CHAPTER 2

Measuring the Business Value of Infrastructure Migration to the Cloud

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Abstract Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS) adoption typically require radical changes in an organisation's IT operations and have widespread implications that go beyond simple cost savings. This chapter presents a practical framework for estimating the Return on Investment (ROI) for IaaS and PaaS from the customer perspective. The proposed framework aims to overcome the main limitations of commonly-used Total Cost of Ownership (TCO) calculators by including both tangible and intangible costs and benefits to provide a more comprehensive ROI estimation. The application of the framework is illustrated using a real-life case study of infrastructure migration.

Keywords Infrastructure-as-a-service • Platform-as-a-service • Return-on-investment

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2.1 Introduction

Cloud computing platforms and applications are proliferating across firms of all sizes worldwide becoming the *de facto* computing paradigm of choice. According to IDG (2018), 73 percent of organisations have at least a portion of their computing infrastructure already in the cloud, and another 17 percent plan to adopt cloud solutions within the short-term. While cloud computing is a well-known reality for large enterprises today, recent years have seen a surge in cloud spending by smaller organisations (IDG 2018). This has resulted in significant growth in the public cloud services market which is now projected to reach $331.2 billion by 2022 (Gartner 2019). Software-as-a-Service (SaaS) is the most common type of cloud computing service and accounts for approximately 43 percent of the market while infrastructure-related services i.e. IaaS and PaaS account for approximately 25 percent of the current market and are experiencing the highest growth rate (Gartner 2019).

The technical benefits of the cloud are well-documented and typically relate to on-demand, self-service resources orchestration, resource pooling and elasticity (Armbrust et al. 2010; Cegielski et al. 2012; Brender and Markov 2013). Cloud computing is also very attractive from a business point of view as it requires lower upfront investment, reduced risk, and improved organisational agility and efficiency (Armbrust et al. 2010; Marston et al. 2011; Leimbach et al. 2014). However, the adoption of cloud computing may also create challenges for firms when an in-depth financial and technical analysis has not been carried out in advance. While selecting the right cloud architecture and the right provider is crucial for an effective delivery of a cloud application, a proper financial analysis is required to make sure the application delivery is sustainable and cost-effective.

As outlined in Chap. 1, there a number a number of methodologies for an *ex-ante* estimation of the business value of cloud migration or adoption (see also Farbey et al. (1993) and Farbey and Finkelstein (2001) for a more detailed discussion) that can be directly applied to IaaS and PaaS services and should be leveraged to better inform the investment decision-making process (Ronchi et al. 2010; Rosati et al. 2019). Total Cost of Ownership (TCO) is arguably the most frequently used technique when it comes to evaluating different cloud vendors and services (Strebel and Stage 2010; Rosati et al. 2017). However, it is important to highlight that

TCO only focuses on cost savings and omits other potential benefits. In contrast, a Return on Investment (ROI) analysis considers the wider strategic implications of cloud adoption and therefore provides a more robust basis for investment decisions (Strebel and Stage 2010; Rosati et al. 2017).

The main objectives of this chapter are to present a practical framework for estimating the ROI on cloud infrastructure and to present a case study to demonstrate how the framework can be applied to an infrastructure migration scenario. The reminder of this chapter is organised as follows. Next, we provide an overview of IaaS and PaaS. Then we introduce the ROI estimation framework followed by a case study. Finally, we conclude the chapter with a discussion and avenues for future research.

2.2 Cloud Architecture and Business Value

Cloud computing adoption for business applications provides a number of potential benefits but the actual realisation of these benefits is not always straightforward. A careful evaluation of the suitability of different cloud solutions for a given business model or application is required. This is not a trivial task given the large number of cloud vendors and associated services available in the market. Despite the recent growth of different service models (Kächele et al. 2013), SaaS, PaaS and IaaS still account for the vast majority of the market (Gartner 2019). In this chapter, we specifically focus on IaaS and PaaS. These two service models, although different in nature, share a number of value drivers that users should explore when estimating the expected benefits of adoption. Figure 2.1 provides visual representation of the main differences between the traditional legacy technology stack and different cloud services.

