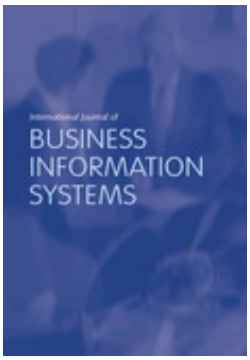


International Journal of Business Information Systems

ISSN online: 1746-0980 - ISSN print: 1746-0972
https://www.inderscience.com/ijbis

Return on investment-based suitability assessment model for cloud migration

Asma Zubaida Mohamed Ibrahim, Masnida Hussin

DOI: 10.1504/IJBIS.2021.10041730

Article History:

Received:	11 March 2020
Accepted:	08 March 2021
Published online:	24 January 2025

Return on investment-based suitability assessment model for cloud migration

Asma Zubaida Mohamed Ibrahim*

City University Malaysia,
U No, Menara City, 8, Jalan 51a/223, Seksyen 51a,
46100, Petaling Jaya, Selangor, Malaysia
Email: asmaamri2012@gmail.com
*Corresponding author

Masnida Hussin

Faculty Computer Science Information Technology,
Universiti Putra Malaysia,
43400 UPM Serdang, Selangor Darul Ehsan, Malaysia
Email: masnida@upm.edu.my

Abstract: Many IT-based organisations have shown an interest in moving their business operation into a cloud-enabled system as they noticed that cloud-oriented gives better revenue and return. In order to migrate, there are many operational features that need to be assessed. For the cloud migration process, the assessment of the organisation is important to ensure the business revenue and returns remain positive. However, due to the fact that numerous business data needs to be collected and analysed, some organisations do not take that action seriously. Failing to carefully measure such data/information for cloud migration will have effect on the return on investment (RoI) outcome. In this work, we present a practical model called as SAROIC for estimating the suitability and the return on investment of cloud computing migrations from the cloud user perspective. This model aims to overcome such limitations by providing a step-by-step process for estimating a comprehensive ROI of cloud migration. This will further help the cloud user in decision making.

Keywords: cloud computing; suitability assessment; return on investment; RoI; cloud migration; decision making.

Reference to this paper should be made as follows: Ibrahim, A.Z.M. and Hussin, M. (2025) 'Return on investment-based suitability assessment model for cloud migration', *Int. J. Business Information Systems*, Vol. 48, No. 1, pp.1–25.

Biographical notes: Asma Zubaida Mohamed Ibrahim is a Lecturer at Faculty of Information Technology, City University Malaysia. She is doing her PhD in University Putra Malaysia in last year. Her main research is cloud computing information system. She has published several work cloud computing in SCADA.

Masnida Hussin is a Senior Lecturer at the Department of Communication Technology and Network, Faculty of Computer Science and IT, University Putra Malaysia, Malaysia. She received her PhD from University of Sydney, Australia in 2012. Mainly her research interest is resource management such as

scheduling, allocation and edge analytic for large-scale parallel and distributed computing. She involved in several network projects such as cloud computing, network cloudification and green computing. She is a member of the IEEE since 2008, also has published several numbers of papers that related to parallel and distributed computing. She also became editorial board member/reviewer in several national and international journals.

1 Introduction

Cloud computing is one of the major improvements in information and communication technology (ICT) that provide benefits, competitive edge, and assist to gain a commendable position to organisations. Cloud computing plays a key enabling role in the success of other distributed and network services such as the internet of things (IoT), big data, block-chain technology and others (Akinrolabu et al., 2019; Rosati et al., 2017; Parker and Bach, 2020). It further facilitates the vast and massive data production that makes a huge impact and significant in business operation. In respects to the growing of cloud computing technology, various sectors (i.e., government, industry) start to have an interest on how the cloud eventually could improve their products and returns. Such sectors have invested a vast amount of money to manage and sustain the network infrastructure including equipment in the data centre, IT specialists, internet service costs, etc. (Wu et al., 2015; Piparo, 2020). Given the widely known advantages of cloud computing, many IT-based organisations have shown interests in moving their legacy assets to cloud environments. Note that one of the main benefits of migrating to cloud is the cost reduction (Rosati et al., 2017). However, there is a huge investment had needs to be made towards maintaining the virtualisation yet high-performance infrastructure. Hence, a measuring tool is needed for assessing the usability of cloud computing in the organisation. Many enterprise software applications that support IT functions are characterised in the need for high computing capability, scalability and resource consumption (Chawla and Kumar, 2017; Akinrolabu et al., 2019). Although rapid progression has been recorded in the area of cloud computing and its services, attaining the implementation of cloud is still under development and there is a lot of room for improvement (Patil and Patil, 2019). It is a necessity for appropriate financial planning in analysing the company's investment prior to adapting this new technology into their business. However, there are existing organisations that run the applications/systems that do not meet the cloud features as it was developed prior to cloud computing (Chang, 2016). According to Kawatra and Kumar (2018), the organisations do not apprehend the benefits of cloud computing due to the deficiency of knowledge and the boundaries idea of the new technologies. Therefore, it slows down the organisations on performing cloud migration for their business to a larger extent. Furthermore, the lack of a standard set of metrics makes the cloud migration more complex (Vidhyalakshmi and Kumar, 2016).

For instance, the migration process needs to consider the virtualisation aspects as it is the foundation of cloud computing. Thus, the virtualisation becomes an additional factor or might be a new factor to be considered in assessing significance for the organisation to migrate its current business operation infrastructure to cloud. The return on investment (RoI) is the most widely used as a measuring tool of financial success in business (Islam

et al., 2017). Generally, it is used as the key performance indicator (KPI) in the organisations to determine investment versus profit.

The ability to effectively calculate the RoI can be a valuable guidance for any business operation, regardless of industry size for knowing the investment's impact that had been made. RoI also becomes as one of the standard that used to understand the financial matrices in cloud migration (Misra and Mondal, 2011; Chawla and Kumar, 2017; Akinrolabu et al., 2019). To help the organisation in making better decision, the total cost of ownership (TCO) and RoI could assist in supplying well-defined costing information. In this work, we study the computing factors which related to cloud environment that influence the business operation. We are taking into consideration types of operational factors (e.g., tangible, intangible and cost) from real business operation. By using the RoI-based suitability assessment the organisations can save the time and easily adapt to the new ICT technology like cloud computing to be embedded into their business operation.

The remainder of this paper is organised as follows. Section 2 describes literature analysis on suitability and RoI factors. Section 3 details the theoretical and empirical method of analysis. The output from empirical study is in Section 4. SAROIC model development presented in Section 5. Section 6 is the implementation of SAROIC model: a case study. Finally, Section 7 concludes the paper.

2 Literature analysis on suitability and RoI factors

In this section, we analysed and focused on suitability and RoI factors from the existing models and frameworks that significantly affected the organisation's investment and revenue for cloud migration. Later, we will review on the cost analysis models that were used to measure the cloud environment.

2.1 Suitability and RoI factors

RoI is as a measurement tool of financial realisation that is widely used in organisations. It is related to the proportional increase of value in an investment over period of time (Misra and Mondal, 2011). It can be measured in different ways: by decreasing investment, increasing revenue, decreasing costs and making profit faster (Rosati et al., 2017). This is due to the interoperability between the cost factors and expenses' fluctuation more reckonings, rather than the absolute values in long-term business operation. In order to make sure that the value of RoI is accurately calculated, we studied and analysed several factors from existing literature that related to suitability function for cloud migration. Given in Table 1 and Table 2 are the source of computing factors for both suitability and RoI scopes that taking into consideration technical/research papers within five years from 2014 until 2019. The aims are to make sure these are the latest factors used in cloud computing requirements.

