Factors Influencing the Adoption of Cloud Computing by Small and Medium Size Enterprises (SMEs)

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Abstract. The main objective of this study is to determine the factors influencing cloud computing adoption by Small and Medium sized Enterprises (SMEs). Based on two dominant theories in the field of diffusion of innovation, a conceptual model is proposed. In order to test the model empirically, an online survey was designed and launched. Decision makers of 101 SMEs agreed to participate in this survey. In order to evaluate the internal, convergent, and discriminant validity of the instrument, factor analysis and reliability tests were performed. Logistic regression is employed to test our hypotheses. The results of regression reveal that decision maker's knowledge about cloud computing is the main influential factor in decision making about its adoption.

1 Introduction

Small and Medium sized Enterprises (SMEs) significantly contribute to each nation's Gross Domestic Product (GDP) and its labor market. Therefore, proposing strategies and developing new systems are not only beneficial for SMEs, but also for the economy as a whole. According to Tan et al. [1], using appropriate Information and Communication Technologies (ICTs) helps SMEs become more efficient and productive; however, SMEs do not have access to enough resources (e.g. financial resources). Cloud computing, which is an alternative to deploying applications and systems on-premises, helps SMEs tackle many issues such as the high cost and risk that are involved in IT projects.

Similar to other innovations, in addition to costs and benefits, there are other factors that influence the decision to adopt cloud computing. Technology adoption is one of the biggest research streams in Information System (IS) field. So far, not many studies have investigated the adoption of cloud computing. Among these studies, few of them focused on the adoption of cloud computing by SMEs. In this research, we study the factors that influence the adoption of cloud computing by SMEs. In order to investigate the factors that influence the SMEs' decision to adopt cloud computing, a conceptual model has been proposed. This model is originated from two prominent theories of this field. These two theories are Rogers's Diffusion of Innovation (DOI) theory and Tornatzky and Fleischer's Technology, Organization, and Environment (TOE) framework. According to this model, twelve factors influence the adoption of cloud computing by SMEs. They are: *External Support, Competitive Pressure*, *Decision makers' cloud knowledge, Employee's cloud knowledge*, *information intensity*,

S. Yamamoto (Ed.): HIMI 2014, Part II, LNCS 8522, pp. 631–642, 2014.

Innovativeness, Relative advantage, Cost, Security and Privacy, Trialability, Complexity, and compatibility with company's norms and technologies.

The conceptual model is then empirically tested. An online survey is completed by IT decision makers of SMEs. The questionnaire consists of around 25 simple and easy to understand questions. A market research company is hired to invite SMEs to participate in this research. The collected data is quantitatively analyzed; in order to check the internal, convergent, and discriminant validity of the questionnaire, factor analysis and reliability checks are performed. Finally, the proposed hypotheses are tested using logistic regression.

1.1 Literature Review

SMEs are vital players of each market. One strategy which has been proven to enhance SMEs' ability to compete against larger companies is the use of appropriate technology [1]. Although adopting new technologies helps SMEs gain a competitive advantage, it usually involves high costs. Cloud computing, as a new computing paradigm, offers many advantages to companies, especially smaller ones. Flexibility, scalability, and reduced cost are just some of many advantages that cloud computing offers to SMEs.

To date, there is no universal definition for cloud computing. Perhaps the most accurate definition of cloud computing is the one offered by the National Institute of Standards and Technology (NIST). They defined cloud computing as "a model for enabling ubiquitous, 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 is composed of five essential characteristics, three service models, and four deployment models." [2]

Cloud computing has three different service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS, which is the basic level of cloud service, is the service of delivering infrastructure services to customers over a network (e.g. Internet). The second level of cloud computing or PaaS is a model of cloud computing by which customers have online access to all requested resources that are required to build their enterprise applications, including the business logic. The last and the most common cloud computing model or SaaS is application based services delivered to customers over a network. Users can access the software anytime and anywhere they desire as long as they have access to internet [3]. Cloud computing offers also four types of deployment models: private, public, community, and hybrid. Private cloud is a type of cloud computing in which the cloud service is exclusively offered to one particular organization. The public cloud, which is the most common deployment model, offers the service to general public. Cloud providers have the full ownership of the infrastructure; they have their own rules, policies, and pricing models. Community cloud offers services to a group of organizations in a community, which may share a set of similar interests such as a common mission, security requirements, policies, and compliance considerations. Finally, hybrid cloud is the combination of two or more previously explained models.