The US National Institute of Standards and Technology (NIST) defines IaaS as:

> *The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).* (Mell and Grance 2011, p. 3)

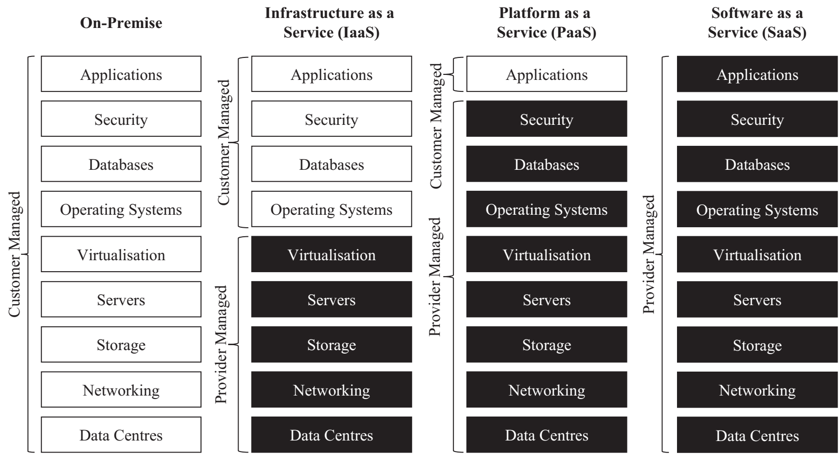

Fig. 2.1 Overview of different cloud services

As such, IaaS provides users with a high level of flexibility but requires a high level of IT skills in order to optimise and manage the infrastructure. In fact, developers are still required to design and code entire applications and IT administrators still need to install, manage, and integrate third-party solutions. Key benefits of IaaS are related to the fact that the typical tasks related to managing and maintaining a physical infrastructure are not required anymore, and additional infrastructure resources are available on demand and can be deployed in minutes instead of days or weeks (Kavis 2014).

PaaS is defined as:

> *The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.* (Mell and Grance 2011, pp. 2–3)

PaaS sits on top of the cloud infrastructure and abstracts most of the standard application functions such as caching, database scaling, security, logging etc. and provides them as a service (Kavis 2014). Similar to IaaS, the user controls the self-installed applications but not the underlying infrastructure and platform. PaaS services mostly speak to developers as the PaaS vendors typically provide them with a suite of tools for speeding up the development process. Cloud platforms also facilitate the development of cloud native systems which, according to the Cloud Native Computing Foundation (CNCF 2018), are increasingly:

- Container-packaged;
- Dynamically managed by a central orchestrating process;
- Microservice-oriented.

Cloud native applications provide clear technical advantages in terms of isolation and reusability, which lower costs associated with maintenance and operations (Rosati et al. 2019). Both IaaS and PaaS are typically consumed by SaaS providers, which in turn offer their services to the final user in exchange for monthly or annual subscription fees (Cusumano 2008; Ojala 2012). In this context, a proper estimation of the TCO and ROI of the cloud represents the basis for adequate and effective pricing strategies, and for evaluating investment decisions (Rosati et al. 2019).

2.3 Measuring the ROI of a Cloud Infrastructure

ROI is one of several financial metrics available to business decision makers to estimate the expected financial outcomes of an investment (Farbey and Finkelstein 2001; Rosati et al. 2017). While TCO focuses merely on costs, ROI includes both costs and benefits therefore providing a more forward-looking and comprehensive assessment of an investment. Despite the fact that the benefits of cloud computing extend well beyond cost savings, these have historically been the main drivers of adoption (CFO Research 2012). Unsurprisingly, TCO, rather than more strategic ROI, has been the main metric of cloud investment evaluation (Brinda and Heric 2017). TCO is attractive as, compared to ROI, it is easier to estimate, and cloud vendors make online TCO calculators available to their customers. However, these tools only focus on relatively simplistic tangible operational cost calculations (Rosati et al. 2017). A similar approach only provides a partial picture of the costs and benefits generated by cloud computing and may under- or over-estimate the financial outcomes of cloud investments and ultimately translate in to sub-optimal investments. To address this limitation, we present a more comprehensive framework for estimating the ROI of cloud investments for IaaS/PaaS (Fig. 2.2).