As shown in Table 1, the 21 key factors have dominated the suitability factors in cloud computing where there are proposed using various approaches, i.e., optimisation, heuristic, learning mechanism, etc. Meanwhile in Table 2, there are ten factors pertinent to the RoI that used in the business operation. These reveal that the suitability and the RoI

factors are significant to take into consideration in order to utilise the ICT services like cloud computing.

Table 1 Factors identified for suitability in cloud

Suitability factors		*Source*
1	Number of servers	Islam et al. (2017), Patil and Patil (2019), Lynn et al. (2020)
2	Size of customer-base	Fitó and Guitart (2014), Lynn et al. (2020)
3	Annual revenue	Kauffman et al. (2018), Patil and Patil (2019)
4	Countries spread	Singh (2017)
5	Duration of peak usage	Ghosh et al. (2015), Misra and Mondal (2011), Lynn et al. (2020)
6	Peak by average	Misra and Mondal (2011), Lynn et al. (2020)
7	Types of services	Lynn et al. (2020)
8	Types of project undertaken	Gholami et al. (2016)
9	Amount of data handling	Wu et al. (2015)
10	Sensitivity of data handled	Misra and Mondal (2011)
11	Critical work done	Misra and Mondal (2011), Lynn et al. (2020)
12	Confidential	Bellandi et al. (2015)
13	Integrity	Halabi and Bellaiche (2018), Ahmed (2017), Masdari and Zangakani (2020)
14	Availability	
15	Pay-as-you-go	Ajeh et al. (2014), Misra and Mondal (2011), Lynn et al. (2020)
16	Faster deployment	Vidhyalakshmi and Kumar (2016)
17	Scalability	Alemeye and Getahun (2015), Vidhyalakshmi and Kumar (2016)
18	Quality of services	Ghosh et al. (2015)
19	Web collaboration	Lee (2017)
20	Enabler for top line growth	Vidhyalakshmi and Kumar (2016)
21	Checklist cloud solution	Jamshidi et al. (2014)

Table 2 Factors identified for RoI in cloud

RoI factors		*Source*
1	Cost reduction	Kawatra and Kumar (2018), Rosati et al. (2017), Lynn et al. (2020), Stewart et al. (2018), Skourletopoulos et al. (2017)
2	Enhanced productivity	
3	Optimise resource utilisation	
4	Improve security	
5	Access to skill and capabilities	
6	Scalability	
7	Agility	
8	Consumer satisfaction	
9	Reliability	
10	Performance	

2.2 Cost-benefit analysis model

There are existing cost-benefit analysis models and frameworks (Rosati et al., 2017; Misra and Mondal, 2011) that have been studied and developed for analysing the impact of cloud computing. Such models were broadly discussed concerning cost-benefits analysis in cloud migration including TCO and RoI. We then classified the model according to:

1 tested

2 not tested to the real user after it has been developed.

Models that were not been tested means it has not been implemented or verified in the organisations or in any suitable situations.

2.2.1 Tested models

We will first discuss the cost-analysis models that have been tested in several business scenarios. In Lynn et al. (2020), the authors have tested the model on a company has already moved its continuous integration and quality assurance environments into a containerisation model running on Microsoft Azure. 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. The cost-analysis model in Aldahwan and Saleh (2018) is proposed by identifying the tangible and intangible benefits of the cloud computing. In this model, they used the higher learning institution (HLI) as a case study to identify the tangible and intangible benefits. However, their model was only tested based on one HLI. The authors in Nanath and Pillai (2013) proposed the cost-analysis model for cloud computing which has been tested in selected projects in Czech Republic. However, the project criteria were not clearly stated. The model for cost-analysis in Aldahwan and Saleh (2018) has been tested towards Amazon as the cloud service provider (CSP) in their organisation. The model was tested with small sample size. The aim was to decide either to adapt Amazon's cloud or not. Kawatra and Kumar (2018) proposed the cost-analysis model that based on the size of operating premises. It was also to decide for Amazon Web Server (AWS) cloud migration. However, the business-related factors like client size and price were not part in their decision-making policy. Goyal (2014) has proposed the cost-analysis model that was tested within the organisation using limited high-performance computing (HPC) configuration. They replicated the hardware and turning them into virtual machines while renting the actual cloud service from the public and private cloud vendors. A business-driven framework for evaluating cloud computing that proposed by Sripanidkulchai and Sujichantararat (2012) was tested for migrating to infrastructure-as-a-service (IaaS). Meanwhile, in Chandra and Borah (2012), the cost-analysis model was developed for assessing the government of India that yet to adapt the cloud technology. They limit the data sources including the factors that involved in developing the model. But they have discussed in their future work to dynamically capture the user's request pattern and cache mobile devices' contents for better assessing during migrating process.

2.2.2 Not tested model

There are cost-analysis models, i.e., Ajeh et al. (2014), Chandra and Borah (2012), Jin et al. (2016) and Misra and Mondal (2011) that were not been tested to any organisations or in any suitable situations. The models were not fully developed, but the studies suggested that the tool might improve the assessing time, further making the decision-making process much easier. They also suggested that the model's results that have been generated through simulations can be used for future reference (Ajeh et al., 2014). Meanwhile in Wu et al. (2015), their cost-analysis model was focused on the multi-criteria decision support to study strategic trade-offs in adoption of cloud-based design, engineering analysis and manufacturing. Jin et al. (2016) added several other factors besides the computing factors, such as the quality of business experience in the evaluation formula. In Misra and Mondal (2011), the authors used their model for cloud migration in middle-size organisations.

3 Theoretical and empirical method of analysis

In order to develop the model, we used two investigation strategies which are theoretical study and empirical study. Specifically, the theoretical study aims to identify and discover suitable factors and ROI factors that significant in cloud services through systematic literature review (SLR). Whereas, the empirical study studied on real organisation feedbacks and perspectives in identifying significant factors that collected from the previous section and factors applied in their organisation.

3.1 Theoretical study

Theoretical study was formulated from the collective of literature reviews (refer Section 2) to identify the business-oriented factors (computing and non-computing factors) specifically that fit in cloud computing. It is the process to understand and predict the trend or phenomena while extending existing knowledge within the limits of assumptions (Dragan and Isaic-Maniu, 2017). We classified the literature studies into two types of related works which are published and unpublished documents. The published documents represent journals and conference proceedings that derived based on database searches such as IEEE, Elsevier, Springer and Google Scholar. Meanwhile, the unpublished documents are white papers of organisation, presentation papers and reference books. The snow ball technique (Sekaran and Bougie, 2010; Dragan and Isaic-Maniu, 2017) was used in this study to make further analysis on the published materials (i.e., journal and proceeding). Specifically, we begin the study by gathering and sorting the latest and recent years' papers related to cloud-oriented RoI. Backward snowball method (Wohlin, 2014) was used to dig in depth of the source of each identified paper by analysing publication year, the chosen domain of study and solution approach used. We then designed the conceptual model to set and plan the research questions, experimental methods and expected outcomes. But the conceptual model was not yet the real assessment model. It was merely a guideline model in order to exhibit a real one. In respond to cloud migration, it needs to be verified and tested in order to become the real model.

Therefore, the output of this theoretical study is the list of suitability factors and the RoI factors that will then be validated and verify in the empirical study.

