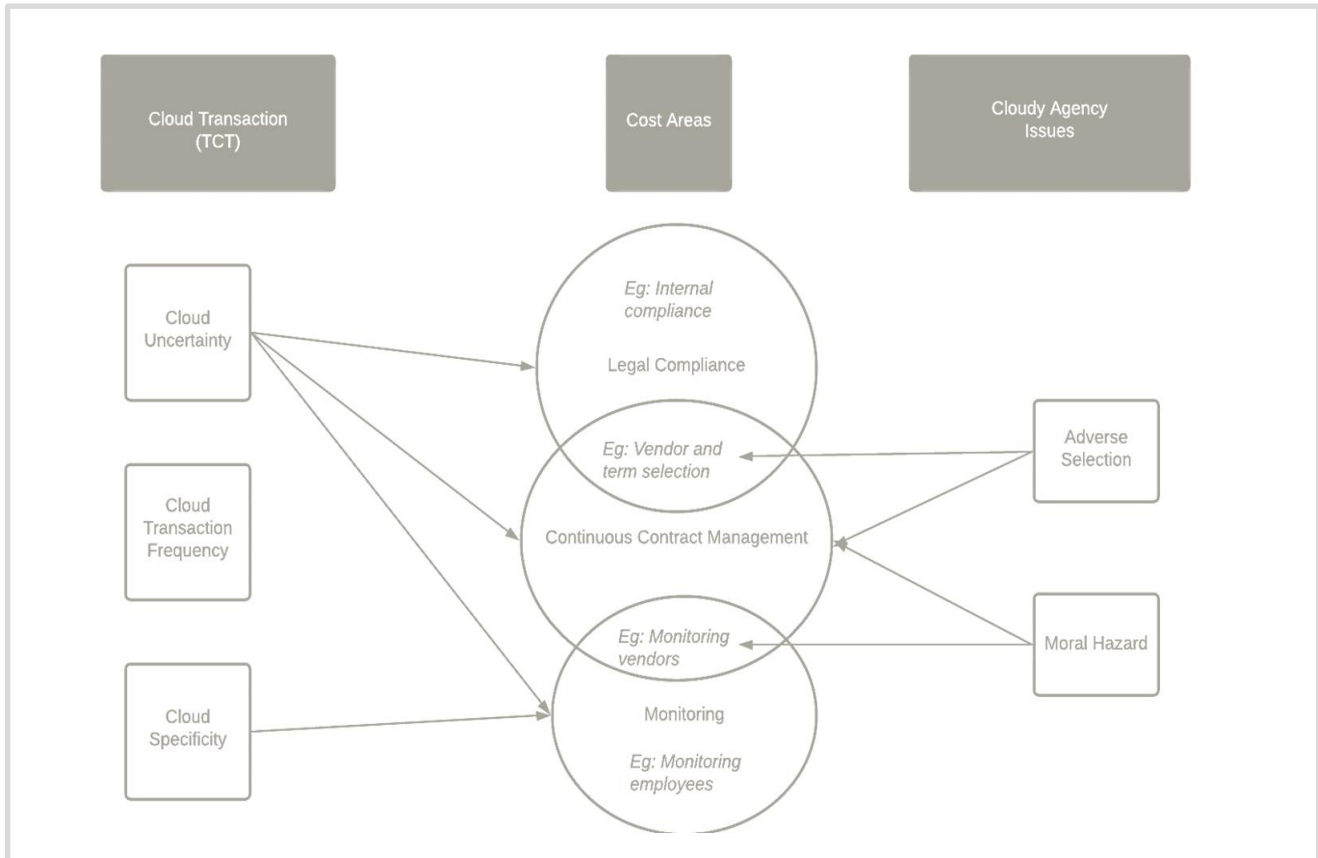


Figure 7: Cloud cost areas explained by agency issues and transaction dimensions (Makhlouf and Chawla, to be published).

7.1.2.2 Consultation

IT systems adoptions usually call for consultants. An ERP adoption is always linked to an ERP consultant or consultants for each module. Out of a sudden, cloud is present in the market. Every company is moving or considering moving. They might seek consultants because they may not have enough knowledge about the cloud journey (Expert 4; Expert 6; Expert 3). External expertise is inevitable throughout the whole transition. This includes expertise in the contract aspects and redesigning and aligning the architecture. In addition, depending on how the adoption process would go, a company may need expertise in data migration or different software products and integrations (Expert 4; Expert 6; Expert 3).

A large consulting company can provide for those different needs. Otherwise, it can be by other entities according to the area. It depends on how the cloud adopter prefers to work. It also depends on how the cloud adopter can harmonize all the needed consulting aspects. It is not in favor of the adopter to have different consultants working on islands and not integrate their efforts for the sake

of the project (Expert 4; Expert 6). An exception would be a legal consultant (Expert 6): it might have to be an independent law firm that studies the clauses of the contract and the service level agreement. As mentioned in the contract management section, such a legal consultant should also help the company comply with changing laws and legislations around cloud computing and data residency.

The Experts drew further attention to the need for change management consultants. Buying the involvement of employees to join the cloud journey might be challenging. Cloud adopters might need a consulting company that accompanies the adoption stages while offering training and change-supporting materials, new processes, and compliance programs (Expert 6; Expert 4).

Some companies might be advanced in their cloud-related architectures and have already equipped their legal department and other departments such as supply chain management and/or procurement with the needed cloud-adequate calibers. The business-process-change section discusses this in detail. In such a case, the consultation costs might be at a minimum. However, since change management is an issue related to the human resources department, this is a question of how much the HR department is collaborating with the IT business units.

In other words, a cloud customer might invest in cloud-skilled calibers, consultation, or both. However, according to the interviewed experts, consultation is undoubtedly needed, at least at the beginning of cloud adoption.

A customer-side expert, Expert 5, reported an interesting finding. He stated that his large company holds regular meetings with other large companies to share their cloud experiences and lessons learned. *‘We share our good experience and bad experience. If we use more than one cloud platform, we do share the different treatments we are getting from the different vendors. We do share the different meditations that every platform would have and how do we deal with this. It is basically more like sharing experience and sharing way of doing things so that we can save time rather than just rebuilding the wheel’.*

7.1.3 Cost Category 3: Service

According to one expert from the consultant side, *‘you also need additional services to track consumption, to audit, to migrate, to ensure you're getting optimal costs et cetera et Cetera.’* This is one aspect. Another aspect is the IT service management (ITSM) frameworks. It is a question for cloud customers: do they need to forget about investments already made on ITSM frameworks such as ITIL or COBIT, including licensing and training? Or would they bear the new costs of a modified, cloud-compatible version of those frameworks? Or would they spend on finding solutions around these frameworks? On the one hand, one of the experts on the customer side explained that they are trying to find a way around ITIL guidelines. On the other hand, an expert from the consultant side stated clearly that those service management frameworks *‘do not speak cloud.’*

7.1.3.1 Meta Services

Moving to the cloud is so much more than just using the cloud provider's service (Expert 3). A company deciding to go for cloud solutions will need additional services to track consumption, audit, migrate, ensure they are getting optimal costs, etc. Moreover, a company will eventually need to manage different cloud environments and on-premises solutions (Expert 3). The vendor's promises might convince a business unit of easy, cost-saving service. However, the IT department has to buy many cloud services and sometimes build solutions such as integrating the interface with the active directory (Expert 5). If the cloud customer does not adopt the needed supporting services, it will be challenging to find the reasons for the sudden increase or overage in usage. Accordingly, it is going to be challenging to manage the cost.

Thus, the Experts highlighted at least four types of tools needed to support cloud services. Those tools are security tools (Expert 7, Expert 5), cloud cost management tools (Expert 5, Expert 3), monitoring tools (Expert 6), configuration management tools (Expert 5, Expert 6, Expert 1), and cloud management platforms (Expert 6, Expert 7, Expert 3).

Security

Although security concerns of the cloud, in most cases, do not mean to favor the on-premises options, quoting expert 5, *'in each and every service that moves to the cloud, each and every connection that we are implementing between the company and the cloud, the security department has to be involved.'* Customer-side Expert 7 stated that his company needed more security applications to adopt cloud services. Such a need for a new set of security tools increased the total cloud-related costs incurred by the IT department. Expert 5, who also represents the cloud customer side, added that the cloud journey imposed investing in changing the hardening and patching processes and the admin access processes to enable the business units to access their services in the cloud from the high proxies and firewalls. That makes investing in security-related cloud-specific tools inevitable (Expert 3).

Cloud Cost Management

Cloud costs management calls as well for tools to automate such painful tasks. Expert 5 stated that although his company uses Microsoft Azure services, they had to adopt another cloud service solely for cost management named Azure-Costs. It is worth mentioning that at the time of conducting the interviews, Azure-Costs was offered by a third-party company, i.e., not Microsoft itself. Expert 3 agreed that cloud customers need to adopt other services to manage the cloud costs and ensure they get the optimal expenses.

Cloud Management Platform

Experts 7, 6, and 3 viewed that such cloud cost management could be a part of a more comprehensive cloud service named cloud management platform (CMP). This CMP should combine many services to manage cloud governance, risk assessment, and cost management.

While in theory, and according to cloud computing definition, the management effort of cloud services is perceived as minimal, cloud customers will need to buy a CMP at some point, primarily if they use multiple services from multiple cloud providers. It gives a complete dashboard view of all the services that the company operates on the cloud and allows IT managers to control that the consumption of cloud resources is happening within specific parameters.

Configuration Management

The cloud resources need to grow and shrink automatically to achieve the expected cost benefits (Expert 3, Expert 1). Although configuration management tools were existing pre-cloud, companies could find a way around them in the on-premises IT resources. In the cloud scenario, a company is probably using a large number of servers with a particular speed that complicates things to be done manually. According to Expert 5 and Expert 1, configuration management tools are an unavoidable extra cost in a cloud project.

7.1.3.2 IT Service Management

Service management frameworks are long-established frameworks to help the IT department manage the IT processes. Organizations pursue those frameworks, spend money on applying them, train their staff for them and try to ensure they get the merits of following them. Then comes the advantages of cloud computing concepts. Organizations want to adopt cloud services and move to the agile way of doing things. Where do the service management frameworks such as ITIL stand now? It is a question for cloud customers. Do they need to forget about investments already made on ITSM Frameworks such as ITIL or COBIT, including licensing and training? Or would they bear the new costs of a modified, cloud-compatible version of these frameworks? Or would they spend on finding solutions around these frameworks? One consultant stated that the answer to this is not straightforward.

Answering those questions about the fit between cloud computing and IT service management frameworks (i.e., ITIL and COBIT) has created a thought-provoking debate in the findings. According to Expert 3, since the industry perceives those frameworks to be great, then they should be able to handle the cloud just like any other infrastructure. While this opinion was relatively supported by Expert 7, Expert 11 was, rebelliously, on the other end of the continuum and clearly stated that ITIL does not speak cloud.

Between those two ends of the continuum, other Experts had other arguments. On the one hand, primarily ITSM frameworks, e.g., ITIL, have processes specifically designed not to allow rapid change. They are designed to ensure that developers cannot just easily put changes in the production environment (Expert 2). On the other hand, the cloud environment is far different from the traditional one. Cloud encourages agility and rapid response (Expert 2), and the operational role of IT departments is shrinking more and more (Expert 5). IT departments with the cloud need more people writing the code than people answering the phone. Expert 5 reported the following *‘honestly speaking, we are already struggling with understanding how the DevOps really work,*

what is agile, and things like this, and we are not alone.This is the challenge we are facing, implementing some sort of a DevOps kind of team inside an ITIL process’.

To manage this conflict, the suggested solution is not to eliminate the ITSM frameworks but to introduce a sort of adaptation. Two of the Experts stated that ITIL, for example, needs to be updated to fit the cloud (Expert 4; Expert 5; Expert 13). Expert 6 illustrated that *‘basically, you are changing the way you’re managing the service completely.’* As well, Expert 4 reported *‘We need to make sure that we are reprioritizing where our services are and aligning our resources to be able to do those things most effectively, which may need to some update to COBIT or ITIL, depending on what service management you are using and make sure that all gated back into the procedures of the organization.’*

Such updates or adaptations will have to be the responsibility of the cloud customer (Expert 4). Expert 5 stated that ITIL has to stay since his company is a large company with thousands of employees. It can remain the big umbrella. Sometimes the agile way the DevOps pursue with the cloud does not fit the ITIL guidelines. In such a case, the customers should try to find a way around it since the agility achieved by the cloud is becoming a business necessity.

7.1.4 Cost Category 4: Communication

Cloud imposes a unique value chain resulting in different communication channels between the cloud vendor, the cloud customer's IT department and the cloud customer's business units. The findings demonstrated cost areas related to managing the shadow IT resulting from communication between business units and the vendor. Shadow IT incurs costs related to security and loss of governance. Experts mentioned the cost of having a new role for continuously reviewing SLA with the actual operations and communicating that with the vendor (Expert 6; Expert 4). One problem that appeared significantly in the findings is the responsibility of ownership. It is not clear who is responsible for what. When experiencing an outage, the SLA states that it is not the vendor to blame. The customer should buy resiliency by investing in two locations. Expert 3 suggested adopting a broker model where the IT department builds a marketplace to control the cloud services. This broker model incurs costs but can also help reduce the costs caused by other communication problems.

The information systems community has discussed communication a lot. People were always an important dimension when thinking about IT in the organization. However, with the cloud, this has become more complicated. A reason for that is the novelty of the whole scenario. Another reason is the nature of the value chain linked to the cloud. If we look at the stakeholders in a cloud scenario, we will find the cloud provider, IT department, and cloud end-users (including non-IT business units). Other stakeholders include the legal department in the organization, finance people, consultants, and others. So, how will all those entities communicate? Managing communication between the interested/ affected stakeholders is a critical success factor. If a company ignores its user community, it is wasting time and putting its business at risk (Expert 4).

This section discusses communication between the different cloud stakeholders. Figure 8 shows the communication channels between the affected parties. Below are subsections demonstrating communication channels between vendor, IT department, and business units. Those channels discuss the areas of problems along with the suggested solutions.

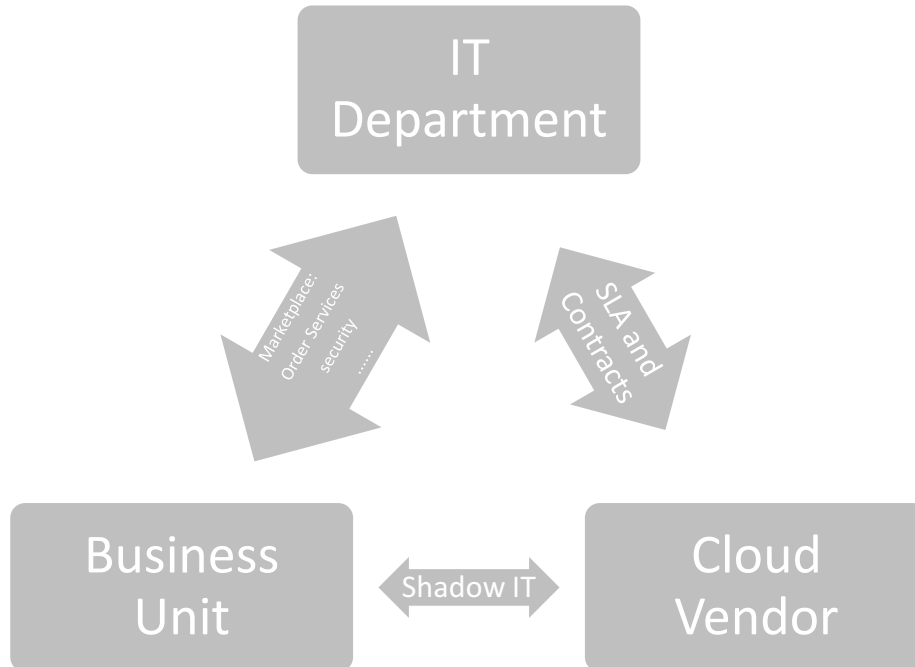


Figure 8: Communication areas and challenges raised by the cloud.

a. Communication channel 1: Cloud Vendor- Customer IT department (Responsibility Ownership)

Looking at Figure 8, the relationship between the vendors and the IT department involves negotiating the service level agreement in the first stages of cloud adoption. This negotiation requires as well the involvement of finance people because money-related decisions are on the table. The legal department also has an imperative role in studying the SLA and identifying the legal liabilities of both parties, the company, and the provider. Thus, the SLA signing is not a light step, and many parties must be involved (Expert 4; Expert 6).

Still, within the link between the IT department and the cloud vendor, there is interaction after signing the SLA. This interaction includes periodically reviewing the SLA, is the provider delivering what is promised? Does the company need to communicate with the provider for corrective actions? The interaction also includes comparing the company’s consumption of cloud services with the available price offers. Did the cost exceed what was expected? Is there a problem with consumption? Or should the company purchase a higher tier of service? (Expert 6; Expert 4)

A major problem arises here between the vendor and IT; who is responsible for what? Vendors say ‘it is a couple-of-hours work, and you are on the cloud. You do not have to worry about infrastructure anymore. We manage everything for you’. However, once the deal is finished and customers are on the cloud, the vendors’ role might end after training. One of the interviewed experts from the vendor side stated that vendors do not manage the cloud for the customers. This managing is the job of the information security department (Expert 13). Thus, there is still a discrepancy between vendor and customer responsibilities (Expert 3).

Customers often do not fully understand what part of the application or infrastructure is their responsibility. Customers do not also understand the responsibility of the vendors. When Amazon experienced an outage and customers complained, Amazon demonstrated that customers could/should build more resiliency by having their applications across availability zones. If customers review the SLA, it is stated that availability zones will go down. There has been a huge problem with communication here. Customers thought it was amazon’s job to build resiliency, whereas amazon was very clear that it was the customer’s job to build resiliency. Such a lack of understanding of who is responsible will remain a source of headache for both parties (Expert3).

b. Communication channel 2: Business unit-Vendor (Shadow IT)

The IT department is the entity that should be ordering the cloud services and interacting with the vendor. However, the cloud is, sometimes, a very attractive option for business units. They want to go for it without involving the IT department. A marketing department might want to go for salesforce.com once they have the budget. Going to IT in such a case might be a non-preferable step. The marketing director would probably be excited about being able to consume salesforce user licenses. The IT director would not be worried about security because that was the marketing director's decision. Then, if that is preached, who is responsible? Is it the marketing director? Is it the IT department? That is a grey area causing what is referred to as the shadow IT problem (Expert 3).

According to Expert 5, it is up to them if a department wants to use AWS or Azure services that are not a part of the service portfolio offered by the company’s central IT department. They can still do it. In this case, the IT department is not adding value to that acquisition. The business units negotiate with the vendors, discuss prices and maybe sign contracts. As a result, the role of the IT department is threatened to minimize. The control of the IT department over the purchased services would be vanishing, and departmental heads are in charge of the IT budget, which means that the IT department has less control. This scenario also has implications on who is responsible for security, data protection, and governance (Expert 3, Expert7).

The IT department must accept the new scenarios to preserve this control again. It needs to allow business departments some level of flexibility. Further, the IT department should think about adding value to those services that will repair the relationship with the business units (Expert 3, Expert 5). The following section discusses further details.

c. Communication Channel 3: IT department- Business units (Brokering)

To solve that shadow IT problem, the IT department must first realize that they need to give end-users some level of flexibility. They need to let end users access services on demand. They might also need to allow individual departments to own the budgets. Otherwise, as mentioned in the previous section, IT is putting itself at risk of losing control and minimizing its role in the company. Thus, a new model is suggested, the broker model or the marketplace model (Expert 3).

The IT department can act as a broker about services. This means that they need to produce, for example, a portal or a marketplace where business units have the flexibility to choose the cloud services they need. With the broker model, the IT department talks to multiple suppliers, negotiates contracts, and ensures that they meet particular security and data protection levels. In that way, end-users get flexibility while the IT department has visibility and control of budgets, governance, and security (Expert 3). If a business unit needs something specific outside the portfolio of services offered through IT, IT can do it in a sort of consultancy service (Expert 6).

Central IT departments offer such consultancy free of charge for the business units. However, they incur costs such as operation overhead like hardening and patching, for example, or ‘admin access’ processes for the different departments to access their services in the cloud from the proxies and firewalls. (Expert 5). Such value-adding practices should encourage business units not to go to the vendor directly (Expert 3).

As another example of value-adding processes offered by IT departments to minimize shadow-IT problems, Expert 5 explained that his company has one big contract offering AWS and Azure to the business units. The IT department made the ordering process very simple and quick. Then IT cross charges the business unit for the costs. This method gives flexibility to the business unit; they have an account and can do whatever they want. But also, the IT does offer some services to make it easier, such as implementing the company’s security measure plan on the servers, VPNs spec to the company, encryption, active direct integration, and all these kinds of bits and pieces.

d. Other Communication Challenges

As mentioned in the introduction of the communication section, stakeholders in a cloud setup are various. Along with the provider, IT department, and the end-users, there are legal entities, finance, compliance, and others. Those entities can act as internal consultants to the CIO for the cloud decision. However, some challenges might arise (Expert 6).

A communication challenge for finance is that the cloud benefits are unclear to them. On the contrary, the financial model of the cloud is to own less and rent more. It means fewer capital expenses and more operating expenses. For finance people, that is not a preferable situation. According to the finance people, a company is financially strong when it has more assets (Expert 13).

Another communication challenge is with the legal department. For example, there are a lot of debates and new laws about data residency (Expert 6). According to some central banks, customers' data cannot be on the cloud (Expert 13). For some countries, it is a sensitive matter where the data is located. An American company using Google or Microsoft probably might not have a problem because data will be in the United States. However, if an Italian company is placing data on the cloud in the USA, are they violating any Italian law? The communication challenge here is whether the legal department of the cloud customer is aware of that (Expert 6).

7.1.5 Cost Category 5: Price

According to vendor-side Expert 10 and Expert 8, the price includes paying only subscription fees, ongoing training, and configuration. Quoting Expert 5 from the customer-side, *'the vendor is usually giving you the price of the service without any kind of management whatsoever.'* Customer-side and consultancy-side experts explained that prices are not straightforward: they depend on how the services scale up and down (Expert 3, Expert 1) and how the cloud customer organizes its cloud resources (Expert 1). If a cloud customer scales up and down appropriately and manages correctly, for example, by having certain times for processing at night and using small services instead of larger ones, the prices will broadly differ. Expert 1 added that his team has an employee who has intelligent ways of managing the cloud resources that help the company reduce the bills they get from the cloud vendor.

The happiest- primarily marketed- scenario is when a cloud customer has one server doing everything. In such a case, a cheap server on the cloud will perform the job just fine. However, once the company builds a more comprehensive IT architecture, the costs can increase exponentially (Expert 1). From another perspective, Expert 5 explained that a customer is given different pricing styles from the cloud vendor. He stated *'For example, if you use the first 5 Terabytes over the storage, this has this cost, but the second 5 Terabytes would affect the total cost of the storage, and if you have two Petabytes, it has different calculation.'*

Furthermore, Expert 13 from the vendor side explained that licenses in the case of IaaS are not cheap, while PaaS is much more expensive because the price includes the license. Nevertheless, PaaS offerings are not comparable to any on-premise systems, making the prices difficult to analogize (Expert 7). Finally, according to Expert 3, *'if you buy reserved instances, it can save up to 50% on your cloud cost. But very few people know how and when to buy these and at what point they make good financial sense.'* Thus, besides the cost allocation issues mentioned in the 'business process reengineering' section, the prices of cloud services are tricky to estimate and manage.

On a side note, one cloud customer might pay millions of dollars for the cloud services. According to expert 3, significant gaps remain in auditing those huge bills. He added, *'essentially if you're using a company like Amazon web services or google or Microsoft or anyone else to a large degree*

you are trusting that the pricing of the invoice they giving you is accurate. And I would say, at the moment, most enterprises are relying a lot on that trust. They are just assuming the bill to be right.'

Data Transfer

Another often undervalued item is data transfer price (Expert 3). Usually, companies tend to underestimate the cost of using the internet. However, the data to be uploaded to the cloud and the availability expected by cloud customers require robust connectivity. In some countries, this is a challenge, and the customers have to change their communication infrastructure (Expert 13). Most cloud providers do not charge customers for uploading the data.

Nevertheless, there is a cost in terms of how long it will take and what capacity is needed on the internal bandwidth. Sometimes, the cost of data transfer is too high. The customers in such a case are better off when they send it on physical discs (Expert3). Expert 1 explained that the price is affected when data travel between data centers or when the services communicate together. *'The vendor will say okay; any internal communication within our data center is cheap. But even if you choose to have two different locations like, let's say, a data center in eastern United States and another data server in Ireland, it means it would be a public communication which means it will cost you traffic because also they charge you for external traffic.'* (Expert 1). In addition to the data transfer, customers pay additional prices for VPN and API interfaces/ gateways (Expert 5; Expert 1).

7.1.6 Cost Category 6: Quality

Under the quality cost category, the expert interviews reported four cost areas: Testing, Monitoring, Insurance, and resiliency (data recovery). The following subsections discuss these costs in detail.

7.1.6.1 Testing

One essential cost that is often not represented is testing. According to Expert 5, *'the actual testing, that would be the challenging part.'* Similar to any new system, it is advisable to go for a parallel adoption. There will be a period when both the old and the new cloud systems are running side-by-side, resulting in double costing (Expert 3, Expert 4, Expert 10, Expert 6). Further testing for migration adds delays for projects of switching between cloud vendors (Expert 3, Expert 6).

Moreover, there is a cost of ensuring that the new application can scale up and down to this changing demand. For the IT department to know whether the cloud application is scaling correctly, it should throw cost-incurring requests to the cloud service to check if it grows as expected (Expert 3). According to Expert 1, it isn't easy to estimate the usage of a particular cloud service. Accordingly, the company might have to go for a trial and error attempt in an experimental manner. Such experimenting is sometimes expensive, but they are necessary to prevent service downtime resulting from demand spikes. Expert 1 illustrated the following example, *'I have seen one example like this. It was a very simple online workout website. You basically show the*

customer some video, so instead of having a mobile app, it will be online, so it can be interactive. It learns from customer behavior, and it adapts. one day, Techcrunch mentioned them and had a backlink to their website. By the time I read the article, their website was down.' Due to deficient testing, the company, in this case, missed a lot of money by losing potential customers.

7.1.6.2 Cost of monitoring

Cloud end users act with cloud services like teenagers with credit cards. They keep consuming the service while not realizing their incurring costs (Expert 2). Expert 5 explained that some end-users in his company incurred thousands of euros in a very short time. The IT department had to interfere and terminate those accounts. Thus, monitoring is vital in the cloud setup. If not wisely monitored, the cloud generates many unnecessary costs (Expert 1, Expert 5, Expert 2, Expert 6).

Expert 3 stated that potentially a marketing department could accidentally consume a lot of AWS resources without paying attention to that. Then, at the end of the month, they get a bill for millions of dollars, and they are responsible for paying that. Perhaps the budget has been allocated, or the budget is not available, and the sales department has this huge invoice to pay with no allocation of funds.

An important question here is who should be monitoring what? There are the usual three players in the cloud setup; the cloud vendor, the customer's IT department, and the cloud end-user (in IT or non-IT business units). From one side, the IT department has to monitor the cloud provider, which occurs through monitoring the adherence to the service level agreement and auditing the invoices. Expert 4 recommended that companies should set up some internal benchmarks against which they can continuously compare the SLA. As for auditing the vendor invoices, Expert 3 believes that a gap remains in this area, and the customer has to trust the vendor invoices, which might reach millions of dollars. On the other side, the IT department needs to find a way to put limits and thresholds for the end-user so as to get notifications when costs become too high (Expert 1, Expert 4, Expert 5).

