Cloud Computing: An Operational Framework in the Implementation of ERP

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Abstract— The present scenario for ERP is the shift from on-premises infrastructure to the cloud environment through utilization of cloud computing technologies. The characteristics of cloud computing offers many promises to cloud-based ERP systems. Cloud based ERP is an alternative to on-premises ERP systems. To implement ERP system with the help of cloud based technology faces many challenges. ERP system implementation is very painful, complex and time consuming and generate the necessity of a massive change in ERP framework to enhance ERP systems infrastructure and functionality. Cloud Computing (CC) platform possess the ability to overcome ERP systems discrepancies with cost-effective, customized and highly available computing resources. Cloud computing is a set of services that provide infrastructure resources using internet media and data storage on a third party server. The research presented in this paper, proposes a framework which is the sandwich of Diffusion of Innovation (DOI) theory and Technological-Organizational-Environmental (TOE) framework. The various components of DOI and TOE are integrated in such a manner that gives the flavour of ERP. All the constituents of DOI and TOE are spindled with the concept of Cloud computing. The present framework is a generic framework which is in favour of SMEs.

Keywords— Enterprise Resource Planning (ERP); Small and Medium Enterprises (SMEs); Cloud Computing (CC); Diffusion of Innovation (DOI); Technology-Organization-Environment (TOE).

I.   INTRODUCTION

Enterprise Resource Planning (ERP) systems are the ultimate aspiration of the business community as they provide collaboration with partners, external applications and information systems. Traditionally, the development of ERP systems involves maintaining a set of hardware and network configurations, typically using a database as an information repository. ERP systems are becoming an integral component of organizational infrastructure, however, ERP solutions have many issues and challenges such as massive upgrading cost, integration among different components, fair utilization of resources, visibility, management change, financial performance tracking, bidding and quoting etc. Due to these problems, a radical change is required within ERP framework to enhance ERP infrastructural and functionality. The emergence of cloud computing is considered to be the best suited option to overcome ERP systems discrepancies [1, 2, 3, 4].

Cloud computing is a technique for enabling convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction. Cloud computing is an alternative of deploying applications and systems on-premises. In Cloud technology, organization can access the available services on-demand. They can access the computing resources at anytime and anywhere using Internet services. Cloud computing (also called utility computing) refers to an IT service model and platform that provides on-demand based IT services over the Internet. Although there are a variety of definitions of cloud computing, the NIST (National Institute of Standards and Technology) definition (version 15) is considered to be the most accurate and comprehensive. According to NIST's definition, the ingredients available in Cloud Computing are composed of five essential **characteristics** (networks, servers, storage, applications, and services), three **Service models**

- SaaS (Software as a Service) which delivers software service on demand, such as, salesforce.com, Customer Relationship Management (CRM) service and Google Gmail;
- PaaS (Platform as a Service) which provides the computing platform for companies to deploy and customize business applications on demand, such as, Google App Engine and Microsoft's Azure;
- IaaS (Infrastructure as a Service) which offers data centre, infrastructure i.e. hardware and software resources on demand, such as, Amazon Elastic Compute Cloud (EC2) and VMware vCloud Data centre. Both of these resources provide virtual computers for renters to run their business applications.

And four **Deployment models** i.e. public cloud, private cloud, hybrid cloud, and community clouds.

Companies normally adopt different service models and deployment models depending on their unique business processes and demands on IT services. SMEs have limited resources in terms of money, expertise and time. The Cloud

based ERP will automatically deliver the tangible benefits like lowering the cost as they only pay for the resources as needed, offering the expert skills to their businesses at much lower rate as compare to on premises and as the experts have enough experience to implement the project which will automatically lower the implementation time. The cloud based environment offers many interesting characteristics i.e. on-demand self-service, broad network access, resource pooling, rapid elasticity, measured services, multi tenancy, scalability, economies of scale, cost effectiveness, customization, efficient resource utilization, maintainability, collaboration, virtualization, green technology, and high performance [5]. The growth rate of the market for cloud computing is forecasted to be very high in the coming times. The market of public cloud services is predicted to grow from US$26 billion in 2012 to US$160 billion in 2020 [6].

