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Understanding determinants of cloud computing adoption using an integrated TAM-TOE model

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Abstract

Purpose – The purpose of this paper is to integrate TAM model and TOE framework for cloud computing adoption at organizational level.

Design/methodology/approach – A conceptual framework was developed using technological and organizational variables of TOE framework as external variables of TAM model while environmental variables were proposed to have direct impact on cloud computing adoption. A questionnaire was used to collect the data from 280 companies in IT, manufacturing and finance sectors in India. The data were analyzed using exploratory and confirmatory factor analyses. Further, structural equation modeling was used to test the proposed model.

Findings – The study identified relative advantage, compatibility, complexity, organizational readiness, top management commitment, and training and education as important variables for affecting cloud computing adoption using perceived ease of use (PEOU) and perceived usefulness (PU) as mediating variables. Also, competitive pressure and trading partner support were found directly affecting cloud computing adoption intentions. The model explained 62 percent of cloud computing adoption.

Practical implications – The model can be used as a guideline to ensure a positive outcome of the cloud computing adoption in organizations. It also provides relevant recommendations to achieve conducive implementation environment for cloud computing adoption.

Originality/value – This study integrates two of the information technology adoption models to improve predictive power of resulting model.

Keywords India, TOE, TAM, Cloud computing, Technology adoption

Paper type Research paper

Introduction

Cloud computing can be viewed as a way to deliver IT enabled services in the form of software, platform and infrastructure using internet technologies. Cloud computing is defined by NIST, 2009 as "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models." The major driver for this widespread adoption is the economic benefit that cuts expenses for existing applications (Sandhu *et al.*, 2010). The emergence of the cloud computing concept has changed the way IT services are developed, deployed, used, maintained, and paid for (Marston *et al.*, 2011). It is significant for its service-oriented architecture, virtualization, utility and autonomic computing (Subashini and Kavitha, 2011; Benlian and Hess, 2011; Misra and Mondal, 2011). While a lot of research is currently taking place in the technology itself, an increased number of studies are witnessed to address business-related issues of cloud computing (Marston *et al.*, 2011). Some studies focus on the opportunities and risks of

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adopting cloud computing but without going into details to importance and effectiveness of adoption factors, their affect on customer decision and response to these factors, and how companies try to handle these issues (Benlian and Hess, 2011).

Cloud computing has three different service models: Infrastructure-as-a-System (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). IaaS is known as the basic level of cloud services which delivers infrastructure services to customers over a network (e.g. internet) such as hardware (e.g. storage and network) and software (e.g. operating systems and virtualization technologies). In this, users have control over operating systems, storage, and deployed applications (Mell and Grance, 2011). Examples of IaaS include Amazon's Web Services Elastic Compute Cloud and Secure Storage Service. PaaS is known as second level of cloud computing which offers online access to all the resources that are required to build an application. The services include application design, development, testing, deployment, and hosting tools which offer access to programming languages and libraries, etc. (Velte *et al.*, 2009). It facilitated users developing and deploying their applications by using infrastructure platform available on the internet. In this case, they need not buy, install and manage the underlying infrastructure platform if programming language is common among the cloud service providers. And, SaaS is known to deliver users a piece of software over a network such as internet. Users can install the software and use the application anytime and anywhere they have access to the network. Cloud deployment models are categorized according to the type of exclusive and non-exclusive method of providing cloud services to the clients, i.e. public cloud, private cloud, hybrid cloud, and community clouds (Mell and Grance, 2010). Goscinski and Brock (2010) identified that hybrid model of cloud computing is generally adopted by the firms. Hybrid cloud is a combination of private and public clouds. A public cloud offers cloud services to the general public in which cloud providers have own the infrastructure and make their own rules and policies. Amazon, Google, IBM and Microsoft are some of the well-known public cloud providers (Grossman, 2009). On the other side, a private cloud differs from public cloud for its bandwidth restrictions made by the providers that improves efficiency of data management and processes, and ensures resiliency and security.

Cloud computing is a kind of computing service that can provide cost advantage, scalability, flexibility, access of the shared resources automatic updates and upgrades to the organization. Still, there are a number of potential risks and challenges associated with cloud computing such as security, performance, higher costs (when compared to on-premise implementation) associated with the subscription model, difficult integration with on-premise applications and limited customization facilities, etc. (Feuerlicht *et al.*, 2011). Also, some concern and challenges are associated with the adoption of cloud computing such as security, service availability, performance, higher costs (when compared to on-premise implementation) associated with the subscription model, lack of interoperability standards, difficult integration with on-premise applications and limited customization facilities (Feuerlicht and Govardhan, 2010; Feuerlicht *et al.*, 2011; Géczy *et al.*, 2012). Based on the inferences from the literature, cloud computing is faced with a number of challenges which can be categorized in three parts(Low *et al.*, 2011; Wang *et al.*, 2010; Ramdani *et al.*, 2009). First challenge is related to technological aspects of cloud computing. Information technology (IT) managers are required to gain clear understanding of the technology, its advantages and its usefulness in their business operations. Understanding benefits of cloud computing over other contemporary technologies for specific functions of IT department determines the extent of adoption of cloud computing and identify the functions where it is applicable to improve predetermined performances of the functions. Further, cloud computing is known for its issues related to structural aspects which include complex structure and compatibility issues. Compatibility issues include level of compatibility with the technical aspects of an organization as well as customization of existing applications to cloud systems Géczy *et al.* (2012). It is real challenge for the organization when adopting cloud solutions, they should be able to move their application or data with no compatibility issue (Marston *et al.*, 2011). Complexity of integrating the existing system and using the cloud services becomes a challenge in implementing and using a cloud solution as it requires a level of expertise that may not be readily available in the organization(Hasan, 2007).