To date, the majority of the studies about cloud computing try to improve the reader's understanding and knowledge about cloud computing [4-5]. Other researchers aim to investigate the concept of cloud computing by studying only one type of cloud computing [6-8]. Some of the studies are focused on a particular system, such as ERP [9], e-learning applications [10], and Virtual Computing Lab (VLC) [11]. Other studies focus on the application of cloud computing in different fields of study, including construction [12], digital forensic investigation [13], the service industry [14], and biology [15]. Many other aim to identify the challenges related to using cloud computing [16-21]. Other studies have proposed different models and strategies (such as changes in policies, regulations, and laws) that can be used to face the issues related to cloud computing [22-26].

Diffusion of technologies is an interesting area of research; however, the diffusion of cloud computing has not yet received much attention from research perspectives. Low et al. investigated the influence of eight factors associated with the adoption of cloud computing in the high-tech industry in Taiwan. The regression analysis shows that while relative advantage has a significant negative influence on the adoption of cloud computing, top management support, firm size, competitive pressure, and trading partner pressure characteristics have a significant positive influence on the diffusion of cloud computing. Compatibility and complexity do not significantly influence the adoption of cloud computing [27].

Another study investigated the adoption of cloud computing by college students. They found that students' characteristics, first-hand experiences with the platform, and instructor support are factors that influence students' perception about ease of use [11]. Similarly, Taylor and Hunsinger [28] conducted research about the acceptance and usage of Google Docs[1] in a university setting. The results of analysis reveal that the person's emotional response is a factor that significantly influences the students' intention to use Google Docs. Many countries such as Australia, Japan, Malaysia, and Taiwan have invested heavily in cloud-related projects. This is another reason for which research about cloud computing is compelling [29].

2 Theory Review

The conceptual framework that is proposed in this research originated from two well-known theoretical frameworks in this field of study, which are Diffusion of Innovation (DOI) theory developed by Rogers [30-31] and the Technology, Organization, Environment (TOE) framework proposed by Tornatzky and Fleischer [32].

Diffusion of Innovation Theory (DOI) is a theory that tries to discover the factors that influence the spread of a new idea or technology in a society [31]. Rogers [30] defined diffusion of innovation as "the process in which an innovation is communicated through certain channels over time among the members of a social system". Any idea, process, product, or technology constitutes innovation, as long as it is perceived as new by individuals. Rogers [30] argues that each innovation has different

[1] Google Docs is a cloud service provided by Google.

attributes that influence its diffusion in society. Relative advantage, compatibility, complexity, trialability, and observability are the five key attributes of innovation. DOI does not take into account the environmental and organizational aspects of the context; therefore, in this study we used the Technology Organization Environment (TOE) framework, which takes into account other aspects of enterprises' context.

TOE framework, which is developed by Tornatzky and Fleischer [32], is originally an organizational psychology theory. However, it has extensively been used by IS researchers. According to TOE framework, three aspects of enterprises' context influence the decision to adopt an innovation at firm level. Based on this theory, the decision to adopt an innovation is influenced by technological, organizational, and environmental aspects of the enterprise. The technological aspect of the TOE framework refers to both the availability and characteristics of the technologies. The organizational context of TOE framework describes the characteristics and resources of the organization, such as its size, structure, and communication processes. The environmental aspect of this framework refers to structure of the industry, technological support infrastructure, and government regulations.