Although monitoring is vital to control costs, monitoring itself is a cost generator. First, IT departments need **monitoring tools** to put limits and thresholds to be notified when a cloud instance is overused. Such tools should allow a level of granularity to dig down and get enough details on consumption (Expert 6, Expert 2). In such a case, three scenarios exist. (1) The vendor might offer free-of-charge functionalities to help the cloud customers monitor their consumption (Expert 10, Expert 8, Expert 1, Expert 2, Expert 6). (2) The cloud customer might adopt third-party services to monitor the cloud service (Expert 7, Expert 1, Expert 2, Expert 6, Expert 5, Expert 3). For example, Azure-costs.com is a famous monitoring tool adopted by cloud customers to monitor Microsoft cloud services. However, it is another cloud service from another vendor, not Microsoft itself (up to the date of conducting the interviews) (Expert 5). (3) Some cloud customers might prefer to build their monitoring tools (Expert 5, Expert 2, expert 6).

Another monitoring cost is the cost of a **monitoring resource**. The cloud customer has to dedicate an employee to be responsible for monitoring the vendor in terms of reviewing the SLA (Expert 4, Expert 7). This includes the costs of recruiting the resource or training an existing resource in the IT department.

One more monitoring cost is **charging back the business units**. The IT department has to allocate the aggregated invoices sent by the vendor. This allocation is a tedious task and considerable time from the top management. However, it is essential that the business units see their consumption and if they are exceeding their threshold because they will pay for it (Expert 5).

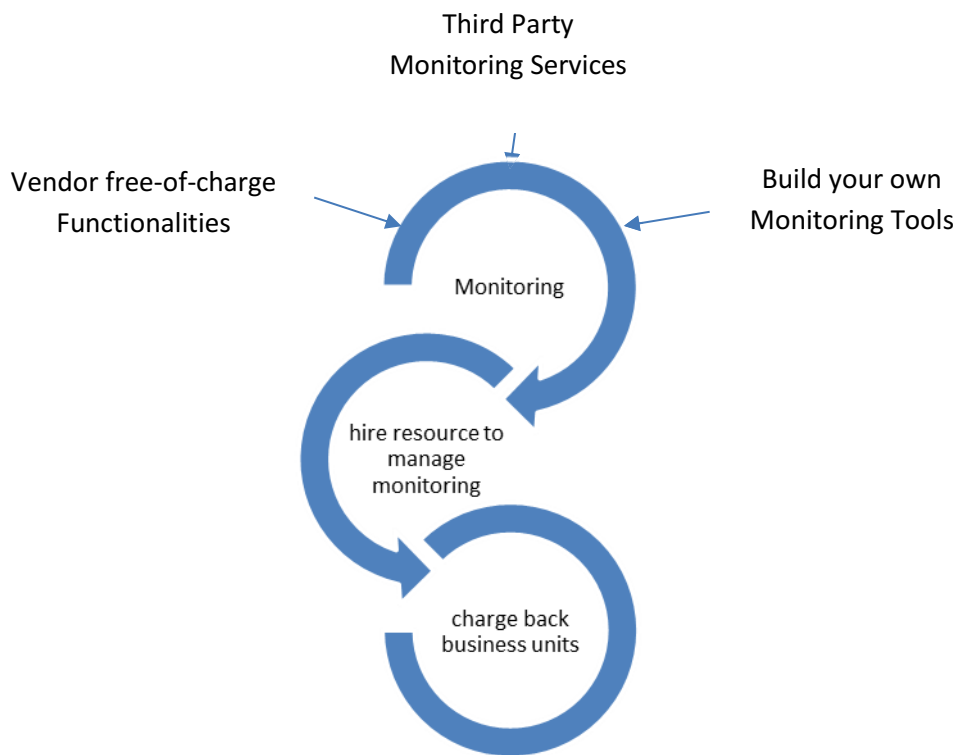


Figure 9: Costs of monitoring cloud services.

7.1.6.3 Cost of insurance

When a company moves to the cloud, it might perceive that the cyber risk liability has moved to the cloud vendor. Nonetheless, putting the company's data in the vendor's data center means it is prone to different types of risks on the vendor's side (Expert 2). How can the customer mitigate such risks? One direct answer could be insurance. Expert 6 anticipated cloud customers to require in the future to check the liability insurance of the cloud vendor to check how much the insurance company will compensate cloud customers in case of failures at the vendor's side that cost the customer serious money. However, such practice is still not common in the industry (Expert 6, Expert 4).

Expert 6 hypothesized the following, ‘*If a provider wants to be insured, if they say okay, we basically want liability insurance, we are providing services to companies if we have a problem, we are trying to manage our business so that we don't have these problems, but if we had a problem and someone had very large damages to the cloud service not working, then we would have to pay them, and we may have a service-level agreement in which we offer to compensate our clients for some of their losses, and so we need to be insured for that. Then obviously, because they are the ones asking for comfort from the insurance company, the insurance company is going to say okay, we need to send technical experts to examine how you do things so that we evaluate the risk. And then, since they are the ones who want the insurance contract, they are going to accept this site investigation. And then that should work*’.

However, Expert 3 believed that if the service provider was to endorse insurance policies, it might appeal negatively to the end-user and suggest that the service provider believes that their services will go down. Consequently, this might be why service providers did not pursue such insurance practices.

From the cloud customer perspective, when a service goes down, the loss attached is not related to infrastructure; it is the loss of revenue due to interrupted operation (Expert 3, Expert 1, Expert 2). According to Expert 3, no insurance policy would be able to mitigate that risk. The insurance premiums for such risks would be huge (Expert 3, Expert 4). In such a case, cloud customers have to accept that risk, focus on building disaster recovery and resiliency (Expert 4, Expert1, Expert 3), and go for typical cyber risk insurance (Expert 2). Another solution is to add clauses in the contract with penalties to the vendor for security breaches or service reliability issues. But according to Expert 4, "*good luck in trying to negotiate those things in a lot of contracts, particularly with the major providers!*". Cloud vendors are cautious with their contracts, putting most of the risk on the customer (Expert 2). Table 12 shows the different risk mitigation options, while the next section reports the expert analysis findings on resiliency and disaster recovery.

Table 12: Risk Mitigation Options in the Cloud

Cloud Risk Mitigation		
<u>Insurance company</u>	<u>Resiliency/ Disaster Recovery</u>	<u>Clauses in the contracts with penalties</u>
Expensive and not feasible.	It is the responsibility of the cloud customers, not the vendors.	Vendors would not easily tolerate that.

7.1.6.4 Cost of resiliency/ Disaster Recovery

Over 99% availability promised by vendors does not mean that cloud customers are risk-free. To mitigate such risk, the experts suggested three approaches, Table 12. One direction is to go for an insurance company, as mentioned in section 7.1.6.3. This solution was discussed by one expert from the consultancy side (Expert 6). However, he was not sure if this would meet commercial success. Another expert commented that cloud service insurance is complicated to implement (Expert 3, Expert 4). The vendor would not easily allow the insurance companies to check the data centers. Also, if the vendor offers to be insured to increase customer trust, this might give a negative message (Expert 3). Experts 4 and 3 highlighted that if insurance is considered, the premium paid by the customers will be very high. Finally, an expert from the consultancy side stated that a company tried to offer that cloud service insurance, but they were unsuccessful (Expert 3).

The second approach for risk mitigation is to add closures in the contracts with penalties to the vendors. Unfortunately, contracts might be tricky to understand. Cloud vendors ensure that contracts are in their favor. Customers have to invest more in comprehending the contracts in the aspects related to data protection and business continuity (Expert 4). Finally, customers tend to be having low bargaining power to add closures in the contracts, especially in front of the big cloud vendors. The vendors will not easily accept amending the contracts.

The third approach is the most agreed-upon answer, *'Put it in two places.'* This approach is building resiliency through disaster recovery. According to Experts 2 and 3, it is the responsibility of the customer to build such resiliency, which has its separate costs. A company needs expertise or resources to manage such issues, plus the expenses paid to the vendor for having the data on two sites (Expert 1, Expert 2). From the customer side, Expert 1 explained that disaster recovery does not cost only storage; the security measures for this storage are expensive. This is because DevOps handle scripts for load balancing, and they work on replicating servers and doing backups. The cost here is not only the cost of storage but also the time to handle security measures. While Expert 1 recommended disaster recovery for critical services, Expert 7 explained that his company used to have the following rule, if an application requires disaster recovery, it does not get to the cloud.

Although building resiliency through disaster recovery is a cost factor, it is interesting to investigate the potential cloud computing offers in such an area (Expert 6). Large cloud vendors are advantageous because they have data centers around the world, including the US, Ireland, Germany, Indonesia, and Africa. So a cloud customer can choose two locations to ensure that if a total data center is down even by a hurricane, another one in Germany can be immediately up and running without affecting the daily operations (Expert 1, Expert 3). Expert 6 added that disaster recovery could spread through more than one cloud vendor in some legally and financially

sensitive services where a company can not afford to lose transaction information. It is usually a matter of good infrastructure design decisions (Expert 1, Expert 6)

7.2 Case Studies

The profiles of the companies are briefly reported, then the output is demonstrated in figures. A thorough discussion is then conveyed in Section 7.3.

7.2.1 Case study 1

Company A is a large enterprise of more than 2000 employees. It operates in 10 countries spread in Africa, Asia, and Europe in the industry of material handling dealerships. It distributes and supports a very famous brand of construction machines, power systems, and material handling equipment.

The data collected were from 3 interviews with an IT top manager. His title was Group IT Services Support Manager. Also, internal documents, such as invoices, were discussed in the interviews. Finally, online resources, such as the following IT Architecture data, were collected.

IT Architecture (based on online sources):

- London-based DR data center
- Microsoft Windows 2012, Microsoft SharePoint, Microsoft Dynamics ERP
- Microsoft Hyper V (for virtualization).
- EMC VNX unified storage.
- EMC Unisphere: the company uses Unisphere, included with VNX, to manage its environment, including RecoverPoint.
- EMC Total efficiency Pack including EMC RecoverPoint: Automatically replicated data from the company's primary data center to the London site. RecoverPoint helped reduce the recovery time objective (RTO) from two hours to 30 minutes. RecoverPoint provides automatic replication of physical and virtual machine data.

Figure 10 reports the findings of case study 1 based on the three interviews, online resources, and cloud usage documents provided by the company.

Resiliency

- Cloud helps enhance resiliency for small enterprises.
- For large enterprises with DR, the cloud is not appealing.
- Some security tools on the cloud that takes a long time to deploy might be appealing.
- Resiliency is easy to build on the cloud, but it is the customers' responsibility.

Testing

- Sometimes a business needs quick projects where there is not enough time to test.
- In the first year, when we wasted half of the commitment, we were like testing the cloud
- Cloud and on-premise solutions can run in parallel with the on-prem in the transition period.
- A hybrid option is used in branches in Subsaharan African territories.

Monitoring

- Monitoring on the cloud is more costly than monitoring on-premise.
- The monitoring functionalities coming with the service give warnings when you reach the money limit, not the usage itself.
- The third-party tools might be helpful, but the company is still busy with the deployment.
- The vendor should enhance its cost control tools.
- Monitoring consumes more manpower.
- Lack of monitoring implies financial costs.

Shadow IT

- The business user is being tricked by the cloud providers
- The potential integrations and security requirements have wiped away many of the expected benefits, which have even incurred more costs.
- Shadow IT instances disrupt the IT operations with unplanned projects
- We never managed to get top management support until we got some failed shadow IT projects. So the management learned it the hard way.

Brokering

- Local IT has faster support than the vendor.
- Local IT knows the company's history.

- The pay as you go does not apply on everything
- With computing as a service and database as a service, price is paid from day one although the service is still being deployed.
- SaaS is not that adaptable and does not have the pay as you go concept.
- Vendor ambiguity vs. customer's lack of knowledge.



Consultation

- Lack of cloud vendors' best practices.
- Cyber Security consultant rationalizing cloud usage and cloud costs.
- Consultancy is needed for the designing phase of cloud solutions.
- Two consultants for cloud-based web portals:
 - For CMS.
 - For security and data privacy.

Contract Management

- Contracts put the company under restrictions of consumption levels and payment terms.
- Challenges in defining the contracted initial sizing.
- Lack of caliber in the legal department.
- A legal consultant with cloud experience may help.

Business Process Change

Business process reengineering

- Procurement intervention is needed, but there is no caliber.
- Headache of cost allocation.
- The Vendors should do solutions that facilitate cost allocation.

Change Management

- Extended IT operation team.
- Building cloud talent is challenging (hiring and training): e.g., for mail system extra junior + security employee.
- The administration of the cloud solution is more than in-house solutions.
- Cloud is asking for continuous team development, not only initial training offered by the vendor.

Rearchitecture

- Synchronization servers
- Integration gateways
- Proper sizing challenge.
- With computing as-a- service and database as a service, deployment took up to 5 months.

Meta- Services

- Being on the cloud exposes you to a different reality. We had to adopt extra security services. It happens magically without noticing that forehead.
- We had to pay an extra subscription to basic hidden functionalities, which disturbs cost estimation.

ITSM Adjustment

- IT service operation/support: No big difference with the cloud.
- IT service delivery: Extended IT operations team and tendency to adopt more solutions.
- ITIL still speaks cloud.

Figure 10: Cloud Computing Cost Areas for Case 1

7.2.2 Case study 2

Unlike company A, Company B is a small Canadian direct-to-consumer company that provides fresh-roasted craft coffee through an e-commerce platform. Based on online resources, below are some of company B's IT architecture components:

- Customer accounts and information are partially saved on the cloud.
- The company adopted some services from Amazon Web Services (AWS).
- The backend of the website is on the cloud.
- Asana is mainly a project management tool on the cloud.
- QuickBooks is an accounting application on the cloud.
- Google drive.
- The company has 16 technology products, which are different modules on the website. Each one is doing a separate service for the customer. So one of them is an application that manages the review system, one is a loyalty program, and one is a CRM chat pot. They also include Google Analytics, WordPress, and G Suite (formerly Google Apps for Work).

One interview was conducted with the Chief Operating Officer (CFO). He is also one of the cofounders of company B. Figure 11 portrays the findings of Case study 2.

- Resiliency**
 - We pay separately for having our data saved on multiple sites.
 - We did a lot of migrations from one website to another. That is why we did the backup..
- Testing**
 - We do not have the privilege to test the service beforehand, but we do a lot of research.
- Monitoring**
 - we have a process to check invoices every month just to monitor because sometimes they add things we did not subscribe for.
 - I do not see bits and pieces of it, but I see all the subscriptions and the fees, the cloud fees that we are paying.
- Shadow IT**
 - Because the size is small, the rule is if you can do it yourself, then do it.
 - Some areas are untouchable. And we speak lot together and come back to the Teck lead whenever needed.
- Brokering**
 - We discovered that we subscribed to a service that we did not need.
 - Communication with the vendor was not organized and information was scattered which did not allow us to track it and understand what is happening.
 - With the small cloud providers, SLAs were not detailed enough.
 - Sometimes, the vendor responsibility is vague.

- At first, the invoices exceeded the anticipated amounts.
- We have a process to check the invoices each month because sometimes they add things we did not subscribe for.
- We make conscious decisions not to invest in Capex.
- The cloud is very suitable to our small agile nature.



- Consultation**
 - When a consultant is needed, we hire a freelancer instead.
 - The company can hire a freelancer to adjust a new cloud service to the company's needs.
 - Using freelancers is one of the advantages of being a small size business.

- Contract Management**
 - With a small cloud vendor, the SLA was not detailed enough. This resulted in paying for a service we did not need.
 - We do not consult our lawyer in the small cloud services that we adopt.
 - We consulted the lawyer on the data residency issue.
 - When the company grows, and the contracts are bigger, legal has to be included.
 - So far, contract management is not a separate cost item.

Business Process Change

- Business process reengineering**
 - When we adopt a new service, we might need business process reengineering.
 - The business is small; the change is not complicated to do.
- Change Management**
 - Instead of hiring full-time employees for adapting the new service, we hire part-time employees or freelancers.
 - Due to our small size, we can act fast and adapt to change.

Rearchitecture

- Sometimes a service requires customization.
- Sometimes a service does not work correctly with our website
- We incur overhead costs to adjust the service to the company's landscape.
- We needed to pay additional costs to Integrate new cloud applications into existing ones.
- Migration is our biggest frustration.
- We had an architecture problem previously. We are trying to fix it with more functionality and more services.

Switching Costs

- It was costly to move from a cloud vendor to another.
- The costs were mainly the disruptions to business operations.
- Due to our small size and limited resources, we do many things ourselves.

- Extra Security Services**
 - We had multiple situations where we needed to adopt more cloud services but our constraint was financial.
 - We had to adopt extra services with extra costs for integrate existing services.
- ITSM Adjustment**
 - Not applicable.

Figure 11: Cloud Computing Cost Areas for Case 2

7.2.3 Case study 3

Company C is a large Enterprise operating in Europe and Africa. Data were collected using two interviews with the Global Head of IT performance and IT Services as a representative for the IT top management. According to him, the company heavily depends on the cloud; most core systems are in the cloud.

Besides the two interviews, data were collected from company C's Annual Reports. Moreover, online resources were used, such as job descriptions of IT roles, video interviews, and industry reports with the company's CIO and financial managers. Figure 12 reports the findings of Case study 3.

Shadow IT

- To manage the problem of shadow IT, we manage the cloud centrally, even with local contracts.
- The company was distributed on shadow IT and still is, but the IT services department is now taking ownership of all the IT Contracts.

Brokering

- The IT department has SLAs with the vendors and OLAs with the business units.

Business Process Change

Business process reengineering

- Support of HR is required in training in redefining all the job descriptions, but with no long-term influence.
- Purchasing must be strongly involved in negotiating and writing the contracts.
- The relationship with the purchasing is the most important relationship for any internal IT department.
- The IT lead buyer needs to understand IT basics.
- IT department might need to educate this IT lead buyer about the cloud.
- Legal must be involved, and there is a need for a specialized IT legal role.
- The IT department was reengineered by creating the cloud CoE.

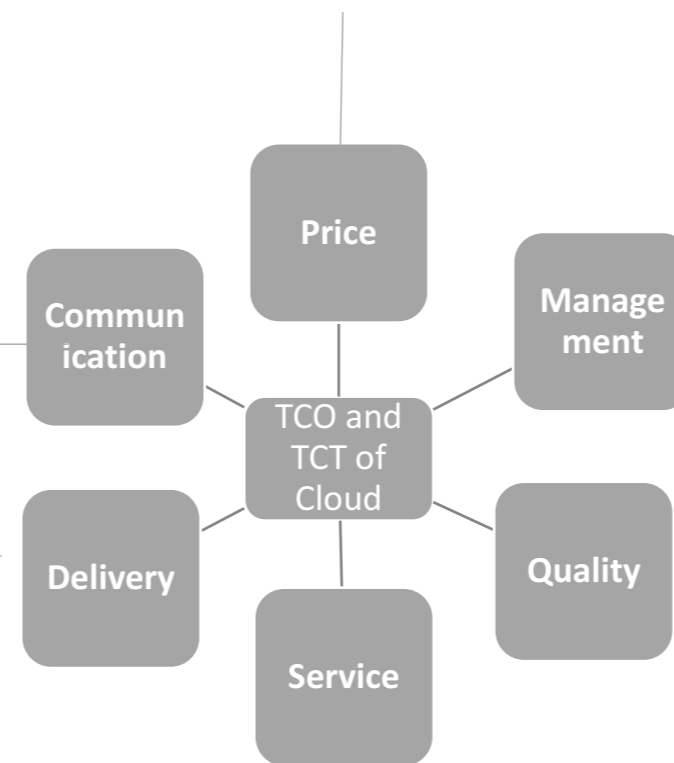
Change Management

- The cost aspect is one part, but change management is very important.
- You do not buy cloud out, turn it on, and you are done. No. the organizational aspect is an integral part of it. Otherwise, you would not reach the preliminary features in the business case.
- The IT departments transform, and the IT managers change their way of thinking.
- Now we manage content, not hardware.
- The difference in the required skill set between on-premises and cloud is significant.
- There has to be a long-term plan for IT skills.
- It is easy to find the needed skills because you are not limited to one physical location.
- Having staff spread out over time zones means better support and better maintenance.
- Suppliers have sufficient training programs, but the company has to pay for them separately.

Rearchitecture

- The implementation is expensive, and the migration is expensive.
- Cloud has become extremely complicated because everything is running on it.
- The infrastructure is complex, but the middleware is much more complicated.
- Middleware is inflating the IT costs.
- You need to be dynamic and make the balance between systems that are over-utilizing or underutilizing what you initially expected.

- The return on investment could be 3 years or five years. Nevertheless, it is coming.
- Cloud computing is agile, easy to manage, standardized and automated and cheaper to maintain. Nevertheless, in order to get there, you need to make investments, like any other IT project.



Cloud management

- Cloud should be managed internally.
- Center of excellence is responsible for managing the cloud centrally.
- You need the skill set to manage the provider.
- Operational level agreements (OLA) were employed.
- Different governance practices are needed.

Contract Management

- Contracts are more difficult.
- Purchasing must be strongly involved in negotiating and writing the contracts.
- Contracts cannot be done by only purchasing, and they cannot be done only by IT.
- Legal must be involved. No contract is signed without them.
- Some companies have a specialized IT legal person, but we do not.
- Negotiating and signing the contract is one, but after that, the also contract needs to be managed.
- Coping with data residency law is difficult.
- Regulations (data, tax, labor,...) are different per country or even per continent.
- Global contracts are preferred but are not always feasible.
- Regulations in South America are very unstable.
- The problem that you have is that you can have of the availability of the cloud but that does not mean that the application itself is actually working.
- The supplier always stated that the SLA is the same as what Microsoft is telling you for a cloud.

Monitoring

- The center of excellence is responsible for monitoring the cloud services
- The monitoring techniques for on-premises do not work for the cloud.
- Monitoring is not complicated, but if you do not monitor cloud usage, there will be surprises.
- To have clear reporting of the consumption of the business, we use power BI.
- The information provided by the vendor is sufficient, but to make it readable, understandable and valuable for the business, you probably need other tools.

Meta Services

- We keep investing in cybersecurity to mitigate the risk of heavily depending on the cloud.
- The backup needs to be changed, and monitoring needs to be changed, security is different.

ITSM Adjustment

- Without ITIL, you cannot manage the cloud.
- If the IT staff are not ITIL certified, you will fail miserably.
- A company must have incident management, problem management, change management, release management,..... and then probably availability management.
- Some processes remain largely the same with some adaptations.
- DevOps can be a complex challenge.

Figure 12: Cloud Computing Cost Areas for Case 3

7.2.4 Case study 4

Company D is a medium-sized governmental entity based in Germany. Data were collected by interviewing a site reliability engineering (SRE) team leader. Other online sources were also used, such as interviews with business unit members using some cloud-based solutions. Figure 13 reports the findings of case study 4. Section 7.3 discusses these findings with the other case studies.

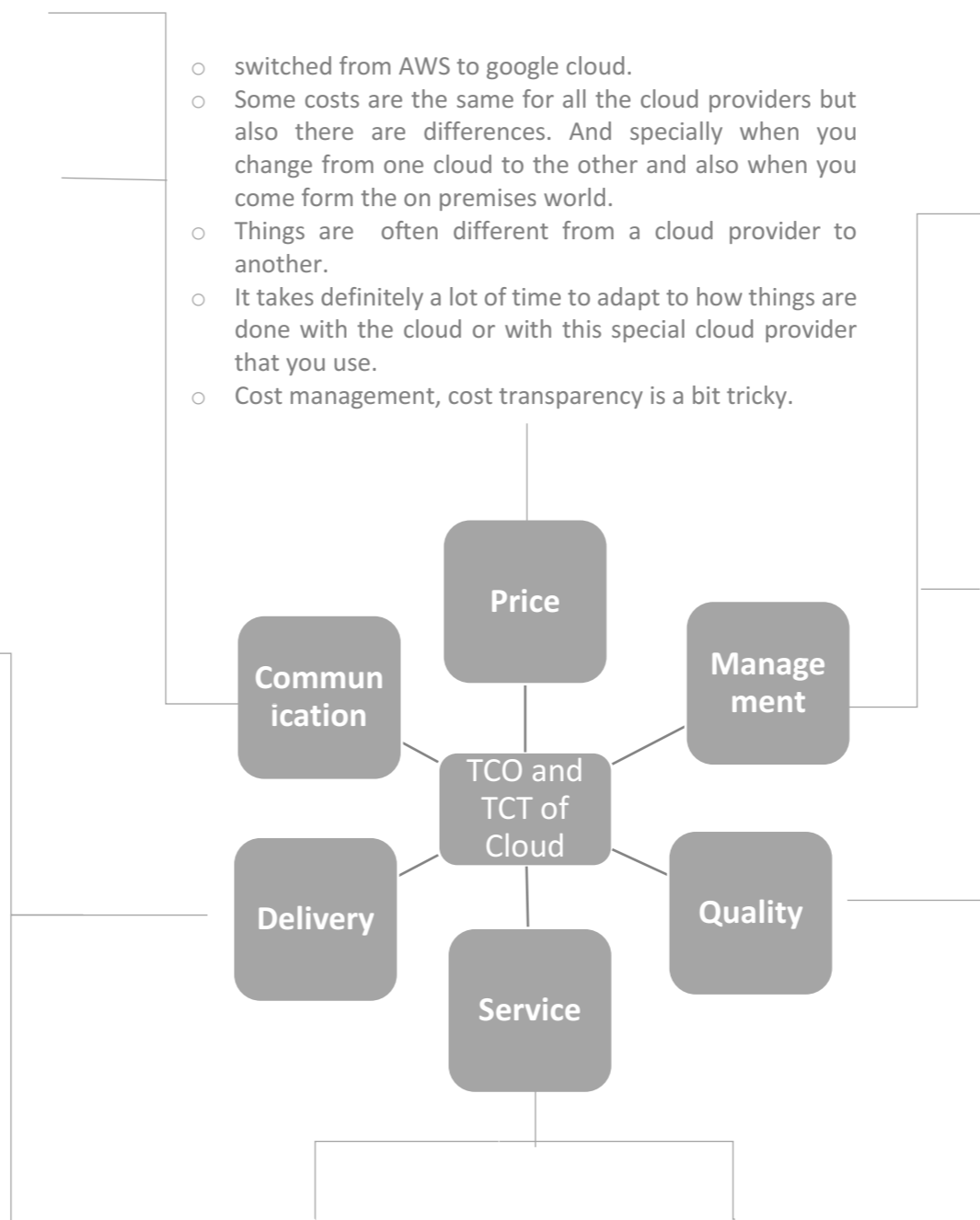
- Shadow IT**
- You can have an internal shadow IT when you have a development department or a team that creates their own infrastructure to handle things.
 - Business units may adopt SaaS services without getting back to IT.

- Brokering**
- No data
- Business Process Change**

- Business process reengineering**
- **Procurement** people do not understand IT so much, but this is not the main problem
 - the main problem is these volatile costs.
 - So, it is not like before, you ordered like five servers, costing each 5 thousand, and then you can have easy math, but now you say, ok we estimate that we need around x amount of money for the next year.
 - But in the cloud, it is if we have more traffic or users, maybe it is more, maybe it is less. Then for them, it is hard to make estimations
 - In the cloud, buying is not very much like buying something with a fixed price, but it is something where you make a contract where you do not know exactly your expected consumption.
 - Finance work with the IT units to understand the bill.
 - Splitting the bills among the departments is a burden.
 - It was hard for the finance department to create their own report on a google cloud platform.
 - The IT department had to create a hand-made reporting so that the non-IT department could understand the bills/ consumption.
 - There are third-party tools for that, but they are expensive.
 - The vendor offers other tooling and exporting data, writing queries, and extracting the stuff for the database, but it is still uncomfortable. It takes time and requires constant recheck.

- Change Management**
- There is definitely a learning curve, but learning is a tricky word. Learning is not just reading and attending an online course.
 - Starting a project first on the cloud is easy. But coming from on-premises is more complicated.
 - Once the contract starts, you have access to the cloud, and you start working around
 - we did also some training and online training, and then you start building things, and you learn while you build.
 - Maybe then you have to change things afterward because you learn that something is different or it is not working like you expected.