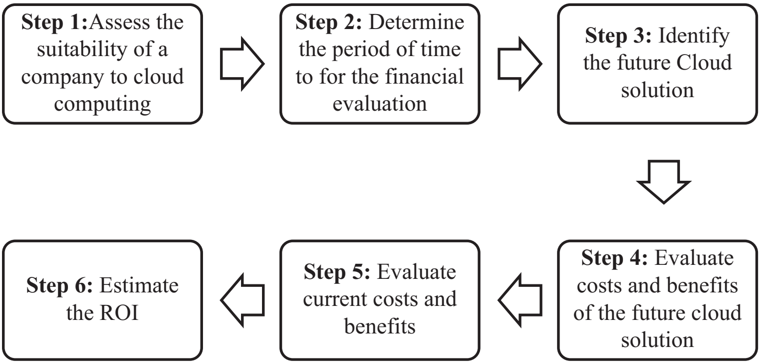

Fig. 2.2 Organisational ROI estimation framework for cloud computing investments

2.3.1 *Step 1: Suitability to Cloud Computing*

The initial phase of the ROI calculation is an assessment of the suitability of the organisation for the adoption of cloud computing. Despite the hype around cloud computing and the promising statements of cloud vendors, IaaS/PaaS adoption may not be the most effective and efficient solution for every organisation or every application deployed by or within an organisation (McKinsey and Company 2009; Misra and Mondall 2011). Misra and Mondall (2011) provide a weighted scoring model for estimating a suitability index. The model includes the following aspects:

- Size of IT resources and customer base characteristics: smaller organisations whose IT infrastructure is based in one country and that generate relatively limited amount of revenues from IT offering are more suitable to cloud computing than IT giants.
- The utilisation pattern of IT resources: cloud computing is particularly attractive for organisations with a highly variable workload profile as they can benefit from the on-demand scalability typical of cloud infrastructures.
- Sensitivity of the data handled by the organisation: cloud services may be riskier for organisations handling very sensitive data, particularly for applications running a public cloud.
- Workload criticality: highly critical workloads require more stringent, reliable and secure resources therefore it may be difficult to find a cloud vendor that is able to provide an adequate Service-Level Agreement (SLA).

The outcome of this initial step may prevent organisations that are clearly not suitable for the cloud from wasting additional resources in the evaluation process. The suitability index may also provide sort of a reality-check for estimated ROI as organisations that are more suitable for the cloud should expect a higher return on investment (Misra and Mondall 2011; Walterbusch et al. 2013).

2.3.2 Step 2: Determine the Period of Time for the Financial Evaluation

Five years is the typical time frame for estimating the ROI of large IT investments such as a cloud infrastructure. This is because the initial implementation requires time and resources; shorter time periods may not be long enough to capitalise such initial investment. Five years is not a fixed rule. Organisations should evaluate cloud investments within the most appropriate time frame for them considering the amount of investment, the overall expected duration of the investment, and its relationship with the overall strategic plan of the organisation. It should be said though that the longer the time frame the harder it becomes to estimate reliable figures associated with costs and benefits. This is particularly the case in fast-changing business environments where technologies, applications, and business models quickly become obsolete.

2.3.3 Step 3: Identify the Future Cloud Solution

The range of cloud computing offerings is very diverse and fragmented. This often makes very difficult to compare one cloud provider or service against others (Rehman et al. 2011). A number of different selection techniques and approaches have been developed over time which are more or less suitable for different cloud services (see Sun et al. (2014) for a detailed review). Regardless of the selection technique adopted, it is critical to identify a *to-be* solution that is directly comparable to the existing architecture. This does not mean that the two alternative architectures have to be comparable from a technical perspective. In fact, this may not be possible due to the different nature of cloud and on-premise solutions. However, they should be able to meet the same business requirements, and monetary values should be measured consistently across the two scenarios (ISACA 2012). Table 2.1 provides a list of key elements to consider during this phase.

