

## Predicting Cloud Computing Adoption in Hospitals Using Regression Analysis

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**Abstract:** Cloud computing are a new archetype move and many researchers are attempting to find out the factors affecting the cloud computing adoption in hospitals. This research aims to provide insights into the factors and the barriers that are expected to influence the adoption of cloud computing in hospitals. The primary data were collected by in-depth interviews with IT departments of different hospitals in India. The collected data was tested using multiple regression analysis. The Technology Organization and Environment (TOE) framework was considered for this study. The findings indicated that all the factors has a significant positive impact on the intention of hospitals to adopt cloud computing. The findings are expected to assist managers to evaluate possible adoption and increase their awareness about issues that influence the cloud adoption when planning to adopt it.

**Key words:** Cloud computing, TOE framework, awareness, findings, managers, regression

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### INTRODUCTION

Recent reforms in various countries directly benefiting the healthcare sector coupled with the explosion of the cost efficiency and new models of cloud computing are the major factors in driving the demand for cloud computing. Adoption of cloud computing helps in tracking and analysing patient data, so that, information on treatments, performance, costs and effectiveness can be analysed properly. Cloud computing is one of the newest paradigms which allow cloud service providers to house cloud services and cloud-based resources in their data centres. Cloud computing will be considered as a utility next to electricity, water, telephone and gas. As per Anonymous (2014), the International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC) define cloud computing as “a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand”. Many hospitals have adopted technology for automating their process, although the IT budget allocated is very low. There is a need for a statutory regulation for a uniformity technology adoption in the government and private healthcare sector. Cloud computing can act as linkage for connected health to support a range of complex, disparate and mission-critical applications. Cloud helps the hospitals to use the applications, hardware and services on a pay per use model which allows them to avoid heavy capital expenditure on buying and deploying expensive technology. Transforming service deliveries through the

cloud require reducing capital expenditure and leveraging existing assets. Cloud can enable service providers to rapidly and cost-effectively integrate their applications, end points and operations capabilities into a set of cloud services that can be deployed to customers be it providers, governments, payers or patients, using a wide range of network connections (fixed and mobile). In many cases these services can be composed of existing applications, infrastructure and research flows that may be located anywhere in a cloud configuration (without requiring co-location) to a set of consumers that can either be permanently or temporarily connected into the cloud.

**The basic concept of cloud computing:** Cloud computing has defined a new paradigm shift in the IT domain (Kantarcioglu *et al.*, 2011). This is due to significant innovations in mass internet adoption, utility computing, virtualisation, distributed computing, shared computing, grid computing, storage, content outsourcing, enhanced security and networking (Catteddu, 2010). The US National Institute of Standards and Technology (Anonymous, 2009a) has defined cloud computing as:

“A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of services (for example, networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”

The availability of cloud computing has been recognized by NIST and it describes the five essential characteristics of cloud computing specific to demand self-service; broad network access, resource pooling, rapid elasticity and measured service (Anonymous, 2009a).

Cloud services can be categorised on the basis of the following three service/delivery models. Platform as a service, software as a service and infrastructure as a service (Ali and Soar, 2014; Buyya *et al.*, 2009; Anonymous, 2009b; Mell and Grance, 2009, 2011).

The Platform as a Service (PaaS) Model enables the consumer to deploy consumer-created, self-created or acquired applications onto the cloud infrastructure with the help of programming languages and tools the provider supports. The cloud infrastructure is managed by the service provider and the consumer does not manage or control or interfere the underlying cloud infrastructure. The consumer only control the deployed applications and possibly the application-hosting environment configurations (Anonymous, 2010; Dillon *et al.*, 2010; Velte *et al.*, 2010).

Software as a Service (SaaS) enables consumers to use the service provider's software package/applications running on a cloud infrastructure. Consumers can access the software package/applications by using client devices provided by the service provider. The consumer may access through a client interface such as a web browser or through a URL provided by service provider. Consumers have access to limited user-specific application configuration settings. The consumer cannot manage or control the underlying cloud infrastructure such as its network, servers, operating systems or storage (Clemons and Chen, 2011; Anonymous, 2010; Mell and Grance, 2009; Velte *et al.*, 2010; Wang *et al.*, 2008).