- Rearchitecture**
- User management was quite different for us; that took some time to manage.
 - We have a CIC pipeline for stuff, and this is completely automated. So, we also had to adapt to the new API of the cloud provider.
 - We had also to rewrite our software in some parts, and that was also something that took quite some time.
 - There was a question if we need the enterprise support and you pay 50,000 a month and get an architect that you can question for 3 days a month and helps you build everything. That is nothing we needed. But in a bigger company, where you have a more complex infrastructure, maybe this makes sense.



- ITSM Adjustment**
- The interviewee was not familiar with ITSM frameworks. However, he could relate to the volatility of the DevOps.
 - It is hard to plan with system administration teams because it is volatile.
 - System administration in general, is very hard because you have to always manage your needs to evolve the infrastructure to make it reliable, work, or comply with all the stuff.
 - And then you have all these daily businesses where incidents happen, where problems occur, and you have to jump on that.
 - You cannot foresee what the next day brings because maybe there is some broken software, some infrastructure service that changes, some third-party staff that changes, and it is a little bit unforeseen.
- Meta Services**
- There are third-party services that can help with cost allocation, but we decided to build our own tool.
 - It was definitely work and discussions to bring it to a level everyone can use. That was a little bit tricky.
 - We used a third-party to startup internal services.
 - The internal security and IT department did not agree with cloud-based email service.

- Cloud management**
- We manage the cloud by ourselves.
 - I see in bigger companies that there is a need for some department like a center of excellence. But we are a small department, and we are the only users of this cloud who are really seriously using it, and we try to get or to keep or to make it as easy as possible for the developers to use the cloud.

- Contract Management**
- The company changed from a cloud provider to another because of regulatory reasons.
 - Managing the contract and SLA is done by my team. But basically, it is me 😊!
 - Basically, there are different departments that sign the contract and check all the legal cases.
 - My department was responsible for defining the technical points for the contract.
 - When we started with google, it was a hard time, or it was even impossible to change the terms of services, for example, SLA. Because they have their fixed ones, they say these are valid for everyone. And they do not talk to you about special deals or something.
 - This was a problem for the legal department first.
 - But the bigger problem was then, especially because we are a German company and a public company, privacy and the whole GDPR staff, and security.
 - We have the legal obligation to keep the data in Europe.
 - The contracts state that data can go through the US.
 - A company can decide where to store the data. But you can not know where the logging happens.
 - Further discussions between the legal department and the vendor were made and ended up with the vendor Calming the guys, but nothing can be negotiated.
 - Three departments were involved, the legal department, the IT security department, and my department.

- Monitoring**
- Although monitoring on the cloud is easy, you have to agree with the constraints you have there.
 - Basically, if you want to do some automatic stuff you have exported, that costs you extra.
 - If you do not like the UI, or it is hard to use, then you also have to deal with it, or you have to also build your own again.
 - We thought about using third-party tools for monitoring, especially.
 - If you want to change the company, then it could be tricky, and it creates additional work to adapt your new services to the new provider then.
 - So in our case, we created our own solution for monitoring

Figure 13: Cloud Computing Cost Areas for Case 4

7.3 Case Studies discussion

This section discusses and compares the findings of the four companies. Using the six TCO categories, the following subsections correspond and analyze how the studied four companies comply with the proposed cost estimation model concerning each cost area.

7.3.1 Management

a. Consultation

IT top management in Company A reported that the road to the cloud was challenging. This opinion was also valid for building solutions on the cloud, where they have made similar ones but on-premise. He reported that his IT departments lacked awareness of the cloud nature, and the vendor was not giving them enough guidance. He believes that the vendor should provide many best practices. According to the company's Top-Management representative, *'as you build the solution, you can assign some resources, and on the long run, those resources are not being used. So you have to keep revising your solutions on the cloud in order to maximize the usage and minimize the expenses. Me as a customer, I am lacking this experience'*.

To substitute for this lack of experience, the IT top management representative believes that consultancy is essential starting from the first phases of designing the cloud solutions. He reported that an optimum way is to have a prominent consultant who has passed through the whole cloud adoption experience. Such a consultant can guide with best practices to reach the maturity and the best usage of the cloud resources. But the company did not opt for such all-inclusive consultancy services in their cloud projects. He concluded this big consultant point because his company has *'suffered a lot in the cloud implementation.'*

Instead of this one big consultant concept, company A had to hire several consulting services throughout the cloud adoption journey. One consultant was for cyber security and was responsible for, among other things, rationalizing cloud usage and controlling cost leakage for unused cloud resources. In other cases, specific cloud projects needed consultancy.

For example, the IT department had a project for building web portals for the company on the cloud. In this project, company A hired two different consultants. One consultant was for doing a solution for a content management system (CMS) on the cloud to be the back end of this portal. The other consultant was to manage this portal's security and data privacy on the cloud.

Having such consultants add to the total cost of the cloud project. The interviewee stated *'In one scenario, I forced the cloud provider, in my case was Microsoft, to provide me with implementation services. And they got me actually two offers; one is for the implementation to be done by a Microsoft vendor and the other to be done by Microsoft consultancy services. The one by Microsoft consultancy service offer was like seven times the cost of having the same deployment done by a*

Microsoft vendor. When we opted for the Microsoft vendor to do the implementation for us, we suffered a lot because on the vendor level as well. They lack a lot of know-how regarding cloud deployment'.

Company B avoids the high costs of the vendors by using freelancers wherever there is a consultancy need. The Top-Management representative reported that as a small company, when a consultant is needed, they hire freelancers, e.g., to adjust a new cloud service to the company’s requirements. Despite affecting the total cost of ownership of cloud services, using freelancers is one of the advantages of being a small size business. It helps the company act quickly and solve problems without committing to full-time hiring.

Table 13 shows some of the codes collected in companies A and B (cases 1 and 2). Companies C and D did not report enough data about consultancies. However, unlike Companies A and B, they conveyed a different cost factor which is cloud management.

Table 13: Consultation Cost Area, a sample of codes.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Lack of cloud vendors' best practices. ○ A Cyber Security consultant was needed to rationalize cloud usage and cloud costs. ○ Consultancy is needed for the designing phase of cloud solutions. ○ Two consultants for cloud-based web portals: <ul style="list-style-type: none"> • for CMS. • Security and data privacy. 	<ul style="list-style-type: none"> ○ When a consultant is needed, we hire a freelancer instead. ○ The company can hire a freelancer to adjust a new cloud service to the company’s needs. ○ Using freelancers is one of the advantages of being a small size business. 	<ul style="list-style-type: none"> ○ no data 	<ul style="list-style-type: none"> ○ No data

b. Cloud Management

According to Company C’s press releases and some of their linked-in job descriptions, the company adopts a cloud-first strategy. Their cloud journey started in 2011, and since then, they have depended heavily on cloud computing. As a side effect of that, based on the interview with the global head of IT performance and IT services, the company was distributed on shadow IT and still is. As a result, the company had to confront a significant decision: should cloud services be managed internally or externally? According to the IT top management representative, *"It was a strategic decision here because we see the cloud as a strategic part of our IT, And we did not want to give it to the outside market because then we are relying on the suppliers for strategic services which could be provided by us internally"*. Ultimately, they decided not to outsource cloud management to external suppliers.

To do that, Company C took several measures. First, the IT services department started taking ownership of all the IT contracts. The aim was to have the cloud services delivered to the IT centrally, and then the IT provides it to the other business units. As well, even if the contracts are local contracts between a cloud vendor and a business unit, the contract management had to be done on a central level.

The second measure taken by Company C to manage the cloud internally was by creating a center of excellence (CoE) dedicated exclusively to cloud computing. This cloud CoE helped to have cloud competencies and skillset within the company. It articulated the strategic importance of cloud computing to the company. The third internal central cloud management measure was employing operational level agreements (OLA) within the company. This OLA helped hold the cloud CoE accountable for their performance and service delivery to the business units.

To sum up, the company employed three measures to manage the cloud centrally. These are 1: managing cloud contracts centrally by the IT service department, 2: creating cloud CoE, and 3: employing operational level agreement (OLA).

Besides the internal central management of cloud computing, another management issue was vital for the company. This issue is governance. The interviewee reported that the cloud needs different governance practices than on-premise scenarios. According to him, *"The solution to this is good management and good governance that you understand how you want to support your applications, how you want to support your infrastructure, your environment, and that when you buy IT services from multiple providers, that you need to ensure by correct service management and correct contract management that these contracts are aligned with each other because that is a necessity. I mean, it is a goal by itself, But especially if they are running all in the cloud, they must be aligned. This alignment is not straightforward at all"*.

Case study 4 also reported that they also manage the cloud by themselves. The company had to go through a learning curve that lasted almost six months. However, unlike case study 3, the company did not have to create a Centre of Excellence because of its medium size. Table 14 provides a sample of codes for the Cloud Management cost area.

Table 14: Cloud Management Cost Area, a sample of codes.

Case 1	Case 2	Case 3	Case 4
No data	No data	<ul style="list-style-type: none"> ○ Cloud is managed internally. ○ Cloud Center of Excellence (CoE) is created to manage the cloud centrally. ○ A different skill set was needed to manage the cloud provider. ○ Operational level agreements (OLA) were employed. ○ Different governance practices are needed. 	<ul style="list-style-type: none"> ○ Cloud is managed internally. ○ No CoE due to the medium size of the company

c. Contract Management

The IT management representative of Company A complained that contracts with the cloud vendors put restrictions for his company on consumption limits and payment terms. Such conditions were not present with in-house developments. Traditionally, with on-prem solutions, the company enjoyed the flexibility of dealing with internal IT departments and internal data center resources. With the introduction of the cloud, the company experienced exceeding consumption limits and overusing cloud resources. In return, the company was directed to pay other subscriptions to extend contracted cloud resources.

Those contracted cloud resources are defined in the initial sizing. The IT management representative explained that they still struggle with such initial sizing. Even though they might have built similar on-premises solutions, they find sizing for cloud contracts is different. *'Me as a customer, I am lacking this experience,'* stated the IT management representative. He also explained that the vendor was not offering best practices to help decide such an issue.

The IT department had to decide alone on the contracted service's size. The legal department was not involved in any means. The IT management representative sees that the legal department can join when the solution reaches its final shape. According to him, the IT department is taking complete control of the contracts. Further, the legal department in the company lacks such a caliber that understands cloud computing since it is still controversial for the technical people themselves. The interviewee of Case 1 concluded that a legal consultant with cloud experience might help, but they did not pursue such an option yet.

Unlike Company A, the legal department in Company C is, to a certain extent, involved. The IT management representative defined two tasks concerning contracts: negotiation and continuous management. Negotiating the contract requires collaboration between the IT department, the legal department, and the purchasing department. However, the purchasing and legal departments do not usually have the needed caliber to understand the cloud. Thus, the IT department sometimes has to spend some time and effort training the purchasing and legal representatives.

Company D also reported the involvement of the legal department in contract negotiation. However, it was clearly stated that nothing could be negotiated in the service level agreements. *'It was a hard time, or it was even impossible to change terms of services, for example, SLA. Because they have their fixed ones, they say these are valid for everyone, and they do not talk to you about special deals or something, or they say, ok, for you, we have an extra agreement [...] We are a German company and a public company, privacy and the whole GDPR staff, and security [...] We have the legal obligation to keep the data in Europe [...] The contracts state that data can go through the US. [...] You cannot negotiate special conditions for you [...] They basically say you have to agree to the general terms of service'* reported Case 4 interviewee.

As for the task of continuous contract management, the IT departments take sole responsibility for this in company C and company D. The interviewees stated that their legal departments do not have a caliber for a continuous contract management process. If the legal can build this caliber, this would facilitate the burden that the IT business units have.

Cloud resources in Company C incur huge expenses with complicated contracts behind them. One aspect of the complication is that if the cloud is available, this does not guarantee that the services running on it are available. *"That can become very complicated because then you are taking into account multiple suppliers most of the time, applications, communication between applications and support systems which need to be adapted to it. So it becomes more difficult to define such a contract. And we have had some challenges in that,"* stated company C's IT top management representative. The company has cloud services that integrate with other services from other suppliers or internal departments. Thus, contractual terms become more complicated.

Another obstacle in contract management faced by Company C and Company D is legal compliance. According to Company C's annual report in 2018, the rapid change in law, regulations, and technology puts the company under litigation risks. Further, according to the interviews, Company C faces different laws per country or continent. In return, global cloud contracts become highly complicated. Sometimes, this forces the company to sign cloud contracts per entity, country, or continent. Those laws include data residency laws and other taxation and employment laws. As for company D, it has always been a concern to comply with the EU General Data Protection Regulation (GDPR).

Company B, as a small company, is still considering the legal department as a future entity to be established. So far, the company uses a law firm to consult on legal issues. For example, the company used the help of the law firm to discuss the data residency and the security measures when they first architected how customer information is stored. However, the COO considers that a lawyer or a legal consultancy is not needed for reviewing the contracts of the cloud services that the company adopts. He further finds that the legal advice offered by the law firm is more detailed than needed or more cautious than desired. He associated that with the small size of the services and contracts that his company adopts.

Contradictorily, the company experienced an incident with a small cloud vendor where they had to pay for cloud services they did not need or use because of some SLA/contractual issues. According to the COO, *'the first few months and we were surprised by additional fees that we didn't anticipate. And we had to go back and revise the agreement and the services that we opted for, and it turned out that we actually subscribed to those services, but we did not know that we needed them'* He further explained that the SLA that his company signed for was a summary and not detailed enough. It showed that the company is adopting a bundle of services. The information of the services' breakdown was sent in another email of many interchanged with the vendor. These

many emails resulted in scattered information that led to unexpected costs that disrupted the first three months of operation.

Table 15 provides a sample of codes in the four companies/ case studies in the cost area of Contract Management.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Contracts put the company under restrictions on consumption levels and payment terms. ○ It is challenging to define the contracted initial sizing. ○ Lack of caliber in the legal department. ○ A legal consultant with cloud experience may help. 	<ul style="list-style-type: none"> ○ With a small cloud vendor, the SLA was not detailed enough, which resulted in paying for a service we did not need. ○ We do not consult our lawyer in the small cloud services that we adopt. ○ We consulted the lawyer on the data residency issue. ○ When the company grows, and the contracts are bigger, legal has to be included. ○ So far, contract management is not a separate cost item. 	<ul style="list-style-type: none"> ○ Cloud contracts are more difficult. ○ Purchasing must be strongly involved in negotiating and writing the contracts. ○ Contracts cannot be done by only purchasing, and they cannot be done only by IT. The legal department must be involved. ○ We do not have a specialized IT legal person. ○ Negotiating and signing the contract is one, but the contract also needs to be managed. ○ Coping with data residency law is difficult. ○ Regulations (data, tax, labor,...) are different per country or even per continent. ○ Global contracts are preferred but are not always feasible. ○ Regulations in South America are very unstable. 	<ul style="list-style-type: none"> ○ The company changed from a cloud provider to another because of regulatory reasons. ○ Managing the contract and SLA is done by my team. ○ Different departments sign the contract and check all the legal cases. ○ My department was responsible for defining the technical points for the contract. ○ When we started with google, it was a hard time, or it was even impossible to change terms of services, for example, SLA. Because they have their fixed ones, they say these are valid for everyone. And they do not talk to you about special deals or something. ○ This was a problem for the legal department first. ○ But the bigger problem was then, especially because we are a German company and a public company, privacy and the whole GDPR staff, and security. ○ We have the legal obligation to keep the data in Europe. ○ The contracts state that data can go through the US. ○ A company can decide where to store the data. But you can not

		<ul style="list-style-type: none"> ○ The problem is that you can have the availability of the cloud, but that does not mean that the application is actually working. ○ The supplier always stated that the SLA is the same as what Microsoft is telling you for a cloud. 	<ul style="list-style-type: none"> ○ know where the logging happens. ○ Further discussions between the legal department and the vendor ended with the vendor Calming the guys, but nothing can be negotiated. ○ Three departments were involved, the legal department, IT security department, and my department.
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Table 15: Contract Management Cost Area, a sample of codes.

7.3.2 Delivery Costs

a. Business Process Reengineering

Multiple business processes and areas are affected by cloud computing. Table 16 reports some codes from the four case studies in this regard. These codes are then discussed in detail.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Procurement intervention is needed, but there is no caliber. ○ Headache of cost allocation. ○ Vendors should do solutions that facilitate cost allocation. 	<ul style="list-style-type: none"> ○ When we adopt a new service, we might need business process reengineering. ○ The business is small; the change is not complicated to do. 	<ul style="list-style-type: none"> ○ HR support is required in training and redefining all the job descriptions, but with no long-term influence. ○ Purchasing must be strongly involved in negotiating and writing the contracts. ○ The relationship with the purchasing is the most important 	<ul style="list-style-type: none"> ○ Procurement does not understand IT so much, but this is not the main problem ○ the main problem is these volatile costs. ○ It is not like before; you ordered five servers, costing each 5 thousand, and then you can have easy math, but now you say, ok, we estimate that we need around x amount of money for the next year. ○ But in the cloud, if we have more traffic or users, maybe it is more, and maybe it is less. Then for them, it is hard to make estimations ○ In the cloud, buying is not very much like buying something with a fixed price, but it is something where you make a contract where

		<p>relationship for any internal IT department.</p> <ul style="list-style-type: none"> ○ The IT lead buyer needs to understand IT basics. ○ IT department might need to educate this IT lead buyer about the cloud. ○ Legal must be involved, and there is a need for a specialized IT legal role. ○ The IT department was reengineered by creating the cloud CoE. 	<p>you do not know exactly your expected consumption.</p> <ul style="list-style-type: none"> ○ Finance work with the IT units to understand the bill. ○ Splitting the bills among the departments is a burden. ○ It was hard for the finance department to create their own report on a google cloud platform. ○ The IT department had to create a hand-made reporting so that the non-IT department could understand the bills/ consumption. ○ There are third-party tools for that, but they are expensive. ○ The vendor offers other tooling and exporting data, writing queries, and extracting the stuff for the database, but it is still uncomfortable. It takes time and requires constant rechecks.
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Table 16: 'Business process reengineering' Cost Area, a sample of codes

Finance and Accounting Processes

Cloud vendors generate one aggregated invoice for a cloud service that several departments utilize. Then the IT department has to execute the cost allocation process. IT has to divide the invoice among the business units according to which components they used and how much they used. Company A’s interviewee reported that this had been a hectic process for the IT department. It is challenging to select and deselect tiny components of the service to provide an estimation of how much cost each business unit has incurred.

For example, the IT department has sourced one cloud tenant for the Marketing department to build different company websites. The marketing department is responsible for overseeing the websites of all business units. Every couple of months, the marketing department asks the IT department for the cost of each website to charge each corresponding department. They have to go to every single component of the cloud solution services. E.g., desk space service, internet access service, and too many details. Too many elements must be revised per each business unit. The interviewee explained that after some not straightforward steps, he managed to provide a 90% accuracy of the cost allocation.

This cost allocation process was new to the IT department in company A. In the example of the company websites, multiple stakeholders are involved, including the IT department, the marketing department, and other end-user business units. Despite being a financial-related process, the finance and accounting departments have not participated in it. The interviewee explained that the accounting department is not aware of the components of a website, for example. He further suggested that the vendor should participate in such a process by providing solutions to facilitate cost allocation.

Unlike company A, the finance and accounting business units in company D collaborate with the IT department regarding the bills of the cloud services. However, similar to company A, splitting the bills among the departments is a burden. According to the company D interviewee, it was hard for the finance department to create reports on the cloud provider's platform. Thus, the IT department had to develop hand-made reporting functionalities so that the non-IT departments could understand the bills/ consumption. Finally, the company D interviewee explained that the cloud vendors offer tools for exporting data, writing queries, and extracting information, similar to the wish of Company A's interviewee. However, *'still, it is not comfortable. It takes time and requires constant recheck.....'* concluded company D interviewee.

It was thought-provoking to find out that the cloud vendor (one of the top 4) that was referred to in Company D could not provide tools or reports that could be easily understood by the ERP system they use (provided by the number 1 ERP vendor). Such an issue has stimulated the appearance of third-party tools to facilitate this burden of cost management, allocation, and transparency, as mentioned in the Meta-Services section. Further, the finance and accounting departments are accustomed to buying servers and depreciating them. The cloud model transforms capital expenses (CAPEX) into operating expenses (OPEX).

'Now, with the cloud, for them, it is very hard that every month it can be different because if there is more traffic, you automatically use more virtual machines, the bill goes up. Next month, it goes down. You through away the virtual machine, the costs go down. So for them, forecasting is way harder, I think. And that is for the finance department and also for the department that buys the stuff, procurement, for them it is hard because they have no hard numbers. They cannot say ok, we now pay 50,000 €, and this takes us the next year or the next three years. No. it is different every month. So, I think that is also something that is tricky and hard,' commented company D interviewee.

Contradicting this point of Capex/Opex, company B believes having more operating expenses suits them as a small company. They made conscious decisions not to invest in Capex to free as much cash as possible to scale the operations. They view this as one of the main advantages of cloud computing. It has helped them reach high computing functionalities without having to put significant investments in advance.

Procurement Processes

The IT department has to compare the prices, negotiate and communicate with the cloud vendor. They, however, lack the caliber with such negotiation and communication skills along with cloud experience. Company A's interviewee explained that they have been suffering to build such cloud-related skills because the cloud is relatively new and has an ever-changing nature. The IT department deals directly and lonely with the cloud vendor throughout the whole procurement process of cloud services.

Considering the involvement of the procurement department, company A still needed time to build a caliber with adequate cloud knowledge and general procurement skills. The interviewee explained that IT people could hardly comprehend the whole cloud nature. Thus it would not be an easy task for procurement. However, he stated, *'If this is available, it will be much better than leaving us the IT alone to deal with the cloud vendors directly.'*

Case 3 has reported a different scenario. IT procurements and cloud costs are enormous in company C. These expenditures have necessitated the involvement of purchasing and procurement departments in negotiating and managing cloud contracts. Thus, the purchasing department has the role of the IT lead buyer who works directly with the IT team in the IT contracts, which represent a considerable amount of value and are purchased directly. According to the IT management representative, *"if we go to purchasing of large IT contracts of the cloud itself, these are huge expenses and are complicated and have large contracts behind it. And those contracts must be negotiated together by the IT and purchasing. It cannot be done by only purchasing, and it can also not be done only by IT"*.

Company C interviewee also explained that the role of the IT lead buyer, although not available in all companies, is not new. It was essential as well for on-premises IT purchases. However, the role became more urgent because of the complicated cloud setup they needed to negotiate. The question was whether the IT lead buyers have the required cloud knowledge. The answer for company C was no. Thus, the IT department had to invest in educating those IT lead buyers.

Company D also has a role of an IT procurement specialist. However, procurement might not fully understand IT because they deal with a lot of hardware. The interviewee remarked concerning purchasing cloud resources: *'they also buy laptops and stuff. But this is, like we said, it is different. And for them, I think, this is new'*. He explained that the usage and traffic are dynamic in the cloud. Thus, the purchasing decisions are hard to make because they differ from buying something at a fixed price. In the cloud scenario, there is a contract where the demand is uncertain. Since there is a budget governing IT expenditure, it becomes tricky if the whole budget is consumed in the first couple of months of the fiscal year.

Legal Processes

As mentioned in the contract management section, the legal department's involvement is essential. In Company C, no cloud contract can be signed without the legal department. However, it was reported that they are usually not competent enough with the technical terminologies in cloud contracts. This competency lack meant that the IT department was responsible for explaining the contracts' technical aspects to the legal department. Then, it is the responsibility of the legal department to understand what the legal implications for the company are.

However, unlike the purchasing department, the legal department in the company did not have a specialized IT legal position. The IT management representative explained that such a position could be valuable to the IT department. According to him, *“at the end negotiating and signing the contract is one, but after that also the contract needs to be managed. That can be done by the IT contract manager or the IT service manager, or whatever the name of the role is. But if you then have an IT legal specialist within your company, this would be very helpful”*.

In company B, the situation was somehow different. The interviewee explained that they did not have a separate legal department. Instead, they return to their lawyer in this aspect. As a small company, this has been a suitable setup, except for some issues mentioned in the contract management section.

Contrasting company B, company A is a large company with a separate legal department. However, the role of this department has been minimal when it comes to cloud computing. The IT management representative explained that the legal department could be involved when the solution reaches its final shape. According to him, IT is taking complete control of the contracts. Further, the legal department in the company lacks such a caliber that understands cloud computing since it is still controversial for the technical people themselves.

Finally, company D, as a German public SME, is an example of involving the legal department despite its not-large size. The legal department checked the contracts and the terms of services. In addition, thorough discussions took place with the vendor to ensure legal compliance to the European laws, for example, data residency issues and where the logging takes place. Nonetheless, the IT department has always done continuous contract management and revision, not the legal department.

HR

The last area of cross-functional reengineering is between the IT department and the human resources (HR) department. Only company C provided some data about HR involvement. When the company moved to manage cloud computing internally, it had to acquire the cloud skills within the company by creating the cloud CoE as mentioned before. Support of HR was then required in training, redefining job descriptions, and so on. However, this role is only from a short-term perspective.

From another perspective, one of the biggest threats the IT department faces is the loss of people in general and of cloud calibers in specific. It became relatively easy to lose good, well-trained, well-experienced staff to other employers. If this happens very often, the quality of the IT department will be negatively affected. Thus, the IT department of company C was eager to ensure its sustainability. The company has done this through training, continuous development, providing good salaries, and creating a good work environment. The IT department also tried to build the proper succession so that if people leave, other people could step into the role and grow into their roles.

These tasks are done mainly by the IT department and are influenced by the IT management style. The HR department is only a facilitator for basic tasks. Strategic tasks such as change management are done by IT, not HR. Change management is discussed in the next section in detail.

b. Change Management

Change management is a fundamental cost category suggested by the Expert Interviews. This section reports some of the codes collected in the case studies in Table 17. Then, a discussion follows covering essential ingredients such as cloud skills and calibers, training, cloud learning curve, changing the mindset, and Freelancing.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Extended IT operation-team. ○ Building cloud talent is challenging (hiring and training): e.g., extra junior + security employee for the mail system. ○ The administration of the cloud solution is more than in-house solutions. ○ Cloud is asking for continuous team 	<ul style="list-style-type: none"> ○ Instead of hiring full-time employees for adapting to the new service, we hire part-time employees or freelancers. ○ Due to our small size, we can act fast and adapt to change. 	<ul style="list-style-type: none"> ○ The cost aspect is one part, but change management is very important. ○ You do not buy cloud out, turn it on, and you are done. No. the organizational aspect is an integral part of it. Otherwise, you would not reach the preliminary features in the business case. ○ The IT departments transform, and the IT managers change their way of thinking. ○ Now we manage content, not hardware. ○ The difference in the required skill set between on-premises and cloud is significant. 	<ul style="list-style-type: none"> ○ There is definitely a learning curve, but learning is a tricky word. Learning is not just reading and attending an online course. ○ Starting a project first on the cloud is easy. But coming from on-premises is more complicated. ○ Once the contract starts, you have access to the cloud, and you start working around ○ we also did some training and online training, and then you start building things, and you learn while you build. ○ Maybe then you have to change things afterward

development, not only initial training offered by the vendor		<ul style="list-style-type: none"> ○ There has to be a long-term plan for IT skills. ○ It is easy to find the needed skills because you are not limited to one physical location. ○ Having staff spread out over time zones means better support and better maintenance. ○ Suppliers have sufficient training programs, but the company must pay for them separately. 	<p>because you learn that something is different or it is not working like you expected.</p> <ul style="list-style-type: none"> ○ User management was quite different for us; that took some time to manage. ○ We also had to adapt to the new API of the cloud provider. So we had also to rewrite our software in some parts, and that was also something that took quite some time.
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Table 17: Change management Cost Area, a sample of codes

Cloud Skill/Caliber

According to company A’s IT management representative, cloud computing has been selling on the idea that it would reduce the administration overhead of the infrastructure. Vendors claim that things will be managed for you when you go to the cloud. This idea proved to be not true in company A’s case. It was true that company A’s IT department did not take care of hardware or system updates. However, the IT department had to do a lot of monitoring for the company’s tenants on the cloud, which has consumed more workforce than those who used to do that on-premise.

