Technological Forecasting & Social Change xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Analyzing the factors influencing cloud computing adoption using three stage hybrid SEM-ANN-ISM (SEANIS) approach

Rakesh D. Raut[a,*], Pragati Priyadarshinee[b], Bhaskar B. Gardas[c], Manoj Kumar Jha[d]

[a] Operations and Supply Chain Management, Room No.211, Administration building, 2nd Floor, National Institute of Industrial Engineering (NITIE), Vihar Lake, Mumbai 87, India

[b] PGDM-Reasearch & Business Analytics, Prin. L. N. Welingkar Institute of Management Development & Research, Lakhamshi Napoo Road, Near Matunga (Central Rly.), Mumbai 400 019, India

[c] Mechanical Engineering Department, 8, Saboo Siddik Polytechnic Road, New Nagpada, Byculla, Mumbai, Maharashtra 400008, India

[d] Marketing Management, National Institute of Industrial Engineering (NITIE), Mumbai 87, India

ARTICLE INFO

Keywords:
Cloud computing adoption
SEM
ANN
ISM
MCDM
SEANIS

ABSTRACT

This investigation aims to propose a hybrid three-stage Structural Equation Modeling (SEM) - Artificial Neural Network (ANN) - Interpretive Structural Modeling (ISM) approach, together abbreviated as the SEANIS, for analyzing the factors influencing cloud computing adoption (CCA) services in the context of Indian private organizations. This study proposed new determinants, namely risk analysis and perceived IT security risk as an extension of the Technology Organization Environment (TOE) model. The data collected from the industry experts were analyzed using SEM and ANN approaches. The results of SEM revealed that trust (T), management style (MS), technology innovation (TI), risk analysis (RA), and perceived IT security risk (PITR) exercised a significant influence on CCA. The SEM results were taken as inputs for the ANN approach and ISM methodology. The results of ANN highlighted that perceived IT security risk, trust, and management style were the most important determinants for CCA. On the other hand, the ISM tool identified five factors, namely, decrease of internal systems availability (F1) (PITR cluster), utilization of internal resources (F14) (MS cluster), assurance of data privacy increases adoption rate (F16) (T cluster), innovativeness (F21), and previous experience (F22) (both from the TI cluster) as the top five significant variables with high driving power, among the 43 factors. The outcome of the hybrid approach is intended to guide the decision and policy-makers for easy evaluation of their organizational goals for choosing the most suitable computing environment for improving the efficiency and effectiveness of their business performance.

1. Introduction

The term ‘cloud’ is symbolic and denotes working assets such as hardware and software available on the Internet. Cloud computing characteristics have been defined by the present concepts such as networking, utility, grid, and service computing (Lin and Chen, 2012). According to Buyya et al. (2008), traditional system-centric resource management style is measured by the demand and supply of cloud assets at marketplace symmetry. Market-oriented cloud computing is linked to the idea and realism for supplying the cloud computing services.

Different types of descriptions of cloud computing are available in the literature. Usually, we use the definition given by NIST, which talks about different types of computing resources, characteristics of cloud computing, associated service models and deployment models. Gartner's definition of cloud discusses scalability, elasticity, and delivery as a service. IDC has discussed cloud computing as an evolving IT model. Forrester defines cloud as an abstraction, scalability, hosting and billing mechanism. IBM defines cloud computing as a platform for effective provisions and reconfigurations of servers as required. In AMR Research, cloud computing is the next generation computing that provides a software environment with less cost and high security. Burton Group states cloud computing as a technological business model that can provide on-demand services (Madhavaiah et al., 2012).

Marston et al. (2011) define cloud computing as an integration of two significant parts of information technology — (a) the power of computers can be used more efficiently, and (b) IT can be utilized as a business tool for real-time applications through hardware and software. Choudhary and Vithayathil (2013) defined cloud computing as a technique that offers in-house information technology services.

* Corresponding author.
E-mail address: rraut@nitie.edu (R.D. Raut).

https://doi.org/10.1016/j.techfore.2018.05.020
Received 20 July 2017; Received in revised form 15 May 2018; Accepted 20 May 2018

Dropbox and amazon.com are good examples of cloud services.

According to Buyya et al. (2008), cloud computing is a group of inter-connected virtualized computers that provide services to the customers. Kim (2009) defined cloud computing as a browser via the Internet provided by a third-party service provider, with the option to pay as per usage. Marks and Lozano (2010) defined cloud computing as on-demand services of the shared hardware and software resources, shared by others on the web; they emphasized its ease of use. There are three service models of CCA – software as a service (SAAS), infrastructure as a service (IAAS), and platform as a service (PAAS); also, there are four deployment models, namely, private, community, public, and hybrid for cloud computing adoption as per the NIST definition of cloud computing.

The cloud computing interoperability problem can be summarized into four types. Firstly, interoperation in the cloud applications can be permitted in one setting that requires link among the requests. Secondly, information is exchanged through requests and cloud operations are activated. This becomes a crucial task as different cloud environment has different structures. Thirdly, the programs are created to connect various cloud environments so that the applications across the cloud can be combined. Hence, the cloud environments should be neutral to any software programs and operating systems. Fourthly, cloud applications can be relocated from one cloud environment to another and the portability of this cloud is also a popular research area (Kumar et al., 2010).