The third platform, Infrastructure as a Service (IaaS), provides the consumers with infrastructure related support such as storage, processing, network and other fundamental computing resources (Bhardwaj *et al.*, 2010). The consumer can deploy and run arbitrary software, including operating systems and applications. Like the other two models, the consumer cannot manage or control the underlying cloud infrastructure. The consumer has control of the storage, operating systems and deployed applications and possibly have limited control over select networking components such as host firewalls (Bhardwaj *et al.*, 2010; Anonymous, 2010; Mell and Grance, 2009; Yadav and Hua, 2010).

There are believed to be four cloud deployment models, public, private, community and hybrid (Ali and Soar, 2014; Catteddu, 2010; Anonymous, 2009b;

Mell and Grance, 2009). Public cloud enables the cloud infrastructure to be made available to the general public. The infrastructure is owned by a cloud service provider and the general public or organization like hospitals, educational institute, etc. can subscribe, pay and use as per their need.

In the private cloud model, the cloud infrastructure belongs to a particular organization and is deployed solely for a single organisation. The organisation may itself manage the infrastructure by themselves or can outsource it to a third party. The cloud infrastructure may exist in the organisation's premises or be based off-premise (Fox *et al.*, 2009).

Community cloud deploys the cloud infrastructure to several organisations that belongs to a specific community and shares similar concern. The cloud infrastructure may be managed by the organisations or by a third party. The infrastructure may exist in the organisation's premise or be based off-premise.

In the hybrid cloud model, the cloud infrastructure is composed of two or more clouds (private, community or public) that remain unique entities but are bound together by standardised or proprietary technology that enables data and application portability (Anonymous, 2009b).

**Adoption rate of cloud computing in Indian hospitals:** At the end of 2011, 4% of the health care industry was using cloud computing but recently the figure has risen drastically as per the market report by markets and markets. As per the recent report, the health care cloud computing market will grow at an exponential rate of 21.3% in the next 3-4 years. By the end of 2016, the market will reach USD 6.79 billion. Private clouds are dominating the market but still public cloud is growing at a faster rate. Around 74% organisation have a hybrid cloud strategy and many are using private and public clouds. Gartner predicted that the public cloud computing market will exceed USD 180 billion in 2015 and will occupy most of new IT investments in 2016.

Still many organisations are facing the problem in sizing their operations with the latest technology to enhance their quality services in health care. With dynamic usage of devices by consumers, cloud computing is gaining more importance in the health care industry. Cloud computing plays a vital role in health care for the data storage as well as for inter device management. Almost 12% cloud computing services are aimed at health care industry globally. Translational medicine is an area where cloud is making its presence in both storage and computing. Securities continue to be the

top concern for adoption for public cloud. Cost pressure and reduction in capital expenses is driving towards adoption of the cloud computing in health care and is gaining momentum in the value chain.

**Technology Organization and Environment framework (TOE framework):** TOE is a classic framework that proposes a generic set of factors that explain and predict the likelihood of innovation/technology adoption (Tomatzky *et al.*, 1990). TOE framework asserts that three principle contexts-technological, organizational and environmental-influence the process by which an organization adopts and accepts a new technology.

The technological context considers the available technologies important to the firm both internal and external that might be useful in improving organizational productivity. Internal technologies refer to those that are already in use by the organisations. External technologies refer to the technologies available in the market and the organisation is presently not using it. Healthcare organisation can take a decision to either adopt cloud computing on the basis of internal technology or they can adopt external technology available in the market place. Successful adoption of cloud computing depend on largely on the degree of the technology competence of the organisation.

The organizational context is defined in terms of resources and manpower available to support the acceptance of the innovation. The criteria include firm size and scope, centralization, formalization, interconnectedness and complexity of the managerial structure and the quality and availability of the firm's human resources. It is composed of main two components top management support and technological readiness. Top management support plays a vital role in initiating, implementing and adopting of cloud computing. They are responsible for the setting the organisation as well as technology strategy. Top managers are involved in utilising resources effectively and provide a supportive climate for the cloud computing. IT human resources are considered the sources of knowledge and skill that are needed to implement cloud computing related IT applications. Hospitals can be segmented on the basis of technology readiness as adopter of new technology to laggards who adopt the new technology in the late and are not motivated to use the technology.

