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Determinants of Cloud Computing Adoption at Firm Level: From the Technological Context

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Abstract: The objective of this study is to identify determinants of cloud computing adoption at firm level. The research model is developed based on the Diffusion of Innovation (DOI) theory. It is proposed that the adoption of cloud computing is being influenced by relative advantage, compatibility and complexity. Data were collected via a questionnaire-based survey completed by 132 mid-to-senior level executives and managers of Small and Medium Enterprises (SMEs) in Malaysia. Of the technological factors covered, only complexity is found to be significant to cloud computing adoption. The findings contribute to knowledge in cloud computing, specifically with regards to the drivers of cloud computing adoption from the technological context. The findings can assist government agencies to accelerate the use of cloud computing by the SMEs and to raise awareness and understanding of SMEs about the concept of cloud computing and its potential benefits.

Key words: Cloud computing, DOI theory, SMEs, Malaysia, potential benefits, understanding

INTRODUCTION

Cloud computing is an emerging computing paradigm where Information Technology (IT) and computing operations are delivered as services in a highly scalable and cost effective manner (Shayan *et al*., 2013). The National Institute of Standards and Technology defines cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks and servers) with minimal management effort or service provider interaction (Mell and Grance, 2009). Cloud computing provides unique features such as low capital investment, low cost of ownership, high availability and lower complexity compared to traditional high-performance computing models (Abolfazli *et al*., 2015).

Malaysia has shown significant potential for using cloud computing in various sectors in the country (Abolfazli *et al*., 2015). Due to its potential to transform businesses and its ability to increase productivity and control costs, the government has taken the initiative to actively promote the use of cloud computing among Small and Medium Enterprises (SMEs). For instance, a 6 months subscription fee rebate or up to RM1, 500 of the total subscription fee for any Software as a Service (SaaS) solution is provided to the SMEs as incentive. In addition, a program known as the SME Cloud Computing Adoption Program has been introduced under Malaysia's National ICT initiative which aims to elevate the competitiveness and efficiency of the SMEs in doing business. With cloud computing, small businesses may now run their business applications from their own personal computers (Mohamed, 2009).

SMEs represent 99% of the businesses in Malaysia, thereby playing a significant role in Malaysia's economic development. Nonetheless, SMEs have given scant attention to investing in IT infrastructure (OECD, 2004). It is not surprising therefore that some of the SMEs do not have any allocation for IT infrastructure. Many of them struggle with limited budgets to compete with large enterprises because of their high capital and operational costs (Abolfazli *et al*., 2015). Several reasons raised by the SMEs for not adopting new technology include maturity of the technology, level of risks and costs and limited technical capabilities in IT (Oliveira *et al*., 2014).

Cloud computing encompasses various layers of cloud computing architecture from Infrastructure as a Service (IaaS) through to SaaS and to Platform as a Service (PaaS). IaaS is a cloud computing model that provides virtualized computing resources over the internet. SaaS involves the use of the provider's applications running on a cloud infrastructure. PaaS on the other hand is a form of cloud computing that delivers applications over the internet. Cloud-based services such as e-Mail or office applications are increasingly being

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Table 1: SME cloud computing market attractiveness index 2015

Countries	Addressable market	Demand drivers	Early adoption	Affordability	Support	Overall score
Japan	101.4	71.0	57.7	64.7	56.6	70.2
Singapore	25.7	68.7	78.0	73.0	73.8	63.8
Hong Kong	29.3	66.7	75.7	75.3	72.3	63.8
South Korea	40.3	78.0	67.7	70.7	58.8	63.1
China	141.9	36.3	37.3	29.3	59.0	60.8
Taiwan	27.6	62.7	73.3	66.7	73.0	60.6
Australia	44.3	72.0	56.7	80.3	46.0	59.9
New Zealand	28.3	71.3	72.3	77.7	48.8	59.7
Philippines	17.8	52.7	66.0	54.3	52.8	48.7
Indonesia	76.8	39.3	39.7	31.3	52.0	47.8
Malaysia	20.6	41.0	57.3	53.0	60.8	46.5
Thailand	22.4	47.0	50.0	48.7	56.8	45.0
India	39.3	24.3	39.3	43.7	42.0	37.7
Vietnam	6.2	26.0	41.0	34.7	35.5	28.7

Asia Cloud Computing Association (2015)

adopted by the organizations for their daily business activities which create both opportunities and challenges (Alshamaila *et al*., 2013; Teo *et al*., 2007).