An applicable example was moving company A’s email system to the cloud. One mail system administrator managed the on-premise email system. By moving to the cloud, this single administrator could not cope with the cloud configuration and monitoring of the cloud-based mail system. As a result, company A had to hire an extra junior administrator. The company also needed a security specialist to overlook the hosted, no-more-in-house cloud solution.

Thus, in this example only, company A had to hire two extra employees. Moreover, according to the interviewee, company A needed to build cloud talent in its local IT to handle any cloud solution. It has been a very challenging task to have such skills before deployment. There has been a general lack of know-how to help deploy cloud services effectively.

Company C contradicted company A in respect of lacking adequate cloud skills. The interviewee believed it has become easier to hire new cloud caliber because a company may not be limited to one physical location anymore. The work can be done almost anywhere because one does not need to be in the data center. It was much more complicated if the data center was in a very remote location to find the suitable staffing for the data center because you are limited to the people in

that geographical area. Now, with cloud computing, that is not the case. Since company C operates in multiple locations, they could look for a specific skill set in various locations and numerous countries, giving them much more flexibility. Moreover, there has been no need any more to have these specialists set together. The collaboration tools that have become available are so advanced, and the IT personnel do not need to be in the same office.

Training

Another main aspect of change management is training. Company A's interviewee explained that he had to offer his team extra cloud training. Cloud technology is changing fast, asking for continuous team development, not only the initial training provided by the vendor. *'This is reflected as well on the cost of the overall solution,'* concluded the IT representative of company A.

This finding was, largely, supported by company C's case. According to the IT management representative, training and building cloud skills costs the company. He explained that *'you could have 40 or 50 people who are specialized in data centers and you are now moving to the cloud, you need to ensure that those people are trained to manage and support the new environment'*.

Although cloud vendors offer a wide range of training that fully supports the company, *'the skill sets that the team will be needing during the build-up and the migration phase are completely different than when you are on run and maintain,'* as noted by Company C's interviewee. He further explained that it is vital to ensure that once a cloud service is running, the employees' skills keep developing in case there are changes or additions to the cloud. He referred that what is unique about cloud computing is that it requires short-term as well as long-term training. This uniqueness means that cloud services are not something you buy, turn it on, and you are done. He remarked that if an organization would address it as such, they would probably miss out on the benefits and not reach the preliminary features of their business case because the organizational aspect is an integral part of it. Thus, company C strategizes a long-term plan for the IT team's cloud-related skills.

Sustainability

Further, the interviewee of company C raised the discussion point of sustainability. He explained that his company has been working hard to ensure the sustainability of the internal IT department while maintaining continuous development. A crucial risk factor is the loss of experienced, well-trained people because IT employers are very competitive, which would negatively affect the quality of the IT department. Accordingly, motivating the staff and offering competitive salaries and a good working environment is essential. Despite being an HR job, the management of the IT department in Company C has been the primary influence in these sustainability practices.

Changing the Mindset

Another issue that has been vital to the IT management in Company C was changing the department's mindset to cope with the cloud-first strategy adopted by the company. *'The majority of the IT managers that I know of are old fashion IT infrastructure managers. They are used to put cables and install servers physically and racks, networking, etc. Now, what is needed is something completely different. All that is not anymore part of infrastructure. Now what we need to do is to manage the content'* highlighted by company C's interviewee.

He added that the way that the IT department, from an IT infrastructure perspective, is organized is entirely different from on-premises than it is on the cloud. Thus, the IT departments had to transform, and the IT managers needed to change their thinking. According to the interviewee, not only is the cloud model different, but the organization and managing the environment are also different. The cloud has become highly complicated since everything is running in it. Thus, the company needed a group of people who comprehend all of these aspects. This need led to the creation of a center of Excellence (CoE), as mentioned in the 'cloud management' section. Quoting company C's IT representative, *'When you have the center of excellence, it means that you are hiring and recruiting people who have the knowledge to manage the cloud for you, and you do that internally.'*

Learning Curve

While company C stressed the long-term training and strategic planning of the IT personnel with cloud skills, Company A and Company D referred to the learning curve effect. According to company D's interviewee, *'there was a lot of learning on the job sort to say. It was not upfront like classes where you have some path to follow'*. Similarly, company A's interviewee stated *'During the last three years and a half we tried too many things, and we have been able to figure out what we need and how the cloud can really benefit us. And several of our group of companies has started maturely porting things to the cloud'*.

Some of the data collected in case study 1 (i.e., company A) were documents of usage diagrams. Those diagrams were discussed with the interviewee showing a fluctuating usage leading to extra money at the beginning of the cloud transformation journey. The graphs then show how the company reached better maturity levels later on.

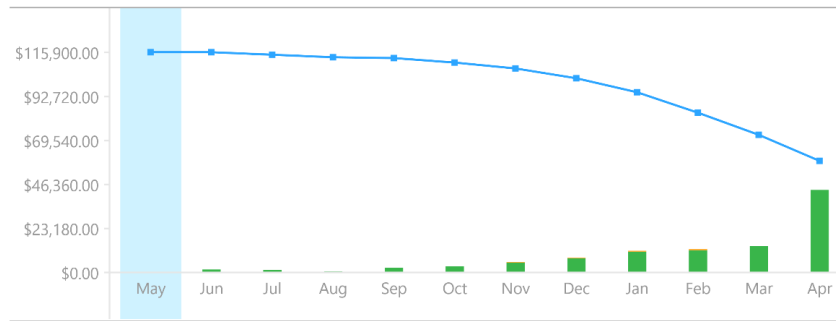


Figure 14: Cloud purchased commitment (line chart) versus actual usage (bar chart) of company A, the first year

Figure 14 shows that the cloud tenant purchased by company A was not efficiently used in the first year of adoption. The company bought a commitment of \$115,900 and consumed only \$58,600. These numbers mean that the company has lost almost 49% of the paid costs on this cloud resource due to wrong estimations and immaturity about its needs.

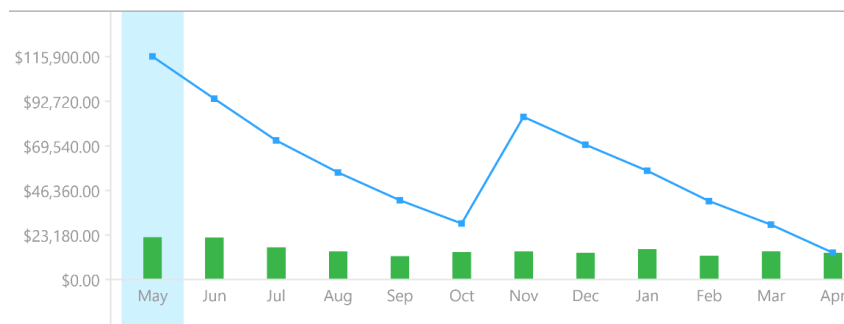


Figure 15: Cloud purchased commitment (line chart) versus actual usage (bar chart) of company A, Second year

Figure 15 shows how the second year had a very different usage pattern. Company A consumed almost 80% of the purchased commitment in the first five months. Then company A bought a new commitment. The interviewee was very satisfied with the company's cloud usage in the second year of adoption. The year ended with approximately \$13,000 of unused commitment, representing a much smaller wasted amount than year 1. The green bars show that the consumption has been relatively stable throughout the months compared to the first year of the cloud transformation journey.

Commenting on those graphs, the interviewee of company A stated, *'This totally shows you the pushing especially in the first year from the vendor and the unmatured sizing or calculation or the unclear requirement from our side... During the last three years and a half, we tried too many things, and we have been able to figure out what we need and how the cloud can really benefit us.'*

While the interviewee of company A mentioned a time of 3 years and a half for his company to have a stable foot on the cloud, the interviewee of company D talked about six months for reaching the peak of the learning curve. He explained that such a period is hard to estimate because once their contact started, they had access to the cloud and started working around while they had already done some training. They started building things and learned while building. Sometimes, they had to change things afterward because they realized something was different or it was not working as expected. Company D's interviewee explained that user management was quite different for them, which took some time to manage.

Further, they have a CICD pipeline for deploying stuff. So, they also had to adapt to the new API of the cloud provider. They also had to rewrite their software in some parts, and that was also something that took quite some time.

Finally, company D's interviewee commented that if a company decides to start a VM, connect a VPC and create a database, that can be made quickly, especially if they have experience with some other cloud providers. But if a company has production, testing, and development environments, this whole thing must be shifted. If a company comes from on-premise and it has to move its services from on-premise to the cloud, it becomes complicated.

Freelancing as a shortcut

Things were much less complicated in Company B. As a small-sized startup, they acted fast to change and could quickly adapt. Company B has been utilizing cloud computing from day one, meaning that it did not have on-premise systems to replace. Further, they mainly depend on hiring freelancers to figure out the coding or do some customization within the cloud service. This option is a one-time fee instead of hiring the required cloud caliber.

While Company A has complained about the high vendor costs of customization and support, company B has been doing it in another way. According to company B's interviewee, *'We do it the other way. It is more that how can we do it ourselves, with our limited resources, and avoid the high costs from the vendors. We were able to find freelancers and people who can join in for a specific project. They do not have to be a full-time employee. That makes things easier for us and do it really cheaper than the vendor.'* The costs of the freelancers are then added to the total cost of ownership of the cloud resource.

d. Re-architecture

In the opinion of company A's interviewee, going to the cloud is, in some scenarios, not similar to having a plug-and-play solution. Some efforts are exerted in preparing the company's infrastructure for the cloud. To do that, the IT department has to provide some gateway for integration with the cloud. Synchronization servers should be in place to facilitate such integration. The interviewee highlighted that this adds to the total cost of any cloud solution they adopted.

However, spending such extra costs on gateways and synchronization servers does not guarantee a peaceful cloud deployment. Company A's interviewee explained a situation in his company where they did not have the needed know-how for implementing the cloud solution. The company asked the vendor to provide implementation services in this particular situation. The vendor suggested two options accordingly. First, the vendor, which is a partner of Microsoft, can do the implementation for the company. Second, the company can pursue the implementation services of Microsoft consultancy services. Company A's interviewee reported that Microsoft consultancy services cost seven times the cost of having the same deployment done by a Microsoft partner. Accordingly, the company opted for the Microsoft partner offer, the vendor.

Despite paying extra costs for such implementation services, company A's interviewee reported that even the vendor, in their case, lacked a lot of knowledge regarding cloud deployment. For the company to have computing-as-a-service and database-as-a-service up and running the way they wanted, they needed up to five months. During this period, they were paying the full capacity of the solution as if it was running at full capacity. *'So at the end of the day, you are suffering; you are incurring a lot of costs unless you get the cloud provider itself to do the deployment for you,'* commented company A's interviewee.

Although company C has been enjoying more benefits of cloud computing than those reported by company A, company C's interviewee expressed some difficulties inflating the cloud computing total costs. As cloud computing promises solid advantages in automation, standardization, and orchestration, those advantages come with costs. The benefits outweigh the costs, but the costs are inevitable. According to company C's interviewee, the global head of IT performance and IT services, *'The implementation of the cloud is expensive. The migration to the cloud is expensive. ... The return on investment could be three years, five years or six years, but it is coming'.*

Cloud computing offers those advantages through various service models such as PaaS, IaaS, and DaaS. However, large enterprises still depend on sophisticated legacy systems. *'The mainframe is the oldest system in the world. It is outdated. We would love to escape away from it. But we can not. And many companies have tried, and they failed,'* complained company C's interviewee. To find a middle ground between keeping the benefits of business-critical legacy systems and yearning for the new potential cloud benefits, middleware has usually been the answer.

According to online resources, company C has MuleSoft middleware and Kolibri. The case-study interviews revealed that there are more. Nevertheless, has middleware been the optimum answer? IT management is struggling with this complicated question. According to the interviewee, *'The cloud has become extremely complicated simply because of the fact that everything is running in it. It means the infrastructure part is complex, but the middleware part is much more complicated. And this middleware part is constantly moving and evolving because of so many different components. If one aspect changes, you have to make changes everywhere, because otherwise, it does not work together anymore'.*

As a result, the middleware and the integrating cloud with legacy systems such as mainframes are, in an unhealthy way, inflating the IT costs. Company C hopes for an integrated solution to escape this complicated setup. For example, SAP is slowly going to the cloud, and Azure is also trying to offer that. Mainframe-as-a-service is starting to evolve through some significant cloud vendors. Company C's interviewee demonstrated that this could be a future direction.

Some of the services offered to the customers in company B are based in the cloud; for example, an application that manages reviews or handles the reporting system. Such cloud-based services sometimes require customization. Sometimes, it does not work correctly with their website, so to be able to fix it and make sure that it is working fluidly with everything, they sometimes pay fees for people to come in and figure out the problem.

The interviewee of company B reported that they had faced incidents concerning how applications and information on the backend speak with each other. For example, for the customer information to be transferred to a loyalty program, company B needed to subscribe to additional cloud services with further costs so we could have that type of integration.

Company B interviewee reported that service customization sometimes causes conflict in defining which part is their responsibility and which part is the vendor's responsibility. If it is a standard service, it is less of an issue. If it is something that company B did a lot of customizations and tweaks, then the question comes as to who is responsible for doing those changes or for managing those changes or issues or requests. They usually go back to the service level agreement. However, for company B, time is critical. Sometimes if it is easier and quicker for them to do it, and the issue is of a small magnitude and easy to fix, even if it is a free service from the vendor, they just go and do it. If it is not, company B goes back to the vendor, depending on who the vendor is; if they say that is not our duty, that is not our responsibility, then they go back to the service level agreement and check if it was mentioned. Such adjustments add to the total cost of cloud services.

Further, the migration and its errors are usually the biggest disappointment and frustration company B faced. It is just disrupting the business, especially since it is small and fragile.

Company D reported two re-architecture points that were essential for the success of its cloud journey. First, the user management was different, and it took time for the company to manage. Second, company D has a fully automated CICD pipeline. Thus, they had to adapt to the new cloud vendor's APIs and rewrite some parts of the software, which has also consumed some time. The interviewee of company D further reported that they had the option to pay 50,000 euros per month to get an architect they could question for three days a month and helps build everything. As a medium-sized company, company D did not go for that option, but the interviewee believed this might be feasible for large companies. Table 18 provides some quotes from the interviews conducted in the four companies/ case studies.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Synchronization servers ○ Integration gateways ○ Proper sizing challenge. ○ With computing as-a-service and database-as-a-service, deployment took up to 5 months. 	<ul style="list-style-type: none"> ○ Sometimes a service requires customization. ○ Sometimes a service does not work correctly with our website ○ We incur overhead costs to adjust the service to the company's landscape. ○ We needed to pay additional costs to integrate new cloud applications into existing ones. ○ Migration is our biggest frustration. ○ We had an architecture problem previously. We are trying to fix it with more functionality and more services. 	<ul style="list-style-type: none"> ○ The implementation is expensive, and the migration is expensive. ○ Cloud has become extremely complicated because everything is running on it. ○ The infrastructure is complex, but the middleware is much more complicated. ○ Middleware is inflating the IT costs. ○ You need to be dynamic and make the balance between systems that are over-utilizing or underutilizing what you initially expected. 	<ul style="list-style-type: none"> ○ User management was quite different for us; that took some time to manage. ○ We have a CIC pipeline for stuff, and this is completely automated. So, we also had to adapt to the new API of the cloud provider. ○ We also had to rewrite our software in some parts, and that was also something that took quite some time. ○ There was a question if we need the enterprise support and you pay 50,000 a month, and you get an architect that you can question for three days a month and helps you build everything. That is nothing we needed. But in a larger company, where you have a more complex infrastructure, maybe this makes sense.

Table 18: Re-architecture Cost Area, a sample of codes

e. Switching Costs

Company B has moved from one cloud vendor to another because they wanted to improve the business they offer to their customers. The interviewee stated that this switching between vendors has been costly and challenging in the form of disruptions to business operations. It has taken more time than usual due to the limited bandwidth on company B's end. Some of company B's customers found issues when making orders or using other functionalities. Besides the bandwidth issues, Company B faced data issues where some customer accounts were not showing or other things did not migrate correctly.

Unlike company B, company D had a particular reason for switching cloud vendors. As a public company, there is a certain amount of money that they are allowed to spend. Thus, they had to do tendering as a legal obligation. The company started with a cloud vendor as a test, but at a certain point, they had to do this public tender, and they chose another cloud vendor.

Upon this switching, some costs were the same for both cloud vendors while others differed. Company D has taken a lot of time to adapt to how things were done with the new vendor. This adaptation period made the learning curve longer. Company D had to rewrite some parts to familiarize the software with the new cloud vendor’s concepts and learn the new APIs. As shown in Table 19, company A did not experience switching from one vendor to another, while company C did not provide data on this matter.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Not applicable 	<ul style="list-style-type: none"> ○ It was costly to move from one cloud vendor to another. ○ The costs were mainly the disruptions to business operations. ○ Due to our small size and limited resources, we do many things ourselves. 	<ul style="list-style-type: none"> ○ No data 	<ul style="list-style-type: none"> ○ We switched the vendor for a legal reason: as a public company, we have to do tendering. We started with the first vendor because it was a test, but we had to do this public tender at a certain point. ○ Some costs are the same for all the cloud providers, but also there are differences. ○ When switching to another cloud provider, often things are different. So it definitely takes a lot of time to adapt to how things are done with the cloud or with this special cloud provider that you use. ○ The learning curve was longer because we had to rewrite some parts just to adapt the software to the new vendor’s cloud API.

Table 19: 'Switching Costs' Cost Area, a sample of codes

7.3.3 Service Costs

Based on the expert interviews, ‘Service’ as a cost categorization resulted in two cost areas: ITSM adjustment and Meta-Services. It has been a question for cloud customers: do they need to forget about investments already made on ITSM frameworks such as ITIL or COBIL, including licensing and training? Or would they bear the new costs of a modified, cloud-compatible version of those frameworks? Or would they spend on finding solutions around these frameworks? On the one hand, one of the experts on the customer side explained that they are trying to find a way around ITIL guidelines. On the other hand, an expert from the consultant side stated clearly that those

service management frameworks *'do not speak cloud.'* This section discusses what the case studies had to say in this aspect.

From another perspective, according to one expert from the consultant side, *'you also need additional services to track consumption, to audit, to migrate, to ensure you're getting optimal costs et Cetera.* This dissertation named these as Meta-Services. As explained in section 8.4, Meta-services are cloud services essential to managing and supporting other cloud services. After discussing ITSM adjustment, the Meta-Services adopted by the studied companies are explained.

ITSM Adjustment

Company A has fully deployed an IT service management (ITSM) framework, namely ITIL. The interviewee reported that, in general, they do not experience significant differences between cloud and on-premise solutions. For example, in the ITIL process change management, any change or configuration needs testing and approval before being applied on-premise or on the cloud. The configuration management process also applies on-premise and in the cloud. The same case is with the ITIL finance management process. As a result, company A interviewee believed that IT service management frameworks still support the cloud in the IT operation and support parts.

The cloud's difference while applying ITSM is in the IT service delivery. Delivering a solution on the cloud was different because it has new roles extending the IT operations team, as mentioned before. The service delivery is also affected due to the tendency to adopt more security solutions with the cloud. According to company A's interviewee, cloud computing has never reduced the operations overhead as it is always perceived.

Company C was not essentially different than company A. IT service management (ITSM) is also intensely employed in company C. When the researcher asked the global head of IT performance and IT services if ITIL speaks cloud, his answer was the following. *'If you are going to implement cloud, and you are going to manage the cloud environment by yourself, if your people are not ITIL certified, forget about it. You will fail miserably. Without it, you cannot manage the cloud; that simple. Because if these processes are not in place, you are just putting out a fire, and you do not know how they came about, what caused it; you do not know anything. ITIL gives you a framework'*. A job post advertised by the company on linked-in correspondingly described ITIL as an added value. The job title was cloud center of excellence lead.

Although ITIL here is a necessity for company C, the company had to adapt some ITIL processes because things are different on the cloud from that on-premise. Those adaptations have not been problematic. The challenge has been working with DevOps since Dev/ops are not always compliant with ITIL. They put the company on the borderline between agility and reporting. Company C's IT management had to balance this complex challenge of aligning Dev/ops with ITIL.

Company D interviewee was not familiar with ITSM frameworks. However, he could relate to the DevOps issues mentioned in Company C. According to company D interviewee, ‘for *system administration in general, I think it is very hard because you have to always manage your own needs to evolve the infrastructure to make it reliable, or to make it work, or make it compliant with all the stuff. [...]And then you have all these daily businesses where incidents happen, where problems occur, and you have to jump on that. [...] you cannot foresee what the next day brings because maybe there is some broken software, there is some infrastructure service that changes, there is some third party staff that changes, and it is a little bit unforeseen*’.

As shown in Table 20, Company B also has no data concerning IT service management frameworks, which is predicted due to its small size.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ IT service operation/support: <i>No big difference with the cloud.</i> ○ IT service delivery: <i>Extended IT operations team.</i> <i>Tendency to adopt more solutions.</i> ○ ITIL still speaks cloud. 	<ul style="list-style-type: none"> ○ Not applicable 	<ul style="list-style-type: none"> ○ Without ITIL, you cannot manage the cloud. ○ If the IT staff are not ITIL certified, you will fail miserably. ○ A company must have incident management, problem management, change management, release management, and then probably availability management. ○ Some processes remain largely the same with some adaptations. ○ DevOps can be a complex challenge. 	<ul style="list-style-type: none"> ○ The interviewee was not familiar with ITSM frameworks. However, he could relate to the volatility of DevOps. ○ It is hard to plan with system administration teams because it is volatile. ○ System administration, in general, is very hard because you have to always manage your own needs to evolve the infrastructure to make it reliable, or to make it work, or make it compliant. ○ And then you have all these daily businesses where incidents happen, where problems occur, and you have to jump on that. ○ You cannot foresee what the next day brings because maybe there is some broken software, there is some infrastructure service that changes, there is some third-party staff that changes, and it is a little bit unforeseen.

Table 20: ITSM Cost Area, a sample of codes

Meta-Services

‘*Being on the cloud exposes you to a different reality,*’ said company A’s interviewee. He explained that when his company moved to the cloud, they were surprised with additional security requirements that they did not need with on-premise solutions. The company has been more

concerned about security in the cloud. Cloud vendors are cross-marketing tempting security solutions to complement the cloud service. Thus, company A found itself buying new security tools while they initially wanted only to migrate a specific application from on-premise to the cloud. According to the interviewee, *'It happens magically without you notice that beforehand.'*

For example, the company wanted to migrate the email system to the cloud. Before moving to the cloud, an employee would need only his credentials to access the email. On the cloud, mailboxes are more prone to security attacks than they used to be on-premise. Unexpectedly, the company found itself being pushed to add an extra layer of security for users to access their mailboxes. The company had to opt for multifactor authentication; while logging into his email, an employee gets an SMS code to confirm access eligibility. Company A's interviewee was frustrated that such a level of security has never been required in a company email. It was only required for financial applications or online banking. According to him, *'no one or very few would have had considered that before migration..... Calculating that correctly from day one is nearly impossible.'*

Company C's findings supported the point of security services adopted by company A. It needed to plan many adjustments to migrate to the cloud. According to company C's interviewee, the global head of IT performance and IT services, *'backup needs to be changed, monitoring needs to be changed, security is different.'* These differences implied that the monitoring techniques used for on-premise solutions do not fit the cloud solutions. The company had to adopt more cloud services to monitor the cloud. The 'monitoring costs' section provides more details.

From another perspective, heavily depending on the cloud makes the company more vulnerable. According to company C's 2018 annual report, the company experienced intrusion and phishing attempts for money transfers. The report also mentioned attempts to disable information technology systems. As a result, the company keeps investing in cybersecurity to mitigate the risk of heavily depending on the cloud.

Company A further had another instance of hidden costs with the 'shared-mailbox functionalities. Some departments used to have a shared mailbox, a single folder where multiple employees could access the emails on that mailbox. On the old email system, the company had 50 shared mailboxes. After moving to the cloud and buying 3000 licenses for emails, the company was surprised that the cloud-based email system did not support the 'shared mailbox' functionality. As a customer, they have to purchase separate licenses for that. *'This was a strange thing for us because the shared mailbox is accessed by a licensed user already; it is not a shared mailbox for a new user, for example. It is a shared mailbox that two or three of the already licensed users are accessing. Why should I pay an additional license for that?'* complained company A's interviewee. He added that such a point makes it very hard to estimate the cost of a cloud service upfront before the actual deployment.

Similarly, company D needed extra services to manage and allocate the cloud costs. However, the interviewee stated that his company decided not to reach out to third-party companies to help.

Accordingly, the IT department developed a tool internally to solve this issue. Quoting company D interviewee, *‘I think the costs of hiring an extra company that makes the bill to suit you is much higher. So, at the moment, we do it by our own. But it was definitely work and discussions to bring it to a level that everyone can use it: different departments, the finance department, our department, and there is also another department that is involved. So yes, That was a little bit tricky.’*

Company D has used other third-party tools to support starting other services. However, concerning the security services reported by company A, company D consented that they refused to move to a cloud-based email system for the same reasons. According to company D interviewee, *‘there was no way that our internal security and IT department would agree with that. So we still use our own email infrastructure’.*

Unlike company D, company B was less cautious in adopting cloud services. Further, the interviewee reported that company B faced multiple situations where they needed to adopt more cloud services to support a harmony between their backend applications. For example, company B’s interviewee stated, *‘for our customer information to be transferred to a loyalty program, we needed to subscribe to some services, additional services with additional costs so we can have that type of integration. Sometimes we are forced to do it because that's going to affect the business.’* Further, it has been tempting to adopt other cloud services that are *‘nice to have.’* In such cases, company B try to find a way around them due to limited financial resources. Table 21 provides a sample of codes from each company/case study regarding Meta-Services.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Being on the cloud exposes you to a different reality. We had to adopt extra security services. It happens magically without noticing that beforehand. ○ We had to pay an extra subscription to basic hidden functionalities, which disturbs cost estimation. 	<ul style="list-style-type: none"> ○ We had multiple situations where we needed to adopt more cloud services, but our constraint was financial. ○ We had to adopt extra services with extra costs to integrate existing services. 	<ul style="list-style-type: none"> ○ We keep investing in cybersecurity to mitigate the risk of heavily depending on the cloud. ○ The backup needs to be changed. Monitoring needs to be changed. Security is different. 	<ul style="list-style-type: none"> ○ There are third-party services that can help with cost allocation, but we decided to build our own tool. ○ It was definitely work and discussions to bring it to a level that everyone can use it: different departments, the finance department, our department, and there is also another department that is involved, so yes. That was a little bit tricky. ○ We used some third-party tools to provide some internal services basically to startup internal services. ○ There was no way that our internal security and IT department would agree with a cloud-based email service.

Table 21: Meta-Services Cost Area, a sample of codes

7.3.4 Quality Costs

To achieve the quality of the cloud transformation journey, the expert interviews reported multiple cost areas: Testing, Resiliency, and Monitoring. The below subsections discuss how each of these cost areas was/ or was not validated by the case studies.

Testing

According to company A’s interviewee, testing is imperative to figure out accurate sizing. However, in his company’s case, they needed quick projects, but they had not enough time to test. Such a rush has been costly. Quoting company A’s interviewee, ‘*You know, even in the first year when we waisted half of the commitment, we were like testing the cloud trying moving things to the cloud bringing them back. We used the tenant because there was no actual or real need at the very beginning*’.

