Identifying contributions for the evaluation of cloud services in state entities

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Abstract. Cloud computing is becoming an important tool that is offering multiple opportunities to state entities. However, this paradigm can also impose constraints and increase risk to this kind of institutions. For this reason, it is necessary for the entities in the state sector to assess cloud services before making the decision of adopting them. In this context, this work presents a review to identify what are the main contributions made in the research literature to carry out such assessment. The objective is to provide and overview of this research area and help practitioners to implement new guidelines to evaluate cloud services and make the best decisions when adopting them.

Key words: adopting, contracting, evaluation, IaaS, PaaS, SaaS, public sector

1 Introduction

Cloud computing is becoming an important tool capable of providing multiple financial, social and technological opportunities to institutions in all industrial sectors [1, 2]. An example of these opportunities is the possibility of reducing the operating costs of IT areas. However, cloud computing can also increase risk and impose new constraints. On the one hand, risks are commonly associated with security and dependency on cloud suppliers [3]. On the other hand, one of the most important constraints stated by IT managers is that there is no guarantee by the cloud supplier on the location of the IT resources and capabilities which creates a sense of loss of physical control on the information [4].

The state sector is not indifferent to the use of cloud computing. Public entities are using this sourcing model in order to provide IT services and capabilities to internal stakeholder (e.g. public employees) and external beneficiaries (private companies, citizens, etc). For example, in most of the public entities of Washington D.C., employees have unlimited access to a corporate document storage service and email service contracted to cloud suppliers. In the same way, the US General Services Administration made in 2009 the transition of the official government portal (usa.gov), that provides services and information to citizens,

to the cloud. Thus, as in other sectors, cloud computing is offering opportunities to state entities such as the possibility of contracting IT capabilities to cloud suppliers, such as hosting services, instead of acquiring and operating their own infrastructure, which allows state entities to focus on their core activities. However, cloud computing can also impose constraints to these kind of entities such as the risk that cloud providers store confidential information outside the legal and territorial jurisdiction of the state [5].

Therefore, it is important for state entities to assess the advantages and limitations of contracting and adopting cloud services before making a decision. However, in several cases, these entities do not carry out a formal analysis because of the lack of conceptual tools and knowledge on the aspects that need to be evaluated during the former stages of the implementation of new IT services [5]. In this context, state entities need tools including relevant evaluation aspects to considerate and assess the possibility of adopting cloud services.

Considering the necessity above mentioned, this research presents a literature review to identify and analyse research contributions to assess the feasibility of adopting cloud services. The main objective of this review is to provide an updated overview of the main existing works to assess the convenience of making such adoption. Other objectives of the review are: first, it aims at helping practitioners in the IT areas of state entities to make the best decisions by giving them the key evaluation elements to assess cloud services. Second, this review will ease researchers search for relevant studies in the area and help them to constitute a base for further research. Last, structuring the literature in a detailed and systematic manner also clarifies which issues are not well covered.

This work is organised as follows: Section two describes the review method and the application of its three first steps (planning, conducting and summarising). Section three presents the application of the last step of the method which consists in a synthesis for each one of the evaluation categories used. Finally, Section four presents the final conclusion and discussion.

2 Study method and description of selected works

The literature review process includes the following steps: (i) planning, (ii) conducting and material collection, (iii) summarising, and (iv) reporting [7, 8].

(i) Planning. It consists in the definition of the criteria to conduct the search and validate the selected works. It aims at identifying the relevant contributions in the research field.

(ii) Conducting and Material Collection. This step is related to perform an exhaustive search for primary approaches by using the criteria previously defined. It also validates and assesses the found approaches with respect to the research questions. The goal of this step is to select a final set of works.

(iii) Summarising. It is to extract the relevant information for each selected work and describe a summary of them with the aim of answering the research questions.

(iv) Reporting phase. This step presents a synthesis of the answers for each research question, besides a material analysis and interpretation is also presented.