Table 2.1 Key objectives of cloud service selection (adapted from ISACA (2012))

Objective	*Guidance/key questions to answers*
Define high-level business (functional) requirements	• What business functions need to be covered? • What are the business drivers for adopting cloud-based services? • How could cloud based services support business processes? • What compliance requirements are relevant?
Define a baseline cloud service model	• What type of cloud service model (e.g. IaaS, PaaS etc.)? • What kind of deployment model (e.g. public, private etc.)? • Where would the services be physically located? • Who would deliver the services? • Start with a model that is simple and low-cost and then exclude options that do not meet compliance and risk requirements.
Assess risks associated with the selected cloud model	• Identify risk areas to be considered (e.g. multitenancy, data usage limitations, security, privacy, migration costs etc.). • Determine countermeasures to mitigate the areas of risk outside the organisation's risk tolerance. These may include: – Data encryption – A revert-back strategy – On-premise backups and audit trailing – Clear and comprehensive SLA – In-house disaster recovery strategy.

2.3.4 *Step 4: Evaluate the Future Costs and Benefits*

Costs and benefits evaluation is arguably the central activity of the ROI estimation. In this step, both operational and non-operational implications of cloud adoption should be taken into account. Costs can be grouped into three main categories i.e. upfront, recurring and termination costs. Table 2.2 provides an overview of the key cost components to be considered for each cost category. This list should not be considered as either rigid or exhaustive. Organisations should carry out their own assessment of potential direct and indirect costs associated with cloud adoption. For example, migration costs are not relevant for organisations aiming to design a greenfield cloud native application.

Table 2.2 Cost categories for the cloud

Category	*Key cost components to consider*
Upfront costs	• Start-up costs to prepare for the transition to the cloud • Technical/legal/consulting costs related to assessing/evaluating cloud alternatives and technical readiness • Network/bandwidth investments • Technical costs (including staff) for implementation/integration • Staff training • Change management
Recurring costs	• Cloud service(s) subscription fees • Cloud consumption costs (server, storage, database, network, throughput, CSP support fees) • Personnel costs (IT, finance, Human Resources)
Termination costs	• Costs relating to contract termination (legal/technical/consulting) • Early termination penalties • Alternative cloud service provider evaluation costs • Technical costs (data extraction/sanitisation) • Reinvestment or transfer back to on-premise (hardware acquisition and setup costs)

Similarly, the benefits generated by the adoption of cloud services can be grouped in to two main categories: tangible and intangible (ISACA 2012). Tangible benefits are clearly easier to identify and typically include additional revenues, faster time-to-market, lower operational costs etc. However, a significant portion of the value generated by the cloud adoption typically fall in to the second category. Figure 2.3 provides an overview of the potential benefits of cloud adoption for business applications. As per the cost drivers presented above, organisations should carry out their own assessment to identify which benefits may actually apply to their specific context.

2.3.5 *Step 5: Evaluate the as-is Costs and Benefits*

ROI estimation should be based on the comparison between two alternative scenarios. In the context of cloud adoption, the alternative scenario is typically an on-premise solution. Care needs to be taken when considering on-premise costs versus those in the cloud. While many are similar, there often subtle differences. Table 2.3 provides an overview of the key cost components to be considered for each cost category.