Second challenge is related to organizational aspects of cloud computing adoption. An organization and its top management should make an effort to access and analyze possible changes in organizational culture, process and work relationships in cloud computing adoption (Elson and Howell, 2009).Support from top management is the main challenge because to receive sufficient financial investment and technological competencies, willingness of top management to understand business-related benefits of cloud computing and its competitiveness, and to implement it in the organization is important also(Wang *et al.*, 2010, Alshamaila *et al.*, 2013). Further, it involves the specialized human resources, i.e. those in the organization with the knowledge and skill to implement the cloud computing services (e.g. employees with computer skills, IT specialists) (Wang *et al.*, 2007). Also, IT managers need to train their employees for cloud computing so that it can be effectively implemented in the organization and improve their performance to achieve business objectives. Trained employees, supported by organizational resources, understand the usefulness of cloud computing and find easiness of performing their duties using cloud computing.

Third challenge is related to competitiveness of cloud computing and trading partner support for cloud services. Managerial understanding related to competitiveness of cloud computing for survival in the market is an important challenge for cloud computing adoption (Wang *et al.*, 2010). Further, cloud computing adoption is facilitated by the cloud service providers. Their availability and support, security-related issues of cloud computing related to third parties' access to their data, the data transmission and data storage pose challenges in cloud computing adoption (Subashini and Kavitha, 2011).

From the above discussion, it can be inferred that technological and organizational variables influence PEOU and PU of cloud computing which further affect cloud computing adoption. And, environmental variables directly influence adoption of cloud computing which include reliability, availability, and security-related concerns. The three categories made here belong to TOE framework, and PEOU and PU are the two main constructs of TAM model. Usefulness is an important indicator because when users believe that using cloud services can improve their business efficiency, performance and productivity then only they are willing to adopt cloud computing (Senk, 2013). And, ease of use of cloud services is an effective motivator in using cloud services because where users can use computing resources and IT solutions without going into detail or having deep knowledge to operate them (CIO, 2011). The TAM model is well known in the literature across a wide range of technology adoption studies for successfully predicting and explaining users' intentions to adopt technologies. Thus the basic model to be utilized in this research study is going to be TAM and some of the constructs of TOE framework are also being added to make the proposed model more relevant in cloud computing case. This justifies the selection of the two models to study cloud computing.

Further, literature witnessed a few studies on cloud computing adoption using different traditional adoption frameworks such as Alshamaila *et al.* (2013) and Low *et al.* (2011) used TOE framework, and Wu (2011) used TAM model. These studies recognized relevance of relative advantage, uncertainty, geo-restriction, compatibility, firm size, top management support, prior experience, innovativeness, industry, market scope, supplier efforts, external competing support, security and trust, perceived benefits, social influence, trading partner pressure in cloud computing adoption (Alshamaila *et al.*, 2013; Lin and Chen, 2012; Low *et al.*, 2011; Wu, 2011). Even though cloud computing has been discussed as a new technology develop that can provide several strategic and operational advantages but the cloud computing adoption rate is not growing as fast as expected (Banerjee, 2009; Buyya *et al.*, 2009; Goscinski and Brock, 2010; Low *et al.*, 2011). Prior studies on cloud computing adoption have addressed areas of new technologies, security requirement and the future expectations in these emerging environments. Organization-specific capabilities such as technical capability which include resources giving the organization functionality, flexibility, and scalability as well as human IT resources resulting from training, experience, and insight can be a source of affecting adoption process (Garrison *et al.*, 2012). Thus, it can be inferred that it is important to address the impact of specific aspects of firm-related variables having influence on cloud computing adoption. This sets the objective for this study. This study is important because it will lead to an understanding of the determinants and the underlying relationships of cloud computing adoption so that an effective adoption of cloud computing can be facilitated in the organizations. Further, the study attempts to develop and test an integrated TAM-TOE model that makes the model more relevant to cloud computing market place and allow a greater prediction of the factors for usage of cloud computing services in organizations.

Technology adoption models

Based on the literature review, this study takes into consideration two of the adoption models, i.e. TAM model and TOE framework based on their relevance to cloud computing adoption. These models are explained as follows:

Technology Acceptance Model (TAM)

Among the many theoretical models, TAM is widely accepted model for understanding IT adoption and usage processes. It explains much of the variance in users' behavioral intention related to IT adoption and usage across a wide variety of contexts (Hong *et al.*, 2006). It predicts a user's acceptance of IT and its usage on the job (Au and Zafar, 2008) and explains the determinants of user acceptance of a wide range of end-user computing technologies (Davis, 1986). TAM seeks to explain the relationship between technological acceptance and adoption and subsequently, behavioral intention to use it (Autry *et al.*, 2010). It poises the PU and PEOU as primary determinants of system use (Chen and Tan, 2004; Au and Zafar, 2008).

Technology-organizational-environmental (TOE) framework

TOE framework was developed by Tornatzky and Fleischer (1990) to examine firm-level adoption of various IS/IT products and services. It has emerged as a widespread theoretical perspective on IT adoption (Zhu *et al.*, 2004). Inclusion of technological, organizational and environmental variables has made TOE advantageous over other adoption models in studying technology adoption, technology use and value creation from technology innovation (Hossain and Quaddus, 2011; Oliveira and Martins, 2010;

Ramdani *et al.*, 2009; Zhu and Kraemer, 2005). Also, it is free from industry and firm-size restrictions (Wen and Chen, 2010). Hence, it provides a holistic picture for user adoption of technology, its implementation, foreseeing challenges, its impact on value chain activities, the post-adoption diffusion among firms, factors influencing business innovation-adoption decisions and to develop better organizational capabilities using the technology (Wang *et al.*, 2010; Salwani *et al.*, 2009; Lin and Lin, 2008; Zhu *et al.*, 2004).