A report by the SME Cloud Computing Market Attractiveness Index 2015 reveals that Malaysian SMEs are ranked 11th out of the 14 countries in terms of readiness to use cloud computing (ACCA, 2015) (Table 1). The ranking is based on 5 indicators of readiness, i.e., size and attractiveness of the addressable market, existing and nascent demand drivers in the market, capability and suitability of the economy as an early adopter of SME cloud based tools, relative affordability of those tools in the economy and levels of existing government and financial support for SMEs, IT programs and cloud computing adoption.

As cloud computing grows in popularity, the question arises as to what factors may influence Malaysian SMEs to adopt cloud computing. In spite of the increasing number of studies on cloud computing, empirically, the factors that influence cloud computing adoption at firm level are however, lacking. Most of the prior studies on cloud computing adoption have focused on both small and large organizations in more than one industry (Gangwar *et al*., 2015; Hsu *et al*., 2014). Another study has focused on a high-tech industry (Low *et al*., 2011), thereby covering a single industry only. Recognizing the importance of SMEs as a backbone of the country's economy, our study focuses on cloud computing adoption in the SMEs. All industries are covered in the study.

The objective of this study is to identify the determinants of cloud computing adoption by the SMEs, focusing specifically on the factors from the technological context. Technological context refers to technologies (both internal and external) thatare relevant to the organization (Tornatzky *et al*., 1990). The technological factors covered are relative advantage, compatibility and complexity.

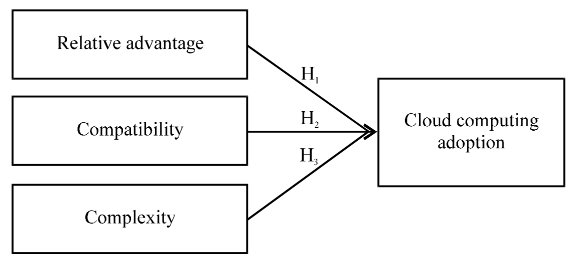

Fig. 1: Research model

The findings of the study may contribute to an understanding of the variables that influence SMEs to use cloud computing. The findings will also be insightful for policymakers in Malaysia such as the Multimedia Development Corporation (MDeC), National IT Agenda (NITA) and SME Corporation Malaysia to decide on appropriate policies, economic incentives, legislative measures and awareness-raising initiatives.

Research model: The research model of the study is based on Roger's Diffusion of Innovation (DOI) theory (Rogers, 1962, 2003) (Fig. 1 for the research model). The DOI theory describes the process of diffusing an innovation via communication channels over time among the members of a social system.

Roger's theory suggests the pertinent attributes of an innovation including relative advantage, compatibility, complexity, trialability and observability. Relative advantage refers to the belief that an innovation provides more benefits than its precursor. Compatibility is the degree to which an innovation is seen to be compatible with the existing values, past experiences and needs of adopters. Complexity is the belief that an innovation is difficult to understand and use. Trialability refers to ease of experimenting an innovation on a limited basis. Observability refers to the degree to which the results of an innovation can be observed by others. It is argued that innovations offering more relative advantage, compatibility, simplicity (ease of use), trialability and observability would be adopted faster than other innovations (Rogers, 2003).

In a meta-analysis on innovation characteristics and innovation adoption-implementation, 10 attributes of innovation are reported to have been commonly examined in prior studies (Tornatzky and Klein, 1982). These attributes are compatibility, relative advantage, complexity, implementation cost, communicability, divisibility, profitability, social approval, trialability and observability. Out of these attributes however, only relative advantage, compatibility and complexity have been consistently found to explain innovation adoption and these factors are therefore, used in our study.