2.1 Planning

The review is aimed at finding out the main assessing elements used in the literature to evaluate the convenience and viability of adopting cloud services in order to help the IT areas of state sector institutions to implement new guidelines and make decisions to adopt cloud services. To perform this analysis, three evaluation categories are defined: (i) *context* to analyse the domain in which the reviewed works were originally intended to, as well as their goal and scope; (ii) *assessment aspects* which is associated to the identification of aspects proposed to assess the adoption of cloud services; (iii) *assessment method* which analyse the procedures used in the reviewed works to guide the proposition of assessment aspects as well as their application to specific contexts. Every category includes evaluation criteria that in turn have related questions to analyse the contribution of each work to the criteria. The elements previously described are shown in Table 1.

Table 1. Categories, criteria and research questions.

Category	Criteria	Question
Context	Domain	Which industrial sector does the research work apply to?
	Goal	What is the main objective of the research work?
	Scope	What service model is the research work intended to?
Assessment aspect	Financial	How can practitioners evaluate the economic feasibility of adopting cloud services?
	Others	Are there other assessment aspects in addition to the economic one?
Assessment method	Assessment method	Which are the methods employed to evaluate or identify the aspects?
	Metrics	What are the metrics used to evaluate the cloud services?

2.2 Conducting and material collection

With the purpose of finding potential research works answering the research questions previously announced, the Scopus database was used by introducing the following criteria:

- Search terms: (Assessment or Evaluation or Evaluating) and (Methodology or Framework or Model) and (Adoption or Contract) and (Saas or Paas or Iaas or Cloud) and (Public sector or Government or Public institution or Public entity or E-government).

- Search area: Computer Science.
- Document type: Conference paper or Journal paper.
- Search field type: Abstract, title and keywords.
- Language: English.

Thus, the query introduced in the database is:

(TITLE-ABS-KEY(assessment)OR TITLE-ABS-KEY(evaluation)OR TITLE-ABS-KEY(evaluating)) AND (TITLE-ABS-KEY(methodology)OR TITLE-ABS-KEY(framework)OR TITLE-ABS-KEY(model)) AND TITLE-ABS-KEY(adoption)AND(TITLE-ABS-KEY(saas)OR TITLE-ABS-KEY(paas)OR TITLE-ABS-KEY(iaas)OR TITLE-ABS-KEY(cloud))AND (TITLE-ABS-KEY(public sector)OR TITLE-ABS-KEY(government)OR TITLE-ABS-KEY(public institution)OR TITLE-ABS-KEY(e-government)) AND (LIMIT-TO(SUBJAREA,"COMP") OR LIMIT-TO(SUBJAREA,"ENGI")) AND (LIMIT-TO(DOCTYPE,"cp") OR LIMIT-TO(DOCTYPE,"ar")) AND (LIMIT-TO(LANGUAGE,"English"))

With these criteria, the Scopus search engine returned 48 candidate articles. To reduce the number of articles included in the analysis, firstly, a review of the articles titles was carried out. This filter reduced the number to 39. Secondly, a reading of articles abstracts was undertaken to filter those works that do not present evidence of answering any of the analysis questions. This filter limited the number of articles to 17 works. Thirdly, a complete reading of the articles was performed to select the final works set made up of 10 articles which were identified and included in the analysis. The articles set includes relevant information about assessment aspects and methods specifically developed for the state sector or initially proposed for the private sector and then adapted for the public one.

2.3 Summarising

In this step, the relevant information of each selected article was identified, extracted and summarised. In the following paragraphs a description of the articles is presented.

In [9], the authors propose a set of assessment aspects to facilitate cloud adoption in small and medium sized enterprises, specifically focusing on two cloud models: Software as a Service (SaaS) and Platform as a Service (PaaS). These aspects were recognised by the authors through interviews with operation managers, IT managers and support staff of the IT area. The identified aspects are described as follows: (i) *Current state of IT infrastructure* which aims at determining if the use of cloud services is required to support new requirements or replace a part of the current internal infrastructure. (ii) *User perception* which is related to the utility delivered to the user to perform its activities such as saving time performing specific tasks. (iii) *Security* related to the lack of control over information expressed by the managers in the interviews. (iv) *Political* concerning regulatory policies enabling a better competition and service offers

by the cloud providers. (v) *Economic* which is focused on operational efficiency and costs reduction of hardware, software and maintenance. (vi) *Social* related to provide opportunities to the development of new user capabilities which could lead to a greater job satisfaction. (vii) *Technological* allowing the assessing of the quality, accessibility, compatibility with devices as well as portability of the service.