Developing TAM-TOE framework

This study takes into consideration two of the technology adoption models, i.e. TAM model and TOE framework which have been widely adopted for studies in organizational context. Though, a wide range of empirical and conceptual studies have justified the significant, dominant and relevant role of TAM model and TOE framework in explaining technology adoption at their individual levels, the models have individual limitations. The two constructs of TAM (PU and PEOU) explain about 40 percent of the system's use (Legris *et al.*, 2003) and the external variables in the extended models of TAM are not clearly defined yet. On the other side, TOE framework has unclear major constructs (Wang *et al.*, 2010) and is too generic (Riyadh *et al.*, 2009). So, TOE framework is needed to be strengthened by integrating it with the models having clear constructs. Therefore, researchers have advocated the need of integrating TAM and TOE so that predictive power of the resulting model can be improved and some of their individual limitations can be overcome.

Integrating the two models (TAM and TOE) is not simple because external variables of TAM model and variables of TOE framework vary across contexts and their significance as well. Thus, there is a lack of common set of variables which can be generalized to explain technology adoption and is applicable to any context and technology. To develop an integrated model, this study follows an approach of including the variables (significant as well as insignificant) of TAM and TOE identified from various studies based on these two models. For this, contrary to the findings of Jeyaraj *et al.* (2006), we argue that since the significance of variables varies with the context such as technology, country of study, and size of companies (turnover, number of employees, etc.), etc., it is advisable that no variable should be discarded just because it has consistently found insignificant in a set of studies and/or contexts.

Proposed framework

Based on the literature, adoption variables relevant to the cloud computing are selected to propose a conceptual framework and their hypotheses.

Relative advantage

Additional benefits of a technology over its other alternatives play a key role in its adoption in an organization. According to Rogers (1983), relative advantage means that "the degree to which a technological factor is perceived as providing greater benefit for firms." Cloud computing has advantage over other technologies such as reduced cost, scalability, flexibility, mobility, and shared resources (Figure 1).

Companies spend a big percentage of their finances on IT infrastructure while <10 percent of their servers are actually utilized which results in expenses that can be avoided using cloud computing (Marston *et al.*, 2011). Also, cloud computing frees organizations from administering and maintaining IT infrastructure every year.

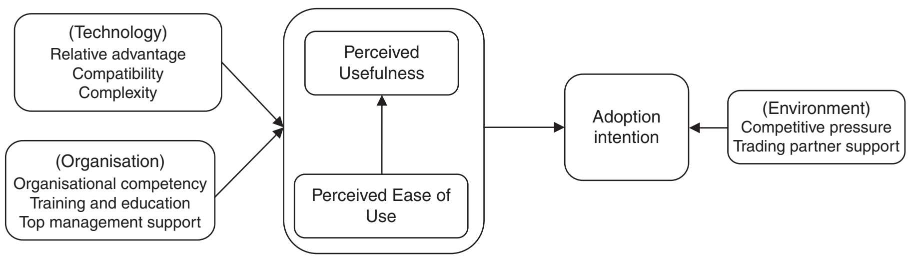
Thus, it reduces total cost of IT operations radically. Cloud computing offers rented services on pay-as-you-use basis which lead to adjusting the level of usage according to the current needs of the organization (Feuerlicht and Govardhan, 2010). As the requirements of cloud computing increases, the cloud user should be able to scale up their resources and infrastructure to satisfy the adaptors' new requirements of storage, number of servers, processing and connection bandwidth (Kim *et al.*, 2009; Benlian and Hess, 2011). Mobility offers users the facility of accessing and working on their documents from anywhere in the world; provided they have a computer access and an internet connection (Jain and Bhardwaj, 2010). Users need not own a computer for using services of cloud computing. Shared resources is another advantage to the companies offered by cloud computing which enables their employees to access resources placed on cloud from any location, and thus it saves businesses' time and money (Jain and Bhardwaj, 2010). So, following hypotheses are proposed:

H1a. Relative advantage has positive effect on PU.

H1b. Relative advantage has positive effect on PEOU.

Compatibility

Rogers (2003, p. 240) defined compatibility as "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." Later, Calisir *et al.* (2009) define the term as "the degree to which the innovation is perceived to be consistent with the potential users' existing values, previous experiences and requirements." Perceived compatibility takes into account whether existing values, behavioral patterns, and experiences of an organization and its employees are in the reconcilability of a new technology and/or innovation (Peng *et al.*, 2012). A number of studies in IT adoption have witnessed valid role of compatibility in PEOU as well as in PU (Peng *et al.*, 2012; Chen and Tan, 2004; Calisir *et al.*, 2009). It is perceived that more the cloud computing platforms are in align with the internet platform, the organization will be able to develop more capacity to utilize the benefits of cloud computing and more is the possibility of reducing the degree of uncertainty among the users of technology. In case of cloud computing, it is needed to understand whether the technology is compatible with existing architecture of technology in organization. It is also needed to take into account the integration (convenience of application import and export) and customization (adjustment of services). Géczy *et al.* (2012) have also explained that cloud-based services should be compatible with the existing formats, interfaces, and other structured data, or else



Sources: Adapted from Devis *et al*. (1986) and Tornatzky and Fleischer (1990)

Figure 1.
Conceptual framework

integration and customization services should be provided by the cloud service providers. So, following hypotheses are proposed:

H2a. Compatibility has positive effect on PU.

H2b. Compatibility has positive effect on PEOU.

Complexity

Complexity is defined as the perceived degree of difficulty of understanding and using a system (Sonnenwald *et al.*, 2001). In case of cloud computing adoption, it is measured as time taken to perform tasks, integration of applications with the specialized cloud infrastructure, efficiency of data transfer, system functionality, and interface design, etc. Generally, it is perceived to quite close to ease of use, there are many studies treating it as two independent constructs. Based on these studies, it can be inferred that complexity is inversely proportional to PEOU and PU (Parveen and Sulaiman, 2008; Chau and Hu, 2001; Igbaria, *et al.*, 1995). So, following hypotheses are proposed:

H3a. Complexity has negative effect on PU.

H3b. Complexity has negative effect on PEOU.