Company A operates in more than ten countries, some of which are located in Subsaharan African territories where internet access is very humble. For those regions, company A opts for a hybrid option where the cloud and the on-premise solutions are running in parallel. As for more stable branches, such as the one located in Dubai, the solutions will be up and running in the transition period until the cloud one is 100% approved. Then, they can decommission what they have on-premise.

While no data was collected from company C about testing, company B stated that they do not have the privilege to test a cloud service before adopting it. But they do a lot of research beforehand. Finally, not much data was mentioned about testing in Company D, except that the company used its first cloud vendor as a test. Then as mentioned earlier, they made a public tender and consequently switched to another vendor. Table 22 demonstrates some of the codes from the case studies concerning Testing as a cost area.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Sometimes the business needs quick projects where there is not enough time to test. ○ In the first year, when we waisted half of the commitment, we were like testing the cloud ○ Cloud and on-premise solutions can run in parallel with the on-prem in a transition period. ○ A hybrid option is used in branches in Subsaharan African territories. 	<ul style="list-style-type: none"> ○ We do not have the privilege to test the service beforehand, but we do a lot of research. 	<ul style="list-style-type: none"> ○ No data. 	<ul style="list-style-type: none"> ○ We used our first cloud vendor as a test.

Table 22: Testing Cost Area, a sample of codes

Resiliency

Company A is a large enterprise with its own disaster recovery (DR) site. Due to this fact, the interviewee suggested that the cloud might not appear as a competitive option because the company already has built-in resiliency. However, he added that some cloud services, such as security tools, take a long time to deploy in-house, making them more appealing on the cloud. Further, the interviewee believes that the cloud appeals to small companies as it helps them build resiliency straightforwardly.

Nevertheless, ‘easily’ here should be understood correctly. The customer has to pay for resiliency separately. *‘Resiliency is the responsibility of the customer. Not everything you build on the cloud is resilient out of the box.’* The concept is *‘this is more easily on the cloud than on your on-prem environment because on the cloud you can right-click, create a duplicate solution in any other country as a second option for you in case of disaster. But, on on-prem solutions, you have to build your own infrastructure on that remote site, and you have to build everything yourself,’* explained the interviewee.

Company B is classified as a small business. That is why the suggestion of company A’s interviewee qualifies here. Company B uses the cloud to build resiliency. Company B’s interviewee stated, *‘We pay separately for having our data saved on multiple sites.’* This way, company B could back up their applications, especially when they switched between the cloud vendors.

The interviewee of Company C believes that upon migrating to the cloud, backup, among other things, needs to change. According to him, although cloud computing facilitates building resiliency, it becomes complicated with large companies with many integrations with other systems that cannot go to the cloud. Table 23 reports codes from the three companies/ cases, while the fourth case (company D) did not provide data in this regard.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Cloud helps enhance resiliency for small enterprises. ○ For large enterprises with DR, the cloud is not appealing. ○ Some security tools on the cloud that takes a long time to deploy might be appealing. ○ Resiliency is easy to build on the cloud, but it is the customers’ responsibility. 	<ul style="list-style-type: none"> ○ We pay separately for having our data saved on multiple sites. ○ We did a lot of migrations from one website to another; that is why we did the backup 	<ul style="list-style-type: none"> ○ Migrating to the cloud, backup, among other things, needs to change. ○ Although the cloud facilitates building resiliency, things become complicated with large companies that have many integrations with other systems which are not able to go to the cloud. 	<ul style="list-style-type: none"> ○ No data

Table 23: Resiliency Cost Area, a sample of codes.

Monitoring

On the cloud, a customer is not the one taking care of hardware, updating, or batching the systems. Nevertheless, the customer needs to take care of much monitoring of his tenants on the cloud. Company A's interviewee clarified that he has to ensure that his company uses the cloud resources optimally, with no overuse and underuse. He has to look into every component's consumption, the consumption of the database-as-a-service, and the computing power consumption.

Although the cloud vendor provides a portal that shows this consumption, company A's interviewee was not fully satisfied with the functionalities of the vendor portal. *'It alerts you when you exceed your money limit. But it does not alert you when you exceed the usage of the resources themselves,'* complained the interviewee. Company A needed more workforce than what was required on-premise to monitor the cloud services effectively. In the example of the cloud-based email system, the company has been using three employees to monitor it fully. On-premise, only one employee used to monitor the in-house email system.

The interviewee further reported that third-party tools could access the cloud tenants, facilitate the IT department's monitoring task, and help control costs. However, company A did not employ them because the IT department has been very busy with the deployment itself. *'I think once the deployment reaches its end, I think we will have to adopt one of those tools to monitor things wisely. But now, I do not have the capacity or the time to monitor that'* justified the interviewee.

Due to that lack of monitoring tools, the IT department was surprised that they exceeded the money limit of some tenants. The company had an incident where they provisioned a tenant to be a part of a solution that is still being built. The company did not notice that they were paying for the tenant, although it has not used it yet. Thus, the interviewee clarified that monitoring tools are necessary from day one unless the vendor enhances its cost control tools.

According to company A, monitoring on the cloud is more critical and costly than on-premise. *'You have to be very attentive to monitoring because it does imply, most of the time, additional costs, which you do not have on-prem. For example, if you overuse the system on-prem, you do not have any financial consequences. You already have the system; you already own it. But if you did that on the cloud without close monitoring, there will be financial implications. So, for example, we did not use to pay great attention to monitoring our resources on-prem. But when it comes to cloud, you have to pay the maximum attention to monitoring every component's performance and whether performance is justified or not because it implies financial cost'* concluded company A's interviewee.

While company A was disappointed due to the lack of monitoring, company C's interviewee anticipated that. According to him, *'you need to be aware of the environment and have clear reporting.... if you do not have that, there will be surprises'*. Monitoring cloud resources and cloud consumption is carried out in company C by the cloud center of excellence (CoE). The interviewee

claimed that monitoring is not complicated, but the monitoring techniques for on-premises do not work for cloud resources. Further, company C had to adopt other tools to make the usage information provided by the vendor readable, understandable, and valuable for the business. The interviewee explained that they had adopted all the extra services from the vendor, *‘otherwise, we would not move to the cloud.’*

Similar to company C, company D’s interviewee stated that monitoring on the cloud is easy. However, according to company D’s interviewee, *‘But you have to agree with the constraints you have there. Basically, if you want to do some automatic stuff you have exported, that costs you extra. If you do not like the UI or it is hard to use, then you also have to deal with it. Or you have to also build your own again’.*

Company D created its own monitoring solution. *‘We thought about using, for monitoring especially, third party companies. And it makes absolute sense. I mean, you have a little bit of vendor login. If you want to change the company, then it could be tricky, and it creates additional work to adapt your new services to the new provider then. So in our case, we are quite happy with how our own solution for monitoring and logging’.*

As a small business, Company B targeted monitoring only from the invoices' point of view. The interviewee reported, *‘I do not see bits and pieces of it, but I see all the subscriptions and the fees, the cloud fees that we are paying. And I just account it with the budget to see how far we are from the budgeted amounts that we were supposed to pay.’* Further, company B dedicated a process for monitoring the invoices. According to company B’s interviewee, *‘we also have a process to check them every month just to monitor because sometimes they add things we did not subscribe for.’* Before this process, the company had to pay for services they did not need for three months, which financially distressed company B.

While Table 24 provides codes comparing the four case studies, Figure 16 depicts the Monitoring cost area in the case studies compared to the expert interviews.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ Monitoring on the cloud is more costly than monitoring on-premise. ○ The monitoring functionalities coming with the service give warnings when you reach the 	<ul style="list-style-type: none"> ○ We have a process to check invoices every month just to monitor because sometimes they add things we did not subscribe for. 	<ul style="list-style-type: none"> ○ The center of excellence is responsible for monitoring the cloud services ○ The monitoring techniques for on-premises do not work for the cloud. ○ Monitoring is not complicated, but if you do not monitor 	<ul style="list-style-type: none"> ○ Although monitoring on the cloud is easy, you have to agree with the constraints you have there. ○ Basically, if you want to do some automatic stuff you have exported, that costs you extra. ○ If you do not like the UI, or it is hard to use, then

<p>money limit, not the usage itself.</p> <ul style="list-style-type: none"> ○ The third-party tools might be helpful, but the company is still busy with the deployment. ○ The vendor should enhance its cost control tools. ○ Monitoring consumes more manpower. ○ Lack of monitoring implies financial costs. 	<ul style="list-style-type: none"> ○ I do not see bits and pieces of it, but I see all the subscriptions and the fees, the cloud fees that we are paying 	<p>cloud usage, there will be surprises.</p> <ul style="list-style-type: none"> ○ To have clear reporting of the consumption of the business, we use power BI. ○ The information provided by the vendor is sufficient, but to make it readable, understandable and valuable for the business, you probably need other tools. 	<p>you also have to deal with it, or you have to also build your own again.</p> <ul style="list-style-type: none"> ○ We thought about using third-party tools for monitoring, especially. ○ If you want to change the company, then it could be tricky, and it creates additional work to adapt your new services to the new provider then. ○ So in our case, we created our own solution for monitoring.
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Table 24: Monitoring Cost Area, a sample of codes

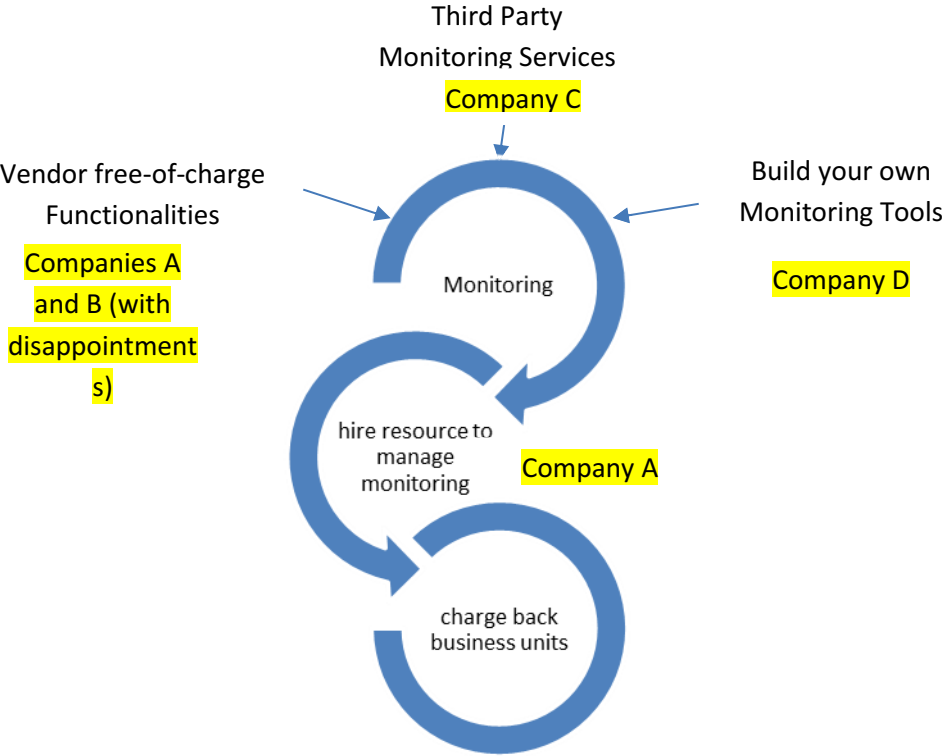


Figure 16: Costs of monitoring cloud services (Case studies vs Expert analysis, see Figure 9).

7.3.5 Communication Costs

Smoothly moving to the cloud is a complex goal. The communication issues in the cloud transformation journey manifest themselves between three entities: cloud vendor, customer IT department, and customer business units. These entities evoked two cost areas in the case studies explained in the following subsections: Shadow IT and Brokering.

Shadow IT

Company A has been experiencing shadow IT problems as it became easy for business units to buy business solutions without involving the IT department. The business units follow the cloud vendor promises of easy adoption without facing the IT people's headaches. *'The business user is being tricked by the cloud providers,'* explained company A's interviewee. In reality, the potential integrations and security requirements have wiped away many of the expected benefits, which have even incurred more costs.

An example of a shadow IT instance experienced in company A was the following. A business unit manager bought a mobile device management solution that is cloud-based. The vendor promised that it is an easy deployment task where the serial number of the tablet devices can be linked easily with the usernames of the end-users. Then the tablets can be used seamlessly by the end-users without the complications of asking the local IT department to provide such tablets. The business unit manager was happy and thought he could distribute the devices to the end-users after a couple of hours. One last step he had to take was to ask the IT department to integrate this cloud service with the active directory, the authentication engine. The details of this last step ruined the promises of the cloud vendor and the expectations of the business unit manager.

'This project itself is a complex project. For example, Apple devices with its MDM solution to be integrated with our active directors which are based on Azure active directory on Microsoft side' commented the company A's interviewee. According to him, such shadow IT instances disrupt the IT operations with unplanned projects. Instead of following the cloud vendor promises, the business units should seek IT for exact details and expected costs of such cloud adoption. However, business units view this as *'too many details and a lot of complications.'*

With this view of the business units, the company experienced some failed shadow IT projects. The IT department presented those failed projects to the top management explaining the operational interruption they suffered. It also explained the effect of such unplanned and uncommunicated projects on the company's IT security. According to the interviewee, *'we are seeking top management support in order to enforce going back to local IT first. We never managed to get that support until we got some failed shadow IT projects. So the management learned it the hard way.'*

Company C supported the findings of company A. According to company C’s interviewee, the company ‘*was distributed on shadow-IT and still is.*’ To solve this problem, the IT services department started taking ownership of all the IT Contracts. Even if those contracts have been local with business units, they must be managed centrally. This department acts as the connection entity between the vendor and the different entities of the company. This way, the central IT department can add value to the cloud services they get from the vendor before giving them to the business units. Quoting company C’s interviewee, ‘*I need to make sure that anyone who is delivering services through me to the business, that my department is able to see ok, these services, have they been defined correctly based on the requirements? Are they reaching our architectural environment and mandatory elements?*’

Since companies B and D are of small and medium sizes, the shadow IT problem is less critically perceived. As a small business, Company B pursues the benefits of being agile. ‘*So our rule is, if you can do it yourself, then do it. You do not need to go back to the tech lead. And our tech lead also promotes that because he is usually like handling different things at the same time*’ commented company B interviewee on the shadow IT concept. He further clarified that some areas in the IT environment are untouchable and need the approval of the technology manager. There is more freedom to adopt tools for areas that do not affect customer critical information. The company's small size facilitates informal communication in case of security suspicions.

As for company D, in a few cases, other business units approach the IT department to integrate some tools with the infrastructure. The department evaluates if it can be integrated or not. Further, company D’s interviewee explained that some shadow-IT projects might not be that bad. According to him, ‘*you can have like an internal shadow IT when you have like a development department or a team that creates their own infrastructure to handle things. Maybe first, for testing, then it goes in introduction somehow, and not everyone is aware that it is working like that*’.

Contrarily, based on data collected from online resources, some business units in company D have SaaS solutions that help them with their business operations. Asking the interviewee about these services, he replied, ‘*what you mentioned I think is a different department. I cannot tell what they are doing. This is a third-party provider, I guess [...] And how they do it, I cannot tell*’. Table 25 shows a sample of Shadow IT cost area codes in the four case studies.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ The business user is being tricked by the cloud providers ○ The potential integrations and security requirements have wiped away many of the 	<ul style="list-style-type: none"> ○ Because the size is small, the rule is if you can do it yourself, then do it. 	<ul style="list-style-type: none"> ○ To manage the problem of shadow IT, we manage the cloud centrally, 	<ul style="list-style-type: none"> ○ You can have an internal shadow IT when you have a development department or a

<p>expected benefits, which have even incurred more costs.</p> <ul style="list-style-type: none"> ○ Shadow IT instances disrupt the IT operations with unplanned projects ○ We never managed to get top management support until we got some failed shadow IT projects. So the management learned it the hard way. 	<ul style="list-style-type: none"> ○ Some areas are untouchable. And we speak a lot together and come back to the Teck lead whenever needed. 	<p>even with local contracts.</p> <ul style="list-style-type: none"> ○ The company was distributed on shadow-IT and still is, but the IT services department is now taking ownership of all the IT Contracts. 	<p>team that creates its own infrastructure to handle things.</p> <ul style="list-style-type: none"> ○ Business units may adopt SaaS services without getting back to IT.
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Table 25: Shadow IT Cost Area, a sample of codes

Brokering

Brokering here suggests that the IT department acts as a broker between the business unit and the vendor while offering some value-adding more than the vendor does. Company A’s interviewee ultimately refused this brokering idea. He believed that IT should not be in a competitive position with the vendor. Contrarily, there should be management governance and IT governance respect in the company. The local IT department should not adjust itself because of the cloud. *‘No, this is not the way to go. IT solutions should be passed as a first step by the local IT in order to confirm their time, their availability, the support of the application with the current infrastructure, and in order to help clarify the total cost of ownership of this solution to the business. It should not be the other way around’* argued company A’s interviewee.

According to him, the value of the IT department is not because it provides more competitive, cost-effective solutions than the vendor. He added, *‘at the end of the day, I can give a more expensive solution because it is more secure.’* According to him, only the IT department knows the history of every component in the company’s IT infrastructure. As well, the IT department is the best when it comes to the security of the overall IT environment.

The IT department signed for the highest support with the cloud vendor (one of the big four), where they can escalate very complex instances. When an incident happens, the company notifies the vendor’s support team, and the local IT department works simultaneously on solving it. According to company A’s interviewee, the IT department usually solves the issue before the vendor’s support team does. *‘When the vendor is engaged even by its most experienced engineers. They are still lacking the history of our IT. They still request too many inputs in order to be able to solve the problem[....] local IT has their own advantages’* concluded Company A’s interviewee.

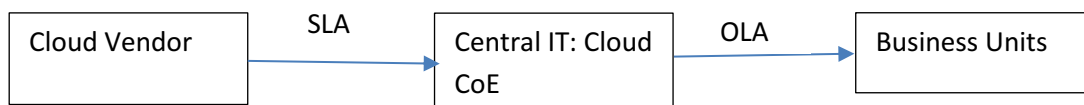
Company B has experienced vagueness of responsibility between them and the cloud vendor. An essential reference for such ambiguity is the service level agreement. If adjusting an issue in a cloud service is of considerable magnitude, company B asks the vendor for interference according

to the SLA. However, Similar to company A, company B' interviewee stated, *'for us, time is very important. Sometimes if it is easier and quicker for us to do it, even if it is a free service from the vendor, we just go and do it.'* He concluded that this adds to the total cost calculations of the cloud services.

Another communication-related issue for company B was that they discovered that they subscribed to services they did not need. This fault resulted from less organized communication with the vendor (a small one) since the information was scattered in different emails and not explicitly mentioned in the SLA. According to company B's interviewee, *'the information was not organized in a way that allows us to kind of track things. And eventually, as we discovered that our needs are different and that we have subscribed for something that we did not want.'*

Since company C has been an early adopter of cloud computing since 2011, the company is today suffering from one of the significant cloud side effects; shadow-IT. Business units have many local contracts that were not synchronized in the past with the central IT department. Recently, as a corrective action, the IT service department started taking ownership of those contracts. *'If they are local or central, they will come to that department, and then it will be managed by that department. And they can still be delivered locally, fine. I am fine with that. It can still be a local contract. I am also fine with that. But it must be managed centrally'* explained the IT management interviewee of company C.

For the sake of this central management, the company dedicated the cloud center of excellence (CoE), as mentioned before. This cloud CoE acts as an intermediary between the cloud vendor and the business units. As shown in the figure below, two types of agreements drive the communication with the cloud vendor from one side and the business units on the other: service level agreement (SLA) and operational level agreement (OLA).



On the one hand, the SLAs act as a benchmark to measure the cloud vendor's performance, i.e., if the service is running correctly from the vendor side. On the other hand, the OLAs help to evaluate the performance of the cloud CoE towards the business units. The IT management interviewee stated the following. *'For that center of excellence to be held accountable for their performance and their delivery, we need to have internal OLAs.'* The OLA was also vital to the company to further measure if the creation of the cloud CoE was a sound business decision. *'It would mean to benchmark the market to see, okay, it is costing us x million euros per year to manage the cloud, how much would it cost if I would give it away. If we would not centralize that, we would not have*

that information’ explained the global head of IT performance and IT services. Table 26 provides a sample of the codes handling the ‘Brokering’ cost area.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> Local IT has faster support than the vendor. Local IT knows the company’s history. 	<ul style="list-style-type: none"> We discovered that we subscribed to a service that we did not need. Communication with the vendor was not organized, and information was scattered, which did not allow us to track it and understand what is happening. With the small cloud providers, SLAs were not detailed enough. 	<ul style="list-style-type: none"> The IT department has SLAs with the vendors and OLAs with the business units. CoE acts as a communication channel between the cloud vendor and the business units. 	<ul style="list-style-type: none"> No data.

Table 26: Brokering Cost Area, a sample of codes

In concluding ‘Communication’ as a cost category, Figure 17 shows where the case study findings compare with the findings of the expert interviews.

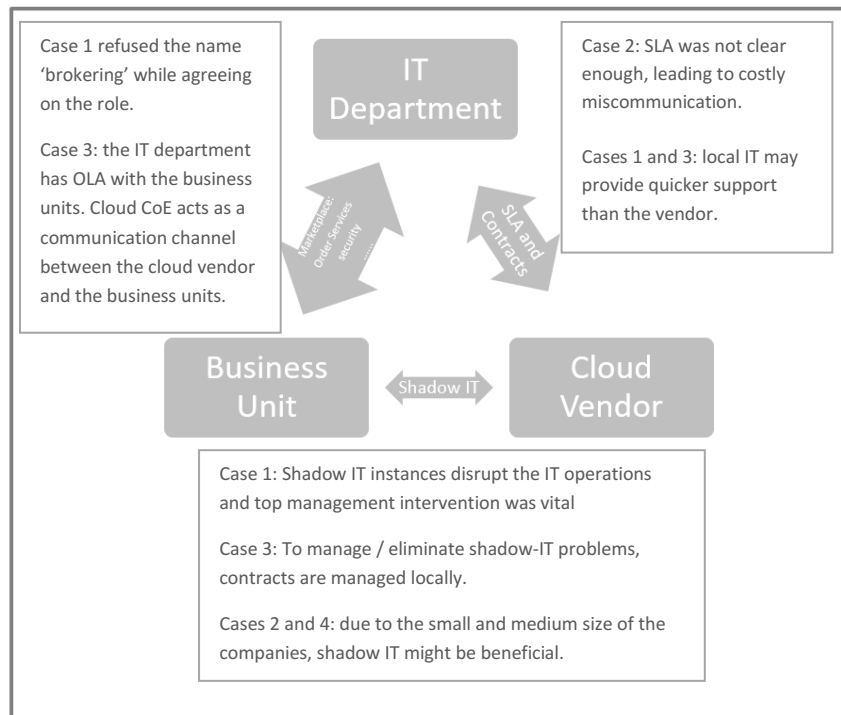


Figure 17: Communication as a cost area: case studies versus expert analysis (see Figure 8).

7.3.6 Price

One of the main advantages of cloud computing is the pay-as-you-go concept, where a cloud user does not have to pay for unused resources. Company A's interviewee commented that *'cloud customers are fooled'* with this concept, assuming that this is a built-in option on whatever cloud component they use. Some of the cloud components do not have this option. Company A faced the fact that they had to pay for specific features they registered for and were not using yet.

Explaining which components do not apply the pay-as-you-go concept, company A's interviewee gave the following example. The company was building a solution on the cloud. This solution took five months to be ready. Throughout those five months, the company was paying for the total capacity as if the solution was running at full capacity. This payment applies to the database as a service and computing as a service. Thus, when the company decided on the expected database size, they got committed to this size from day one. They did not pay as they grew the data on the cloud as the pay-as-you-go concept suggests. Nevertheless, they paid from the beginning even when the company was not using the full size.

Asking company A's interviewee if the pay-as-you-go concept applied when they used the software-as-a-service solutions, he replied with a NO. According to him, SaaS solutions are the ones they are struggling with the most. They did not have the flexibility, and the pay-as-you-go concept did not apply, even if the sizing might seem more effortless.

As mentioned in the 'Contract Management' section, this sizing was a significant challenge for company A. Sizing defines the price as the company decides upon it in the contract, which means it pays the price of this size from day one. Company A's IT department lacked experience in identifying the proper sizing. This problem was still valid for solutions similar to previously in-house-developed ones, which has primarily affected the total cost of the cloud solution.

Calculating the total cost is the company's task. The vendor sends a quotation with the price of the requested service to adopt. According to company A's interviewee, the price is not straightforward. The initial price offered by the vendor shows, for example, the cost of one Giga of data transfer from on-premise to the cloud. Nevertheless, the actual price depends on the consumption of specific resources. This consumption is difficult to know in advance. According to company A's interviewee, *'you have to build your solution and have it working for a certain amount of time where you will be able to calculate all the resources required.'* This period, according to him, can be as long as an entire quarter.

Further, company A's interviewee explained that when calculating the TCO of the cloud solution, you include, for example, a storage system, a couple of servers, and other technical specifications. When comparing this TCO to in-house developments, it is cheaper. He continued, *'But this is the face value of the cloud. But to have the solution finally working on the cloud, it is still not competitive enough against on-premises solution because of the complexities and the know-how*

and the hidden costs and too many things '. He finally concluded that his company has sister companies of 10000 employees, where the IT managers share with him the same amount of disappointments when it comes to cloud solutions.

The same point of view was expressed in company D. Company D's interviewee commented on the vendor's role in TCO calculations, saying, *'they all have these calculations where you can say, ok, I need five virtual instances, five databases, and stuff. But then you have traffic, that is, you have to estimate how much traffic it will be. Is it traffic that goes between regions? Is it outgoing? It costs from 0 to 10 gigabytes more than from 10 to 20* '. The dilemma of sizing reported by company A was also confirmed in company D. *'When we had this tendering offering, and we had to estimate what we needed, it was very hard for us to come up with an example that shows the real costs for some projects, for example, not even for the whole set up'* complained company D's interviewee.

The top management interviewee of company C explained that the cloud's price does not include all the costs. The implementation of the cloud is expensive, and migration to the cloud is costly. Moreover, a cloud project's return on investment (ROI) can range from three to six years. However, the benefits of automation, standardization, and orchestration offset those costs.

Nevertheless, how much is the price in relation to the TCO? According to the interviewee, subscription fees can count for 50-60 % of the total costs. Further, total cost estimations are expected to have 15-20 % inaccuracy in the first year after migration. *'It is ok if at the beginning of the business case you say, ok we are aiming at 1 million euros a year costs, and after migration and you are done, and it is finished, you are at 1.2, that is acceptable. Why? Because optimization can now start and after the optimization, you should be able to at least get to the million or below* '. It is important to note that those are costs per year, not the overall cost. This is because, in cloud computing, one deals with operating expenses, not capital expenses.

According to the expert interviews, moving from capital expenses (Capex) to operating expenses (Opex) might be an unpleasant option for finance managers. Also, according to company D, *'it is very hard that every month it can be different because if there is more traffic, you automatically use more virtual machines the bill goes up. Next month, it goes down. You through away the virtual machine, the costs go down. So for them, forecasting is way harder, I think. And that is for the finance department and also for the department that buys the stuff, procurement, for them it is hard because they have no hard numbers. They cannot say, ok, we now pay 50,000, and this takes us the next year or the next three years. No. it is different every month. So, I think that is also something that is tricky and hard'* stated company D's interviewee.

However, this was not the case with company B. According to company B's interviewee, *'We make conscious decisions not to invest in Capex....it is a different approach because the company is small, so you need to keep as much cash as you can free, to scale the operations. Usually, moving forward, you make those Capex decisions to invest in your own servers or in your own*

infrastructure outside of IT even. And that is usually driven by security and stability discussions. But in our case, it was not even on the table to invest in infrastructure. So it was one of the benefits for us as a small company that cloud can actually allow us and enable us to do the same functionality and services without having to invest in Capex ’.