In [10] the authors analyse the main elements that need to be considered when adopting cloud services in the Indian public context. They take thus into account the following aspects for adopting and managing cloud services: (i) *Technical*, it is related to the necessity of initially training people in the use of devices allowing them to access to the services. (ii) *Cultural*, it focuses on the creation of moral values that promote the correct use of services. (iii) *Political*, it is related to the system of public policies that should be established with the purpose of maintaining the cohesion between society and the planned objectives in the moment of adopting cloud services. (iv) *Social*, this aspect is based on equality and justice principles. Under these principles, it is fundamental to train people about rights and duties when accessing to cloud services. (v) *Psychological*, it concerns the training in the good utilisation of services, civic participation, resolution of concerns and development of communication skills. (vi) *Cost*, it includes the cost of hardware, software, and human resources to maintain IT infrastructures versus the cost of contracting cloud services

The authors in [11] study the relevant aspects and benefits of adopting cloud services in the context of public and private companies. This study was carried out through interviews to internal and external IT staff involved in the decision of adopting cloud services. The interviews were analysed by means of descriptive statistics giving as a result the following aspects: (i) *Mobility and accessibility* that refer to the capability of accessing to cloud services from any location and any device. (ii) *Service responsibility* concerning the degree of responsibility in topics such as security, information reliability and information integrity that the cloud provider is able to agree. (iii) *Security*, addressing how cloud providers will guarantee the security in terms of encryption, access authentication, anti-virus protection, firewall, and service availability. (iv) *Longevity of data storage* that implies information maintenance and evaluates how long backups should stand.

In [12] the authors evaluate the convenience and viability of adopting cloud services through interviews with IT managers, outsourcing specialists, SaaS decision-makers and IT experts. Their answers were summarised under the following five evaluation aspects: (i) *organisational aspect* is related to evaluating the organisational changes required for adopting cloud services according to aspects such as service levels agreed with the IT provider. (ii) *Performance* that involves not only speed or quality, but also associates security issues as well as knowledge of current regulations. (iii) *Decision* that is associated to the selection between public, private or hybrid solutions depending on the nature of the final user, i.e. general public or government employees. (iv) *Contracts* that could be short-term or long-term depending on the responsibilities and agreements between the provider and the public entity. (v) *Relationships with providers*,

since the responsibilities move from the personnel of the public entity IT area to the SaaS supplier. As a consequence, it is crucial to define the mechanisms to establish the appropriate relationships between the two involved parts.

In [13], the authors focus their study on the identification of factors that influence positively the adoption of cloud services, specifically by using the SaaS model. To this end, they use a combination of TOE (Technology - Organisation - Environment) framework and DOI (Diffusion Of Innovation) model, in addition to interviews with IT managers of public sector in Australia. The identified aspects obtained from this approach were: (i) *Competitiveness*, described as the organisation capability to innovate with a service and generates a competitive advantage. (ii) *Compatibility*, defined as the ability to use a cloud service without generating a great negative impact in the organisation. (iii) *Cost* described as a relevant factor which considers the potential benefits such as costs reduction and decrease in investments in own IT infrastructures. (iv) *Technological capability*, referred in this work as the organisation current state of technology. This aspect will determine if the organisation is ready to adopt cloud services, or conversely, it has technological or organisational limitations that would cause negative impacts.