3 Research Model and Hypotheses

In order to study the adoption of cloud computing by SMEs, a conceptual model is proposed. According to this model, twelve variables influence the decision to adopt cloud computing, which are depicted in Figure 1. All factors except complexity have a positive influence on the adoption of cloud computing. A very important study by Tornatzky and Klein [33] reveals that relative advantage, complexity, and compatibility are the characteristics of innovation that have the most influence on the adoption of an innovation.

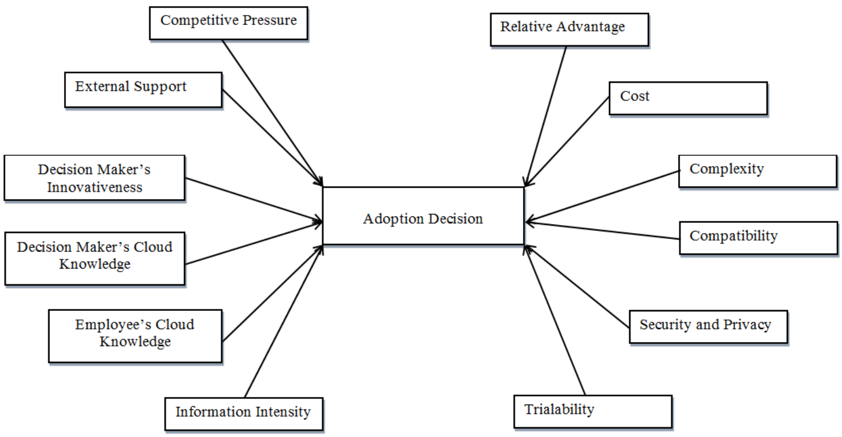

Fig. 1. Conceptual Model

3.1 Hypotheses

Based on the model, 12 different hypotheses have been proposed. Chau and Hui [34] argue that the size and structure of SMEs force them to rely on external parties. In this context, external support is defined as "The perceived importance of support offered by cloud providers". The first hypothesis is:

H1: Higher levels of perceived external support from cloud providers positively affects the likelihood of cloud computing adoption by SMEs

Competitive pressure is the level of competition among firms within the specific industry in which the company operates [35]. The following hypothesis is developed:

H2: Businesses that operate in more competitive environments are more likely to adopt cloud computing.

Having enough knowledge about an innovation is the first step in the adoption process. Therefore in the context of cloud computing, the following hypotheses have been developed:

H3: Decision Makers' knowledge about cloud computing is positively related to the decision to adopt cloud computing.

H4: Employees' knowledge about cloud computing is positively related to the adoption of cloud computing

Innovativeness is defined as "the level of decision makers' preference to try solutions that have not been tried out; and therefore are risky" [34]. Hypothesis 5 is:

H5: Decision Makers' innovativeness is positively related to the adoption of cloud computing.

According to Thong [35], information intensity is defined as "the degree to which information is present in the product or service of a business". The following hypothesis is related to this construct:

H6: Information intensity is positively related to the adoption of cloud computing

An advantageous technology is one that enables companies to perform their tasks more quickly, easily, and efficiently. Moreover it improves the quality, productivity, and performance of the company. The following hypothesis below is formulated:

H7: Decision makers' perception about the relative advantage of using cloud computing is positively related to cloud adoption

A technology that is difficult to understand, and whose use is considered to be complex, is less likely to be successfully adopted. Therefore, the following hypothesis is developed:

H8: The perceived level of complexity of the cloud computing has a negative impact on the adoption of cloud computing.

In this study, compatibility is defined as "the degree to which cloud computing is perceived as consistent with the existing values, past experience, and needs of companies". The related hypothesis is as follows:

H9: High levels of compatibility between cloud computing and a company's norms and technologies have a positive influence on cloud adoption.