As mentioned earlier, company B has faced an incident of disappointments with the cloud invoices due to miscommunication that resulted in subscribing to a bundle including extra services they could not afford. Such additional services were discussed under the Meta-Services cost areas. Company A’s interviewee has also stated that cloud computing comes with many excellent options. According to him, *‘when you go to the cloud, you find you have the luxury to use a little bit, or a lot of other security technologies which should have been more difficult for you to deploy on-prem.... right click you have visibility, right-click you do protection and control and visibility on the security of your data. You can do retention policies. You can do classification...’.* But each right click of those has its price.

Table 27 reports a sample of codes from the four case studies.

Case 1	Case 2	Case 3	Case 4
<ul style="list-style-type: none"> ○ The pay-as-you-go does not apply to everything ○ With computing-as-service and database-as-a-service, the price is paid from day one, although the service is still being deployed. ○ SaaS is not that adaptable and does not have the pay-as-you-go concept. ○ Vendor ambiguity vs. customer’s lack of knowledge. 	<ul style="list-style-type: none"> ○ At first, the invoices exceeded the anticipated amounts. ○ We have a process to check the invoices each month because sometimes they add things we did not subscribe for. ○ We make conscious decisions not to invest in Capex, which makes cloud computing very suitable for our small agile nature. 	<ul style="list-style-type: none"> ○ The return on investment could be three years or five years. Nevertheless, it is coming. ○ Cloud computing is agile, easy to manage, standardized and automated, and cheaper to maintain. Nevertheless, to get there, you need to make investments, like any other IT project. 	<ul style="list-style-type: none"> ○ Vendor price calculators are not enough. ○ It was very hard for us to come up with an example that estimated the real costs for some projects. ○ Moving from Capex to Opex is frustrating in cost estimation ○ Cost management and cost transparency are a bit tricky.

Table 27: Price as a Cost Area, sample of codes

This chapter has covered the findings and discussion of the expert interviews and the case studies. As mentioned in the methodology section (chapter6), this research follows a design science approach where expert interviews helped primarily explore the cost areas for building the preliminary cloud computing cost estimation model (see Figure 6: Cost areas that evolved via expert interviews). The researcher used case studies as a means for iteratively testing the validity of each cost area. This was reported in section 7.2 and thoroughly discussed in section 7.3. The coming

chapter, chapter 8, reflects on the kernel theories used to design the model and raises the curtain on the final output, a customer-centric cloud computing cost estimation model.

8 Conclusion

This dissertation contributes to cloud computing cost estimation by presenting a customer-centric model for total cloud running costs. Under the umbrella of design science research, this dissertation used transaction cost theory and the total cost of ownership approach to design an artifact that paves the road for the cloud-enabled digital transformation journey. This chapter first explains how the transaction cost theory (TCT) helped derive some cost factors. Then the cost areas are mapped according to TCT and total ownership cost. After that, the cost estimation model, the main output of the dissertation project, is presented. Finally, the researcher reports some insights and lessons learned.

8.1 Cloudy Transaction Costs

Cloud computing is price effective if investigated only from the neoclassical perspective. However, according to institutional economics and transaction cost economics, cloud customers should look beyond the price. Applying transaction cost theory to cloud computing, Figure 18 shows the following: a. Cloud has high asset specificity represented in change management costs, meta-services, and business process reengineering costs. b. The considerable level of uncertainty of cloud computing signifies managing contracts, investing in monitoring, and reviewing legal compliance. The high transaction frequency may compensate for the needed investments triggered by uncertainty and asset specificity.

Cloud asset specificity

Williamson (1985), as cited in (Shelanski & Klein, 1995, p. 337), defined asset specificity as **“durable investments that are undertaken in support of particular transactions, the opportunity cost of which investments is much lower in best alternative uses or by alternative users should the original transaction be prematurely terminated.”** This definition means that a company might have to make particular investments for some specific transactions. **Those investments might not be utilized for anything other than those transactions. In such a case, those transactions are of high asset specificity.**

The original definition of Williamson (1985), as cited in (Shelanski and Klein, 1995: 337), highlighted asset specificity investments that support a transaction. Accordingly, we define cloud asset specificity by defining the costs that the cloud customer incurs only to support the cloud service. This does not neglect the **switching costs** highlighted by Nuseibeh (2011) nor the **customization costs** added by (Yigitbasioglu, 2014). This dissertation sees those two points as necessary, but the findings view them as incomplete in defining cloud asset specificity.

Hence, the findings added several cost categories to determine the asset specificity of cloud services. Quoting the definition of Williamson (1985), those costs are durable investments undertaken in support of a particular transaction, which is cloud service adoption in this case. The

cost categories are: (1) Change management costs. (2) Meta Services costs. (3) Business Process reengineering costs. **In other words, cloud asset specificity is a function of change management costs, meta-services costs, and business process reengineering costs incurred by the cloud customer.** It is worth noting that change management and business process reengineering happen with other technologies. However, those two elements are very different with the cloud than on-premise.

Cloud Uncertainty

The findings of this dissertation project report some uncertainty areas and their implied costs: contract management, monitoring, and legal compliance. Legal compliance was partially included in the consultancy cost area in terms of legal consultants. Accordingly, the researcher decided not to have it as a separate cost element in the cost estimation model.

Cloud Transaction Frequency

Frequency means how often the transaction repeats. Williamson explained that the more a transaction repeats, the more it pays off to invest in its specific assets (Geyskens et al., 2006). We identify cloud transaction frequency as to how often services are adopted and how often a service is called. The findings show that cloud transactions have high frequencies, especially in IaaS and PaaS. This is supported by the pay-as-you-go and scalability facilitated by the cloud. This, in return, means that investing in cloud-specific assets- such as business process reengineering activities and change management practices- is worth it.

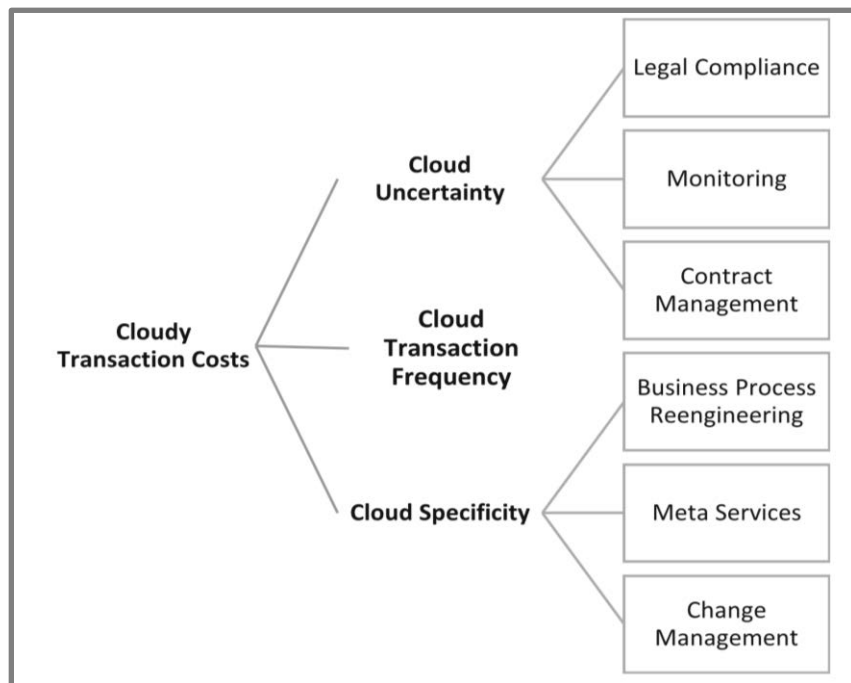


Figure 18: Cost areas based on cloud transaction dimensions (Makhlouf, 2020a).

8.2 Kernel Theories of the Cost Model

As explained in the methodology chapter, the researcher intentionally excluded some theories that could have been beneficial. For example, the activity-based costing (ABC) theory is relevant to the topic of this project and is excellent for allocating overhead costs. Thus, it will be beneficial and recommended for cloud customers to use ABC to guide their cloud cost allocation. However, the focus of this project is to calculate the running costs. After calculating those costs, the company can use ABC to allocate them to the different business departments. Cost allocation was reported in the findings as one of the main challenges that frustrate the IT and the accounting/ finance departments. This frustration increases the running costs. But developing an artifact allocating cloud costs using ABC theory is beyond this project's scope.

Further, previous research applied other theories too to cloud computing, such as resource dependency theory and diffusion of innovation theory (e.g. (Nuseibeh, 2011)). However, these theories study the propensity of the organization to adopt cloud computing. In this dissertation, we assume that the decision is already made to go for the cloud. We aim to study the running costs of the cloud since its advantages have become a business necessity. Further, some research applied other economic theories on cloud computing, such as game theory and market equilibrium (Anselmi et al., 2017; Dong et al., 2017; Pal & Hui, 2012). However, such research focused on price competition (e.g. (Chaisiri et al., 2012)) and more vendor-side interactions (e.g., between IaaS and PaaS). In this dissertation, we explore the running costs that a cloud customer incurs beyond the price. Those running costs were not apparent in previous cloud TCO research. Considering the pricing only had shown to be misleading and incomprehensive of the total cost of ownership.

Thus, out of an ocean of theoretical foundations in operations research, accounting, and economics, the researcher chose to use transaction cost theory and the total cost of ownership approach as kernel theories for building our artifact. Table 28 maps the cost areas to both theoretical foundations: total cost of ownership and transaction cost theory. Following that, the next section explains the main output of the dissertation.

Table 28: Mapping cloud cost areas to kernel theories.

Total Cost of Ownership Dimensions	Transaction Cost Theory Dimensions	
	Cloud Uncertainty	Cloud Specificity
Quality	<ul style="list-style-type: none"> ○ Monitoring ○ Resiliency ○ Testing 	
Management	<ul style="list-style-type: none"> ○ Contract management 	<ul style="list-style-type: none"> ○ Cloud Management ○ Consultation
Delivery		<ul style="list-style-type: none"> ○ Change Management ○ Re-architecture ○ Business Process Reengineering
Communication	<ul style="list-style-type: none"> ○ Shadow IT 	<ul style="list-style-type: none"> ○ Brokering Costs
Service	<ul style="list-style-type: none"> ○ Meta Services: e.g. Security Services 	<ul style="list-style-type: none"> ○ Meta Services: e.g. Cost Management Service ○ ITSM adjustment
Price		<ul style="list-style-type: none"> ○ Subscription Fees ○ Data Transfer

8.3 Sunny: A customer-centric model for total cloud running cost

Studying the cost estimation of running cloud computing is vital for an informed digital transformation journey. Some might argue that the cost factors are similar to any typical IT system, for example, ERP. One just needs to eliminate the infrastructure costs and will get the results required of the cloud cost estimation. Prior research, as well as this dissertation, refuses this argument. For example, Expert 4 explained that the problem is that cost estimation of the cloud sounds simple, but it is not necessarily so. With ERP, for instance, there are different versions, different API layers, different modules, and all those sources of consideration. ERP operates even in the same suite-product from the same vendor. Contrarily, one operates differently in a cloud model (Expert 4).

Cloud computing is more service-oriented, while traditional IT outsourcing focuses more on a single provider. In other words, the classical value chain of outsourcing has broken up in the clouds. Cloud providers can offer their customers new flexibilities with new services and business models. Cloud computing also allows modifying existing services without engaging in significant investments (Boehm et al., 2011).

As mentioned in section 3.1, cost factors contributing to TCO calculation for IT initiatives can have various categorizations. David et al. (2002) used the following categories: acquisition costs, control, and Operations. Mceen and Smith (2010) used other categories; One-time (start-up) costs, ongoing (lifetime) and enhancement costs, Ancillary costs, and one-time (end-of-life) costs. Although these categorizations were used for IT outsourcing decisions, this dissertation adopts the purchasing activities contributing to TCO introduced by Ellram and Siferd (1993).

The word ‘purchasing’ here is critical since it is not that compatible with the as-a-service model. However, these activities are pretty comprehensive. Those TCO activities also do not depend on the time dimension, which is beneficial because cloud services represent ongoing consumption and long-term relationships with vendors. The activities- denoted here as cost categories- are management, delivery, service, communications, price, and quality. Figure 19 represents the cost areas that evolved under the cost categories throughout the coding and analysis of the expert interviews. The cost areas and the figure were thoroughly explained in section 7.1.

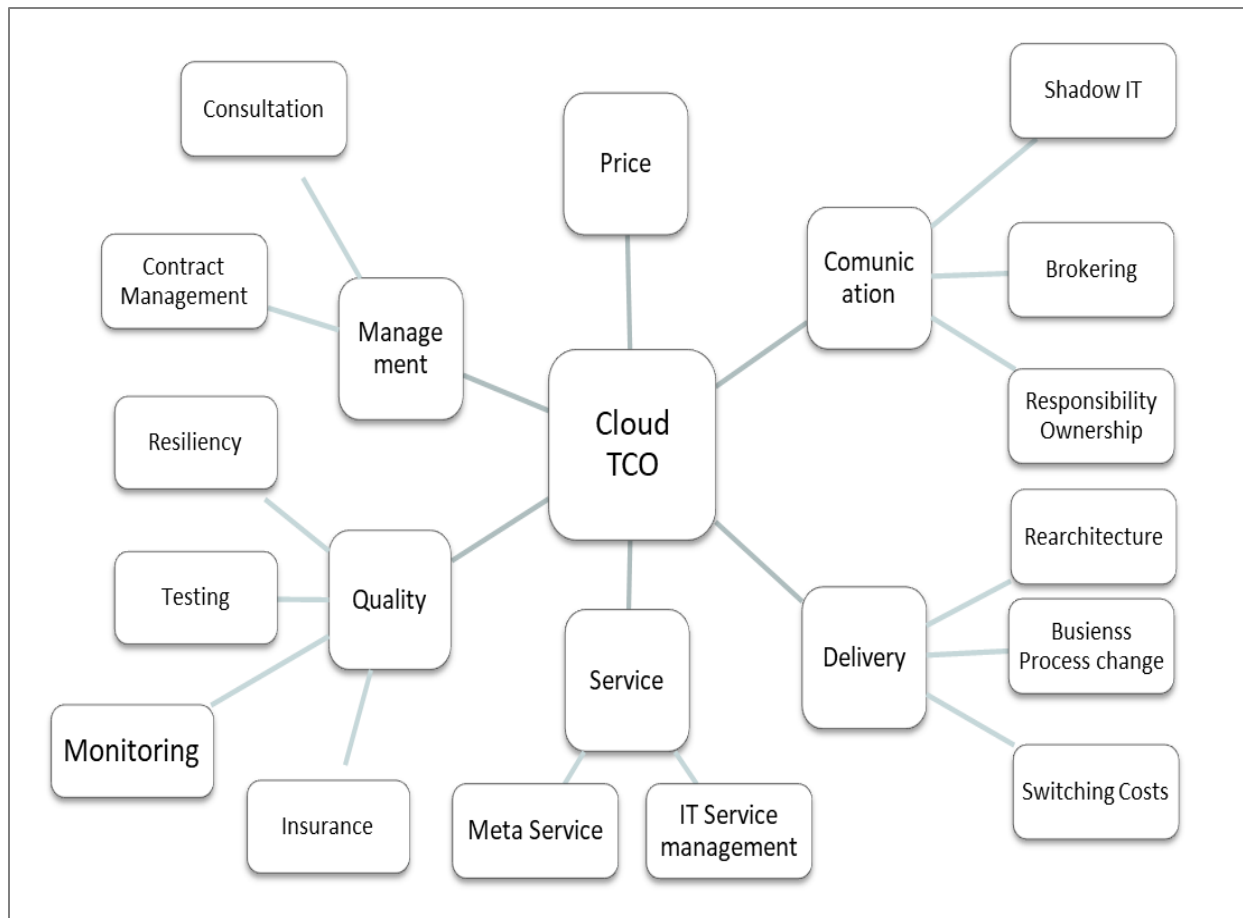


Figure 19: Cost areas that evolved via expert interviews.

The output of the expert interviews was a preliminary cost estimation model. The researcher tested this model for validation through case studies. As explained in the methodology chapter, this dissertation implemented four case studies. Sections 0 and 7.3 have thoroughly explained the findings and discussion of the case studies. Figure 20 compares the adaptability of the case studies to the preliminary cost areas proposed by the expert interviews.

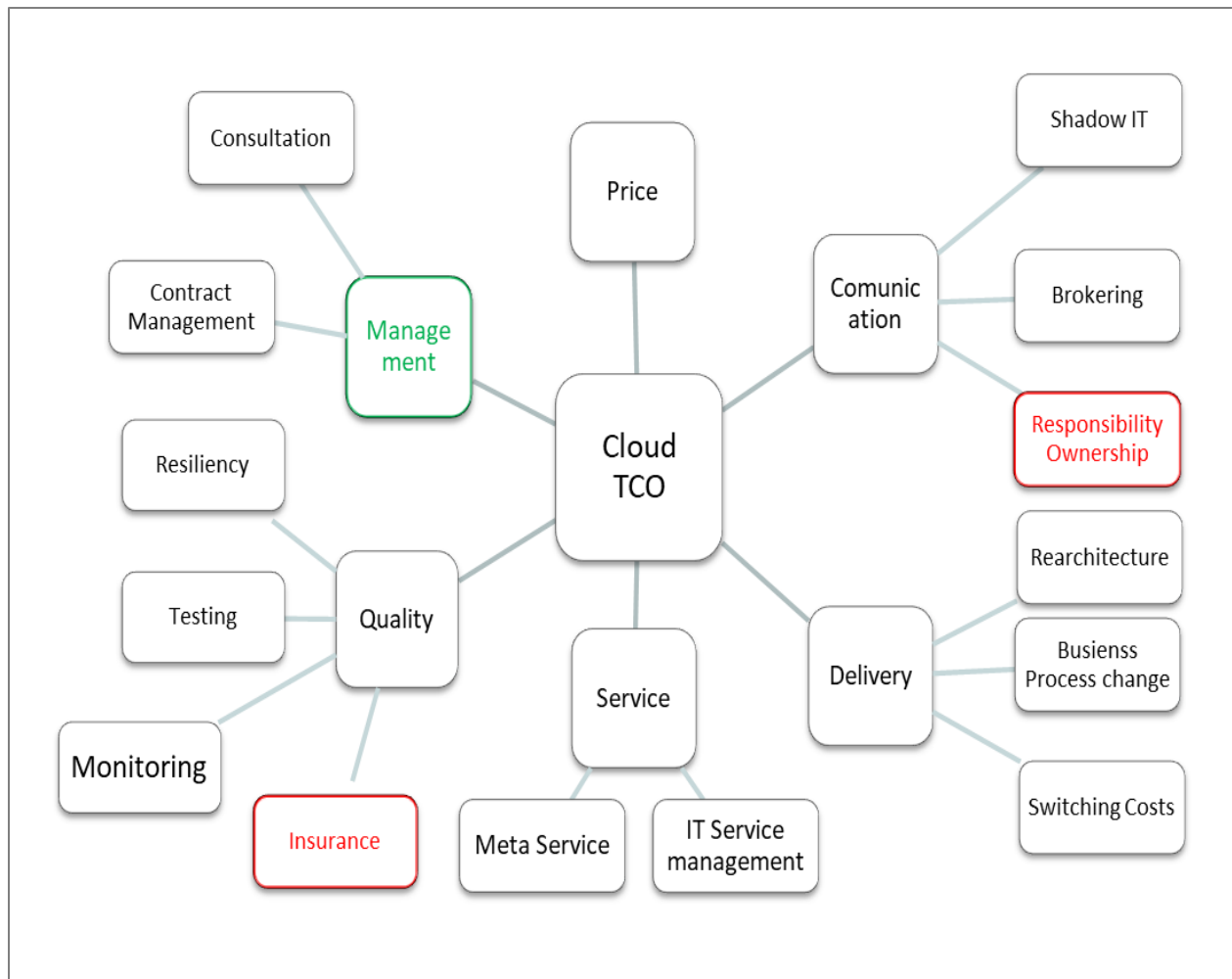


Figure 20: Cost areas proved by Case Studies.

Figure 20 shows cost areas that were not proved in the case studies (highlighted in red) and cost areas that were further stressed (highlighted in green). Based on that, making some design decisions for the cost estimation model was essential. For example, one of the cost factors that appeared in expert interviews is ‘insurance.’ Despite being justified by some experts, it was not proved by case studies. It was argued that such insurance premiums would be very high. Service providers also did not pursue such insurance practices because it might appeal negatively to the end-user and suggest that the service provider believes that their services will go down. Thus, the researcher decided to exclude it. As well, ‘responsibility ownership’ was a primary concern for cloud customers. Although it might cause cost frustrations, it is not feasible to be considered a cost factor. It was, however, implied in the ‘communication’ cost category.

A cost area that was further stressed in the case studies was cloud management. Company C was distributed on shadow-IT and still is. As a result, the company confronted a critical decision: should cloud services be managed internally or externally? According to the IT top management representative, *"It was a strategic decision here because we see the cloud as a strategic part of our*

IT, And we did not want to give it to the outside market because then we are relying on the suppliers for strategic services which could be provided by us internally". In the end, they decided not to outsource cloud management to external suppliers. To do that, the company took several measures. 1: managing cloud contracts centrally by the IT service department, 2: creating cloud CoE, 3: employing operational level agreement (OLA).

Besides the internal central management of cloud computing, another management issue was vital for the company; governance. The interviewee reported that the cloud needs different governance practices than on-premise scenarios. He said, *"The solution to this is good management and good governance; that you understand how you want to support your applications, how you want to support your infrastructure, your environment, and that when you buy IT services from multiple providers, that you need to ensure by correct service management and correct contract management that these contracts are aligned with each other because that is a necessity. I mean, it is a goal by itself, But especially if they are running all in the cloud, they must be aligned. This alignment is not straightforward at all".*

Case study 4 also reported that they also manage the cloud by themselves. The company had to go through a learning curve that lasted almost six months.

As described in the methodology chapter, three tests (suggested by Yin, 2009)were employed to govern the quality of the case studies. First, the Construction Validity test, which relates to establishing correct operational measures for the concept being studied (Rowley, 2002), was employed through the following tactics. (a) I used multiple sources of evidence, i.e., triangulation. I collected data through interviews, documents of cost analysis as well as internet-available sources of the company's cloud portfolio. (b) I sent an executive summary of the case study findings to the interviewed top manager of the studies company. Second, I used multiple case studies to test for external validity. External validity is concerned with the generalizability of the case study findings. This generalisability is analytical, not statistical. The output of the expert interviews hypothesized a template with which the case study output was compared. According to (Rowley, 2002), if two or more case studies support the hypothesized template, the generalization can be claimed. In this dissertation, four case studies supported the hypothesized template. The final test was Reliability. To test the reliability of the case study, we documented each step of the case study. Interviews were recorded and transcribed using speech recognition software. The researcher manually reviewed the transcripts for adjustments and then used text mining to extract and report findings. As well, documents and other sources collected were kept in what is called a case study database.

Using design science research and deploying expert interviews and case studies, Figure 21 presents Sunny, a customer-centric model for total cloud running cost. I name it 'Sunny' as a metaphor denoting clearing the clouds (cloud computing) and any vagueness in costs that are associated with it. This model changes the way customers should calculate their TCO of cloud projects. The cost

areas theorized by this dissertation should be included in the cloud TCO frameworks. Each cost area is thoroughly explained below.

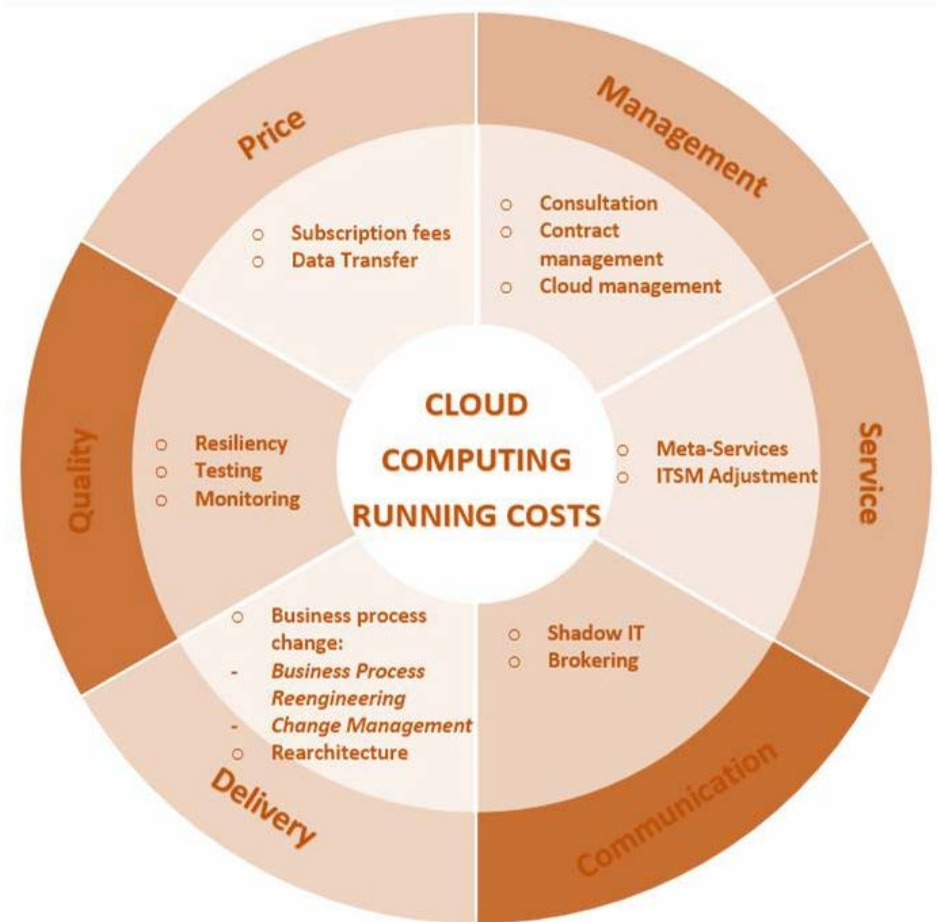


Figure 21: Sunny: a Customer-Centric Model for Total Cloud Running Costs

Management Costs

Cloud customers should expect that they will pay considerable attention to the management of cloud resources. This cost category includes **continuous contract management, consultation** in multiple areas along the cloud journey, and costs of tools and practices for **cloud management**.

While cloud computing is similar to outsourcing an internal IT activity, it is critical to continuously review the vendor for compliance with the contract terms and SLA and even ensure that these terms match the customer's interests. This continuous review might require significant

investments adding to the total costs. Further, due to the nature of the service, it becomes vital to evaluate and select new terms for the agreement (Expert 6). Continuous contract management costs also include the costs of addressing the information asymmetry between the cloud customer and the vendor before the agreement is concluded.

Moreover, external expertise is inevitable throughout the whole transition, which introduces the consultation cost area. This includes legal expertise for the contract aspects. In addition, depending on how the adoption process would go, a company may need expertise in data migration or different software products and integrations (Expert 4; Expert 6; Expert 3).

The case studies added Cloud Management as a separate cost area. For example, companies C and D, made a strategic decision to manage cloud resources internally because they are a strategic part of the IT that should not be managed by the outside market. Thus, costs for Cloud Management may include creating a central entity such as a cloud Center of Excellence (CoE), employing operational level agreements (OLA) within the company, and internal central contract management.

Service Costs

When a company adopts a cloud service, costs are incurred in the area of **ITSM adjustment**. The cloud's difference while applying ITSM is in the IT service delivery. Delivering a solution on the cloud is different because it has new roles extending the IT operations team. According to company A's interviewee, cloud computing has never reduced the operations overhead as it is always perceived. From another perspective, a major challenge facing cloud customers is working with DevOps since DevOps are not always compliant with ITIL (one of the dominant ITSM frameworks). They put the company on the borderline between agility (imposed by cloud computing) and reporting (imposed by ITIL). Company C's IT management, for example, had to balance this complex challenge of aligning DevOps with ITIL.