The author in [14] argues that it is necessary to develop an in-depth study about the critical aspects for adopting cloud services in state entities. Specifically, this work analyses an e-invoicing service through an integrated model based on the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) with the aim of identifying and evaluating the main aspects for adopting cloud services. The identified aspects are: (i) *Use expectation* aiming at assessing the cloud service convenience through the evaluation of the user intention to employ the service. (ii) *Trust* which is motivated by the adoption and use of cloud services according to the credibility of the e-government from the perspective of users. (iii) *Perceived Risk* described as a risk identified by a citizen, which will determine if the citizen will use a cloud service or not.

In [15], the authors propose to evaluate important aspects when adopting cloud services, through the use of the TOE framework and a set of interviews with cloud services providers and healthcare sector experts. As a result, the following aspects were identified: (i) *Privacy* of patients data and their health status during the processing and the storage of this information. (ii) *Security* that need to be assured through access controls and authentication, as well as safe mechanisms to transfer data. (iii) *Reliability* that is related to keeping information free of errors in order to support decision making process in critical moments. (iv) *Legal environment* since the health care organisations are concerned about legal remedies that can be used by patients or their relatives if personal information is hacked or leaked out. (v) *Top management support* is considered as fundamental for the provision of resources for adopting cloud services.

The authors in [16] propose a model to predict the aspects influencing the adoption of cloud services. This model is an extension of the Technology Acceptance Model (TAM), which includes three additional perspectives named as computational self efficacy, trust and job opportunity. The proposed method

consists in neural networks and linear regressions. The aspects included in the model are: (i) *Usefulness perception*, defined as the benefit that the users perceive when they use a new technology, e.g. a new acquired learning or usefulness to perform a task. (ii) *Ease of use* is related to how simple is to interact with a cloud service and learn from it. (iii) *Trust* is composed by three elements: ability of the users to generate skills when using a cloud service; integrity which refers to the commitment of the cloud service provider to comply with the agreements; and benevolence which is the assurance that the provider will provide the entity with the best service possible. (iv) *Job opportunity* refers to the users perception of the potential future employability when using cloud services.

According to [17], cloud computing is a technology model which brings substantial benefits to the organisations and their clients. Through interviews with IT executives and a market research, the next aspects were determined as the main ones for adopting cloud services: (i) *Security*, since it is difficult to hire and maintain personnel with experience in security. (ii) *Reliability*, composed by the availability and the system migration to avoid service interruption, as well as the infrastructure capability and the Internet bandwidth of the company. (iii) *Cost*, focused on the cost of the bandwidth needed to provide and use cloud services, since there are geographic locations where the bandwidth is limited and the service cost is high.

The adoption of cloud services in Indonesian companies is studied in [18] through 147 interviews by means of the combination of the TOE framework and the DOI model. As a result, a set of ordinal variables are generated in order to perform a logistic regression and identify the main aspects for adopting cloud services. From this process, the following aspects were established: (i) *Compatibility* is specified as the ease of adopting a service according to the current IT infrastructure, necessities and operation of the company. (ii) *Market competition* defined as the company perception about the adoption of cloud services as mechanism for surviving in a highly competitive environment . (iii) *Government support* which can be provided through different means, e.g. issuing regulation policies for the protection of customer information, diminishing bandwidth costs, diminishing taxes for software and hardware acquisition, improving IT national infrastructure, among others.

3 Reporting

The contribution of the 10 selected articles according to the three assessment categories previously established are condensed as follows: Table 2 presents the context, Table 3 shows the assessment aspects, and, finally, Table 4 describes the assessment methods. Considering the information in Table 2, a summary for the research questions associated to the context category are described as follows:

- **Which industrial sector does the research work apply to?** Even though all the analysed works present contributions for the state sector, [9, 17, 18] were initially intended for the private sector and then their contributions analysed and adapted for the state sector. In addition, only two

Table 2. Contributions related to the context element.