We believe that the opportunity to use cloud computing on a trial basis positively influences the adoption of cloud computing; therefore the next hypothesis is:

H10: Higher level of trialability has a positive influence on the adoption of cloud computing

In this study, the cost of cloud computing is defined as "the degree to which decision makers perceive the total cost of using cloud computing to be lower than other computing paradigms". In the context of cloud computing the next hypothesis is:

H11. Decision makers who perceive cloud computing as being less costly than other computing paradigms are more likely to adopt cloud computing

In the context of cloud computing, security is defined as the security of the service, data centers, and media. It also takes into account the privacy and confidentiality of the companies' data. Therefore, in the context of cloud computing:

H12: The more secure that decision makers perceive cloud computing to be, the more they are willing to adopt cloud computing.

4 Research Methodology

Data collection procedure of this research is based on a survey. We developed a questionnaire which was reviewed and modified by a panel of experts, consisting of three IT professors and four PhD students. We used Qualtrics to develop our online questionnaire. The responses to our questions were captured on a 5 point Likert-type scale. The survey was sent to more than 500 decision makers. The response rate of 20% left us with 101 completed questionnaires. Both adopter and non-adopter companies were asked to participate in this survey. In order to assure the quality of the responses, several quality assurance (QA) questions were added to the questionnaire. The questions asked of participants were adapted mainly from papers already published in this field. In addition to the standard questions, we also developed some questions that are specific to the context of cloud computing.

In order to complete our research, the collected data needed to be analyzed. The statistical software used in this study is SPSS version 20. During the first stage, we used Factor Analysis (FA) to assess the construct validity of the theoretical model that is proposed. This method allows researchers to analyze the correlation between items and to determine a new set of variables that are highly correlated to each other. Reliability of the construct can also be checked by Cronbach's alpha; an alpha above 0.7 is considered adequate [37]. In order to test our hypotheses and predict the adoption of cloud computing, logistic regression is used.

5 Data Analysis Results

Our sample contained less than 5% missing values; therefore replacing them with the series mean is an appropriate method. A reliability test was performed on our pilot sample and some of the items which negatively influenced the reliability of the questionnaire were removed. Competitive pressure had an alpha lower than 0.7; therefore it was removed from further analysis. While a value of Cronbach's alpha of above 0.7 is acceptable, the inter-item correlation should be more than 0.3. [37] In this research, explanatory factor analysis (EFA), using the Principal Component extraction method based on constructs which yield Eigenvalues greater than 1 and the Varimax rotation method was performed.

Table 1. Final Results of Factor Analysis

	Component								
	1	2	3	4	5	6	7	8	9
RltAdv_effcny	.816								
RltAdv_prdt	.756								
RltAdv_eftv	.752								
RltAdv_fst	.738								
RltAdv_prfmc	.738								
RltAdv_Quik	.734								
RltAdv_advntg	.723								
RltAdv_Qlty	.723								
RltAdv_easy	.688								
RltAdv_tech	.598								
RltAdv_cap	.572								
CldKnw_Strct		.829							
CldKnw_models		.810							
CldKnw_gnrl		.800							
CldKnw_prcModel		.782							
CldKnw_type		.779							
CldKnw_cmpt		.735							
CldKnw_aver		.726							
CldKnw_bnft		.702							
Cost_Inv			.802						
Cost_CapEx			.717						
Cost_licsng			.679						
Cost_time			.676						
Cost_oprtng			.663						
Cost_prsnl			.655						
Cost_upgrd			.568						
Cost_mntnnc			.568						
ScPrv_cnfdtlty				.813					
ScPrv_Srvr				.790					
ScPrv_Mdia				.786					
ScPrv_data				.774					
ScPrv_cld				.759					
Cmpx_lng					.879				
Cmpx_tme					.865				
Cmpx_complct					.756				
Cmpx_gnrl					.716				
EmpCldKnw_bsc						.839			
EmpCldKnw_usg						.743			
EmpCldKnw_cmpr						.740			
InfoInt_rra							.872		
InfoInt_fst							.784		
InfoInt_Updt							.763		
ExtSup_CustSup								.773	
ExtSup_TechSup								.580	
ExtSup_CustHotln								.576	
INV_Impr									.873
INV_rsk									.793
Initial Eigenvalues	17.728	4.281	3.504	2.542	2.043	1.765	1.390	1.325	1.144
Variance	16.407	14.134	9.907	9.738	6.876	5.543	5.358	4.097	3.944