From another perspective, according to one expert from the consultant side, *'you also need additional services to track consumption, to audit, to migrate, to ensure you're getting optimal costs et Cetera.'* As well, Company C's interviewee stated, *'backup needs to be changed, monitoring needs to be changed, security is different.'* Thus, **Meta-Services**, such as cloud-management-as-a-service, security-as-a-service, and others, are becoming essential for the success of an IT ecosystem that has cloud-based ingredients. The findings of the Expert Interviews highlighted at least four types of services needed to support cloud services. Those are security tools (Expert 7, Expert 5), cloud cost management tools (Expert 5, Expert 3), monitoring tools (Expert 6), configuration management tools (Expert 5, Expert 6, Expert 1), and cloud management platforms (Expert 6, Expert 7, Expert 3). According to the case studies, these are costly services that inflate the total cost of ownership calculations.

Communication

Smoothly moving to the cloud is a complex goal. The Cloud computing transformation journey imposes a unique value chain resulting in different communication channels between the cloud vendor, the cloud customer's IT department and the cloud customer's business units. These entities evoked two cost areas: Shadow-IT and Brokering.

The expert interviews reported the **shadow-IT** problem where the business units seek to adopt cloud services while the IT department is not adding value to that acquisition. The business units negotiate with the vendors, discuss prices and maybe sign contracts. As a result, the role of the IT department is threatened to minimize. The control of the IT department over the purchased services would be vanishing, and departmental heads are in charge of the IT budget, which means that the IT department has less control. This scenario has also implications on who is responsible for security, data protection, and governance (Expert 3, Expert7).

Case study 1 showed that shadow IT instances disrupt the IT operations with unplanned integration and implementation projects. The central IT department only managed to get the top management support in this issue after Company A had experienced some failed shadow-IT projects. As well, Company C had to manage cloud services centrally to manage such shadow-IT problems.

The Expert interviews suggested another solution to these shadow IT costs, which is **Brokering**. However, this is a cost area in itself. The IT departments should adopt a brokering mindset between the business units and the cloud vendor. Such a mindset incurs costs of providing value-added services to complement the cloud service and manage responsibilities throughout the company's IT environment. According to Case 1, Local IT has faster support than the vendor and they best know the company's architecture. Case 3 went to an extra level with this Brokering mindset where they established the cloud center of excellence (CoE) to act as a communication channel between the cloud vendor and the business units. Moreover, while the IT department has SLAs with the vendors, they further employed operational level agreements (OLAs) with the business units.

Delivery

According to Expert 6, *“going to the cloud requires that every part of the organization be more mature it requires some more skills across the entire organization.”* Further, Expert 4 explained, *‘In fact, some companies should not move to the cloud because they are just so immature in their process that is just going to cost a lot of money and put their business at risk.’* Thus, the adoption of cloud services imposes business process change that demonstrates itself in **business process reengineering** and **change management**. In addition, costs related to **Rearchitecture** are incurred.

Cloud computing adoption trigger business process reengineering for both IT and non-IT processes. The IT department needs to change the follow-up processes, the testing processes, the

processes for interacting with developers, and the ‘ ordering a server ’ processes. Moreover, some processes need to be eliminated such as helpdesk procedures (Expert 4, Expert 9; Expert 10).

Some non-IT processes, which involve the finance, legal, and procurement departments, need to be dramatically engineered. The case studies reported the need for a specialized IT legal role. Generally, the employees in the legal department are usually not competent enough with the technical terminologies in cloud contracts. This competency lack meant that the IT department was responsible for explaining the contracts' technical aspects to the legal department. Moreover, taxation and data residency issues become a challenge with the global presence of cloud resources.

Another extremely more-challenging business process is cost allocation (Expert 2, Expert 5, Expert 7). This finding was supported by Cases 1 and 4. The IT department is then asked to participate in allocating cloud computing costs to the business units. According to company A’s interviewee, *‘it is not comfortable. It takes time and requires constant recheck.....’* Company D reported that they had to choose between adopting a third-party tool or making a solution themselves that could understand the bills and consumption of the cloud resources. Due to monetary limitations, they opted for the last option.

Finally, supply chain and procurement departments should engage in providing periodic reviews of the cloud contracts and SLAs (Expert 4, Expert 6). This engagement was present in Company C and extremely needed in companies A and D.

One highly under-estimated yet significant cost factor is **Change management**. It denotes the costs of activities ranging from buying the interest of the employees in cloud computing to deleting, amending, and adding jobs inside and outside the IT department. New job positions emerge to fill some gaps in delivering the cloud. Expert 3 highlighted a shortage of architects who can design cloud applications. *‘If you look at amazon web services, they have got a ridiculous number of products, like hundreds of products, and there are very few specialists out there who can design an application that brings in all of amazon products and makes the best of them’* (Expert 3). This shortage was supported by Expert 7, who stated that his company had to introduce new jobs such as Cloud Security Engineer, Cloud Architect, and Cloud Operations Support. Meanwhile, it is difficult to train an infrastructure caliber for a cloud management position. Also, if the organization decides to fire them, this has its costs (Expert 4, Expert 6).

Thus, the Expert interviews highlighted the importance of developing a change management strategy. This strategy should include training, personal development, mentoring and coaching, and all the workshops that need to be done from a communication point of view. Further job descriptions need to be written and validated. All of this needs to be planned out and made into an integrated set of activities, where the organization would lead a workforce to a particular place (Expert 4).

Those findings were supported by the case studies. Although cloud vendors offer a wide range of training that fully supports the company, Company C strategized a long-term plan for the IT team's

cloud-related skills. *'The skill sets that the team will be needing during the build-up and the migration phase are completely different than when you are on run and maintain,'* noted by company C's interviewee. He further added *'you could have 40 or 50 people who are specialized in data centers and you are now moving to the cloud, you need to ensure that those people are trained to manage and support the new environment'*.

Further Company A and Company D referred to the learning curve effect. According to company D's interviewee, *'there was a lot of learning on the job sort to say. It was not upfront like classes where you have some path to follow'*. Similarly, company A's interviewee stated *'During the last three years and a half we tried too many things, and we have been able to figure out what we need and how the cloud can really benefit us. And several of our group of companies has started maturely porting things to the cloud'*.

Not only do processes and employees change when a company moves to the cloud, but also the company's IT architecture, which incurs costs for customizations and adjustments. Thus, the last ingredient of Delivery costs is **Rearchitecture** (Expert 4; Expert 7; Expert 6). According to Expert 4, *'clients we have seen have taken 18 months or 12 months beforehand to actually get all of this work done before they're ready to actually go live to implementation and sign the contract'*. Prerequisites for migration are various and the cloud journey does not take off with signing the contract. Before that, along with contract negotiations, several angles ask for excessive efforts. Examples include new processes, new configurations, new taxonomies, new data structures, and many other architectural issues. The major mistake organizations make is ignoring all that until they are ready to go live. In that case, they must do it in a hurry, which almost goes wrong (Expert 4; Expert 7).

These findings were further proved by the case studies. For Company A to have computing-as-a-service and database-as-a-service up and running the way they wanted, they needed up to five months. During this period, they were paying the full capacity of the solution as if it was running at full capacity. Moreover, some efforts were excreted in preparing the company's infrastructure for the cloud. To do that, the IT department had to provide some gateway and synchronization servers for integration with the cloud, which added to the total cost of any cloud solution they adopted.

Meanwhile, Company C's interviewee complained that *'the implementation of the cloud is expensive. The migration to the cloud is expensive.'* To find a middle ground between keeping the benefits of business-critical legacy systems and yearning for the new potential cloud benefits, middleware has usually been the answer. This has unfortunately inflated the IT costs.

As a small company, Company B reported that the migration and its errors are usually the biggest disappointment and frustration. They had faced incidents concerning how applications and information on the backend speak with each other. As well, Company D had to rewrite its software in some parts, and that was also something that took quite some time.

Quality

The findings of this dissertation project proved that the quality of cloud services is not self-evident. Cloud customers have to build and pay for **resiliency** themselves. According to Experts 2 and 3, it is the responsibility of the customer to build such resiliency, which has its separate costs. This was also supported by the case studies (Cases 1, 2, and 3). While Expert 1 recommended disaster recovery for critical cloud services, Expert 7 explained that according to his company, if an application requires disaster recovery, it does not get to the cloud.

Moreover, companies have to pay for cloud resources to perform proper **testing**. According to Expert 5, *'the actual testing, that would be the challenging part.'* Similar to any new system, it is advisable to go for a parallel adoption where both the old and the new cloud systems are running side-by-side, resulting in double costing (Expert 3, Expert 4, Expert 10, Expert 6).

Further, for the IT department to know whether the cloud application is scaling correctly, it should throw cost-incurring requests to the cloud service to check if it grows as expected (Expert 3). According to Expert 1, it isn't easy to estimate the usage of a particular cloud service. Accordingly, cloud customers might have to go for a trial and error attempt in an experimental manner. Such experimenting is sometimes expensive, but they are necessary to prevent service downtime resulting from demand spikes. Companies A and B did not have the luxury of testing, which resulted in dissatisfying results. Quoting company A's interviewee, *'You know, even in the first year when we wasted half of the commitment, we were like testing the cloud trying moving things to the cloud bringing them back. We used the tenant because there was no actual or real need at the very beginning.'* Company D reported that it used its first vendor as a step to test the cloud.

Finally, **monitoring** cloud services, vendors, and even business users has been proven as an important cost area. Expert 2 compared cloud customers to teenagers with credit cards. They keep consuming the service while not being aware of the costs they are incurring (Expert 2). Expert 5 explained that some end-users in his company incurred thousands of euros in a very short time. This means that although a cloud customer is not the one taking care of hardware, updating, or batching the systems, the customer needs to take care of much monitoring of the tenants on the cloud (Expert 1, Expert 4, Expert 5). Company A's interviewee clarified that he had to ensure that his company uses the cloud resources optimally, with no overuse and underuse.

On another side, IT departments have to monitor the cloud providers by monitoring the adherence to the service level agreement and auditing the invoices. Expert 3 believes that a gap remains in the latter as the customer has to trust the vendor invoices, which might reach millions of dollars. Company B has, therefore a separate process for reviewing the invoices.

Although the cloud vendors offer reporting tools, company A's interviewee was not fully satisfied with the functionalities of the vendor portal. He stated *'It alerts you when you exceed your money limit. But it does not alert you when you exceed the usage of the resources themselves.'* Company

C interviewee added *'you need to be aware of the environment and have clear reporting.... if you do not have that, there will be surprises.'* Moreover, the monitoring techniques that work for on-premises solutions do not work for the cloud. Accordingly, cloud computing customers are left with two options. First, cloud customers might adopt third-party services to monitor the cloud service (Expert 7, Expert 1, Expert 2, Expert 6, Expert 5, Expert 3). That was supported by the findings of Case 3 and was a potential choice for Case 1. Second, some cloud customers might prefer to build their monitoring tools (Expert 5, Expert 2, expert 6). This was the option that Company D chose.

Price

While cloud computing is always marketed by its pay-as-you-go advantages, the data have proved that this is not a straightforward task. Company A's interviewee even commented that *'cloud customers are fooled'* with this concept, assuming that this is a built-in option on whatever cloud component they use. Some of the cloud components do not have this option. Company A faced the fact that they had to pay for specific features they registered for and were not using yet. From another perspective, cloud vendors offer price calculators on their websites. However, the case studies' findings proved that vendor price calculators are not enough. Moreover, it is very hard for cloud customers to come up with an example that estimated the real costs for some projects.

Company D's interviewee commented *'they all have these calculations where you can say, ok, I need five virtual instances, five databases, and stuff. But then you have traffic, that is, you have to estimate how much traffic it will be. Is it traffic that goes between regions? Is it outgoing? It costs from 0 to 10 gigabytes more than from 10 to 20 '*. Company C's interviewee explained that the cloud's price does not include all the costs. The implementation of the cloud is expensive, and the migration to the cloud is costly, which makes a cloud project's return on investment (ROI) range from three to six years. Finally, while company B was surprised with functionalities they did not subscribe for, Company D agreed that cost management and cost transparency in cloud computing are a bit tricky.

8.4 Concluding Insights

Comparing ‘Sunny’ with other trials of cost estimation in the literature, many of the publications focused on price. Moreover, evaluation and selection of the vendor have been reported as a one-time task. Contrarily, this dissertation has proven that there has to be a long-term relationship where the contract management and service level agreements are continuously managed. Sunny proposes new cost elements such as resiliency, monitoring, testing, shadow IT, brokering, cloud management, meta-services, and ITSM adjustment. Only one paper targeted some of these new factors; Kawatra and Kumar (2017). However, their methodology was very weak as it was based on a case study of setting up a lab. Most importantly, their study was merely focusing on education. In this dissertation, a strong methodology was followed that utilized the design science approach and collected data using expert interviews and 4 case studies. The experts and the companies participating in the case studies represented various business sizes and different industry fields. This in return minimizes the bias in our findings and maximizes the generalizability of the model's applicability.

From another perspective, while the main output of this dissertation is ‘Sunny,’ the customer-centric cloud cost estimation model, there are some lessons learned that emerged throughout the dissertation project. These range from introducing a new concept in the cloud computing ontology through ‘Meta-Services’ to criticizing the most-cited cloud computing definition. Moreover, as a final step, the model fitness is explained in this section by answering the design Science research checklist of A. Hevner & Chatterjee (2010:20).

Meta-Services

Over the past decade, the cloud computing stakeholders have developed a mutual understanding of the main three service models, IaaS, PaaS, and SaaS. Meanwhile, the findings of this research have reported that other services emerged to support the cloud computing environment, such as Security-as-a-Service, Monitoring-as-a-Service, and Cost-Management-as-a-Service. Those services became an essential component for successfully running the cloud. However, there is no explicit conceptualization for those services. Thus, I conceptualize those cloud-related services as Meta-Services.

Interestingly, cloud customers, vendors, and consultants already have a mutual understanding of that concept. Nonetheless, this understanding lacks explicitness. Explicitness denotes that an ontology is not elusively staying somewhere in human minds. Contrarily, explicitness indicates that an ontology is available for others to use (Borst, 1999; Gruber, 1993; Husáková & Bureš, 2020). Thus, the researcher wrote paper 4 (details in section 10.2) to be published, providing an explicit, mutual understanding of a type of service that the customers, vendors, and consultants see as a core for cloud success.

Using the as-a-service philosophy, a company can have an email system as a service instead of investing in building and managing that themselves. Unpredictably, the company invests in other

cloud services to support this email-as-a-service. Interviewed consultancy-side experts stated that cloud customers have to buy services to track consumption, audit, migrate and ensure that they are getting optimal costs. Customer-side experts reported that their companies had to subscribe to many third-party services to manage the cloud portfolio better. Findings from the case studies similarly indicate that the cloud forced the company to adopt additional security services increasingly.

Such services that emerge because of the move to the cloud can be coined as Meta-Services, by which I mean cloud services that serve cloud services. Dedicated IT companies are emerging and building their business models only by selling these Meta-Services. This contribution agrees with Gartner's estimations that cloud customers will spend 28 % of their budgets on 'cloud-related services' by 2022 (*Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17.5 Percent in 2019*, n.d.). Introducing Meta-Services as a new concept that should be added to cloud computing ontologies should help cloud customers make more informed decisions about their cloud adoption journey. This contribution should also help cloud vendors make more realistic promises to their customers.

NIST Definition

This research project puts the most cited definition of cloud computing in question (more than 19000 citations according to Google Scholar). The NIST definition associates 'minimal management efforts' to cloud computing provision. The findings of this project highlight other management efforts after the provision of a cloud instance. As well, the release and provisioning might not be a straightforward task. Sometimes, a company has to build/ adopt a solution or write codes to decide when to release and when to provision. Otherwise, the cloud costs would offset the benefits.

Further, the rapid provision contradicts the change management practices, ITSM adjustments, process reengineering, and contract management. Contrarily, the rapid provision motivates companies to move to the cloud while neglecting or delaying those cost areas, which has caused cost inflations, as shown in the case studies.

Model Fitness

The solution's fitness indicates the solution's operationalization to solve real-world problems (vom Brocke et al., 2020). During this design science project, the researcher published a research paper (See details in Appendix 10.2, Paper 2) applying one of the kernel theories on the problem space and provided a part of the solution- to be later on included in the artifact. As part of the evaluation process and to examine the fitness, the paper was sent to a community of cloud computing practitioners, the Cloud Standards Customer Council. A law consultant commented that he agrees

with the contract management and legal compliance issues. He added that he reflects on these issues daily when guiding cloud service providers on drafting their Cloud Agreements. A CEO of a cloud computing consultancy also praised the article. Finally, a co-chair of this cloud community group, who also holds a vital IT compliance position in Boeing, commended that article.

The reuse of the design knowledge asks for referencing the kernel theories and recording creative insights that contributed to building the final artifact. One of the creative insights that the researcher developed is meta-services, for which a separate paper is to be published to introduce it as a contribution to the cloud computing ontology (Appendix 10.2, Paper 3).

Finally, the fitness of the design knowledge usually trades off with its projectability and generalizability. Vom Brocke & Buddendick (2006) and vom Brocke (2007) suggested techniques such as configurations, instantiations, specializations, aggregation, and analogy to handle this tradeoff. Hence, the researcher presents how different case studies adapt to the proposed models in this design process. Table 29 ends this dissertation project by answering the design Science research checklist suggested by A. Hevner & Chatterjee (2010:20)

Questions	Answers
1. What is the research question (design requirements)?	What costs should a customer estimate when running a cloud service?
2. What is the artifact? How is the artifact represented?	A model
3. What design processes (search heuristics) will be used to build the artifact?	Literature review Expert interviews
4. How are the artifact and the design processes grounded by the knowledge base? What, if any, theories support the artifact design and the design process?	Transaction cost theory (TCT) Total Cost of Ownership
5. What evaluations are performed during the internal design cycles? What design improvements are identified during each design cycle?	Expert Interviews

<p>6. How is the artifact introduced into the application environment, and how is it field tested? What metrics are used to demonstrate artifact utility and improvement over previous artifacts?</p>	<p>Case Studies</p>
<p>7. What new knowledge is added to the knowledge base, and in what form (e.g., peer-reviewed literature, meta-artifacts, new theory, new method)?</p>	<p>Sunny: a customer-centric cost estimation model.</p> <p>‘Cloudy transaction cost’ paper (Appendix: Paper 2)</p> <p>‘Meta-services’ paper (Appendix: Paper 3)</p> <p>‘Contracting the cloud’ paper (Appendix: Paper 4)</p>
<p>8. Has the research question been satisfactorily addressed?</p>	<p>Yes</p>

Table 29: Answering the design Science research checklist of A. Hevner & Chatterjee (2010:20)

9 References

- Aggarwal, S., & McCabe, L. (2009). *The compelling TCO case for cloud computing in SMB and mid-market enterprises. Hurwitz-Whitepaper*. Newton, MA: Hurwitz & Associates. Available at:
<http://www.netsuite.com>
- Akerlof, G. A. (1978). 15 - THE Market for "Lemons": Quality Uncertainty and the Market Mechanism. In P. Diamond & M. Rothschild (Eds.), *Uncertainty in Economics* (pp. 235–251). Academic Press.
<https://doi.org/10.1016/B978-0-12-214850-7.50022-X>
- Amazon Web Services. (2017). *An Overview of the AWS Cloud Adoption Framework*.
https://d1.awsstatic.com/whitepapers/aws_cloud_adoption_framework.pdf
- Anselmi, J., Ardagna, D., Lui, J. C., Wierman, A., Xu, Y., & Yang, Z. (2017). The economics of the cloud. *ACM Transactions on Modeling and Performance Evaluation of Computing Systems (TOMPECS)*, 2(4), 1–23.
- Anthes, G. (2010). Security in the cloud. *Communications of the ACM*, 53(11), 16–18.
<https://doi.org/10.1145/1839676.1839683>
- Araujo, J., Maciel, P., Andrade, E., Callou, G., Alves, V., & Cunha, P. (2018). Decision making in cloud environments: An approach based on multiple-criteria decision analysis and stochastic models. *Journal of Cloud Computing*, 7(1), 7. <https://doi.org/10.1186/s13677-018-0106-7>
- Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I., & Zaharia, M. (2010a). A view of cloud computing. *Communications of the ACM*, 53(4), 50–58. <https://doi.org/10.1145/1721654.1721672>
- Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I., & Zaharia, M. (2010b). A view of cloud computing. *Communications of the ACM*, 53(4), 50–58. <https://doi.org/10.1145/1721654.1721672>

- Assunção, M. D., Calheiros, R. N., Bianchi, S., Netto, M. A. S., & Buyya, R. (2015). Big Data computing and clouds: Trends and future directions. *Journal of Parallel and Distributed Computing*, 79–80, 3–15. <https://doi.org/10.1016/j.jpdc.2014.08.003>
- Aubert, B. A., Rivard, S., & Patry, M. (1996). A transaction cost approach to outsourcing behavior: Some empirical evidence. *Information & Management*, 30(2), 51–64. [https://doi.org/10.1016/0378-7206\(95\)00045-3](https://doi.org/10.1016/0378-7206(95)00045-3)
- Ayaburi, E. W. Y., Maasberg, M., & Lee, J. (2020). Decision Framework for Engaging Cloud-Based Big Data Analytics Vendors. *Journal of Cases on Information Technology (JCIT)*, 22(4), 60–74. <https://doi.org/10.4018/JCIT.2020100104>
- Bahli, B., & Rivard, S. (2003). The information technology outsourcing risk: A transaction cost and agency theory-based perspective. *Journal of Information Technology*, 18(3), 211–221. <https://doi.org/10.1080/0268396032000130214>
- Barbosa, F. P., & Charão, A. S. (2012). Impact of pay-as-you-go Cloud Platforms on Software Pricing and Development: A Review and Case Study. In B. Murgante, O. Gervasi, S. Misra, N. Nedjah, A. M. A. C. Rocha, D. Taniar, & B. O. Apduhan (Eds.), *Computational Science and Its Applications – ICCSA 2012* (pp. 404–417). Springer. https://doi.org/10.1007/978-3-642-31128-4_30
- Barley, S. R., & Kunda, G. (2001). Bringing Work Back In. *Organization Science*, 12(1), 76–95.
- Baumard, P., & Ibert, J. (2001). What approach with which data. *Doing Management Research*, 76–83.
- Bayramusta, M., & Nasir, V. A. (2016). A fad or future of IT?: A comprehensive literature review on the cloud computing research. *International Journal of Information Management*, 36(4), 635–644. <https://doi.org/10.1016/j.ijinfomgt.2016.04.006>
- Benlian, A. (2009). A transaction cost theoretical analysis of software-as-a-service (SAAS)-based sourcing in SMBs and enterprises. *ECIS 2009 Proceedings*. <https://aisel.aisnet.org/ecis2009/4>

- Benlian, A., Hess, T., & Buxmann, P. (2009). Drivers of SaaS-Adoption – An Empirical Study of Different Application Types. *Business & Information Systems Engineering*, 1(5), 357.
<https://doi.org/10.1007/s12599-009-0068-x>
- Bildosola Agirregomezkorta, I., Río Belver, R. M., Cilleruelo Carrasco, E. J., & Garechana Anacabe, G. (2015). *Design and implementation of a cloud computing adoption decision tool: Generating a cloud road*. <https://doi.org/10.1371/journal.pone.0134563>
- Blumberg, B., Cooper, D., & Schindler, P. (2014). *EBOOK: Business Research Methods*. McGraw Hill.
- Boehm, B. W., & Valerdi, R. (2008). Achievements and Challenges in Cocomo-Based Software Resource Estimation. *IEEE Software*, 25(5), 74–83. <https://doi.org/10.1109/MS.2008.133>
- Böhm, M., Leimeister, S., Riedl, C., & Krcmar, H. (2011). Cloud Computing – Outsourcing 2.0 or a new Business Model for IT Provisioning? In F. Keuper, C. Oecking, & A. Degenhardt (Eds.), *Application Management: Challenges – Service Creation – Strategies* (pp. 31–56). Gabler.
https://doi.org/10.1007/978-3-8349-6492-2_2
- Borst, W. N. (1999). *Construction of engineering ontologies for knowledge sharing and reuse*. 1.
- Buyya, R., Yeo, C. S., & Venugopal, S. (2008). Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities. *2008 10th IEEE International Conference on High Performance Computing and Communications*, 5–13.
<https://doi.org/10.1109/HPCC.2008.172>
- Cameron, E., & Green, M. (2019). *Making Sense of Change Management: A Complete Guide to the Models, Tools and Techniques of Organizational Change*. Kogan Page Publishers.
- Cayirci, E., & de Oliveira, A. S. (2018). Modelling trust and risk for cloud services. *Journal of Cloud Computing*, 7(1), 14. <https://doi.org/10.1186/s13677-018-0114-7>

- Cegielski, C. G., Allison, J. L., Wu, Y., & Hazen, B. T. (2012). Adoption of cloud computing technologies in supply chains: An organizational information processing theory approach. *The International Journal of Logistics Management*, 23(2), 184–211. <https://doi.org/10.1108/09574091211265350>
- Chaisiri, S., Lee, B.-S., & Niyato, D. (2012). Optimization of Resource Provisioning Cost in Cloud Computing. *IEEE Transactions on Services Computing*, 5(2), 164–177. <https://doi.org/10.1109/TSC.2011.7>
- Choudhary, V., & Vithayathil, J. (2013). The Impact of Cloud Computing: Should the IT Department Be Organized as a Cost Center or a Profit Center? *Journal of Management Information Systems*, 30(2), 67–100. <https://doi.org/10.2753/MIS0742-1222300203>
- Choudhury, V., & Sabherwal, R. (2003). Portfolios of Control in Outsourced Software Development Projects. *Information Systems Research*, 14(3), 291–314. <https://doi.org/10.1287/isre.14.3.291.16563>
- Clemons, E. K., & Chen, Y. (2011). Making the Decision to Contract for Cloud Services: Managing the Risk of an Extreme Form of IT Outsourcing. *2011 44th Hawaii International Conference on System Sciences*, 1–10. <https://doi.org/10.1109/HICSS.2011.292>
- Data Residency – Do you know where your data resides? (2020, July 7). *DCirrus*. <https://dcirrus.com/data-residency-do-you-know-where-your-data-resides/>
- David, J. S., Schuff, D., & St. Louis, R. (2002). Managing your total IT cost of ownership. *Communications of the ACM*, 45(1), 101–106. <https://doi.org/10.1145/502269.502273>
- Dhar, S. (2012). From outsourcing to Cloud computing: Evolution of IT services. *Management Research Review*, 35(8), 664–675. <https://doi.org/10.1108/01409171211247677>
- Ding, Q., Tang, B., Manden, P., & Ren, J. (2018). A learning-based cost management system for cloud computing. *2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC)*, 362–367.