Approval and usage of any innovative technology by small companies have a significant impact on the economy of a country. Since cloud computing helps SMEs in saving money and becoming more efficient and productive, its widespread use has a direct influence on GDP as a whole. More efficient, productive and innovative businesses have a positive impact on the economy.

Companies need to adopt innovation as the present market is highly competitive. Organizations can achieve competitive advantage by adopting cloud computing as it allows businesses to access the most advanced technologies over a network (e.g. Internet). Time, money and energy can be saved if companies move to cloud computing. Then, these resources can be used in other areas that will add more values to their business. Thus, the companies will become more productive by increasing their efficiency. In this way, cloud computing can strengthen the economy by enhancing the productivity of firms. As cloud computing service providers give IT services, they can resolve IT-oriented issues quickly by using fewer resources. If the services are offered at a larger scale, greater efficiency and higher profitability can be ensured. Extensive use of cloud computing can decrease the cloud data centers as companies do not have to maintain their data-centers. Large data centers that are operated by cloud service providers use the assets in a more efficient way than the smaller ones. The cloud computing concept follows virtualization that consumes less power. This can, therefore, also be a case of achieving environmental sustainability.

Cloud computing gives a tangible benefit to businesses by reducing the investment in manpower (Luftman and Zadeh, 2011). Students can get assistance in their research in universities with the help of cloud computing labs, enjoying the advantage ofs pay-per-usage (Sarkar and Young, 2011; Sultan, 2010; Vouk, 2008). Small and medium-scale enterprises (SMEs) can be significantly benefited from cloud computing by getting access to large data centers that were earlier inaccessible due to cost constraints (Weinhardt et al., 2009; World Economic Forum, 2010). The advantages of CCA over traditional computing are scalability, independence of device and location, reduced cost, and agility. However, even though CCA has many benefits, organizations have not recognized this technique, as they are concerned about the privacy and security of the data, which act as barriers to the CCA (Priyadarshinee et al., 2017; Sharma et al., 2017). Hence, there is a need to identify and rank the crucial factors affecting the adoption of CCA.

In the literature, many studies have focused on the cost-benefit analysis and methods of implementation. Very few research activities emphasized on the strategies of CCA, issues related to CC service selection, and the interrelationship between the crucial factors affecting CC adoption (Lee and Seo, 2016; Sharma et al., 2017). The present study aims to enlist the critical factors affecting CC adoption in the Indian private organizations and to explore their interrelationship by employing both qualitative and quantitative approaches. This research is intended to help the decision and policy-makers in understanding the cause-effect relationship between the factors and identifying the critical determinants of CC implementation, which will help in taking effective decisions. Also, it would help develop policies or strategies for the effective implementation of CC activities in the case sector. In addition to this, cloud service providers can also use findings of this study for marketing purposes. Hence, the present investigation is a novel attempt to identify and analyse the crucial factors/criteria influencing CCA by private organizations in the Indian context by employing the three-stage SEM-ANN-ISM methodology.

This article is organized in the following sequence-the results of literature survey on CCA are discussed in Section 2, followed by the description of research methodology in Section 3. Results and discussion of the data analysis carried out using the three methodologies are detailed in Section 4, and in Section 5 discussion and conclusions of the study are elaborated. Lastly, managerial implications, limitations and future aspects of the study are discussed in Section 6.

2. Literature survey

2.1. Papers published in the area of CC adoption

Alshamaila et al. (2013) studied the CC adoption process among small and medium-sized organizations by employing qualitative study and considering Technology-Organization-Environment (TOE) framework. The findings of the study highlighted that external computing support, supplier efforts, market scope, industry, innovativeness, prior experience, top management support, size, trialability, compatibility, geo-restrictions, uncertainty, and relative advantage were the significant factors. Baabdullah et al. (2014) examined the consumer adoption of M-internet and M-government from the perspectives of the unified theory of acceptance and use of technology (UTAUT2), perceived risk, and trust. The results of the study revealed that intention of usage was driven by enablers like perceived risk, trust, performance expectancy, and effort expectancy. Borgman et al. (2013) used the TOE framework for investigating the factors driving CC adoption and governance. It was concluded that technology and organization affected the decisions of implementation.

McGeogh and Donnellan (2013) explored the hindrances to large-scale adoption of CC services for critical business services and suggested strategies to overcome these barriers. Also, a case study that examined the CC adoption in Intel Corporation was presented. Conway et al. (2014) addressed the challenges faced by the small and medium enterprises in CC adoption by employing an IT-CMF framework. Espadanal and Oliveira (2012) identified determinants of CC adoption by firms based on the TOE framework and Diffusion of Innovation (DOI) model. Dutta et al. (2013) explored potential risks that firms may face during CC adoption and ranked them from the IT consultants' and practitioners' perspectives. GaurangKumar and Minubhai (2012) tried to achieve trust in cloud computing through the controls of preventive, detective, and corrective approaches. Also, the various steps to achieve confidence in the cloud were detailed. Gupta et al. (2013) focused on the adoption of CC in the micro and small businesses and the benefits of CCA implementation. It was found that ease and convenience were considered to be the most significant driver for the implementation.

Khanagha et al. (2013) examined the influence of management innovation on organizations' ability to adopt cloud computing and discussed how organizations could overcome the barriers to the implementation of the same. Lee et al. (2013) analyzed the newly established Korean SaaS markets and found that customer factors in the