Organizational competency

Tan *et al.* (2007) described organizational readiness as "managers" perception and evaluation of the degree to which they believe that their organization has the awareness, resources, commitment, and governance' to adopt an IT. Broadly, it has been described with two dimensions, i.e. financial readiness (financial resources for cloud computing implementation and for ongoing expenses during usage), and technological readiness (infrastructure and human resources for cloud computing usage and management) (Musawa and Wahab, 2012; Oliveira and Martins, 2010). We argue that firms those have effective infrastructure, expertise in their employees, and financial support increases the usefulness of the technologies. So, following hypothesis is proposed:

H4. Organizational readiness has positive effect on PU.

Top management support

Similar to other disciplines of management, IT adoption literature has also recognized the role of top management support in initiation, implementation and adoption of several information technologies. Salwani *et al.* (2009) explains it as the perceptions and actions of top officials on the usefulness of technological innovation in creating values for the firm. It ensures long-term vision, reinforcement of values, commitment of resources, optimal management of resources, cultivation of favorable organizational climate, higher assessments of individual self-efficacy, support in overcoming barriers and resistance to change (Wang *et al.*, 2010; Jang, 2010; Ramdani *et al.*, 2009; Toe *et al.*, 2009). From the literature, top management support has been found to positively related to affect PU and PEOU in adoption of information technologies. So, following hypotheses are proposed:

H5a. Top management support has positive effect on PU.

H5b. Top management support has positive effect on PEOU.

Training and education

Training is described as a degree to which a company instructs its employees in using a tool in terms of quality and quantity (Schillewaert *et al.*, 2005). Since cloud computing is a complex information system, an organization needs to train and educate its employees before implementing it. It reduces employees' anxiety and stress about the use of cloud computing, and provides motivation and better understanding about its benefits for their tasks. It reduces ambiguity and help employees developing knowledge for effective usage in future. It also improves its PEOU and usefulness. So, following hypotheses are proposed:

H6a. Training and education has positive effect on PU.

H6b. Training and education has positive effect on PEOU.

Competitive pressure

From the early stages of research in technology adoption, the role of competitive pressure is recognized as an effective motivator (Lin and Lin, 2008; Lippert and Govindarajulu, 2006). Zhu and Kraemer (2005) defined it as "the degree of pressure that the company feels from competitors within the industry." Competition in the industry is generally perceived to positively influence the IT adoption specially when technology directly affects the competition and it is a strategic necessity to adopt new technologies to compete in the market (Ramdani *et al.*, 2009). This fact is applicable in the context of cloud computing. Adopting information systems is useful for a firm to alter the competitive environment in terms of rules of competition, industry structure and outperforming their competitors (Porter and Millar, 1985). Thus, first-movers in implementing cloud computing are tended to derive considerable advantages in terms of competitive advantages and smooth survival. So, following hypothesis is proposed:

H7. Competitive pressure has positive effect on cloud computing adoption.

Trading partner support

Trading partners in cloud computing are related to the cloud service providers. The service providers are required to ensure data availability all the time or rather, at the time when they need to use it. This raises the concerns over the effectiveness of cloud service providers. Kim and Suwon (2009) argue that adoption of high availability architecture, and tested platform and applications provide 100 percent availability of the data. Also, the authors mentioned that service-level agreements and a combination of precautionary measures (backup on on-premises storage, backup cloud, etc.) are the main driving factor to ensure desired levels of availability. Chow *et al.* (2009) raised certain questions related to the availability such as, effectiveness of server efficiency with the availability of the cloud user's own data center, points of failure and attack and faithfulness of cloud provider in running a hosted application and in giving valid results. Further, Kim and Suwon (2009) mentioned another serious availability concern as vendors' availability. Cloud service providers are required to address these issues while they offer their services. Further, support is the key demand for problem resolution in case of cloud computing and on-premises computing for which enterprise as well as end users pay to the cloud service providers. So, cloud computing vendors are expected to hire and train adequate support staff to provide best possible support to their clients (Kim and Suwon, 2009).

Security is another trading partner-related concern. Security in cloud computing is not just about authenticity, authorization, and accountability but is more concerned with data protection, disaster recovery, and business continuity (Katzan, 2010). Many companies are found reluctant to host their internal data on computers which are external to their own company and which might be co-hosted with other company's applications. Further, privacy and confidentiality concerns are also included in security because service providers have access to all the data and the same could intentionally or unintentionally use it for unauthorized purpose.

So, following hypothesis is proposed:

H8. Trading partner support has positive effect on cloud computing adoption.

PU

PU is defined as the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context. So, following hypothesis is proposed:

H9. PU has positive effect on cloud computing adoption.

PEOU

PEOU refers to the degree to which the prospective user expects the target system to be free of effort (Davis, 1989). The TAM model suggests that PEOU influences PU, because technologies that are easy to use can be more useful (Schillewaert *et al.*, 2005). So, following hypotheses are proposed:

H10a. PEOU has positive effect on cloud computing adoption.

H10b. PEOU has positive effect on PU.

Methodology

Objective of the study is to identify the factors affecting cloud computing adoption in organizations using integration of TAM model and TOE framework. For this, questionnaire-based survey method was followed in which data were gathered from the organizations those have implemented cloud computing. For the variables identified from the literature (Table I), the questionnaire was comprised of two parts: company profile and adoption variables. The items were framed on five-point Likert scale. Two consecutive rounds of pre-testing were conducted in order to insure that respondents can understand the items used in the study: first, the questionnaire was reviewed by the academic researchers experienced in questionnaire design and next, the questionnaire was piloted with IT experts known. Further, responses on the questionnaire were collected from the top and middle-level IT professionals of the companies who in the process of adoption (potential adopters). This way, purposeful sampling was used for the data collection in which the respondents were approached through e-mail and/or telephone to know whether they are aware of cloud computing and if yes, whether they are willing to adopt cloud computing or they are in the process of adoption. If so, a suitable time was decided with an appointment for data collection. Most of the responses were collected through personal visits to the respondents and a round of conversation was held before seeking their responses on the