Relative advantage, compatibility and complexity have also been covered by prior studies on cloud computing adoption at organizational (Low *et al*., 2011; Gutierrez *et al*., 2015) and individual levels (Alshamaila *et al*., 2013; Lin and Chen, 2012). Other IT studies have found relative advantage, compatibility and complexity as significant factors of innovation adoption (Alam *et al*., 2008; Ramdani and Kawalek, 2007; Sin *et al*., 2009).

Relative advantage: Relative advantage refers to the benefits that cloud computing could offer to its adopters. The relative advantages of cloud computing include customization, ease of data analysis, reduction of deployment time, low IT costs and IT employee costs, ubiquitous access (Hsu *et al*., 2014), increased business communications speed, improved efficiency in inter-firm coordination, better customer communications and enhanced access to market information mobilization (Low *et al*., 2011). Prior studies have discovered relative advantage as one of the influential factors when considering cloud computing adoption in organizations (Gangwar *et al*., 2015; Low *et al*., 2011; Gupta *et al*., 2013). The following hypothesis is therefore, proposed:

- H_1: relative advantage is positively correlated with cloud computing adoption

Compatibility: Compatibility refers to the degree to which an innovation fits the existing values, needs and prior experience of potential adopters (Rogers, 2003). Prior studies have covered compatibility as one of the important factors for an organization to adopt cloud computing (Oliveira *et al*., 2014; Gutierrez *et al*., 2015). It is argued that when technology is compatible with work application systems, organizations are usually likely to consider the adoption of new technology (Rogers, 1962) Hence, the following hypothesis is proposed:

- H_2: compatibility is positively correlated with cloud computing adoption

Complexity: Complexity refers to the degree to which an innovation is perceived as difficult to understand and use (Rogers, 2003). In contrast to other innovation characteristics, complexity is seen to be negatively associated with the probability of adoption. It is argued that adoption of new Information Systems (IS) innovations is less likely to take place if it is considered to be more challenging to use (Rogers, 2003). Difficulty in understanding and applying a new technology increases the associated risk (Cho and Kim, 2002). This may therefore, result in slower recognition of the technology's value, fear of failure and resistance (Gupta *et al*., 2013). Hence, an innovation that is perceived as easy to use is more likely to be used by an organization. The following hypothesis is therefore, proposed:

- H_3: complexity is negatively correlated with cloud computing adoption

MATERIALS AND METHODS

Data collection: A cross-sectional survey questionnaire is used for data collection. The questionnaire was refined based on expert's reviews and pre-testing before actual distribution. Pre-testing was carried out to determine the strengths and weaknesses of the questionnaire in terms of question format, wording and flow. Ten academicians with IS background and three SME managers participated at the pretesting stage.

The unit of analysis of the study is the organization (i.e., SMEs). The classification of the SMEs in Malaysia is based on the total sales turnover generated by a business in a year or the number of people a business employs (SME, 2010). A manufacturing company is classified as an SME if its annual sales turnover does not exceed RM 50 million or its full-time employees do not exceed 200. For services or other sectors, an organization is considered as an SME is its sales turnover does not exceed RM 20 million or its full-time employees do not exceed 75.

The targeted respondents range from mid-to-senior level executives and managers of the SMEs. They are considered as the most appropriate key informants in this study as they are well positioned in the organization and know their respective organization's IT resources and technological environment (Cohen *et al*., 2014).

Convenience sampling is used for sample selection. The questionnaires were personally administered to respondents at multiple workshops participated in by the

SME respondents. Being aware of the fact that convenience sampling suffers from sampling bias as the sample does not represent the population (Hair, 2007), we do not therefore claim generalization of any findings of the survey.

Of the 343 questionnaires distributed at the workshops, we received 140 responses. Eight responses contained major missing values and were excluded from further analysis. The final analysis involved 132 responses, equivalent to a usable response rate of 38%.