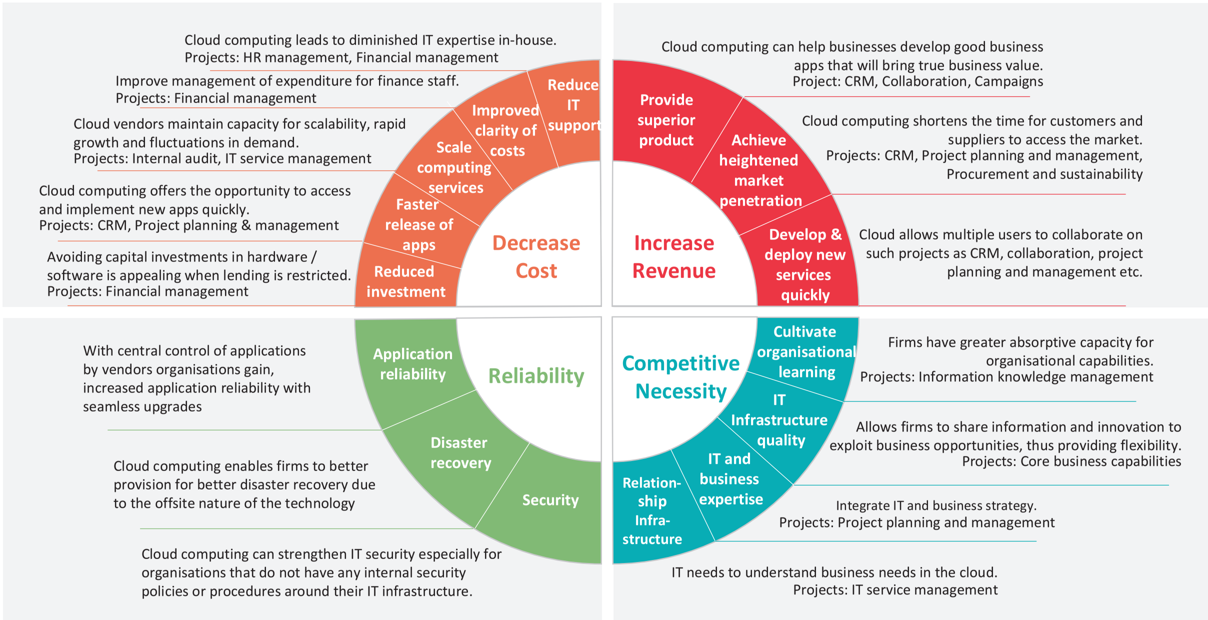

Fig. 2.3 IC4 Cloud computing strategic alignment model (Lynn 2018)

Table 2.3 Description and explanation of cost categories for on-premise

Category	*Key components to consider*
Upfront costs	• Large capital expenditure and investments in: – Physical hardware and infrastructure – Bandwidth – Software – Property and facilities, heating and cooling – Staff training – Procurements costs
Recurring costs	• Ongoing operational costs such as: – Utilities (electricity, bandwidth) – Premises and facilities (security, physical access, HVAC, electrical and UPS) – Property costs (rent and rates) – IT audits – IT personnel costs (maintenance, admin, developer) – Software/OS licenses
Termination (disposal) costs	• Disposal of physical hardware and infrastructure components • Depreciation • Compliance costs (secure data backup/cleansing) • Secure removal and disposal of IT and associated equipment

The benefits of the on-premise solution are then measured using the current performance of the organisation in terms of revenues, growth, customer satisfaction etc. Both costs and benefits of the on-premise solution represent the baseline for evaluating the incremental value or costs generated by the cloud adoption.

2.3.6 Step 6: Evaluate the as-is Costs and Benefits

The last step in the process consists of inserting all the numbers gathered in the previous steps in to an extended version of the ROI formula as presented in equation below:

$$\mathrm{ROI} = \frac{\begin{array}{c}\left[\left(\text{Tangible Benefits} + \text{Intangible Benefits}\right) - \right. \\ \left.\left(\text{Upfront Costs} + \text{Recurring Costs} + \text{Termination Costs}\right)\right]\end{array}}{\left(\text{Upfront Costs} + \text{Recurring Costs} + \text{Termination Costs}\right)} \tag{2.1}$$

where

$$\text{Cloud TCO} = \text{Upfront Costs} + \text{Recurring Costs} + \text{Termination Costs} \tag{2.2}$$

and

$$\text{Tangible Benefits} = \text{Incremental Revenues} + \text{Lower Costs} \tag{2.3}$$