The objective of this paper is to contribute to a growing body of research on cloud computing, by studying the SME adoption process. The framework that is being proposed in this study adapts selected elements from DOI theory, Innovation Decision Process and TOE framework. DOI is a theory developed by Rogers, which is originated from Sociology field (Rogers, 1962) [7]. Roger defined the innovation-decision process as: "the process through which an individual or other decision making unit passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision". Diffusion is the process by which an innovation is communicated through certain channels over a period of time among the members of a social system. An innovation is an idea, practice, or object that is perceived to be new by an individual or other unit of adoption. The TOE is a multi-perspective framework that was developed by Rocco DePietro, Edith Wiarda and Mitchell Fleischer. The TOE framework is an organization-level theory. It represents one segment of the innovation process, i.e. how the firm context influences the adoption and implementation of innovations [8].

II. RELATED WORK

A review of the related work that uses either TOE or DOI framework or both helps to identify the various factors to understand cloud based ERP adoption.

Table 1: Related work using the DOI theory and TOE framework

Articles	Perspective	Theories used	Factors Identified
Cloud computing adoption by SMEs in the north east of England (Son & Lee 2011) [9]	Business	TOE	Organizational Capability: Learning Capacity, IT Capability External Environment: Competitive Pressure, Expectation of Network Dominance Characteristics of Cloud Computing: Perceived Benefits, Perceived Barriers
Understanding the determinants of cloud computing adoption (Low, Chen and Wu 2011) [10]	Business	TOE	Technological: Relative Advantage, Complexity, Compatibility Organization: Top Management Support, Firm Size, Technology Readiness Environment: Competitive Pressure, and Trading Partner Pressure
Cloud computing adoption by SMEs in the north east of England (Alshamaila, Papagiannidis and Li 2013) [11]	Business	TOE, DOI	Technological: Relative Advantage, Uncertainty, Geo-restriction, Compatibility, Complexity, Trialability Organizational: Size, Top management support, Innovativeness, Prior IT Experience Environmental: Competitive pressure, Industry, Market scope, Supplier efforts and External Computing Support
Cloud Computing in Support of Supply Chain Information System Infrastructure: Understanding When to go to the Cloud (Wu et al. 2013) [12]	Business	DOI, Information Processing View	Information Processing Requirements: Business Process Complexity, Entrepreneurial Culture Information Processing Capacity: Compatibility and Application Functionality, Relative Advantage
An Integrated Theoretical Framework for Cloud Computing Adoption by Small and Medium- Sized Enterprises (Saedi & Iahad 2013) [13]	Business and Technical	TOE and Actor Network Theory	Technology: Cost-savings, Relative advantages, Compatibility, Accessibility, Lack of Data Security/Privacy Organization: Size, Size of IT Resources, Top Manager Intentions Environment: Supplier SLA, Supplier Competencies, Government Support, Competitor Pressures, Friends and Family Members Advice, IT Specialist and Consultants Advice, Business Network Advice