Out of the responses received, 65 and 31% of the organizations are from services and other sectors and manufacturing, respectively. Majority of the organizations (75%) have <30 full-time employees, showing that most of the participating organizations are within the small-size category. In addition, 65% of the organizations have annual sales turnover of less than RM1 million.

Measures: All items are adapted from existing literature on cloud computing and other IT studies: relative advantage (Oliveira *et al*., 2014), compatibility (Oliveira *et al*., 2014; Shin *et al*., 2009), complexity (Oliveira *et al*., 2014; Lian *et al*., 2014) and cloud computing adoption (Choudhary and Vithayathil, 2013). Each item is measured using reflective indicators. A seven-point Likert scale ranging from "strongly disagree" to "strongly agree" was used for the determinants.

Cloud computing adoption was measured by a range of cloud-based technologies used in an organization such as e-mail (e.g., Gmail); raw storage (e.g., Dropbox) and raw computing (e.g., Amazon EC2) (Choudhary and Vithayathil, 2013). A seven-point Likert scale ranging from "not used at all" to "used very extensively" was used for cloud computing adoption.

RESULTS AND DISCUSSION

Partial Least Squares (PLS) (via Smart PLS Version 2.0 Software) was used for statistical analysis. PLS is a Structural Equation Modelling (SEM) technique that allows simultaneous testing of multiple independent and dependent constructs.

A two-step approach was used for the analysis: measurement model (relationship between a construct and its measures) and structural model (relationship between the constructs) (Joreskog and Sorbom, 1993). Testing the measurement model involves construct reliability, convergent validity and discriminant validity.

Construct reliability is evaluated using composite reliability. The constructs are deemed reliable when the composite reliability scores are above the recommended cut-off of 0.70 (Wynne, 1998). As shown in Table 2, the composite reliabilities of all constructs range from 0.852 (cloud computing adoption) to 0.968 (relative advantage) hence demonstrating satisfactory reliability of the constructs.

Table 2: Construct reliability and discriminant validity (Fornell-Larcker Criterion)

Variables	CR	AVE	CC	CMP	CPX	RA
CC	0.852	0.658	0.811	-	-	-
CMP	0.952	0.768	0.189	0.877	-	-
CPX	0.936	0.649	-0.236	-0.157	0.806	-
RA	0.968	0.834	0.096	0.584	0.032	0.913

CC: Cloud Computing adoption; CMP: compatibility; CPX: complexity; RA: Relative Advantage; CR: Composite Reliability. Numbers in bold denote the square root of the Average Variance Extracted (AVE)

Table 3: Discriminant validity: cross-loadings

Variables	CC	CMP	CPX	RA
CMP1	0.098	0.827	-0.119	0.522
CMP2	0.179	0.876	-0.235	0.519
CMP3	0.142	0.914	-0.126	0.585
CMP4	0.139	0.904	-0.164	0.540
CMP5	0.232	0.875	-0.121	0.466
CMP6	0.139	0.860	-0.042	0.476
CPX1	-0.087	-0.285	0.627	-0.160
CPX2	-0.247	-0.097	0.638	0.056
CPX3	-0.153	0.005	0.724	0.135
CPX4	-0.126	-0.123	0.888	-0.055
CPX5	-0.123	-0.132	0.841	0.021
CPX6	-0.211	-0.108	0.872	-0.016
CPX7	-0.236	-0.156	0.914	0.067
CPX8	-0.198	-0.180	0.883	0.037
RA1	0.077	0.489	-0.005	0.880
RA2	0.105	0.444	-0.039	0.884
RA3	0.099	0.584	0.076	0.944
RA4	0.066	0.559	0.067	0.921
RA5	0.087	0.550	0.052	0.933
RA6	0.081	0.588	0.040	0.914
CC comp	0.799	0.047	-0.314	-0.004
CC e-Mail	0.770	0.193	-0.118	0.054
CC storage	0.861	0.244	-0.109	0.197

Convergent validity refers to the degree to which the indicators of a measure converge or are associated with each other (Hair *et al*., 2006). Item loadings with a cut-off value of 0.6 are acceptable (Wynne, 1998). The item loadings in our study meet this criterion (Table 3). In addition, the average variance shared between a construct and its items (i.e., AVE) for all constructs are above the threshold value of 0.50 (Fornell and Larcker, 1981) (Table 2).