In the case of a cloud migration rather than a greenfield cloud adoption, the additional value generated by the investment should be measured as the incremental value the cloud generates compared to the previous architecture. Therefore Eq. (2.1) would become:

$$\text{ROI} = \frac{\Delta \text{Gross Profit Margin}}{\text{TCO}} \tag{2.4}$$

where

$$\begin{aligned}\Delta \text{Gross Profit Margin} = {} & \left(\text{Revenues}_{\text{Cloud}} - \text{TCO}_{\text{Cloud}} + \text{Additional Savings}_{\text{Cloud}}\right) \\ & - \left(\text{Revenues}_{\text{Premise}} - \text{TCO}_{\text{Premise}}\right)\end{aligned} \tag{2.5}$$

2.4 Case Study

This section presents the application of this framework to a real-life study of a cloud infrastructure migration. We specifically focus on IaaS rather than PaaS adoption as the former requires estimating more cost components than the latter. As such, IaaS adoption provides a more comprehensive example that can then be adapted to a PaaS adoption scenario.

2.4.1 Company and Application Overview

The Company participating to this study operates in the financial services industry and provides a suite of applications for the delivery and support of financial and business technology solutions across EMEA, South America, Asia and Australasia. Through its development of proprietary technology, the Company has developed core products for currency conversion, multi-currency pricing, commercial and retail foreign exchange. In the year prior to the study, the Company reached almost €200 million in revenues and had almost 200 employees. The specific application being migrated has a customer and user base across Europe and the South Pacific region which includes both Business-to-Consumer (B2C) and Business-to-Business (B2B) customers.

When the forex exchange application was first developed, the Company did not consider cloud technology to be sufficiently sophisticated and capable of hosting it. They therefore decided to install it on an on-premise infrastructure in the Company's headquarters. The application was originally monolithic by design. However, over several years the Company incrementally migrated the application to a microservices architecture.

As the cloud evolved and adoption became mainstream, the Company has already moved its Continuous Integration and Quality Assurance environments into a containerisation model running on Microsoft Azure. These environments are managed by the Company's internal development team. In addition to the application servers, the cloud migration includes a container registry, a source code repository, a configuration server, and SQL databases. The development team also intend to use containerisation in its production environments. The Company indicated that the environments for user acceptance testing and production (currently managed by the internal infrastructure team) may also be migrated, depending of the outcome of the ROI estimation.

2.4.2 Suitability Index

The Company's main business drivers behind its decision to adopt the cloud are:

- Efficiency gains through automation of IT operations and implementation of site reliability engineering principles and practices;
- greater efficiency in development lifecycle;
- increased performance and reliability of applications;
- reduced cost;
- technical scalability to support business growth.

The Company's current IT setup is capable of supporting two million transactions per year across 1000 POS terminals while the Company requires the capability to scale to 30,000 terminals and 50 million transactions annually.

The initial step of the ROI calculation involves assessing the suitability of the Company to the cloud. A questionnaire was designed in order to capture all the information required to estimate the suitability index as proposed by Misra and Mondall (2011):

Size of the Company's IT resources: The infrastructure comprised a cluster of less than 100 servers and is hosted on-premise in a local data centre in the Company's headquarters. The customer base is geographically dispersed across Europe and the South Pacific and is served by the on-premise infrastructure. An indication of the size of Company's customer base can be derived from the scale of their operations, and their transaction volumes; the current system is capable of supporting 2 million transactions per year across 1000 POS terminals across the regions listed above.

Utilisation pattern of the resources: The Company may experience some peak surges by virtue of the fact that their system provides an online retail currency conversion service, and such transactions are typically seasonal in nature. As such, the Company's utilisation pattern could be profiled as having moderately variable workloads with occasional surges.

Sensitivity of the data they are handling: The Company classified the sensitivity levels of the data they handle as "sensitive" (personal information, contact details) and "very sensitive" (bank related data, transactional data). The data captured during customer transactions on the forex application is limited to the customer's name, address and proof of identification. The system does not handle and process online credit card payments thus credit card information is not stored. As such, the company has no PCI DSS compliance requirements. Currently, payments are processed using the 3D secure authentication standard with a third-party service provider. There are other related compliance requirements for service management and customer value (ISO 20000-1) and information security management (ISO 27001) that the Company has to adhere too.