3.2 Empirical study

In general, the empirical study is a way of gaining knowledge by means of direct and indirect observation or experience. The main of this study is to validate and verify the suitability factors and RoI factors that has been retrieve from the theoretical study. After the validation and verification of the factors are done, the model is developed. This model is known as the SAROIC model.

The empirical study involved a sequential process:

1 questionnaires preparation

2 respondents' identification

3 evidence collection strategy

4 conduct interview session

5 reporting process.

Initially, the interview questions were setup and verified to ensure it meets the study objectives. In our work, the empirical study did not merely aim for getting feedbacks from the respondents, it was to validate the process of our list of factors that derived from the theoretical study. In preparing the document for validating process, we used a sampling technique to filter all information from varies of sources (i.e., published and unpublished documents). It was then classified into a single and similar population. Selection of samples was made continuously until no further information was available; called as saturation process (Taherdoost, 2018). The respondents that were initially identified were contacted to setup an appointment. The respondents consist of academic staff, a software engineer, a software developer, a chief executive director, cloud services provider, an IT executive, a technical assistant and three project executives. We then grouped them into three major respondents which are ICT industries, academic sectors, and internet service providers (ISPs). The respondents' profile was selected based on their experience (more than three years) working and involving in cloud computing. The level of saturation reached once the number reached up to twenty respondents. We used audio recordings during the interview session where later it was transcript into text. The feedbacks and responses were well documented for reporting and analysing purposes. Our assessment model was then developed by referring to the inputs from extensive theoretical and empirical studies; where at each methodology there are different findings realised. It is significant to match and map both findings into a single form of concept in SAROIC model. There are two assessment modules in SAROIC which are suitability measurement module and RoI valuing module. Both modules are inter-related to each other depending on the suitability value as we are focusing more on the assessing the suitableness of organisation to be migrated to cloud environment. Note that the suitability issue is significant to ensure the business return meets the organisation's target. Prior to valuing RoI, we evaluated the relevant factors and form a suitability formula to identify the suitability threshold. Later, an index was produced for scaling the factors' significance. If the organisation earns a score that shows highly relevance for cloud

migration, then the assessment proceeds to RoI valuation. It is where the final level of readiness for cloud migration takes place. With the RoI outcome, it helps the organisation to make decisions either to continue for cloud migration process or not. We designed solutions for the organisation if the output identifies that the level of readiness is low; by providing suggestions to investigate more on other operational factors. However, the final decision is still depending on the organisation's business operation.

Our assessment model, the SAROIC was used to investigate for both computing and non-computing factors in prior to exploit RoI in the evaluation process. In relation to the existing cost-analysis models, our work initially was developed to closely cater the beneficial factors that proposed in Ajeh et al. (2014), Chandra and Borah (2012) and Jin et al. (2016). Our assessment model was then being tested in helping the potential adopters to be ready for cloud migration. For user acceptance testing purposes, we chose the education domain that relied on online system in running the organisation's business; as has been tested by Aldahwan and Saleh (2018). Our model further provides suggestion modules when the RoI value was negative.

4 Output from empirical study

The respondents in our empirical study were chosen from ICT industries (users), academic sector (academician), and ISPs as cloud providers. Based on the empirical study, it shows that consistent growing in data collection happened when it reached 20 respondents. We refer it as a saturation point. 60% of the respondents have more than five years of experience in ICT industries as cloud users. In response to our two modules in SAROIC model, the two main factors considered are the suitability factors and the RoI factors validation and verification is discussed.

4.1 Suitability factors

As part of the output from the theoretical study (mentioned in Section 3), we have listed cloud deployment factors that were taken from various sources of academic documents. The factors have been validated by the respondents in order to find the suitable factors that relevant in cloud migration. We group the level of applicability into not relevant (NR), moderate relevant (MR) and relevant (R). The input from the respondents (experts) is varied according to their expertise. However, we only take into account the R factor to cloud migration is when the responds reached more than 15 scores (Table 3). We set these scores at 15 to maintain the quality of this developed model. Fifteen scores above are chosen to make sure that at least 75% respondents agreed to the factors are relevant.

4.2 RoI factors

In identifying the RoI factors for cloud migration, we classified the business-related factors into separated group are the tangible and intangible benefits of cloud, upfront cost, recurring cost and termination cost. The process is similar as in the previous section where the listed factors were given to the experts. However, we chose 16 out of 20 respondents to be part in the interview regards to their experience in doing RoI outcome in their organisations. We only take into account the RoI factors to be modelled in to our SAROIC model when the score reached more than ten scores at R output. It is

shown in Table 4 to Table 8. This is to make sure that the chosen RoI factors for SAROIC are reflected from the real business requirements.

Table 3 Cloud deployment factors chosen for SAROIC

Suitability factors		*NR*	*MR*	*R*	*For SAROIC*
1	Number servers	0	0	20	√
2	Size customer-base	1	3	16	√
3	Annual revenue	1	2	17	√
4	Countries spread	2	3	15	√
5	Peak average	1	8	11	×
6	Types of services	2	10	8	×
7	Types of project undertaken	1	9	10	×
8	Amount of data handling	0	1	19	√
9	Sensitivity of data handled	0	1	19	√
10	Critical work	0	4	16	√
11	Confidential	1	1	18	√
12	Integrity	0	1	19	√
13	Availability	0	0	20	√
14	Pay-as-you-go	1	5	14	×
15	Faster deployment	3	5	12	×
16	Scalability	0	2	18	√
17	Quality of services	2	8	10	×
18	Web collaboration	5	11	4	×
19	Enabler for top line growth	14	4	2	×
20	Checklist cloud solution	14	3	3	×

Table 4 Tangible cloud factors

Factors	*NR*	*MR*	*R*	*For SAROIC*
Cost reduction	0	0	16	√
Enhanced productivity	4	4	8	×
Optimise resource utilisation	1	2	13	√
Improve security	0	1	15	√
Access to skill and capabilities	0	7	9	×
Scalability	0	1	15	√
Agility	0	1	15	√
Consumer satisfaction	1	7	8	×
Reliability	0	2	14	√
Performance	0	0	16	√

The output for this empirical study which is the significant factors (with √) for measuring suitability and RoI are used as main factors in SAROIC model. Only these significant factors will be measure in SAROIC model.

Table 5 Intangible cloud factors

Factors	*NR*	*MR*	*R*	*For SAROIC*
Avoidance of missed opportunity	3	5	8	×
Focus on core business	1	6	9	×
Employee satisfaction	1	1	14	√
Collaboration	0	1	15	√
Risk transfer	0	0	16	√

Table 6 Upfront cost

Factors	*NR*	*MR*	*R*	*For SAROIC*
Technical readiness	0	0	16	√
Implementation	0	0	16	√
Integration	1	1	14	√
Configuration	0	1	15	√
Training	0	6	10	√
Organisation change	0	8	8	×

Table 7 Recurring cost

Factors	*NR*	*MR*	*R*	*For SAROIC*
Cloud subscription	0	0	16	√
Change management	0	2	14	√
Internet cost	1	2	10	√
Vendor management	1	5	9	×
Cloud coordination	0	7	9	×
Risk mitigation	0	0	16	√
Downsize/upsize	0	2	12	√