Table I. Questionnaire development based on items from the literature

Variable(s)	Reference(s)
Relative advantage	Feuerlicht and Govardhan (2010), Géczy *et al.* (2012), Jain and Bhardwaj (2010)
Compatibility	Géczy *et al.* (2012), Wang *et al.* (2010), Chung *et al.* (2008)
Complexity	Gardner and Amoroso (2004), Sonnenwald *et al.* (2001)
Organizational competency	Lin and Lin (2008), Tan *et al.* (2007), Zhu and Kraemer (2005)
Top management support	Wang *et al.* (2010), Tan *et al.* (2007)
Training and education	Schillewaert *et al.* (2005), Amoako-Gyampah and Salam (2004)
Competitive pressure	Lin and Lin (2008), Tan *et al.* (2007)
Trading partner support	Hada *et al.* (2011), Kerr and Teng (2010), Buecker *et al.* (2009), Kim *et al.* (2009)
Perceived ease of use	Wu (2011)
Perceived usefulness	Schillewaert *et al.* (2005)
Adoption intention	Wu (2011)

questionnaire. Other responses were collected through e-mail. This conversation was aimed to understand their preparedness for cloud computing adoption and their related future plans.

The enterprises from manufacturing, IT and finance sectors were chosen from an official national database of Bombay Chamber of Commerce and Industry, India. The four service industries mainly included in this study are manufacturing, finance and information and communication technology which includes telecommunication services, information technology enabled services, and computer software services. The reasons for choosing these four industries are their high adoption rate in these sectors (CIO Report, 2010).

Data analysis

A Questionnaire survey was used to collect the empirical data for this study. The list of 1,000 random organization was obtained from the Bombay Chamber of Commerce and of Industry of India. Mails or telephone calls were then made to screened the organizations on the basis of questions like they are aware of cloud computing, whether they are willing to adopt cloud computing or they are in the process of adoption. Out of total 1,000 organizations, 433 were found to be eligible for this survey on the basis of screening question. Most of the responses were collected through personal visits to the respondents and a round of conversation was held before seeking their responses on the questionnaire. Other responses were collected through e-mail. Out of 433 organizations, 330 responses were gathered and 280 responses were found valid. For the data analysis, several data analysis techniques were applied.

Sample characteristics

Sample characteristics are identified based on their number of employees and turnover. These parameters are used to categorize the sample firms in three categories which are mentioned in Tables II and III. The count shows that the sample is equally distributed among the categories.

The data were tabulated in a MS Excel sheet. The reliability of the questionnaire was calculated which was followed by exploratory factor analysis and confirmatory factor analysis.

Reliability and confirmatory factor analysis

Reliability analysis revealed Cronbach's α value as 0.821 and is comparable with the reliabilities reported in earlier studies. Further, the scale was factor analyzed using principal component analysis and varimax rotation. The result for Bartlett's test of sphericity was 0.000 and the KMO value 0.583 (Table III). This value is more than 0.5 which shows high measure of sampling adequacy and ensures factorability of the data.

From a total of 49 items, three of the items were dropped in the exploratory factor analysis. The reliabilities of sub-scales varied between 0.620 and 0.947; which exceeded the recommended level of 0.6. Exceeding this threshold proves that the factors emerged are reliable and valid for their factor structure. The variables were grouped in 11 factors and all together accounted for 71.171 percent of the total variance. This value of total variance explained means that the set of factors extracted from the data explain adoption intention to a very high extent and a very less part of the adoption remains unexplained.

Confirmatory factor analysis

To test the stability of the scale, confirmatory factor analysis was employed on the sample using structural equation modeling. A measurement model was developed using AMOS V20.0 and Maximum Likelihood method was chosen for confirmatory factor analysis (Figure 2). A range of indices were used to assess the model fit. The analysis demonstrated broadly satisfactory levels of fit (Browne and Cudeck, 1993) as CMIN/DF was obtained as 1.268 which should be below an absolute value of 5. CFI was obtained 0.948 which should be above 0.9. It shows that the set of factors in the model has high stability. The RMSEA obtained was 0.041. It should vary between 0.04 and 0.07. Since the value of RMSEA is within limits, it shows that the data has very less error value. In other words, the items explain their respective factors in the best manner. The eight-factor model had the best overall fit to the data with a χ^2-statistic of 1,902.774, goodness of fit index of 0.755, and an adjusted goodness of fit index of 0.702. It shows that the set of factors in the model has high stability. Table IV shows inter-construct correlations and descriptive statistics.

Hypotheses testing

To test proposed hypotheses, the measurement model was converted to structural model in AMOS (Figure 2). Using regression weight table, the results are interpreted (Table V).

Category	Criterion of categorization	No. of firms
Small	Number of employees $\leqslant$ 400	85
Medium	400 $\leqslant$ number of employees $\leqslant$ 800	93
Large	Number of employees > 800	102

Table II. Categorization of firms with respect to size

Category	Criterion of categorization (in million of INR)	No. of firms
Small	Turnover $\leqslant$ 750	79
Medium	400 $\leqslant$ number of employees $\leqslant$ 3,000	123
Large	Number of employees > 3,000	78