Workload criticality: The Company indicated that migrating the RFX application was highly critical. A primary reason for this is the ease with which cloud services enable firms to easily and efficiently handle potential failover situations, thereby preserving business continuity and preventing data loss. This circumvents and eliminates the internal administrative overhead required for presenting the business case for the purchase of additional hardware.

Given the information provided above and the weights proposed in Misra and Mondall (2011), the Company obtained a suitability index of 3876 which falls within the intermediate category (Misra and Mondall 2011). This suggests that further investigation such as an ROI study is required before deciding to adopt the cloud infrastructure.

2.4.3 ROI Estimation

A five-year time frame was adopted for the ROI study and the Company was asked to fill in a detailed questionnaire in order to identify the required costs and expected revenues associated with both the current on-premise solution and the alternative cloud infrastructure. This phase of the study spanned over three months and required the involvement of ten people across five different departments i.e. top management, IT, finance, business unit, and human resources.

Both the cloud (*to-be*) and the on-premise infrastructure (*as-is*) were designed to deliver the same amount of revenues over the time period of the analysis. Therefore, any change in value has to be driven by the cost reduction and/or intangible benefits. Table 2.4 summarises the TCO calculation for both scenarios.

The cloud infrastructure is expected to generate a cost saving of €352,464 over five years mostly due to the lower upfront costs and no termination costs. In fact, the estimated upfront costs of the cloud solution only included IT training (€9000) and cloud assessment and consulting costs (€20,000). The company also identified a number of potential intangible benefits related to cloud migration such as:

- enhanced productivity;
- improved compliance and security;
- the ability to focus on core business;
- access to the cloud provider's expertise and capabilities.

These suggest an approximate total net positive cost saving of €81,000. This ultimately results in an expected ROI of:

$$\text{ROI} = \frac{€352,464 + €81,000}{€3,086,188} = \frac{€433,464}{€3,086,188} = 14.05\%$$

Table 2.4 TCO summary

On-premise		*Cloud*	
Upfront on-premise cost	€114,500	Upfront cloud cost	€29,000
Recurring on-premise cost	€3,316,652	Recurring cloud cost	€3,057,188
Termination on-premise cost	€7500	Termination cloud cost	€0
TCO on-premise	€3,438,652	TCO cloud	€3,086,188

Based on the positive, although not very high, expected ROI and considering other further strategic considerations, the Company decided to migrate the RFX application to the cloud. The Company also realised that an unforeseen benefit arising from the project was the increased transparency and comparison of the costs associated with their on-premise infrastructure and that of their cloud service consumption. This may help with decision making and developing the business case for future considerations when deciding between a reinvestment in on-premise hardware or adopting cloud services.

2.5 Conclusion

In this chapter, we presented a practical framework for estimating the return on cloud computing investments from the customer perspective. We focused specifically on Infrastructure-as-a-Service and Platform-as-a-Service as they have more extensive organisational implications than simpler SaaS applications. Several online tools and methodologies based on relatively simplistic tangible operational cost calculations have been made available to firms for calculating the total cost of ownership of their cloud investments. However, cloud services also generate intangible costs and benefits that should be taken into account when embarking on the cloud journey. Investment decisions taken on the basis of partial assessments of the potential business value generated by cloud adoption may result in sub-optimal budget and capital allocation and ultimately undermine an organisation's competitive advantage. Our framework aims to overcome such limitations by providing a step-by-step process for estimating a comprehensive ROI of cloud adoption. The actual implementation of the framework is shown though a real-life case study of infrastructure migration.

Future research may explore how the ROI estimation framework presented above can be adapted to different cloud migration scenarios (Jamshidi et al. 2013) or to relatively new paradigms of cloud computing such as serverless computing (or Function-as-a-Service—FaaS) (Lynn et al. 2017). Finally, further studies may also investigate the relationship between the adoption of more comprehensive ROI measures to and the effectiveness of IT investment decision-making.

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