Table 8 Termination cost

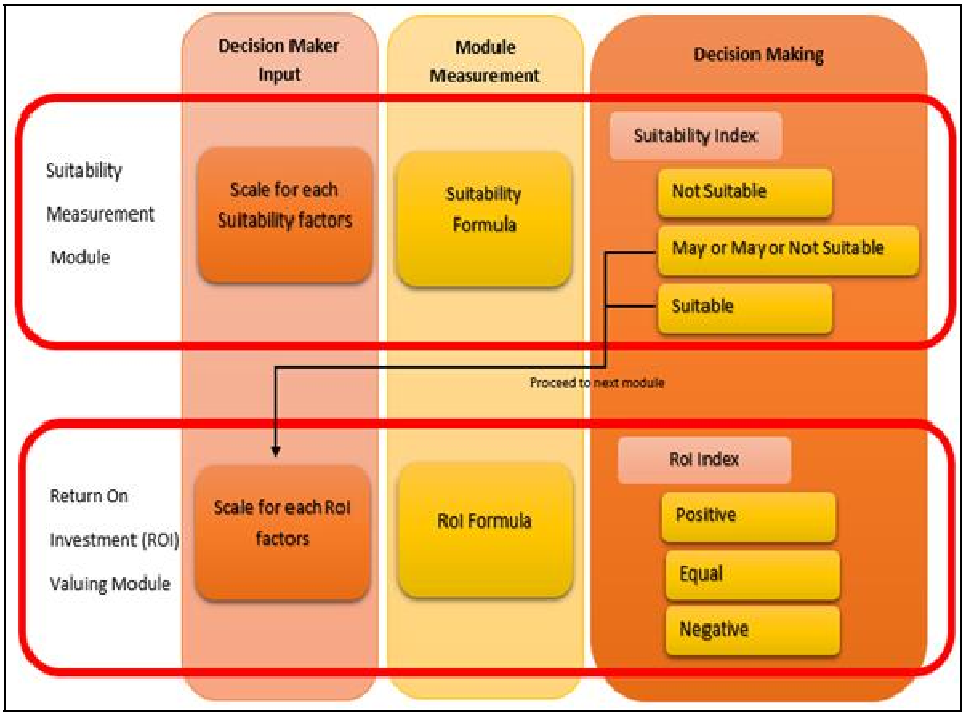
Factors	*NR*	*MR*	*R*	*For SAROIC*
Extracting data from the previous cloud providers' storage and checking for their accuracy and completeness	0	0	16	√
Configuration cost to replace cloud service	0	2	14	√
Penalties of early termination	1	2	13	√

As mentioned in the earlier section, our SAROIC consists of two assessment modules (i.e., suitability measurement and RoI valuing). The connection between these two modules is the suitability value. It is where the organisation must acquire certain value (as threshold) in the suitability measurement module in order to proceed to the RoI valuing module. The finale outcome of SAROIC model is the RoI index. Based on the RoI index, suggestions and descriptions were presented to the organisations as a guideline for making the final decision for cloud migration.

5 SAROIC model

Our SAROIC model (refer Figure 1) provides an in-depth study for assessing cloud migration from RoI perspective. This model provides a systematic assessment procedure that started from the suitability and RoI factors identification process up to validating process. In order to measure the suitableness of the organisation to adapt the cloud environment, there are two assessment modules that need to implement, i.e., suitability measurement module and RoI valuing module (refer Figure 1). Each module has different factors that influence in decision-making process for cloud migration. Those modules are given in details as follows.

Figure 1 SAROIC model (see online version for colours)



5.1 Suitability measurement module

The suitability in our model acts as a measurement parameter to assess readiness of the organisation for adapting the cloud environment in their business operation. It basically aims to minimise risks of mistakes and unreasonable high costs in the organisations (Islam et al., 2017). We utilised the suitability measurement that has been proposed in Misra and Mondal (2011). Such measurement was chosen due to the similarity in sampling size and populations with our work. As for SAROIC, the suitability measurement module is divided in two sections, which are suitability weightage and suitability formula (indexing).

5.1.1 Decision-making input

Based on the empirical study output (Section 4), we concluded that there are 11 factors from the business operation that were highly relevant for cloud migration in this SAROIC model. Table 9 summarise the 11 factors.

Table 9 Suitability factors

1	Number servers
2	Size of customer-base
3	Annual revenue
4	Countries spread
5	Amount of data handling
6	Sensitivity of data handled
7	Critical work done
8	Confidential
9	Integrity
10	Availability
11	Scalability

The factors were opted in our evaluation in order to scale their importance in the organisations' usage. From the 11 factors, we grouped them into several key factors which are largeness (L), value of security (VoS), workload variation (WV), scalability (SC) and critical work done (CWD). Those key factors and its attributes are given as follows.

5.1.1.1 Largeness (L)

This factor represents the size of IT resources or largeness of current resources in the organisations. It plays an important role in business operation in terms of costing and budgeting. By considering IT resource utilisation and maintenance costs, cloud computing has been found to be suitable for any type of organisations either large, small, or medium-scale size business enterprises (Islam et al., 2017; Misra and Mondal, 2011). In particular, the data centre that is able to support high processing capacity leads to reducing operation and maintenance costs (Basu et al., 2017). It causes the TCO of data centres to increase the resources processing capacity while reducing the IT resources costs. For organisations with adequately large data centres, they have the option to 'sell' their data centres and convert it into cloud environment. By 'selling' or insourcing the IT resources, it further improves the organisation's revenue. The three attributes taken into consideration in the L factor are:

a The number of servers (NoS) in data centre

   There are various numbers of servers that run in the data centre. We then grouped it into respective range as follows:

   - less than 100 servers (small)
   - from 101 to 2,000 servers (medium)
   - from 2,001 to 10,000 servers (large)

- more than 10,000 servers (very large).

b The number of countries (NoC) that spreads across

This attribute is mentioned by the authors in Chandra and Borah (2012) where NoC are significant when the CSPs have subsidise organisations that spread globally. For instance, if there are larger numbers of countries where the data centres are spread in, the greater number of resources able to facilitate various requirements. It implicitly reduces the operational cost. This attribute breaks up into several regional as follows:

- one country
- more than one but less than four countries
- less than or equal to six countries
- less than ten countries
- above ten countries.

c The annual revenue (AR) from IT section

It represents the amount of revenue generated from the IT resources of the organisation. It is important to decide either AR should still maintain in high yet offers convenient data centres or adapt seamless switch over to the cloud. It can be divided into several AR level as given below:

- less than $100 million (small)
- between $100–$500 million (medium)
- above $500 million (large).

5.1.1.2 Value of security

This key factor is to protect IT resources and data from unauthorised disclosure, fraud, waste, or abuse at all costs. Such security requirements are important to be well-assessed and verified before the organisation run in the cloud computing environment. Security issue is one of the major apparent deficiencies in cloud environment (Varghese and Buyya, 2018). The solutions for securing the cloud resources and guaranteeing its services are still an open challenge. The security attributes (Misra and Mondal, 2011) that addressed in our model are sensitivity of the data (SoD), confidentiality and privacy (CaP), integrity (I) and availability (A). We emphases the importance of VoS from the critical to not-critical security concerned as four attributes below:

a SoD

The definition of sensitivity may be vary according to organisation perceptions and the usage of the data (Akande and Van Belle, 2014). In our assessment model, the level of data sensitivity is divided into three; very sensitive, average sensitive and not sensitive. In addition, those data are considered ‘sensitive’ and subjected to specific processing conditions as follows:

- Personal data revealing racial or ethnic origin, political opinions, religious, or philosophical beliefs.
- Trade-union membership.
- Genetic data, biometric data processed solely to identify a human being.