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

According Hair et al. for 100 observations, the factor loadings of 0.55 and higher are significant. As such those constructs that had factor loadings lower than 0.55 were suppressed. One way to measure the appropriateness of the factor analysis is Bartlett's test of sphericity. The Bartlett's test was significant in this study, which proves the suitability of factor analysis. The Kaiser-Meyer-Olkin (KMO) criterion is another measure of Sampling Adequacy. Our model's KMO value was estimated as 0.839, which is considered excellent [38].

The preliminary results of factor analysis identified 11 different factors. This is consistent with our conceptual model. However, there is high cross loading among some of the constructs. After investigating the results of factor analysis, some of the items that have high cross loading or that have very low factor loading were deleted. In order to control the magnitude of factor reduction, items were deleted one by one.

As it can be seen in the table, nine different factors were identified. Together these nine factors account for 76% of total variance of all the variables in the research. In this study the composite values are calculated based on the average of variables in the scale [37]. The reliability of the final set of variables was checked again. Table 2 summarizes the final results of the reliability test. All items have high levels of Cronbach's alpha and inter-item correlation means.

Table 2. Reliability of Composite Scores

Construct	*Number of Items*	*Inter-Item Correlation Mean*	*Cronbach's Alpha*
Relative Advantage	*11*	*0.641*	*0.951*
Complexity	*4*	*0.612*	*0.864*
Security and Privacy	*5*	*0.787*	*0.949*
Cost	*8*	*0.531*	*0.899*
External Support	*3*	*0.646*	*0.842*
Decision Maker's Innovativeness	*2*	*0.591*	*0.743*
Decision Maker's Cloud Knowledge	*8*	*0.725*	*0.953*
Employee's Cloud Knowledge	*3*	*0.638*	*0.838*
Information Intensity	*3*	*0.622*	*0.826*

Means, standard deviations, and the results of normality tests of these new variables (composite values of each factor) are summarized in Table 3.

When performing logistic regressions, one of the important considerations is multicollinearity of the data. If multicollinearity exists among variables, the significance of the coefficient values is not properly predicted. In our sample, employees' Cloud Knowledge and decision makers' Cloud Knowledge have high collinearity. In the context of SMEs, the role of decision makers is more important; thus we elected to keep the decision maker's cloud knowledge and remove employees' cloud knowledge from further analysis. Logistic regression calculates the log likelihood value of each independent variable. The binary dependent variable has values of Yes (1) and No (0).

Table 4 is the classification summary of the model, which is one way to assess the model's goodness of fit. As it can be seen in the table, the model's classification accuracy is 79.2%, which means 79.2% of the time, the model correctly predicted the adoption decision.

Table 3. Descriptive Analysis for Composite Scores

	Descriptive Statistics			*Skewness*	*Tests of Normality Kolmogorov-Smirnova*	
Constructs	*N*	*Mean*	*Std. Deviation*	*Statistics*	*Statistics*	*Sig.*
Relative_Advantage	*101*	*4.1989*	*.71613*	*-1.167*	*.075*	*.000*
CloudKnowledge	*101*	*3.9097*	*.86839*	*-.701*	*.144*	*.000*
Cost	*101*	*3.7339*	*.80325*	*-.209*	*.128*	*.176*
Security_Privacy	*101*	*4.1010*	*.78262*	*-1.509*	*.191*	*.000*
Complexity	*101*	*2.3168*	*.94729*	*.679*	*.142*	*.000*
Employees' Cloud Knowledge	*101*	*3.9264*	*.84143*	*-.683*	*.105*	*.008*
Information Intensity	*101*	*4.4059*	*.61933*	*-1.079*	*.208*	*.000*
External_support	*101*	*4.1584*	*.70015*	*-1.292*	*.132*	*.000*
Innovativeness.	*101*	*3.5000*	*.94340*	*-.902*	*.213*	*.000*
Intention to Use	*30*	*3.8556*	*1.09223*	*-0.846*	*.153*	*0.072*
Valid N (listwise)	*101*					