The environmental context represents the setting in which the firm conducts business and influenced by the industry itself its competitors, the firm's ability to access resources supplied by others and interactions with the

government. It refers to the hospital industry, competitors and the government policy. Competitive pressure is the degree which hospitals can face from the rivals in the same industry. The competitive pressure plays a vital role in the adoption of the new technology. The adoption of the cloud technology improves operating efficiency, data accuracy and reduction in operating cost. Hospitals are trying to adopt cloud computing to take competitive advantage over the others. Hospitals intended to adopt cloud computing are interested in the ability for the service providers to ensure the availability of the data when needed. Service level agreements and a combination of precautionary measures can be used for data availability. Security is another area of concern with the trading partners. Vendor scarcity refers to the lack of reputable and qualified cloud service provider.

**Literature review:** There are many factors that affect the adoption of cloud computing and the top management of the organization should evaluate these factors systematically before implementing cloud solution. They have taken into consideration of Diffusion of Innovation (DOI) and TOE (Technology Organization Framework) which is studied in Portugal services and manufacturing sector (Oliveira *et al.*, 2014). TOE framework integrated with DOI theory has provided valuable insights for the Malaysian public sector IT personnel characteristics and behaviour while they determine the factors that influence cloud adoption (Sallehudin *et al.*, 2015). There was a great emphasis given on the knowledge domain while adopting cloud computing. There is a great integration between TOE framework and DOI framework while analyzing the influencing factors for cloud computing adoption by university technology transfer offices (Rohani, 2015). Healthcare organisations are adopting hospital information technology systems on cloud although there are many challenges like data security, data loss, internet connectivity issue, disinterest among top management and IT managers towards adoption of new technology. It has given stress on the opportunities that cloud computing will bring in patient record management and scalability of information technology in health care sector (AbuKhouza *et al.*, 2012). Several areas of ICT like green IT, performance computing, artificial intelligence, high speed internet use needs to be developed and act as a catalyst to achieve the optimum features of cloud computing. The cloud computing and the different enablers needs to function as a symbiotic relationship rather than standalone technology (Dwivedi and Mustafee, 2010). There is a need to understand the business related issues surrounding

cloud computing and identify the strength, weakness, opportunities and threats for the cloud computing industry (Marston *et al.*, 2011). TOE framework was used for a study in Jordan hospital and was found to play a important role in the hospital’s decision to consider cloud computing as beneficial investment. All the factors of TOE framework had a significant impact on the intention of hospital’s to adopt cloud computing (Harfoushi *et al.*, 2016). TOE framework is widely accepted as guide line for information technology adoption for every sector where there is a need to replace the existing system or integrating the existing system with the latest technology in the market (Zhu *et al.*, 2004). Cloud computing has changed the industry’s perception of infrastructure service delivery model and deployment models. Business use of cloud based services is expanding and there is a need for in-depth analysis and further research (Praveena and Rangarajan, 2014). Emphasis needs to be given on mobile cloud computing for the mobile health care application, so that, the services can be dynamically scalable to users through the internet (Regunathan and Lavanya, 2017). Although, cloud computing and Internet of Things (IoT) are two very different technologies but their adoption and use are expected to be more and more complementary, making them important components for future. Cloud and IoT merged together can be seen as disruptive, beneficial and as an enabler for a large number of application scenarios in various sectors (Velusamy *et al.*, 2013). Alharbi *et al.* (2016) in their study identified different factors that will influence adoption of cloud computing in Saudi healthcare organizations. The study integrated TOE is triangle and HOT-fit model to provide a holistic view of adoption of cloud computing in hospitals. The study found the different perspectives of cloud adoption and they are technology organizational, environmental and human perspective.

**Barriers in implementation of cloud computing in hospitals:** The potential barriers involved in cloud computing adoption in hospitals are:

**Data confidentiality/security:** As per HIPAA, the unauthorised users are not authorised to access the patient’s data. The patient’s data are very sensitive and is considered as important asset to the hospitals. Enhanced security has to be maintained that will increase the users trust level towards the implementation of cloud computing. There are chances that health-related information on the cloud may be exposed to or stolen by individuals with no right to view that information. As patient data will reside at a location distant from their own

facility there is a concern about the possibility that sensitive data could be lost, misused or fall into the wrong hands. Technology vendors have to build robust security and disaster recovery features into the cloud technology to ensure that all administrative and clinical data is securely and safely maintained. Providers are often unwilling to make investments in cloud-based initiatives. Hence, it is important to take the entire ecosystem into confidence before embarking on any large-scale cloud initiative. Cloud computing is usually accessible to many different customers. If the provider fails to separate the resources, it could cause very serious security risks. For example, a customer requests to delete data certain patient data stored in the virtual infrastructure. The deleted data may be still stored on the disk but are just not available (Clemons and Chen, 2011). In the multiple tenancies environment, hardware resources are reused by other customers. In this case, a third party could have access to another customer’s “deleted” data. This presents a higher risk to the cloud customers than with dedicated hardware. If the malicious insider is a system administrator then he or she could use his or her privileges to steal critical data.

**Loss of data:** Loss of patient data will incur huge loss of reputation as well valuable data needed for the clinical practice. Improved database management system is still a concern for security and an appropriate backup and recovery technique has to be implemented. The cloud is not immune to sensitive information being deleted and rendered irrecoverable through an accidental or malicious act.

**System unavailability:** In the healthcare industry, system availability plays an important role and in the absence of it can cause irreversible damages to patient treatment. The authorized users of a cloud service will be denied access to applications and data due to deliberate attack. It can also lead to intolerable system slowdown. The organizations may expose themselves to a great risk if they don’t fully understand their cloud service provider environment, applications and services associated with it and the incident resolution time and security issues attached to it (Table 1).

Table 1: Barrier categories

Barriers	Mean	Participants opinion
Professional working at hospitals	3.71	Agree
Financial	3.48	Agree
Human resources	3.72	Agree
Legal and regulatory	3.12	Neutral
Technical barrier	3.45	Agree

**MATERIALS AND METHODS**

This study is exploratory in nature and the data were gathered by using self-administered survey questionnaires. A quantitative research was conducted to find out how the technology organization and environment factors affect the cloud computing adoption in hospitals in India. The data was collected from the IT department employees who are working in various private and public hospitals. About 250 respondents were selected for the purpose of study. Multiple regression analysis was used.

**RESULTS AND DISCUSSION**

- $H_1$ : there is no significant relationship between the independent variables (technology organization and environment) taken together and dependent variable (cloud computing)

Multiple correlation coefficient (R) can be considered to be one measure of the quality of the prediction of the dependent variable. A value of 0.844 indicates that there is a strong positive relationship between the independent variables taken together and the cloud computing adoption in hospitals (Table 2).

Coefficient of determination ( $R^2$ ) is the proportion of variance in the dependent variable that can be explained by the independent variables.  $R^2 = 0.713$  which means that 71.3% of the changeability of cloud computing adoption has been explained by the independent variables taken together (Table 3).

Technology organization and environment context have a significance value less than 0.005. It can be

Table 2: Results of regression model summary for the effect of the independent variables upon cloud computing adoption in hospitals

Model summary				
Model	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	SE of the estimate
1	0.844*	0.713	0.617	0.313

\*Predictors: constant, environment, technology, organisation

Table 3: Results of regression coefficients for the effect of the independent variables upon cloud computing adoption in hospitals

Model 1	Coefficients <sup>a</sup>				
	Unstandardized coefficients (B)	SE	Standardized coefficients (β)	t-values	Sig.
Constant	1.310	0.989	-	1.324	0.002
Technology	0.292	0.168	0.345	1.737	0.000
Organisation	-0.897	0.233	-0.776	-3.851	0.000
Environment	0.229	0.128	0.328	1.783	0.002

<sup>a</sup>Dependent variable: cloud computing adoption

concluded that there is a significant relationship between cloud computing adoption and technology organization and environmental factor.

**CONCLUSION**

Recent developments have ensured the increasing use of cloud computing as it is an online shared computing resource making it economical, ensuring an increase in performance, productivity and competency. The analysis have tried to predict the relationship between three factors, i.e., technology organization and environment factor taken together in adoption of cloud computing in hospitals. The three factors of TOE framework, i.e., technology organization and environment are connected to each other and significantly influence the decision of organizations, particularly hospitals to adopt cloud computing. It provides an insight to IT personnel in designing a framework of implementing the cloud computing. The research can help the IT managers to clearly understand how and when to implement the cloud computing.

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