- Health-related data.

b CaP

CaP refers to the prevention of the unauthorised access of the data (Djemame et al., 2016). We considered several levels of CaP in assessing the security aspects in the organisation and given as:

- Very confidential and privacy.
- Average CaP.
- Not-at-all confidential and privacy.

c Integrity (I)

The I attribute in the sense of security issue is referring to data which can only be accessed or modified by those authorised (Sharma, 2016). In order to assess the I attribute in the organisation; we have identified the importance according to several levels as follows:

- Very integrity: Data have never been compromised.
- Average of integrity: Less than two cases of data modification have occurred. The cases have been resolved.
- Not a concern for integrity: More than two cases of data modification have occurred. The cases have not yet been resolved.

d Availability (A)

The A attribute refers on how much time services are available for effectively running the business operation. Below is the scale that used as down time per year suggested by IBM (2019):

- < 99.999% not more than five minutes per year.
- < 99.9% not more than 526 minutes.
- 90.0% more than 36.5 days.

5.1.1.3 Workload variation

The WV key factor refers to resources and workloads that exist and run in the organisations. It is categorised into two separated attributes which are:

a Size of customer-base (SCB)

The SCB or the number of users is important indication to value the resources availability in the data centre. It also demonstrates the processing utilisation of the in-house data centre resources (Rosati et al., 2017). In Misra and Mondal (2011), the SCB were counted as more than 10 million, from 100,000 to 10 million, and less than 100,000. However, based on the on our empirical study, we had categorised the SCB as below:

- more than 500,000
- from 100,000 to 500,000
- less than 100,000.

b Amount of data handling (ADH)

This factor represents a number of data generated in a day. Large amount of data will require a large bandwidth in concerning data processing and storage in cloud environment (Vidhyalakshmi and Kumar, 2016). This attribute is significant to be considered in cloud migration due to extensive amount of cost that spent on the data which will affect the bandwidth maintenance and charges. In response to that, we have divided the ADH into several size of data:

- more than 100 terabytes/month
- from 1 to 100 terabytes/month
- from 500 gigabytes to 1 terabytes/month
- from 100 gigabytes to 500 gigabytes/month
- less than 100 gigabytes/month.

5.1.1.4 Scalability (SC)

The SC refers to the feature of the system in which every application or infrastructure is able to expand to handle and adapt the increased load. In cloud environment, SC enables data centre to accommodate larger workloads without disruption of existing infrastructure (Vidhyalakshmi and Kumar, 2016). For instance, it is important for the organisations to be scaled-up or down the data storage capacity to meet the demands of the business. In this work, we refer the SC in three levels as follows:

- organisation that do not need SC
- SC is needed in certain time
- organisation that really needs the SC because of the growing business.

5.1.1.5 Critical work done

This attribute refers to rigorous demands of resources, platforms, applications, and security that need to be handled by the organisations. In cloud environment, the CWD is important in order to deliver better quality of service (QoS). Particularly, the more critical to complete the demands, the more challenging in managing the processing requirements (Luna et al., 2015). We categorised the level of criticalness into:

- highly critical (may not be suitable for the cloud)
- critical (may be suitable if organisation is large)
- less critical (suitable)
- standard.

We then explicitly use the factors for assessing suitability and revealing its credit value (refer Table 10).

In order to calculate suitability value (threshold), each suitability factor is given a weightage. This weightage is used as significance indication of the suitability factor for cloud migration. The weightage of each factor is given by the respondents during empirical study where it ranged between 1 (the lowest) to 10 (the highest). Such

weightage aims to reveal the comparative importance of the factor to be used in suitability assessment. Note that the weightage given might work for some organisations, but not to others. The weightage can be modified by the organisations which are depending on the importance of the suitability factors to their current business.

Table 10 Recorded weightage for suitability factors

Suitability factors			*Weightage*
1	Credit for largeness (CL)		8
	a	Credit number of servers (CNoS)	8
	b	Credit number of countries (CNoC)	7
	c	Credit annual revenue (CAR)	4
2	Credit for value of security (CVoS)		1
	a	Credit sensitivity of data handled (CSoD)	6
	b	Credit confidential and privacy (CCaP)	8
	c	Credit integrity (CI)	8
	d	Credit availability (CA)	8
3	Credit workload variations (CWV)		6
	a	Credit size of customer-base (CSCB)	7
	b	Credit amount of data handling (CADH)	6
4	Credit of scalability (CSC)		1
5	Credit critical work done (CCWD)		1

5.1.2 Module measurement

Based on the identified suitability factors and the given weightage, the calculation for the suitability is carried using the formula as shown in Figure 2. This formula is derived from Misra and Mondal (2011). Enhancement has been made to the formula to adopt the VoS which has not been used for assessment in their work.

Figure 2 Suitability formula of SAROIC model

```
L = ((NoS ∗ CNoS) + (NoC ∗ CNoC) + (AR ∗ CAR)); // Largeness usage
VoS = ((SoD ∗ CSoD) + (CaP ∗ CCaP) + (I ∗ CI) + (A ∗ CA)); // Value of security
WV = ((4 – SCB) ∗ CSCB) ∗ 8) + (ADH ∗ CADH)); // Workload
CS = SC ∗ CSC; // Scalability
C = CWD ∗ CCWD; // Critical Work
Suitability value = ((L ∗ CL) + (WV ∗ CWV) + (CS ∗ ADH) + (C ∗ C(C ∗ (65 – L))) + VoS);
```

5.1.3 Decision making

Based on the suitability value, we then classified the measurement description into three groups of thresholds (refer Table 11). Such descriptive threshold is meant to provide inference either the organisation is ready or not for using and adapting the cloud computing in their business operation.

In our work, the organisation which obtained less than 975 suitability index were provided several solutions or strategies for improving its readiness for cloud migration. Mainly, the suggestions are for conducting further investigation on some operation matters such as the computing redundancy that incurred extra cost, ability to run in virtualised environment, security and industry regulations.

Table 11 Suitability index as threshold

Index	*Measurement description*
< 975	*Not suitable* for cloud migration
	May to reconsider the suitability factors
976 to 1,449	*May or may not be suitable* for cloud migration
	Further investigations need to be done
> 1,450	*Suitable* for cloud migration
	Proceed to RoI valuing

The cloud computing, by its nature, requires facilities and applications to be adapted as a service instead of physically present in the organisation data centre. Meanwhile, the system resources need to be adequately provided high availability to meet the employees and customer's demands. Note that some organisations are not yet willing to commit the time or additional budget to perform these transitions (Gholami et al., 2016). In addition, the organisations might feel unsecured and tried to sidestep from performing cloud migration.

The CSP normally handle the sensitive data that stored anywhere in a world. Hence, it needs a systematic planning from the organisation in order to gain the benefits from cloud computing environment. It is also important for the organisation to design and deal with their data compliance during the planning process prior to cloud migration. For example, there is an ISO 27017 (Wahlgren and Kowalski, 2013) that offered security guidelines for cloud migration.

As for the suitability index between 975 and 1,449, the organisation needs to thoroughly reinvestigate and recalculate the relevant factors. Otherwise, the organisations can try to proceed to the next module which is the RoI valuing. When the suitability index is at 1,450 and above, the organisations is considered fully ready for migrating their business operation into the cloud environment. The RoI valuing module takes place to further assess the readiness of the organisations in terms of investment/return when they migrated to cloud-enable computing environment. Note that only the organisations that reached the suitability index of more than 975 will execute the RoI outcome. That means not all organisations (or use-cases) will go through both assessment modules in SAROIC model.

5.2 RoI valuing module

There are two assessment steps to identify the RoI factors and calculating the RoI outcome in RoI valuing module of the SAROIC model. The RoI factors that were identified and classified in this work focus only those implemented in cloud environment. For RoI outcome, we utilised the formula that proposed by Vidhyalakshmi and Kumar (2016) as the formula meets with scope of study. Therefore, we do not introduce a new procedure or strategy in finding the RoI outcome.