Table III. Categorization of firms with respect to turnover

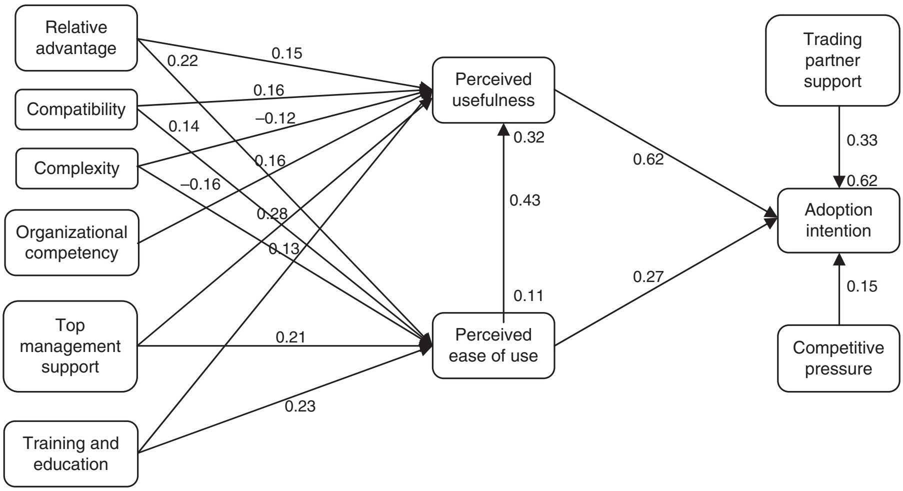


Figure 2.
Structural equation modeling using AMOS

Relative advantage is supported to positively affect on PEOU (*H1a*) and PU (*H1b*). Therefore, this study supports the prior studies of Chwelos *et al.* (2001) and Musawa and Wahab (2012) that perceived benefits were the most influential determinants of the technology usage. This is also in line with the findings of Amoako-Gyampah and Salam (2004) who found positive relationship of relative advantage of ERP system for its adoption. It allows users to understand the various ways that the cloud computing will make them productive and to perceive the system to be easy to use and more meaningful in day to day routines. Compatibility is found supportive to positively affect PEOU (*H2a*) and PU (*H2b*). This finding is consistent with those of Chau and Hu (2001), Chebrolu and Ness (2012), Morgan and Conboy (2013), Lin and Chen (2012), Achjari and Quaddus (2002), Lin and Lin (2008) and Wang *et al.* (2010). The positive relationship of compatibility with PEOU indicates that high compatibility of cloud computing enables users not to make major changes in their jobs and work style. Complexity is also found negatively affect PEOU (*H3a*) and PU (*H3b*). This is in consistent with Parveen and Sulaiman (2008), Ramdani *et al.* (2009) and Wang *et al.* (2010). Organizational readiness is supported to positively affect on PU (*H4*). The results are similar to those of Lin and Lin (2008), Kowtha and Choon (2001), Durbhakula and Kim (2011), Wang *et al.* (2010), Oliveira and Martins (2010) and Musawa and Wahab (2012).

Top management commitment is supported to positively affect on PEOU (*H5a*) and PU (*H5b*). The results are similar to those of Schillewaert *et al.* (2005), Low *et al.* (2011), Ramdani *et al.* (2009) and Teo *et al.* (2009). Training and education is supported to positively affect on PEOU (*H6a*) and PU (*H6b*). The results are similar to those of Lee *et al.* (2010), Amoako-Gyampah and Salam (2004), and Kerimoglu *et al.* (2008). Competitive pressure is supported to positively affect on adoption intentions (*H7*). This is not in consistency with Ramdani *et al.* (2009), Wen and Chen (2010) and Premkumar and Roberts (1999), and is consistent with Kamien and Schwartz (1982), Low *et al.* (2011) and Oliveira and Martins (2010). Trading partner support is supported to positively affect on adoption intentions (*H8*). This is in line with Teo *et al.* (2009), Power and Sohal (2002), Lin and Lin (2008), Oliveira and Martins (2010), Wang *et al.* (2010) and Low *et al.* (2011). The results also showed that PU (*H9*) and PEOU (*H10a*)

Table IV. Inter-construct correlation and descriptive statistics

Constructs	Inter-construct correlations											Descriptive statistics	
	Relative advantage	Compatibility	Complexity	Organizational competency	Top management support	Training and education	Trading partner support	Competitive pressure	Perceived ease of use	Perceived usefulness	Adoption intention	Mean	Standard deviation
Relative advantage	1.000											3.232	0.957
Compatibility	0.016	1.000										3.156	0.992
Complexity	0.053	0.048	1.000									3.260	0.960
Organizational competency	−0.033	0.016	−0.095	1.000								3.166	0.964
Top management support	−0.036	0.022	0.087	0.165	1.000							3.098	0.962
Training and education	−0.084	−0.020	−0.068	0.043	0.138	1.000						3.126	0.973
Trading partner support	0.047	−0.035	−0.010	−0.073	0.175	0.101	1.000					3.181	0.946
Competitive pressure	0.107	0.013	0.345	0.081	0.089	−0.213	0.076	1.000				3.670	1.198
Perceived ease of use	0.213	0.148	0.173	0.198	0.331	0.118	0.112	0.098	1.000			3.876	1.023
Perceived usefulness	0.298	0.117	0.182	0.102	0.276	0.264	0.132	0.005	0.323	1.000		3.109	1.234
Adoption intention	0.109	0.009	0.056	0.112	0.116	0.008	0.332	0.264	0.226	0.447	1.000	3.576	0.986

Sl. no.	Hypotheses	Path coefficient	Findings
H1a	Relative advantage has positive effect on perceived usefulness	0.151	Supported ($p < 0.1$)
H1b	Relative advantage has positive effect on perceived ease of use	0.223	Supported ($p < 0.1$)
H2a	Compatibility has positive effect on perceived usefulness	0.164	Supported ($p = 0.001$)
H2b	Compatibility has positive effect on perceived ease of use	−0.139	Supported ($p < 0.1$)
H3a	Complexity has negative effect on perceived usefulness	−0.119	Supported ($p < 0.05$)
H3b	Complexity has negative effect on perceived ease of use	0.161	Supported ($p < 0.1$)
H4	Organizational readiness has positive effect on perceived usefulness	0.163	Supported ($p < 0.001$)
H5a	Top management support has positive effect on perceived usefulness	0.281	Supported ($p = 0.01$)
H5b	Top management support has positive effect on perceived ease of use	0.209	Supported ($p < 0.05$)
H6a	Training and education has positive effect on perceived usefulness	0.129	Supported ($p < 0.001$)
H6b	Training and education has positive effect on perceived ease of use	0.234	Supported ($p < 0.1$)
H7	Competitive pressure has positive effect on cloud computing adoption	0.152	Supported ($p < 0.1$)
H8	Trading partner support has positive effect on cloud computing adoption	0.331	Supported ($p < 0.001$)
H9	PU has positive effect on adoption	0.618	Supported ($p < 0.05$)
H10a	PEOU has positive effect on adoption	0.274	Supported ($p < 0.05$)
H10b	PEOU has positive effect on PU	0.434	Supported ($p < 0.001$)

Table V. Results of hypotheses testing

have direct effect on adoption intention of cloud computing services. And, PEOU has positive effect on PU (*H10b*). These findings are in line with earlier studies in IT adoption.