- Dong, C., Wang, Y., Aldweesh, A., McCorry, P., & van Moorsel, A. (2017). Betrayal, Distrust, and Rationality: Smart Counter-Collusion Contracts for Verifiable Cloud Computing. *Proceedings of the 2017 ACM SIGSAC Conference on Computer and Communications Security*, 211–227. <https://doi.org/10.1145/3133956.3134032>
- Duncan, B. (2018). Can eu general data protection regulation compliance be achieved when using cloud computing? *Cloud Computing*, 1–6.
- Eisenhardt, K. M. (1989). Agency Theory: An Assessment and Review. *Academy of Management Review*, 14(1), 57–74. <https://doi.org/10.5465/amr.1989.4279003>
- Ellis. (2012, May 15). Top 10 Cloud Influencers, Thought Leaders. *Wired*. <https://www.wired.com/insights/2012/05/top-10-cloud-influencers/>
- Ellman, J., Lee, N., & Jin, N. (2018). Cloud computing deployment: A cost-modelling case-study. *Wireless Networks*. <https://doi.org/10.1007/s11276-018-1881-2>
- Ellram, L. (1993). Total Cost of Ownership: Elements and Implementation. *International Journal of Purchasing and Materials Management*, 29(3), 2–11. <https://doi.org/10.1111/j.1745-493X.1993.tb00013.x>
- Ellram, L. (1994). A taxonomy of total cost of ownership models. *Journal of Business Logistics*, 15(1), 171.
- Ellram, L. M., & Siferd, S. P. (1993). Purchasing: The Cornerstone of The Total Cost of Ownership Concept. *Journal of Business Logistics : JBL*, 14(1).
- Erek, K., Proehl, T., & Zarnekow, R. (2014). Managing Cloud Services with IT Service Management Practices. In M. Mora, J. Marx Gómez, L. Garrido, & F. C. Pérez (Eds.), *Engineering and Management of IT-based Service Systems: An Intelligent Decision-Making Support Systems Approach* (pp. 67–81). Springer. https://doi.org/10.1007/978-3-642-39928-2_4
- Evans, B. (n.d.). *The Top 5 Cloud-Computing Vendors: #1 Microsoft, #2 Amazon, #3 IBM, #4 Salesforce, #5 SAP*. Forbes. Retrieved April 29, 2021, from

<https://www.forbes.com/sites/bobevans1/2017/11/07/the-top-5-cloud-computing-vendors-1-microsoft-2-amazon-3-ibm-4-salesforce-5-sap/>

Fisher, C. (2018). Cloud versus On-Premise Computing. *American Journal of Industrial and Business Management, 08*(09), 1991–2006. <https://doi.org/10.4236/ajibm.2018.89133>

Foster, I., Zhao, Y., Raicu, I., & Lu, S. (2008). Cloud Computing and Grid Computing 360-Degree Compared. *2008 Grid Computing Environments Workshop*, 1–10.

<https://doi.org/10.1109/GCE.2008.4738445>

Gartner. (2021, April 21). *Gartner Forecasts Worldwide Public Cloud End-User Spending to Grow 23% in 2021*. Gartner. <https://www.gartner.com/en/newsroom/press-releases/2021-04-21-gartner-forecasts-worldwide-public-cloud-end-user-spending-to-grow-23-percent-in-2021>

Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17.5 Percent in 2019. (n.d.). Gartner.

Retrieved April 29, 2021, from <https://www.gartner.com/en/newsroom/press-releases/2019-04-02-gartner-forecasts-worldwide-public-cloud-revenue-to-g>

Geyskens, I., Steenkamp, J.-B. E. M., & Kumar, N. (2006). Make, Buy, or Ally: A Transaction Cost Theory Meta-Analysis. *Academy of Management Journal, 49*(3), 519–543.

<https://doi.org/10.5465/amj.2006.21794670>

Gorden, R. L. (1998). *Basic interviewing skills*. Waveland Press.

Grossman, R. L. (2009). The Case for Cloud Computing. *IT Professional, 11*(2), 23–27.

<https://doi.org/10.1109/MITP.2009.40>

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition, 5*(2), 199–220. <https://doi.org/10.1006/knac.1993.1008>

Guha, R., & Al-Dabass, D. (2010). Impact of Web 2.0 and Cloud Computing Platform on Software Engineering. *2010 International Symposium on Electronic System Design*, 213–218.

<https://doi.org/10.1109/ISED.2010.48>

- Han, R., Ghanem, M. M., Guo, L., Guo, Y., & Osmond, M. (2014). Enabling cost-aware and adaptive elasticity of multi-tier cloud applications. *Future Generation Computer Systems, 32*, 82–98. <https://doi.org/10.1016/j.future.2012.05.018>
- Hanafizadeh, P., & Zareravasan, A. (2020). A Systematic Literature Review on IT Outsourcing Decision and Future Research Directions. *Journal of Global Information Management (JGIM), 28*(2), 160–201. <https://doi.org/10.4018/JGIM.2020040108>
- Harmon, R., Demirkan, H., Hefley, B., & Auseklis, N. (2009). Pricing Strategies for Information Technology Services: A Value-Based Approach. *2009 42nd Hawaii International Conference on System Sciences*, 1–10. <https://doi.org/10.1109/HICSS.2009.350>
- Hauff, S., Huntgeburth, J., & Veit, D. (2014). Exploring uncertainties in a marketplace for cloud computing: A revelatory case study. *Journal of Business Economics, 84*(3), 441–468. <https://doi.org/10.1007/s11573-014-0719-3>
- Hevner, A., & Chatterjee, S. (2010). Design science research in information systems. In *Design research in information systems* (pp. 9–22). Springer.
- Hevner, A. R. (2007). A three cycle view of design science research. *Scandinavian Journal of Information Systems, 19*(2), 4.
- Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly, 28*(1), 75–105. <https://doi.org/10.2307/25148625>
- Hofmann, P., & Woods, D. (2010). Cloud Computing: The Limits of Public Clouds for Business Applications. *IEEE Internet Computing, 14*(6), 90–93. <https://doi.org/10.1109/MIC.2010.136>
- Hsu, P.-F., Ray, S., & Li-Hsieh, Y.-Y. (2014). Examining cloud computing adoption intention, pricing mechanism, and deployment model. *International Journal of Information Management, 34*(4), 474–488. <https://doi.org/10.1016/j.ijinfomgt.2014.04.006>

- Husáková, M., & Bureš, V. (2020). Formal Ontologies in Information Systems Development: A Systematic Review. *Information*, 11(2), 66. <https://doi.org/10.3390/info11020066>
- Jain, T., & Hazra, J. (2019). Hybrid Cloud Computing Investment Strategies. *Production and Operations Management*, 28(5), 1272–1284. <https://doi.org/10.1111/poms.12991>
- Jayeola, O., Sidek, S., Abd Rahman, A., Mahomed, A. S. B., & Hu, J. (2022). Cloud Computing Adoption in Small and Medium Enterprises (SMEs): A Systematic Literature Review and Directions for Future Research. *International Journal of Business and Society*, 23(1), 226–243.
- Jeans, D. (2022, 01). *Amazon's Devoted Cloud Customers Face A Decision After Outages: Leave, Stay Or Diversify?* <https://www.forbes.com/sites/davidjeans/2022/01/27/amazon-aws-outages-multi-cloud/>
- Kashef, M. M., & Altmann, J. (2012). A Cost Model for Hybrid Clouds. In K. Vanmechelen, J. Altmann, & O. F. Rana (Eds.), *Economics of Grids, Clouds, Systems, and Services* (pp. 46–60). Springer. https://doi.org/10.1007/978-3-642-28675-9_4
- Kawatra, K., & Kumar, V. (2017). Cost benefit analysis of cloud computing in education. *International Journal of Business Information Systems*, 27, 205. <https://doi.org/10.1504/IJBIS.2018.10009814>
- Khandkar, S. H. (2009). Open coding. *University of Calgary*, 23, 2009.
- Klems, M., Nimis, J., & Tai, S. (2009). Do Clouds Compute? A Framework for Estimating the Value of Cloud Computing. In C. Weinhardt, S. Luckner, & J. Stößer (Eds.), *Designing E-Business Systems. Markets, Services, and Networks* (pp. 110–123). Springer. https://doi.org/10.1007/978-3-642-01256-3_10
- Lampe, U., Siebenhaar, M., Hans, R., Schuller, D., & Steinmetz, R. (2012). Let the Clouds Compute: Cost-Efficient Workload Distribution in Infrastructure Clouds. In K. Vanmechelen, J. Altmann, & O. F. Rana (Eds.), *Economics of Grids, Clouds, Systems, and Services* (pp. 91–101). Springer. https://doi.org/10.1007/978-3-642-35194-5_7

- Li, H., Dai, Y., Tian, L., & Yang, H. (2009). Identity-Based Authentication for Cloud Computing. In M. G. Jaatun, G. Zhao, & C. Rong (Eds.), *Cloud Computing* (pp. 157–166). Springer.
https://doi.org/10.1007/978-3-642-10665-1_14
- Li, Z., & Keung, J. (2010). Software Cost Estimation Framework for Service-Oriented Architecture Systems Using Divide-and-Conquer Approach. *2010 Fifth IEEE International Symposium on Service Oriented System Engineering*, 47–54. <https://doi.org/10.1109/SOSE.2010.29>
- Lian, J.-W., Yen, D. C., & Wang, Y.-T. (2014). An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital. *International Journal of Information Management*, 34(1), 28–36. <https://doi.org/10.1016/j.ijinfomgt.2013.09.004>
- Low, C., Chen, Y., & Wu, M. (2011). Understanding the determinants of cloud computing adoption. *Industrial Management & Data Systems*, 111(7), 1006–1023.
<https://doi.org/10.1108/02635571111161262>
- Makhlouf, R. (2020a). Cloudy transaction costs: A dive into cloud computing economics. *Journal of Cloud Computing*, 9(1), 1. <https://doi.org/10.1186/s13677-019-0149-4>
- Makhlouf, R. (2020b). Cloud computing is a cost saver only if...: Towards a model for cloud cost estimation: student research abstract. *Proceedings of the 35th Annual ACM Symposium on Applied Computing*, 176–179. <https://doi.org/10.1145/3341105.3374223>
- Marston, S., Li, Z., Bandyopadhyay, S., Zhang, J., & Ghalsasi, A. (2011). Cloud computing—The business perspective. *Decision Support Systems*, 51(1), 176–189.
<https://doi.org/10.1016/j.dss.2010.12.006>
- Martens, B., & Teuteberg, F. (2011). Towards a Reference Model for Risk and Compliance Management of IT Services in a Cloud Computing Environment. In F. Keuper, C. Oecking, & A. Degenhardt (Eds.), *Application Management: Challenges – Service Creation – Strategies* (pp. 135–163). Gabler. https://doi.org/10.1007/978-3-8349-6492-2_6

- Martens, B., & Teuteberg, F. (2012). Decision-making in cloud computing environments: A cost and risk based approach. *Information Systems Frontiers*, 14(4), 871–893.
<https://doi.org/10.1007/s10796-011-9317-x>
- Martens, B., Walterbusch, M., & Teuteberg, F. (2012). Costing of Cloud Computing Services: A Total Cost of Ownership Approach. *2012 45th Hawaii International Conference on System Sciences*, 1563–1572. <https://doi.org/10.1109/HICSS.2012.186>
- McCafferty, D. (2015). How Unexpected Costs Create a 'Cloud Hangover'. *CIO Insight*, URL: <https://www.cioinsight.com/it-strategy/cloud-virtualization/slideshows/how-unexpected-costs-create-a-cloud-hangover.html>.
- McKeen, J. D., & Smith, H. (2010). Developments in Practice XXXVII: Total Cost of Ownership. *Communications of the Association for Information Systems*, 27(1).
<https://doi.org/10.17705/1CAIS.02732>
- Meghana, K., Latha, Y. M., Kumar, V. S. D., & Angadi, S. (2013). Methodology of cloud computing. *International Journal of Emerging Science and Engineering (IJESE)*, 1(5), 53–55.
- Mell, P., Grance, T., & others. (2011). *The NIST definition of cloud computing*.
- Mietzner, R., Unger, T., Titze, R., & Leymann, F. (2009). Combining Different Multi-tenancy Patterns in Service-Oriented Applications. *2009 IEEE International Enterprise Distributed Object Computing Conference*, 131–140. <https://doi.org/10.1109/EDOC.2009.13>
- Muhleman, R., Kim, P., Homan, J. V., & Breese-Vitelli, J. (2012). Cloud Computing: Should I Stay or Should I Cloud? *The Conference on Information Systems Applied Research*, 1508.
- Nayak, J., Naik, B., Jena, A., Barik, R. K., & Das, H. (2018). Nature inspired optimizations in cloud computing: Applications and challenges. In *Cloud computing for optimization: Foundations, applications, and challenges* (pp. 1–26). Springer.

- Ngwenyama, O. K., & Bryson, N. (1999). Making the information systems outsourcing decision: A transaction cost approach to analyzing outsourcing decision problems. *European Journal of Operational Research*, *115*(2), 351–367. [https://doi.org/10.1016/S0377-2217\(97\)00171-9](https://doi.org/10.1016/S0377-2217(97)00171-9)
- Noor, T. H., Zeadally, S., Alfazi, A., & Sheng, Q. Z. (2018). Mobile cloud computing: Challenges and future research directions. *Journal of Network and Computer Applications*, *115*, 70–85.
- Nuseibeh, H. (2011). Adoption of Cloud Computing in Organizations. *AMCIS*.
- O’Loughlin, M. (2016). IT service Management and cloud computing. *Axelos. Acedido*, 01–11.
- Oracle. (2016). *Oracle Cloud Adoption Principles*.
<https://www.oracle.com/us/products/consulting/resource-library/oraclecloudadoptionprinciples-3006727.pdf>
- Pal, R., & Hui, P. (2012). Economic Models for Cloud Service Markets. In L. Bononi, A. K. Datta, S. Devismes, & A. Misra (Eds.), *Distributed Computing and Networking* (pp. 382–396). Springer.
https://doi.org/10.1007/978-3-642-25959-3_28
- Pallas, F. (2014). An Agency Perspective to Cloud Computing. In J. Altmann, K. Vanmechelen, & O. F. Rana (Eds.), *Economics of Grids, Clouds, Systems, and Services* (pp. 36–51). Springer International Publishing. https://doi.org/10.1007/978-3-319-14609-6_3
- Peffer, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. <https://doi.org/10.2753/MIS0742-1222240302>
- Posner, E. A. (2000). *Agency Models in Law and Economics* (SSRN Scholarly Paper ID 204872). Social Science Research Network. <https://doi.org/10.2139/ssrn.204872>
- Rastogi, R., & Aggarwal, N. (2022). A Review on Virtualization and Cloud Security. *2022 2nd International Conference on Innovative Practices in Technology and Management (ICIPTM)*, *2*, 162–166.

- Rosati, P., Fowley, F., Pahl, C., Taibi, D., & Lynn, T. (2019). Right Scaling for Right Pricing: A Case Study on Total Cost of Ownership Measurement for Cloud Migration. In V. M. Muñoz, D. Ferguson, M. Helfert, & C. Pahl (Eds.), *Cloud Computing and Services Science* (pp. 190–214). Springer International Publishing. https://doi.org/10.1007/978-3-030-29193-8_10
- Rowley, J. (2002). Using case studies in research. *Management Research News*, 25(1), 16–27. <https://doi.org/10.1108/01409170210782990>
- Sahandi, R., Alkhalil, A., & Opara-Martins, J. (2013). Cloud computing from smes perspective: A survey-based investigation. *Journal of Information Technology Management*, 24(1), 1–12.
- Sasubilli, M. K., & R, V. (2021). Cloud Computing Security Challenges, Threats and Vulnerabilities. 2021 6th International Conference on Inventive Computation Technologies (ICICT), 476–480. <https://doi.org/10.1109/ICICT50816.2021.9358709>
- Schubert, L., & Jeffery, K. (2012). Advances in clouds. *Report of the Cloud Computing Expert Working Group. European Commission.*
- Sharma, M., Gupta, R., & Acharya, P. (2020). Prioritizing the critical factors of cloud computing adoption using multi-criteria decision-making techniques. *Global Business Review*, 21(1), 142–161.
- Shelanski, H. A., & Klein, P. G. (1995). Empirical Research in Transaction Cost Economics: A Review and Assessment. *Journal of Law, Economics, & Organization*, 11(2), 335–361.
- Singer, G., Livenson, I., Dumas, M., Srirama, S. N., & Norbistrath, U. (2010). Towards a model for cloud computing cost estimation with reserved instances. *Proc. of 2nd Int. ICST Conf. on Cloud Computing, CloudComp 2010.*
- Singh, D., Banyal, R., & Sharma, A. K. (2019). Cloud Computing Research Issues, Challenges, and Future Directions. In *Emerging Trends in Expert Applications and Security* (pp. 617–623). Springer.
- Strebel, J., & Stage, A. (2010). An economic decision model for business software application deployment on hybrid cloud environments. *Multikonferenz Wirtschaftsinformatik, 2010*, 47.

- Sun, P. (2020). Security and privacy protection in cloud computing: Discussions and challenges. *Journal of Network and Computer Applications*, 160, 102642.
- Sunyaev, A. (2020). Cloud Computing. In A. Sunyaev (Ed.), *Internet Computing: Principles of Distributed Systems and Emerging Internet-Based Technologies* (pp. 195–236). Springer International Publishing. https://doi.org/10.1007/978-3-030-34957-8_7
- Truong, H.-L., & Dustdar, S. (2010). Composable cost estimation and monitoring for computational applications in cloud computing environments. *Procedia Computer Science*, 1(1), 2175–2184. <https://doi.org/10.1016/j.procs.2010.04.243>
- Tsai, W.-T., Sun, X., & Balasooriya, J. (2010). Service-Oriented Cloud Computing Architecture. *2010 Seventh International Conference on Information Technology: New Generations*, 684–689. <https://doi.org/10.1109/ITNG.2010.214>
- van der Werff, L., Fox, G., Masevic, I., Emeakaroha, V. C., Morrison, J. P., & Lynn, T. (2019). Building consumer trust in the cloud: An experimental analysis of the cloud trust label approach. *Journal of Cloud Computing*, 8(1), 6. <https://doi.org/10.1186/s13677-019-0129-8>
- Vaquero, L. M., Rodero-Merino, L., Caceres, J., & Lindner, M. (2009). A break in the clouds: Towards a cloud definition. *ACM SIGCOMM Computer Communication Review*, 39(1), 50–55. <https://doi.org/10.1145/1496091.1496100>
- Varghese, B., & Buyya, R. (2018). Next generation cloud computing: New trends and research directions. *Future Generation Computer Systems*, 79, 849–861.
- Vithayathil, J. (2018). Will cloud computing make the Information Technology (IT) department obsolete? *Information Systems Journal*, 28(4), 634–649. <https://doi.org/10.1111/isj.12151>
- vom Brocke, J., Winter, R., Hevner, A., & Maedche, A. (2020). Special Issue Editorial – Accumulation and Evolution of Design Knowledge in Design Science Research: A Journey Through Time and Space. *Journal of the Association for Information Systems*, 21(3). <https://doi.org/10.17705/1jais.00611>

- Vouk, M. A. (2008). Cloud Computing – Issues, Research and Implementations. *Journal of Computing and Information Technology*, 16(4), 235–246. <https://doi.org/10.2498/cit.1001391>
- Walterbusch, M., Martens, B., & Teuteberg, F. (2013). Evaluating cloud computing services from a total cost of ownership perspective. *Management Research Review*, 36(6), 613–638. <https://doi.org/10.1108/01409171311325769>
- Wei, Y., & Blake, M. B. (2010). Service-Oriented Computing and Cloud Computing: Challenges and Opportunities. *IEEE Internet Computing*, 14(6), 72–75. <https://doi.org/10.1109/MIC.2010.147>
- Weinhardt, C., An, A., Blau, B., & Stöber, J. (2009). Cloud Computing – A. *Classification, Business Models, and Research Directions*". *Business & Information Systems Engineering*.
- West, D. M. (2010). *Saving money through cloud computing*. Governance Studies at Brookings.
- Williamson, O. E. (1979). Transaction-Cost Economics: The Governance of Contractual Relations. *The Journal of Law and Economics*, 22(2), 233–261. <https://doi.org/10.1086/466942>
- Williamson, O. E. (2002). The Theory of the Firm as Governance Structure: From Choice to Contract. *Journal of Economic Perspectives*, 16(3), 171–195. <https://doi.org/10.1257/089533002760278776>
- Yigitbasioglu, O. (2014). Modelling the intention to adopt cloud computing services: A transaction cost theory perspective. *Australasian Journal of Information Systems*, 18(3), 193–210.
- Yimam, D., & Fernandez, E. B. (2016). A survey of compliance issues in cloud computing. *Journal of Internet Services and Applications*, 7(1), 1–12.
- Yin, R. K. (2009). *Case Study Research: Design and Methods*. SAGE.
- Youseff, L., Butrico, M., & Da Silva, D. (2008). Toward a Unified Ontology of Cloud Computing. *2008 Grid Computing Environments Workshop*, 1–10. <https://doi.org/10.1109/GCE.2008.4738443>

Zhang, Q., Cheng, L., & Boutaba, R. (2010). Cloud computing: State-of-the-art and research challenges. *Journal of Internet Services and Applications*, 1(1), 7–18. <https://doi.org/10.1007/s13174-010-0007-6>

Zimmerman, D. (2014). Five cloud essentials for the boardroom: What banking and financial markets executives need to know about cloud computing. *Journal of Payments Strategy & Systems*, 8(1), 84–93.

10 Appendix

10.1 Interview Guide

RQ1

What are the business process reengineering activities required upon cloud adoption?

RQ 1.1: What are the required changes in the IT organization upon cloud adoption?

1. Q: How do the IT department processes change upon cloud adoption? How different is that in the different service types SAAS, PaaS, and IAAS?
2. Q: How different are the project management activities in cloud adoption projects from normal IT projects?
3. Q: What are the continuous integration and continuous delivery (CI/CD) practices and tools you suggest to the customers? (To automate software delivery lifecycle through automated builds and testing).
4. Q: If we are to divide the adoption process into phases, what could they be? What are the quality activities you suggest in each phase?
5. Q: What are the amendments you would suggest in the GRC (Governance, risk management, and compliance) processes? How different are the GRC processes for the cloud services from the on-premises systems? Is there a difference between SaaS, PaaS, and IaaS?
6. Q: Who is responsible for managing the IT portfolio when the customer adopts a cloud service? If it is the vendor, how do you calculate the cost for that?
7. Q: What could be the difference in IT portfolio management activities before and after introducing the cloud?
8. Q: What configuration management tools do you suggest for your customers? According to the AWS adoption framework, *'Repeated service delivery management processes should be automated to improve efficiency and accuracy and reduce cost. IT infrastructure definitions should be captured in industry-standard notation and stored in configuration management tools, just like code. You use these definitions to automatically re-create the IT infrastructure when needed.'*
9. Q: *'Business process redesign needs to be done in tandem with the cloud adoption.'* What are the business processes to be redesigned in the IT department? And Outside the IT department?
10. Q: Do some customers require more security foundations than others according to the type of their business and data? How is that? How is that reflected in costs? Do your cloud services require certain security software or systems to be installed at the customers?

RQ1.2: Upon cloud adoption, what are the required changes in the business processes in affected business areas?

11. Q: What are the process changes in the affected business departments upon the cloud adoption? How different is that in the different service types SAAS, PaaS, and IAAS?
12. Q: In Oracle Cloud adoption principles, it is said that ‘the business must configure itself to do something unique and valuable’ for the technology to provide a competitive advantage. How do you comment on that? Do you agree with that?

RQ1.3: What are the required changes in the service management practices?

13. Q: How different is governance when the cloud is adopted? What is the difference between normal IT and cloud in the perspective of governance?
14. Q: ‘With the shift of platform products to the Cloud, it has become clear that many of the long-standing processes, methodologies, standards, and best practices will need to be augmented to adapt for Cloud computing’ (Oracle Cloud adoption principles, 2016) can you give some examples of those standards and best practices that will need to be changed?
15. Q: How will the ITIL/COBIT practices change after cloud adoption?
16. Under the ITIL processes, how will the process of service portfolio management change?
17. Under the ITIL processes, how will the process of financial management for IT services change?
18. Under the ITIL processes, how will the process of capacity management change?
19. Under the ITIL processes, how will the process of incident management change?
20. Under the ITIL processes, how will the process of service catalog management change?
21. Under the ITIL processes, how will the process of service level management change?
- 22.
23. Q: In the area of incident and problem management, what is the share between a vendor and a customer in those processes? What does the vendor do, and what does the customer do? How does the ITIL/ COBIT framework change here?
24. Q: How are ITIL/COBIT and your cloud services integrated? Who is responsible for such a task? ITIL consultant, the customer, or the vendor? Does this come included in your price/ TCO calculations? How does that differ in PaaS, SaaS, and IaaS?

RQ1.4: What are the change management activities required by a cloud customer to ensure successful adoption?

25. Q: What are the organizational structure changes needed in the IT department upon the cloud adoption? How different is that in the different service types SAAS, PaaS, and IAAS? What about outside the IT department?
26. Q: What are the competency gaps your customers usually find in the staffing of the cloud team?

27. Q: What are the IT roles required to support the adoption and running of cloud computing services? What are their job descriptions (qualifications/ knowledge/ experience) required to carry out the role effectively?
28. Q: What are the career planning activities that you suggest to ensure sustained cloud running? How does that differ by the various service types? (PaaS/ IaaS/ PaaS) . Q: What are the training courses and cloud certifications that you encourage your customers to provide to their staff?
29. Q: What are the skills and competencies needed in business units for managing the cloud? What are the career planning activities that you suggest to ensure sustained cloud adoption? How does that differ by the various service types? (PaaS/ IaaS/ PaaS)
30. Q: What activities do you suggest to customers to manage resistance to change? Within and outside the IT department.
31. Q: Talking about the importance of people in the organization and the need for new skills, it was stated that 'ways of measuring success will change as your organization migrate to cloud services ' (Oracle cloud adoption principles, 2016). Why is that? And how?

RQ 2: Based on the total cost of ownership approach, what are the costs that a customer should estimate before moving to the cloud?

32. What is your definition of TCO? How do you calculate it for the customer? How different is that in the different cloud services?
33. Q: 'the move from the Capex to Opex provides the need to consider all costs associated with the delivery of the service' (Oracle cloud adoption principles, 2016). Can you give examples of these costs?
34. Q: Were you involved in projects where customers were more ready than other customers for cloud adoption? What were the aspects of readiness? Organizational and technical.
35. Q: If a customer is currently using a cloud service of another vendor and wants to switch to your company, what are the difficulties or challenges this customer might face?
36. Q: How is the new cloud service integrated with on-premise systems?
37. Q: If a customer wants to integrate a service from your company with a service from another company, how feasible is that? What are the integration and interoperability mechanisms or middleware that a customer has to use?
38. Q: How can a customer ensure disaster recovery with other cloud vendors? What are the practices that you would suggest to a customer to ensure business continuity with other cloud players?
39. Q: Does your company provide a monitoring service for its cloud services? How important is that for performance and operational excellence?

10.2 Publications

This research project had further generated four papers. Paper 1 was an abstract paper to allow for discussing the expected output of this dissertation. Moreover, as a part of the Design Science Research approach applied in this research, paper 2 was an addition to the knowledge base as it applied one of the kernel theories on the problem space and provided a part of the solution that was later on included in the artifact. Finally, the reuse of the design knowledge asks recording creative insights that contributed to building the final artifact. Thus, papers 3 and 4 explain in detail some of the creative insights the emerged form designing the cost estimation model. These two papers are still to be published.

	Title	Description	Publication details
Paper 1	Student Research Abstract: Cloud Computing is a Cost Saver only if...: Towards a Model for Cloud Cost Estimation	An abstract paper explaining the motivation of the research project while providing some preliminary findings.	<ul style="list-style-type: none"> ○ SAC '20: Proceedings of the 35th Annual ACM Symposium on Applied Computing ○ March 2020 ○ Pages 176–179 ○ https://doi.org/10.1145/3341105.3374223
Paper 2	Cloudy transaction costs: a dive into cloud computing economics	An application of TCT to some of the research findings, providing an addition to the knowledge base.	<ul style="list-style-type: none"> ○ Journal of Cloud Computing: Advances, Systems and Applications ○ January 2020 ○ https://doi.org/10.1186/s13677-019-0149-4
Paper 3	Cloud Meta-services: an Ontological Contribution	Explicit conceptualization of an important cost area to be added to existing cloud ontologies.	To be Published
Paper 4	Contracting for the Cloud: An Analysis	An attempt to estimate the costs from a legal lens	To be published

	of Costs and Issues	using Transaction Cost Theory and Agency Theory Co authored with K.Chawla from Tilburg School of Economics and Management.	
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