Ref	Category		
	Domain	**Goal**	**Scope**
[9]	Private Sector	To identify aspects for assessing the feasibility of adopting cloud services	SaaS and PaaS
[10]	Public Sector	To evaluate the convenience of adopting cloud services by using a set of aspects previously identified	SaaS
[11]	Public and private sector	To identify aspects and benefits for adopting cloud services	Cloud computing services in general
[12]	Public sector	To evaluate the convenience of adopting cloud services by using a set of aspects previously identified	SaaS
[13]	Public sector	To identify aspects and benefits for adopting cloud services	Cloud computing services in general
[14]	Public sector	To evaluate the convenience of adopting cloud services by using a set of aspects previously identified	SaaS, specifically e-invoicing services
[15]	Health care in the public sector	To evaluate the convenience of adopting cloud services by using a set of aspects previously identified	SaaS, specifically health care service
[16]	IT in the public and private sectors	To predict aspects for adopting cloud services	Cloud computing services in general
[17]	Private sector	To identify aspects for adopting cloud services	Cloud computing services in general
[18]	Private sector	To evaluate the convenience of adopting cloud services by using a set of aspects previously identified	SaaS

works were developed from their beginning for both sectors [11, 16]. Last, only two sub sectors were identified: healthcare and IT.

- **What is the main objective of the research work?** Two common objectives are: (i) To identify aspects for evaluating the convenience and viability of adopting cloud services. (ii) To evaluate the convenience and viability of adopting cloud services by using a set of aspects previously identified.
- **What service model is the research work intended to?** Works evaluating cloud services specifically for the state sector are mainly related to the SaaS service model. Works originally intended for the private sector and then adapted for the state sector deal additionally with PaaS service model. Therefore, we found a lack of propositions to the evaluation of the convenience of adopting cloud services specifically for the IaaS model.

Summarizing the Table 3, it is concluded the following for the assessment aspects element:

- **How can practitioners evaluate the economic feasibility of adopting cloud services?** According to the review, to obtain top management support is one of the main aspects to ensure the economic feasibility of adopting cloud services. This is necessary in order to assure the financial resources to contract the services. Other important economic aspects practitioners need to estimate before making the decision of adopting cloud services are: (i) op-

Table 3. Contributions related to assessment aspects element.

Ref	Assessment aspects	
	Financial	**Other**
[9]	Operational efficiency and cost reduction of hardware, software and infrastructure maintenance	• Current state of IT infrastructure • User perception • Security • Political • Social • Technological
[10]	Cost of hardware and software and human resources cost to maintain systems	• Technical • Cultural • Political • Social • Psychological
[11]	There is no information	• Mobility and accessibility • Service responsibility • Security • Longevity of data storage
[12]	There is no information	• organisational • Performance • Cloud Type • Contracts • Relationships change
[13]	Cost reduction and investments decrease in own infrastructure	• Competitiveness • Compatibility • Technological capability
[14]	There is no information	• Use expectation • Trust • Perceived risk
[15]	Top management support to assure financial resources	• Privacy • Security • Reliability • Legal environment
[16]	There is no information	• Usefulness perception • Ease of use • Trust • Job opportunity
[17]	Bandwidth costs	• Security • Reliability
[18]	Government support to obtain taxes and cost reductions	• Compatibility • Market competition • Government support

erational efficiency gains for the state entity, (ii) decreased investments in acquiring software, hardware and other IT infrastructures, (iii) costs reduction in human resources and maintenance of IT infrastructures, (iv) Bandwidth costs necessary to access the cloud services.

- **Are there other assessment aspects in addition to the economic one?** The other assessment aspects can be grouped in four great sets: (i) social and cultural aspects, (ii) technological and security aspects, (iii) user environment perception aspects and (iv) political and regulatory aspects.

Table 4. Contributions related to the assessment method element.

| Ref. | Assessment method | |
	Method	Metrics
[9]	Descriptive statistics of interviews with operation managers, managers and IT support personnel	Activity time reduction
[10]	There is no assessment method	Metrics are not defined
[11]	Descriptive statistics of interviews and surveys	• Service availability percentage • Data encryption level
[12]	Classification of interview answers in five areas of SaaS adoption	• Control and deliver levels of providers IT service • Time contract with provider
[13]	Combination of TOE framework and DOI model to assess interviews	Metrics are not defined
[14]	Integrity model based on UTAUT 2	Metrics are not defined
[15]	TOE framework to assess interviews	• Data privacy level • Data quality level
[16]	• TAM model plus three additional perspectives (computational self efficacy, trust and job opportunity) • Linear regression and neural networks	Metrics are not defined
[17]	Interviews with IT executives and a market research	Bandwidth use level
[18]	• Interviews assessment, TOE framework and DOI model • Logistic regression and neural networks	Metrics are not defined