Table 4. Classification Table

Observed		Adoption		Percentage Correct
		No	Yes	
Adoption	No	16	14	53.3
	Yes	7	64	90.1
Overall Percentage				79.2

Table 5 summarizes the results of our regression including the variables that are in the equation, their significance levels, their coefficients, and Wald values. Among eight independent variables, only Cloud Knowledge has a significant relationship with the adoption decision.

Table 5. Logistic Regression Results

	B	S.E.	Wald	df	Sig.	Exp(B)
CloudKnowledge	2.245	.659	11.607	1	.001	9.440
Cost_Reduction	-.241	.568	.181	1	.671	.785
External_Support	.122	.567	.047	1	.829	1.130
Relative_Advantage	-.434	.672	.417	1	.518	.648
Security_Privacy	-.310	.512	.367	1	.545	.733
Complexity	.121	.350	.119	1	.731	1.128
Information_Intensity	-.571	.544	1.103	1	.294	.565
Innovativeness	.465	.295	2.485	1	.115	1.592
Constant	-3.534	2.903	1.482	1	.223	.029

Based on the results, the probability of adopting cloud computing is higher for individuals who have greater knowledge about cloud computing. For an additional unit increase in cloud knowledge, the log odds of adopting cloud computing increases by a factor of 2.245. The high value of exponentiated beta means that for each unit increase in decision maker's knowledge about cloud computing, the chance of cloud computing adoption increases significantly.

6 Limitations and Future Studies

This research has some limitations, because of which the results cannot be generalized to all SMEs. Our main limitation is related to the sample size. Sample size becomes problematic because in order to get significant results, there should be at least 10 observations per each group of the dependent variable. Having eight different variables, our ideal sample size is 160, which is well beyond our actual sample size. Moreover, our sample is selected from North American companies. The results of this research are thus only applicable to SMEs located in North America. Moreover, the data is not restricted to a specific industry; this is problematic because each industry has its own characteristics and requirements. Performing further research in this field is highly recommended. Cloud computing is a new phenomenon; not many studies have been conducted in this field. The same study may be replicated using larger sample sizes, and in different industries. Performing a longitudinal study would also prove useful.

7 Conclusion

Similar to any innovation, the diffusion of cloud computing depends on various factors. In this research, we not only study the technical aspects of cloud computing, but also others such as environmental, organizational, and managerial factors. For this purpose, a conceptual model is proposed and empirically tested. The proposed model is developed based on two well-known theoretical frameworks in the field of technology adoption, which are: DOI developed by Rogers [30], and the TOE framework developed by Tornatzky and Fleischer [32]. Based on the research model, a set of hypotheses were proposed. In order to empirically test the model, we asked decision makers of SMEs to participate in an online survey. After the internal validity of the items was checked, factor analysis was performed. At this stage, some of the items were deleted. Removing these items left us with nine different factors.

Since this research is predictive in nature, regression analysis was used to test the hypotheses. Furthermore, our dependent variable is binary, therefore the most appropriate method of analysis is logistic regression. Based on the results, the only factor which significantly influences the adoption decision of cloud computing is the decision maker's knowledge about cloud computing. This knowledge is defined as the knowledge about the underlying structure of cloud computing, benefits of cloud computing, different types of cloud computing (SaaS, PaaS, and IaaS), various deployment models (public, private, or hybrid), and the pricing model of cloud computing.

This research contributes to both academia and business practice. First of all, the model proposed in this study is unique and has not been used in previous studies. Cloud providers can use the results of this study to increase the rate of adoption among SMEs. Based on the results of this study, cloud knowledge is the key factor in the diffusion of cloud computing. Cloud providers can use various mass media such as Facebook, LinkedIn, and Twitter to increase awareness about cloud computing.

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