5.2.1 Decision maker input

In regard to preliminary study, there are four key factors to identify the significant use of the RoI factors for assessing cloud migration. The factors are given as follows.

5.2.1.1 Tangible benefits and intangible benefits

Tangible benefits are calculated based on the cost difference of cloud and on-premise applications. Note that there are always options for the organisation to run their business on-premise application basis instead of utilising the cloud computing. Meanwhile, the intangible benefits are quantified by listing out the cloud application usage along with weightage and ranks. The intangible benefits may vary from customer to customer based on the business scenario for which cloud applications are used. The tangible cost included the server, hardware, network, storage, electricity usage, etc. The intangible cost can be varied such as the processing rack, shared and storage cost, salary of employees, performance changes, lighting, cooling, etc.

5.2.1.2 Upfront cost

The upfront costs are largely associated with the system development and integration, as well as the purchase and installation of computing infrastructure. It includes the continuing costs for capturing and transmitting real-time data, system upgrading process, general maintenance, and ongoing operation for increasing resource availability (Aldahwan and Saleh, 2018).

5.2.1.3 Recurring cost

The recurring cost is normally related to the license fee/price of the service which includes the maintenances of server, device and other hardware acquisition costs (Vidhyalakshmi and Kumar, 2016).

5.2.1.4 Termination cost

The CSP might charge their customers due to many reasons. One of the reasons is the termination cost after using the cloud services. There are some cases where the organisations stop the service at one CSP but continue with other CSP. It might be occurred due to the change in the business operation or goal (Vidhyalakshmi and Kumar, 2016).

5.2.2 Module measurement

The second valuing step in the RoI valuing module, two values was retrieved. These values; the TCO and the RoI value are meant for cloud environment.

5.2.2.1 Cloud TCO

The TCO analysis is intended to uncover the lifetime costs of acquiring, operating and maintaining services or assets. TCO is helpful to determine the difference between the purchasing price and the long-term cost of investment. For the classification of TCO,

three types of cost components will be used which are the upfront cost, recurring cost, and the termination cost as per discussed earlier. Given in Figure 3 is the TCO formula.

Figure 3 TCO formula

$$\text{TCO} = \sum(\text{Upront cost} + \text{Recurring cost} + \text{Termination cost})$$

5.2.2.2 Cloud RoI

In response to the identified RoI key factors, the RoI outcome is measured using the RoI formula given in Figure 4. Such formula is expended from the basic RoI formula (Chawla and Kumar, 2017) to meet our objective in cloud migration decision.

Figure 4 RoI formula

$$\text{RoI outcome} = \frac{\sum((\text{tangible} - \text{intangible}) - \text{uprontcost} + \text{recurringcost} + \text{terminationcost})}{\sqrt{\sum(\text{uprontcost} + \text{recurringcost} + \text{terminationcost})}}$$

5.2.3 Decision making

Once the organisations obtained the RoI outcome, it will be further investigated to distinguish the benefit of cloud migration for their business. Table 12 shows the three-level index for measuring such purpose. The three-level index was used by the authors in Vidhyalakshmi and Kumar (2016). Once the RoI valuing module measurement is complete, the organisation is aware of their RoI outcome and is able to decide either to continue with cloud migration or not.

Table 12 RoI index

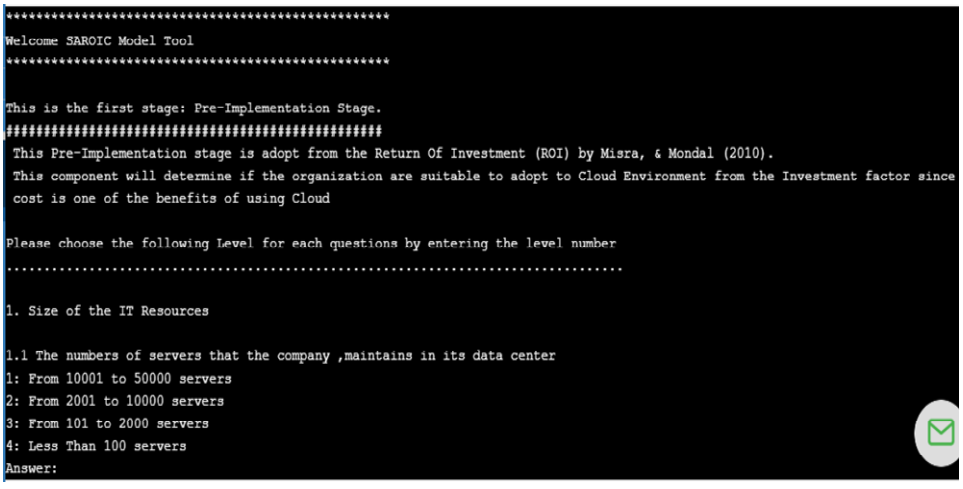
Index	*Measurement description*
RoI < 0	Negative result means the costs outweigh the returns. The investment is a net loss.
RoI = 0	The visible net profit is same as the net lost. Neither gain nor lost will happen.
RoI > 0	Positive result means the returns exceed the costs. The investment is a net gain.

6 Implementation of SAROIC model: a case study

In order to simulate our assessment model, we developed an automation tool for making the assessment process easier. The tool we used is the Java programming language that has been structured as per question and answer (Q&A) format (refer Figure 5). There is no interface design process involved during the tool development. The automation tool comprehends both assessment modules with all related factors that described in the earlier sections. The respondents then can easily specify the input according to their current operation in the organisation. In this work, we had chosen a middle-size private university that is currently ready to move their business operation to cloud services. But they still want to know further either they is completely ready or not in term of business

perspective. The university has the capacity size of 50,000 students and 300 employees. We set for the interview session with the university's information system officer (ISO) unit that took place on 24th May 2019.

Figure 5 SAROIC model tools (see online version for colours)



6.1 Suitability value

Table 13 shows the weightage that was given by the university's ISO unit after completing the suitability model. The automation tool was then generated the inputs to produce the suitability value. As a result, the university gained 1,395 points (refer Figure 6). It indicates that the university falls into the second group of suitability index; which is it may or may not be suitable to fully migrate to cloud environment. That means further investigations need to be done before making the final decision. The ISO unit is still in the phase of observing all factors that was suggested by the SAROIC model mainly because they disregarded the security factors (CSoD, CCaP, CI and CA) that are currently at low values. They will take more considerations of those factors in order to prepare for cloud migration. However, the ISO unit agrees to continue for the measuring RoI value. They were keen to know on how much the organisation's return even though they are not fully ready for the cloud migration.