Considering the information explained in Table 4 about assessment method, the following conclusions were determined for each one of the research questions:

- **Which are the methods employed to evaluate or identify the aspects?** The aspects are evaluated or proposed according to three main methods: (i) assessment based on framework or model, (ii) assessment based on descriptive statistics, and (iii) assessment through regression model and neural networks.

- **What are the metrics used to evaluate the cloud services?** In the research work metrics depend on the type of aspect identified or evaluated. Concerning units of measure, quantitative units are assigned to those aspects that can be measured in percentages or ordinal values. On the contrary, qualitative units are focused on aspects related to IT environment perception and peoples perception.

4 Discussion and conclusion

This article presents a review of research works to assess the convenience of adopting cloud services by using three evaluation categories: context, assessment aspects and assessment method. Each category includes criteria with related questions to analyse the contribution of each work to the criteria.

The first category, context, is intended to analyse the domain, goal and scope of the reviewed approaches. Regarding the domain, we found that some of the works, initially intended for the private sector, could be analysed and adapted for the state sector. This fact shows that even though each sector involves different issues, some of them are common and the evaluation aspects can be adapted from a sector to another. In addition, the revision of the works for healthcare and IT subsectors evidences the need for specific works dealing with the specific characteristics of a given context. With respect to the second criterion, we found two main goals: (i) to identify and propose key assessment aspects for the adoption of cloud services; (ii) to evaluate the convenience of adopting cloud services by using aspects identified in previous works. The first goal is formulated mainly by works originally addressing the private sector and then adapted to the public one. The second goal is defined by works specifically intended the state sector. Concerning the third criterion, scope, it was possible to determine that most of the works evaluate SaaS and PaaS models. With respect to the SaaS evaluation, only two works evaluates SaaS for specific services, namely, e-invoicing and healthcare. The works addressing cloud services in general are too generic and do not tackle the characteristics of each cloud model. Lastly, we can identify a lack of research specifically related to IaaS model.

Concerning the second category, namely, assessment aspects, in the financial evaluation, one of the main conclusions is that top management support is important to facilitate the adoption of the service. Indeed, without its sponsor, even though the general evaluation of the service shows the feasibility of its adoption, it could be affected because of the difficulty to obtain the economic resources to contract it. In addition, most of the identified financial aspects, such as the decrease in investments in acquiring software and other IT infrastructures, are mainly oriented to reduce costs in IT operation. Therefore, the reviewed works do not show how the adoption of cloud services could be economically viable in terms of generation of financial benefits for citizens, communities, general state and other beneficiaries of the services. Regarding the other assessment aspects, they include social and cultural aspects that need to be evaluated in the state sector such as the cultural impact and the user perception and acceptance of

the services. In the same way, political and regulatory aspects are considered as the state entities are subject to changes in regulation and leadership because of elections and official designations. Respecting to the technology aspects, only quality aspects of the service such as data security, capability and availability are considered. As a consequence, there is a lack of evaluation of functionality aspects that are essential, mostly when evaluating SaaS propositions, to establish the match level between the offered service and the functional requirements of the state organisation.

Respecting to the third category, assessment method, frameworks for technology adoption such as TAM, TOE and DOI, initially intended for the private sector, are extended or adapted to the evaluation of cloud services for the state sector. Similarly, there is a limited quantity of works that have clearly defined metrics to measure the assessment aspects.

Finally, only one work [12] suggests to evaluate organisational aspects such as the need of establishing Service Level Agreements and signing contracts with cloud providers. It constitutes an issue not well covered and further research is needed because of the importance of defining customer and provider responsibilities in the cloud sourcing model [19].

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