Understanding the Determinants of Cloud Computing Adoption within the UK (Lumsden & Gutierrez 2013) [14]	Business	TOE	Technological: Relative Advantage, Complexity and Compatibility Organizational: Top Management Support, Firm Size and Technology Readiness Environmental: Competitive and Trading Partner Pressures
An exploratory study to understand the critical factors affecting the decision to adopt cloud computing in Taiwan hospital (Lian, Yen and Wang 2014) [15]	Business	TOE and HOT-fit (Human-Organization-Technology fit)	Four dimensions: Technology, Human, Organizational, and Environmental Top factors: Data Security, Perceived Technical Competence, Cost, Top Manager Support, Complexity, CIO Innovativeness, Compatibility, Adequate Resource and Perceived Industry Pressure
Exploring the factors influencing the adoption of Cloud computing and the challenges faced by the business (Nedev 2014) [16]	Business	TOE	Technical Factors: Relative Advantage, Complexity and Compatibility, Redundancy, Performance and Security Organizational Factors: Top Management Support, Firm Size and Technological Readiness Environmental Factors: Competitive and Trading Partners Pressure
Factors influencing the Adoption of Cloud Computing by Small and Medium Enterprises (SMEs) in Developing Economies (Yeboah- Boateng & Essandoh 2014) [17]	Business	TOE	Technological: Trialability of Cloud Services, Existence of Required IT Infrastructure and Resources, Compatibility with Existing Systems, Strength of In-built Security Systems, Learning Capability of Employees, Limited Technical Knowledge about Similar Technologies, Non-performance of Cloud Services to support Operations Organizational: Top Management Support and Involvement, Resistance towards New Technologies, Conformity with Work Culture and Style, Impact of Organizational Structure and Size, First Adopters in Our Industry Environmental: Adequate User and Technical Support from Provider, Choice of Skilled and Expert Cloud Vendors, Influence of Market Scope, The Nature of Industry, Relationship with Providers, Government and Competitors
Understanding determinants of cloud computing adoption using an integrated TAM-TOE model (Gangwar, Date and Ramaswamy 2015) [18]	Business	TOE and TAM	Technological: Relative Advantage, Compatibility, Complexity Organizational: Readiness, Top management commitment, Training and Education Environment: Competitive Pressure and Trading Partner Support Others: Perceived Ease of Use and Perceived Usefulness
An Integrated Theoretical Framework For Cloud Computing Adoption By Universities Technology Transfer Offices (TTOs) (Mahsa Baradaran Rohani, Ab. Razak Che Hussin 2015) [19]	Technology-Transfer-Offices	TOE and DOI	Technology: Relative Advantage, Compatibility, Complexity, Uncertainty Organizational: Size, Collaboration, Technology Readiness, Information intensity, Satisfaction Environment: Competitive Pressure, Partners, CC Provider, Government Support Human: Top Management Support, Innovativeness, Cloud Knowledge
An Exploration Of Adoption Factors For Cloud- Based ERP Systems In The Public Sector (Sædberg, A., Haddara, M 2016) [20]	Public Sector	TOE	Technology: Availability characteristics Organizational: Formal and informal linking structure, Communication process, Size, slack Environment: Industry characteristics and market structure, Technology support infrastructure, Government regulation

III. PHASE WISE IMPLEMENTATION OF CLOUD BASED ERP

Frameworks are useful tools which indicate the relevant decision making variables. These variables interact with each other to determine the objectives. It is the step by step analysis for determining the organization's compatibility with cloud computing adoption. The present framework is the sandwich of DOI theory and TOE framework. These two concepts complement each other. DOI focuses on characteristics of the technology and does not recognize environmental factors. It is the process by which an innovation is communicated through certain channels over a period of time among the members of a social system.
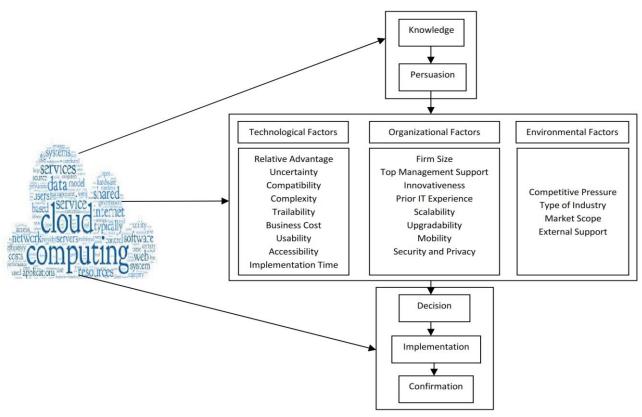