Figure 6 Suitability formations through the tool

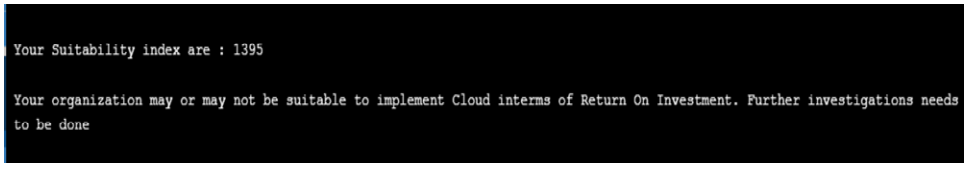


Table 13 Input for suitability weightage

Suitability factors			*Weightage*
1	Credit for largeness (CL)		8
	a	Credit number of servers (CNoS)	2
	b	Credit number of countries (CNoC)	2
	c	Credit annual revenue (CAR)	3
2	Credit for value of security (CVoS)		1
	a	Credit sensitivity of data handled (CSoD)	1
	b	Credit confidential and privacy (CCaP)	1
	c	Credit integrity (CI)	2
	d	Credit availability (CA)	2
3	Credit workload variations (CWV)		6
	a	Credit size of customer-base (CSCB)	3
	b	Credit amount of data handling (CADH)	4
4	Credit of scalability (CSC)		2
5	Credit critical work done (CCWD)		2

6.2 RoI outcome

In the RoI valuing module, the university returns a negative value. Meanwhile, the TCO in a year is approximately USD60,000 which does not meet the university's expected return. It shows that our model is effectively usable as the result from the suitability module explicitly correlated with the RoI outcome (refer to Figure 7).

Figure 7 RoI output from the automation tool

```
The total TCO for your organization in one year are RM 243000.00
The total ROI for your organization are -1.0

Negative result means the costs outweigh the returns.The investment is a net loss
```

The university needs to have proper budget planning especially the costs that are related to RoI factors (i.e., upfront cost, tangible cost, intangible cost and termination cost). The ISO unit also has mentioned that they are planned for cloud migration, only that it does not well studied especially on the business-related factors. In addition, they noticed that several operational factors considered in SAROIC not been highlighted in their planning for cloud migration. It is where RoI turns negative value. The university also understood that an unpredicted 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.

Once the case study completed, we had a through discussion with the ISO unit in order to get their feedbacks and comments. It is important to review the respondents'

perspectives in order to improve and made further amendment towards better assessment model. The ISO unit is willing to assess their suitability and RoI value for cloud migration using our SAROIC once they are ready with the respective factors. The ISO unit agrees that the investigation and assessment in SAROIC model are comprehensive in regard to the significant factors for cloud migration. Such criteria make them believed that SAROIC is able to help them in deciding the right decision for cloud migration. They also agree that the automation tool used in calculating the respective values makes the job of the organisation's economic planner much easier. Therefore, we conclude that the validating process of SAROIC with the university is a success.

7 Conclusions

In this work, we present a practical model name as SAROIC for estimating the suitability and the RoI of cloud computing migrations from the cloud user perspective. We identified methodologies based on tangible operational cost calculations for calculating the TCO of the cloud user investments. Though, cloud services also generate intangible costs and benefits that should be taken into account in this model. The RoI decisions that are taken based on partially assessment done of the potential business value generated by cloud migration may result in sub-optimal budget and capital allocation and ultimately undermine the cloud user competitive advantage (Lynn et al., 2020). Our model aims to overcome such limitations by providing a step-by-step process for estimating a comprehensive ROI of cloud migration. We were focused on the assessing the suitableness of organisation for cloud migration, hence the RoI valuing module was executed only when the organisation meets the suitability threshold. The automation tool was developed to ease the assessment process. The SAROIC model was tested and validated by the education basis business (the private university) that planned for cloud migration. The testing and validating process is a success where the results show that it is practical and useable to the organisations. It is important for the organisation to well understand their business operation prior to adapting a new ICT like cloud computing. Finally, further studies may also investigate the relationship between the migration of more comprehensive ROI measures to and the effectiveness of IT investment decision making.

References

Ahmed, N.M. (2017) 'Measuring cloud security risk by mean failure cost', *2016 IEEE Symposium Series on Computational Intelligence, SSCI 2016*, IEEE, pp.1–8, DOI: 10.1109/SSCI.2016.7849915.

Ajeh, D.E., Ellman, J. and Keogh, S. (2014) 'A cost modelling system for cloud computing', *Proceedings – 14th International Conference on Computational Science and its Applications, ICCSA 2014*, IEEE, pp.74–84, DOI: 10.1109/ICCSA.2014.24.

Akande, A.O. and Van Belle, J-P. (2014) 'A proposed framework to assess and increase the cloud computing readiness of financial institutions in South Africa', *2014 5th International Conference – Confluence the Next Generation Information Technology Summit (Confluence)*, pp.46–52, DOI: 10.1109/CONFLUENCE.2014.6949250.

Akinrolabu, O., New, S. and Martin, A. (2019) 'CSCCRA: a novel quantitative risk assessment model for SaaS cloud service providers', *Journal of Computer Networks and Communications Computers*, Vol. 8, No. 3, pp.1–17, DOI: 10.3390/computers8030066.

Aldahwan, N.S. and Saleh, M.S. (2018) 'Developing a framework for cost-benefit analysis of cloud computing adoption by higher education institutions in Saudi Arabia', *2018 International Conference on Smart Computing and Electronic Enterprise, ICSCEE 2018*, IEEE, pp.1–9, DOI: 10.1109/ICSCEE.2018.8538380.

Alemeye, F. and Getahun, F. (2015) 'Cloud readiness assessment framework and recommendation system', *IEEE Africon*, Vol. 1, No. 1, pp.1–5.

Basu, S., Sengupta, A. and Mazumdar, C. (2017) 'A quantitative methodology for cloud security risk assessment', *Proceedings of the 7th International Conference on Cloud Computing and Services Science*, Closer, pp.120–131, DOI: 10.5220/0006294401200131.

Bellandi, V. et al. (2015) 'Toward economic-aware risk assessment on the cloud', *IEEE Security and Privacy*, Vol. 13, No. 6, pp.30–37, IEEE, DOI: 10.1109/MSP.2015.138.

Chandra, D.G. and Borah, M.D. (2012) 'Cost benefit analysis of cloud computing in education', *2012 International Conference on Computing, Communication and Applications, ICCCA 2012*, April, DOI: 10.1109/ICCCA.2012.6179142.

Chang, V.I.C. (2016) 'A proposed framework for cloud computing adoption', *International Journal of Organizational and Collective Intelligence*, Vol. 6, No. 3, pp.75–98, DOI: 10.4018/ijoci. 2016070105.

Chawla, N. and Kumar, D. (2017) 'Enablement of Internet of things using cloud computing', *3rd IEEE International Conference on "Computational Intelligence and Communication Technology*, pp.1–7, http://doi.org/10.1109/CIACT.2017.7977306.

Djemame, K. et al. (2016) 'A risk assessment framework for cloud computing', *IEEE Transactions on Cloud Computing*, Vol. 4, No. 3, pp.265–278, DOI: 10.1109/TCC.2014.2344653.

Dragan, I-M. and Isaic-Maniu, A. (2017) 'Analyzing the profitability performance of SMEs using a neural model', *Economic Computation and Economic Cybernetics Studies and Research*, Vol. 51, No. 4/2017, pp.55–71.

Fitó, J.O. and Guitart, J. (2014) 'Business-driven management of infrastructure-level risks in cloud providers', *Future Generation Computer Systems*, Vol. 32, No. 1, pp.41–53, Elsevier B.V., DOI: 10.1016/j.future.2012.05.008.

Gholami, M.F. et al. (2016) 'Cloud migration process – a survey, evaluation framework, and open challenges', *Journal of Systems and Software*, Vol. 120, pp.31–69, Elsevier Inc., DOI: 10.1016/j.jss.2016.06.068.

Ghosh, N., Ghosh, S.K. and Das, S.K. (2015) 'SelCSP: a framework to facilitate selection of cloud service providers', *IEEE Transactions on Cloud Computing*, Vol. 3, No. 1, pp.66–79, DOI: 10.1109/TCC.2014.2328578.