Discriminant validity indicates the degree to which a measured variable is distinct. This is measured by the: Fornell-Larcker Criterion (the square root of AVE where all inter-construct correlations are compared) and cross-loadings (how strong each item loads on the other constructs). The square root of the AVE of each construct is greater than the cross-correlations between them (Fornell and Larcker, 1981) (Table 2). In addition, each indicator loading is greater than all of its cross-loadings (Wynne, 1998) (Table 3). The variance explained is 0.08.

Table 4: Hypotheses testing

Hypothesis	Relationship	β	SE	t-values	p-values
H_1	RA→CC	0.019	0.112	0.172	0.863
H_2	CMP→CC	0.144	0.105	1.369	0.171
H_3	CPX→CC	-0.214	0.093	2.302	0.021*

*Significant at $p<0.05$

The standardized path coefficients with values <0.10 should be interpreted as corresponding to small-effect sizes (Kline, 2011).

The hypotheses were tested by examining the path coefficients using a bootstrap procedure with 5,000 resamples (Hair, 2007). The result of the hypotheses testing is summarized in Table 4.

Of the technological factors suggested by the DOI theory only complexity is found to affect SME's decisions to adopt cloud computing (β = -0.214, p = 0.021). Hence, only H_3 is supported. Relative advantage (H_1) and compatibility (H_2) on the other hand are found to be not significant. The result is consistent with other studies on cloud computing adoptionwhich have found complexity as a factor that affects the likelihood of organizations adopting cloud computing while relative advantage and compatibility do not (Gutierrez *et al*., 2015).

Our finding suggests complexity is an important determinant for the Malaysian SMEs to adopt cloud computing. This is consistent with Roger's view that adoption is a function of a variety of factors, including complexity of the innovation (Adam's *et al*., 1992).

Nonetheless, relative advantage and compatibility are not supported by the results as major drivers of cloud computing adoption. One plausible reason for this finding is that although, organizations may have realized the relative advantage of cloud computing, they may have a lower level of cloud computing knowledge (Low *et al*., 2011). The relative infancy of cloud computing may have led the organizations to not have sufficient levels of confidence to adopt cloud computing hence, resulting in longer adoption periods (Dwivedi and Mustafee, 2010). In addition, cloud computing is a new technology that has complex charging mechanisms; the organizations may therefore, consider trading-off the relative advantage and charging service costs (Low *et al*., 2011). Hence, increased awareness at all managerial levels about the high standard solutions provided by cloud vendors, including its sophisticated security and data protection technologies may facilitate the SMEs to adopt cloud computing in future (Gutierrez *et al*., 2015).

CONCLUSION

Based on the DOI theory, this study proposes a model to identify determinants of cloud computing adoption at firm (i.e., Malaysian SMEs) level. The determinants are relative advantage, compatibility and complexity of cloud computing. Data were gathered via a survey questionnaire. Of the DOI factors, only complexity of cloud computing is found to be a significant factor of cloud computing adoption. The finding suggests complexity is an important determinant for the Malaysian SMEs to adopt cloud computing. Relative advantage and compatibility on the other hand do not influence cloud computing adoption.

The findings may have few implications. First, to make the benefits of cloud computing adoption more obvious to the SMEs, government agencies such as SME Corporation Malaysia and MDeC could promote the use of cloud computing or launch awareness campaigns to help the SMEs to understand the concept of cloud computing and realize its potential benefits. Second, this study provides a useful reference for academicians for undertaking future studies in this subject area, especially in the Malaysian context.

Our study focuses on cloud computing adoption in the Malaysian SMEs only. The findings may therefore, not be representative of the other populations as a whole and need to be interpreted with care. The use of convenience sampling for sample selection also limits the generalization of the findings. In addition, we use quantitative survey as our research design. Future studies may consider qualitative approaches such as interview to offer more detailed and thorough explanations for the underlying factors.

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