Cloud computing adoption using TAM and TOE resulted in $R^2 = 0.62$, i.e. the variables described above explained 62 percent of the variance of cloud computing adoption.

Discussion

The study identified relative advantage, compatibility, complexity, organizational readiness, top management commitment, and training and education as important variables for affecting cloud computing adoption using PEOU and PU as mediating variables. Also, competitive pressure and trading partner pressure were found directly affecting cloud computing adoption intentions.

Findings of the study show that relative advantage has strong impact on PEOU and PU. It is witnessed that cloud computing adoption by companies is dependent on several advantages of strategic importance such as scalability, mobility, and pay-per-use, etc. It allows users to understand the various ways that the cloud computing will make them productive and to perceive the system to be easy to use and more meaningful in day to day routines. The relative advantages of cloud computing lead to greater results such as greater efficiency of internal processes, increased employee productivity, improved customer service, reduced inventory costs, and improved coordination with trading partners. Developed managerial understanding of these advantages of cloud computing over their existing system enhances relationship with customers and business partners, and helps managers better manage their management structure and policies. It is also perceived that more opportunity will make the easier use of technology.

Compatibility was found to have a strong impact on PU because cloud computing is found to be consistent with existing technological architecture existing format, interface, and other structural data. Since cloud computing can integrate all needed functions together and offers exchanging data with other programs frequently used by the users, compatibility can have a strong relationship with PU in use of cloud computing. It is a real challenge for those who have installed many complex applications consisting of many internal systems. Manager should take initiatives to change existing processes to meet compatibility of cloud solutions to their existing infrastructure. Cloud computing should also be compatible with companies' policy, IT development environment, and business needs (Lin and Chen, 2012). Compatibility issues raised such as management style and culture of the organization, structure and integration of the processes, transparent information flow and innovativeness should be accessed by each organization and accordingly, strategies need to be developed to effectively address those issues.

Thus, organization should make necessary contribution to making cloud computing system compatible with the organization and its processes. The positive relationship of compatibility with PEOU indicates that high compatibility of cloud computing enables users not to make major changes in their jobs and work style.

This study describes complexity in terms of efficiency of data transfer, interface design, and system functionality. Cloud computing is found easy to learn and taking lesser time in performing tasks of employees. It identified that complexity of cloud computing has negative effect on organizational beliefs that lesser the complexity in using cloud computing, more is the enhancement in their job performance and the ease of using it. To further increase the ease of use of cloud computing, cloud computing developers should design the systems to be more user-friendly and more relevant to the employees' jobs. The findings also indicate that cloud computing is not complex to those who hold a level of expertise to integrate existing applications with the specialized cloud infrastructure as well as knowledge about the new technology, and resistance to changes in established business processes. Anxiety of using cloud computing in an organization is eased by service providers by offering easy to use development tools and integration of data and systems as well as by ensuring the integrity of each layer and the links between the layers (Lin and Chen, 2012; Raymond and Uwizeyemungu, 2007).

The findings also indicate that cloud computing adoption is dependent upon orgzanizational infrastructure and expertise related to the technology. The organizations with higher levels of organizational readiness for cloud computing are more likely to use cloud computing services. Thus, managers and policy makers need to focus on financial and technological resources such as physical infrastructures, intangible knowledge, and hiring of employees with IT skills. Also, managers need to understand that employing specialized IT workforce with skill sets across the conventional IT environment and the cloud platform and developing strategic projects to support business growth enable cloud computing adoption.

Further, top management has an effective role in convincing their employees with their persuasions and motivating their work behavior. It demonstrates commitment and continuous support for developing conducive implementation environment (such as by providing necessary resources such as time, space, equipment, and people) for cloud computing adoption. Thus, technological adoption is generally carried out using top down approach especially because it is must for the top management to realize the role of a technology in improving organizational performance, overcoming perceived performance gap, and exploiting a business opportunity.

Training to employees enables them to understand functional and technical perspectives of cloud computing, and to gain first-hand information and experience. It makes them well-educated, experienced, responsible, and knowledgeable to effectively use cloud computing. Thus, it becomes easy for them to use and understand its relevance in their job performance. Thus, managers develop strong and effective training modules so that cloud computing can be effectively implemented in their organizations. This improves necessary technical know-how of the employees and develop a dedicated manpower for cloud computing.

Significant and positive relationship between competitive pressure and adoption implies that when competitors implement cloud computing as a competitive instrument, other organizations face strong competition and thus feel pressure of adopting cloud computing so as to maintain a competitive edge. It is important to understand that stiff competition drive organizations to switch from other technologies to cloud computing without investing sufficient time in infusing the innovation in the organizations (Zhu *et al.*, 2006).

Findings also supports that adoption of cloud computing is essentially driven by trading partners and their requirements. This is supported by the fact that cloud computing requires the cooperation and coordination of business partners so that it can function to its full potential. Thus, cloud computing adopters encourage the formation of networks with other players and the sharing of resources so that the needs of diverse and ever faster changing customer requirements can be satisfied. Further, high availability of cloud providers and their support is ensured by cloud service providers by employing multiple network providers so that even if one of them experiences difficulties or a complete failure, the provider services will not be put in jeopardy due to the immediate availability of another network provider. Also, they adopt high availability architecture, and test platform and applications, and maintain a backup on on-premises storage, or use a backup cloud, or simply not store mission-critical data on the cloud. With applications, the users may keep an on-premises version of the application, so that they may work offline while the cloud is down. Security-related issues in trading partner support indicate that lesser the risk in using cloud services, higher the trust developed on the privacy and integrity. Thus, in order to secure cloud computing from security threats, various security measures, identity management standard, access control, configuration management, are incorporated into cloud system.