Goyal, S. (2014) 'Public vs private vs hybrid vs community – cloud computing: a critical review', *International Journal of Computer Network and Information Security*, Vol. 6, No. 3, pp.20–29, DOI: 10.5815/ijcnis.2014.03.03.

Halabi, T. and Bellaiche, M. (2018) 'A broker-based framework for standardization and management of cloud security-SLAs', *Computers & Security*, Elsevier Ltd., DOI: 10.1016/ j.cose.2018.01.019.

IBM (2019) 'The strengths of IBM spectrum scale', *IBM Systems Data Sheet*, Vol. 1, No. 1, pp.1–6 [online] https://www.ibm.com/support/knowledgecenter/en/STXKQY_5.0.2/com.ibm. spectrum.scale.v5r02.doc/bl1ins_strengt.htm.

Islam, S. et al. (2017) 'A risk management framework for cloud migration decision support', *Journal of Risk and Financial Management*, Vol. 10, No. 10, pp.1–10, DOI: 10.3390/ jrfm10020010.

Jamshidi, P., Ahmad, A. and Pahl, C. (2014) 'Cloud migration research: a systematic review', *IEEE Transactions on Cloud Computing*, Vol. 1, No. 2, pp.142–157.

Jin, Y., Wen, Y. and Guan, K. (2016) 'Toward cost-efficient content placement in media cloud: modeling and analysis', *IEEE Transactions on Multimedia*, Vol. 18, No. 5, pp.807–819, DOI: 10.1109/TMM.2016.2537199.

Kauffman, R.J., Ma, D. and Yu, M. (2018) 'A metrics suite of cloud computing adoption readiness', *Electronic Markets*, Vol. 28, No. 1, pp.11–37, DOI: 10.1007/s12525-015-0213-y.

Kawatra, K. and Kumar, V. (2018) 'Cost benefit analysis of cloud computing in education Cost benefit analysis of cloud computing in education', *International Journal of Business Information Systems*, January, Vol. 1, pp.1–18, DOI: 10.1504/IJBIS.2018.089112.

Luna, J. et al. (2015) 'Leveraging the potential of cloud security service-level agreements through standards', *IEEE Cloud Computing*, Vol. 2, No. 3, pp.32–40, DOI: 10.1109/MCC.2015.52.

Lynn, T., Mooney, J.G., Rosati, P. and Fox, G. (2020) *Measuring the Business Value of Cloud Computing*, 20 January [online] http://www.palgrave.com/gp/series/16004.

Masdari, M. and Zangakani, M. (2020) 'Efficient task and workflow scheduling in inter-cloud environments: challenges and opportunities', *Journal of Supercomputing*, Vol. 76, No. 1, pp.499–535 [online] http://doi.org/10.1007/s11227-019-03038-7.

Misra, S.C. and Mondal, A. (2011) 'Identification of a company's suitability for the adoption of cloud computing and modelling its corresponding return on investment', *Mathematical and Computer Modelling*, Vol. 53, Nos. 3–4, pp.504–521, Elsevier Ltd., DOI: 10.1016/j.mcm. 2010.03.037.

Nanath, K. and Pillai, R. (2013) 'A model for cost-benefit analysis of cloud computing', *Journal of International Information Management Association*, Vol. 22, No. 3, pp.93–118.

Parker, B. and Bach, C. (2020) 'The synthesis of blockchain, artificial intelligence and internet of things', *European Journal of Engineering Research and Science*, Vol. 5, No. 5, pp.588–593 [online] http://doi.org/10.24018/ejers.2020.5.5.1912.

Patil, A. and Patil, D.R. (2019) 'An analysis report on green cloud computing current trends and future research challenges', *SSRN Electronic Journal*, September 2018, pp.813–820, DOI: 10.2139/ssrn.3355151.

Piparo, T.L. (2020) *The Challenges with the Service Level Agreement for the Cloud Computing Buying Organization*, Researchgate.Net, 24 January, [online] https://www.researchgate.net/profile/Teo_Lo_Piparo/publication/344553064_The_challenges_with_the_service_level_agreement_for_the_cloud_computing_buying_organization_A_negotiation_guideline_for_ever-changing_contract_requirements_based_on_transaction_cost_.

Rosati, P. et al. (2017) 'Quantifying the financial value of cloud investments: a systematic literature review', *IEEE 9th International Conference on Cloud Computing Technology and Science Quantifying*, December, DOI: 10.1109/CloudCom.2017.28.

Sekaran, U. and Bougie, R. (2010) *Research Methods for Business: A Skill Building Approach*, Wiley, New York, DOI: 10.1017/CBO9781107415324.004.

Sharma, S. (2016) 'Data integrity challenges in cloud computing', *4th International Conference on Recent Innovations in Science Engineering and Management*, Vol. 4, No. 1, pp.736–743.

Singh, S.K. (2017) 'Conceptual framework of a cloud-based decision support system for arsenic health risk assessment', *Environment Systems and Decisions*, Vol. 37, No. 4, pp.435–450, Springer, USA, DOI: 10.1007/s10669- 017-9641-x.

Skourletopoulos, G. et al. (2017) 'Cost-benefit analysis game for efficient storage allocation in cloud-centric internet of things systems: a game theoretic perspective', *2017 IFIP/IEEE Symposium on Integrated Network and Service Management (IM)*, IFIP, pp.1149–1154, DOI: 10.23919/INM.2017.7987453.

Sripanidkulchai, K. and Sujichantararat, S. (2012) 'A business-driven framework for evaluating cloud computing', *Proceedings of the 2012 IEEE Network Operations and Management Symposium, NOMS 2012*, pp.1335–1342, DOI: 10.1109/NOMS.2012.6212071.

Stewart, C.A. et al. (2018) 'Return on investment for three cyberinfrastructure facilities: a local campus supercomputer, the NSF-funded jetstream cloud system, and XSEDE (the extreme science and engineering discovery environment)', *2018 IEEE/ACM 11th International Conference on Utility and Cloud Computing (UCC)*, IEEE, Vol. 11, No. 1, pp.223–236, DOI: 10.1109/UCC.2018.00031.

Taherdoost, H. (2018) 'Sampling methods in research methodology; how to choose a sampling technique for research', *SSRN Electronic Journal*, January 2016, DOI: 10.2139/ssrn.3205035.

Varghese, B. and Buyya, R. (2018) 'Next generation cloud computing: new trends and research directions', *Future Generation Computer Systems*, Vol. 79, pp.849–861, Elsevier B.V., DOI: 10.1016/j.future.2017.09.020.

Vidhyalakshmi, R. and Kumar, V. (2016) 'Determinants of cloud computing adoption by SMEs', *International Journal of Business Information Systems*, May, Vol. 22, pp.375–395, DOI: 10.1504/IJBIS.2016.076878.

Wahlgren, G. and Kowalski, S. (2013) 'IT security risk management model for cloud computing: a need for a new escalation approach', *International Journal of E-Entrepreneurship and Innovation (IJEEI)*, Vol. 4, No. 4, p.13, DOI: 10.4018/ijeei.2013100101.

Wohlin, C. (2014) 'Guidelines for snowballing in systematic literature studies and a replication in software engineering', *ACM International Conference Proceeding Series*, Article No. 38, pp.1–10, DOI: 10.1145/2601248.2601268.

Wu, D., Terpenny, J. and Gentzsch, W. (2015) 'Economic benefit analysis of cloud-based design, engineering analysis, and manufacturing', *Journal of Manufacturing Science and Engineering*, Vol. 137, No. 4, Transactions of the ASME, DOI: 10.1115/1.4030306.