Fig. 1 Framework of Cloud based ERP implementation

This study proposed an integrated framework of DOI and TOE which is used to study the determinants of Cloud based ERP adoption. To implement the Cloud based ERP the framework has been divided into three phases. In the **first** phase, **Knowledge** is the process that passes through an individual or the other decision making unit which has knowledge of an innovation, and forming an attitude towards the innovation. The innovation decision process starts with the knowledge stage, the individual (or some other decision making unit) is exposed to an innovation existence and also give the guidance how it functions. The **persuasion** stage refers to the situation when a client (or some other decision making unit) shapes a favourable or unfavourable attitude towards the implementation phase of cloud based ERP. The knowledge helps to implement Cloud based ERP favourably.

In the **second** phase of the framework, **TOE** represents one segment of a phase of the innovation process i.e. how the firm influences the adoption and implementation of the innovation. The central indicator for the adoption of a new Information System is innovation. The environmental context is taken into the account to implement the innovation. Higher the need for an innovation by an organization, the higher is the probability that it will adopt the innovation. In the organizational level multi perspective framework is taken into the account. It is a framework which includes Technological, Organizational and Environmental context which influences the decision to adopt an innovation.

Technological context, which represents the internal and external technologies related to the organization; both technologies that are already in use at the firm, as well as those that are available in the marketplace but not currently in use [21]. These technologies may include either equipment or practice. The technological factors in this study are relative advantage, uncertainty, compatibility, complexity, trialability, business cost, usability, accessibility and implementation time.

Organizational context is related to the resources and the characteristics of the firm, e.g. firm size, top management support, innovativeness, prior IT experience, scalability, upgradability, mobility and security and privacy.

Environmental context, which refers to the arena in which a firm conducts its business; it can be related to surrounding elements such as competitive pressure, type of industry, market scope and external support. These three contexts present both constraints and opportunities for technological innovation [22]. These elements influence the firm's decision.

The **Third** phase of the framework signifies the condition when a client or some other decision making unit involves in the activities that leads to a **decision** either to adopt or not to adopt the innovation. After taking the positive decision in the next stage i.e. **implementation** stage, the individual or some other decision making unit puts an innovation into the actual use. The **confirmation** which is the final stage refers to the state when an individual or some other decision making unit tries to reinforce the innovation decision which is already made or backs down from a previous adoption decision.

All the three phases are integrated to implement the innovation. As the ERP system integrates the entire enterprise, both internally and externally, allows a seamless flow of the information. This framework consists of one full end-to-end integrated system. This system connects the entire organization as a single unit. This connectivity facilitates the flow of information across the three phases. It allows an enterprise to better function as a single entity rather than as many separate phases. An ERP system running on a different phase with a single tenant was appropriate and given the technology and infrastructure of its time advances to the new technology. The emerging technology, cloud computing, Software as a Service (SaaS) significantly alter the implementation of ERP. Cloud computing delivers a product where the resources, software and the information are provided as a utility over the internet. The concept of cloud computing refers to both infrastructure and the ability to deliver the application over the internet. This framework is used to implement the innovative idea i.e. cloud based ERP which is having the characteristics like accessibility, business cost, implementation time, mobility, scalability, upgradability and usability.

IV. CONCLUSION

In this paper, we investigated the issue of how Cloud computing technology can be employed in ERP systems which is based on the concept of DOI theory and TOE framework. This framework proposes the various factors that are playing a significant role in the adoption of cloud services: relative advantage, uncertainty, compatibility, complexity, trialability, business cost, usability, accessibility, implementation time, firm size, top management support, innovativeness, prior IT experience, scalability, upgradability, mobility, security and privacy, competitive pressure, type of industry, market scope and external support. In the context of globalization, the proposed framework will be the blessing for the SMEs in which the process of performing the business will be economical, mobile, scalable and techno savvy.

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