Conclusion

This study witnessed the factors affecting cloud computing adoption in organizations. To underpin the basis of these factors in existing literature, the study chose TAM for its wide acceptance in technology adoption literature. Since the relevance of TOE framework is found increasing in the recent literature, this study developed an integrated TAM-TOE framework for cloud computing adoption. It extended TAM using a set of TOE variables relevant to cloud computing adoption as external variables of TAM, i.e. relative advantage, compatibility, complexity, organizational readiness, training and education, and top management commitment; which have direct effect on either of the two constructs of TAM or both, and has indirect effect on adoption. Thus, the two constructs of TAM act as mediating variables for external variables of TAM. Further, competitive pressure and trading partner support were proposed to have direct impact on adoption. Findings show that PU, PEOU, relative advantage, compatibility, complexity, organizational readiness, training and education, top management commitment, competitive pressure and trading partner support are important determinants for cloud computing adoption in organizations. Also, it integrated TAM model and TOE framework using variables of TOE as external variables of TAM. The proposed hypotheses were empirically tested and results were interpreted. Further, an integrated model approach resulted in IT adoption literature by proposing novel way of integrating two popular adoption frameworks. This model addresses the key concerned areas of cloud computing adoption and has relevance to the IT professionals by enabling them to consider effective concerned areas so that they can take effective course of actions during cloud computing adoption in their organizations. Thus, this study is a special attempt to contribute in cloud computing adoption literature. This study is limited in terms of using limited set of variables and exclusion of non-adopters. Future research should validate findings of the study in other contexts.

This study is limited to the sectors in India which have substantial number of companies having adopted cloud computing. Case-based approach may be adopted to study cloud computing adoption in the sectors having limited players adopting cloud computing.

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Appendix

Table AI. Rotated component matrix

Factors and their items	Factor loading
F1: Relative advantage (α = 0.909)	
Using cloud computing, we pay only for what I use	0.881
Using cloud computing, we are able to scale up our requirement when required	0.850
Using cloud computing, we can access information from any time from any place	0.842
Using cloud computing, we need not administer my IT infrastructure	0.806
Performance of cloud services does not decrease with growing user base	0.745
Using cloud computing, we can access share resources placed on cloud	0.724
Using cloud computing, we need not maintain my IT infrastructure	0.636
F2: Compatibility (α = 0.947)	
In case of any incompatibility issue, we ask cloud service provider to offer integrated services	0.885
Cloud services are compatible with existing technological architecture of my company	0.867
Customization in cloud-based services is easy	0.832
The changes introduced by cloud computing are consistent with existing practices in my company	0.821
Cloud computing development is compatible with my firm's existing format, interface, and other structural data	0.813
We incur re-training cost in case of non-customizable cloud-based services	0.774
There is no difficulty in importing applications/ data from cloud services	0.727
There is no difficulty in exporting applications/ data to cloud services	0.515
F3: Complexity (α = 0.722)	
Cloud computing is flexible to interact with	0.878
Using cloud computing exposes me to the vulnerability of computer breakdowns and loss of data	0.844
When we use cloud computing, we find it difficult to integrate my existing work with the cloud-based services	0.722
When we perform many tasks together, using cloud computing takes up too much of my time	0.644
F4: Organizational competency (α = 0.869)	
My company hires highly specialized or knowledgeable personnel for cloud computing	0.876
We have sufficient technological resources to implement cloud computing – unrestricted access to computer	0.855
We have sufficient technological resources to implement cloud computing – high bandwidth connectivity to the internet	0.802
We allocate a percent of total revenue for cloud computing implementation in the company	0.712
F5: Top management support (α = 0.838)	
Our top management exhibits a culture of enterprise wide information sharing	0.882
The company's top management provides strong leadership and engages in the process when it comes to information systems company	0.82
My top management is likely to consider the adoption of cloud computing as strategically important	0.671
My top management is willing to take risks involved in the adoption of cloud computing	0.643

(*continued*)

Factors and their items	Factor loading
F6: Training and education (α = 0.884)	
My level of understanding was substantially improved after going through the training program on cloud computing	0.936
.My company provided me complete training in using cloud computing	0.886
The training gave us confidence in use of cloud computing	0.778
F7: Trading partner support (α = 0.735)	
Our agreement with cloud service providers ensures that they have high availability architecture, and tested platform and applications for readiness of services	0.755
Our Organization ensure that cloud provider considerably invest in security controls and monitoring of access to the contents	0.744
We check whether the cloud service provider has policy for handling personally identifiable information	0.704
We ensure that cloud vendors implement strong access and identity management to ensure unauthorized access to cloud computing	0.625
F8: Competitive pressure (α = 0.804)	
We are aware of cloud computing implementation in our competitor organizations	0.782
We understand the competitive advantages offered by cloud computing in our industry	0.661
F9: Perceived ease of use (α = 0.687)	
The procedure of using cloud computing is understandable	0.828
It is easy for us to learn using the cloud computing.	0.779
It is easy to make use of cloud computing	0.726
F10: Perceived usefulness (α = 0.620)	
Using cloud computing allow me to manage business operation in an efficient way	0.884
Using cloud computing allow me to increase business productivity	0.861
Using cloud computing enables allow me to accomplish my organizational task more quickly	0.861
The use of cloud computing services improves the quality of business operation	0.868
Using cloud computing advances my competitiveness	0.851
F11: Adoption intention (α = 0.910)	
Overall I think that using cloud computing services is advantageous	0.650
Overall, I am in favor of using the cloud computing services	0.596

Notes: Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization. Rotation converged in 7 iterations

Table AI.

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