CLOUD CMPUTING ADOPTION IN TAIWAN:

AN EMPIRICAL STUDY

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Abstract

Cloud computing is a new information technology (IT) paradigm that revolutionizes traditional IT provisioning with its cost-reducing, elastic provisioning, and ubiquitous access features. With that promising propaganda, more and more firms are planning to adopt cloud services. Therefore, a thorough understanding of cloud computing adoption from a firm's point of view is very important. Although there is abundant exploratory or descriptive literature discussing the drivers and barriers of cloud computing adoption, there are very few empirical studies using large-scale data to validate these antecedents. Moreover, an integrated framework with theoretical foundation to evaluate whether a firm should step into cloud is lacking in the current literature. To bridge this gap, our study uses the technology organization environment (TOE) framework in innovation diffusion theory to develop a cloud service adoption model. Our research model is empirically tested using 200 Taiwanese firms. We found that (1) cloud adoption in Taiwan is still at its initial stage since the adoption rate is very low (SaaS adoption rate=30%; PaaS adoption rate=5%; IaaS adoption rate=13%). (2) The perceived benefits, business concerns, and IT capability within the TOE framework are significant determinants of cloud computing adoption, while external pressure is not a significant predictor, in contrast to our hypothesis. We explain the phenomena using the innovation diffusion curve viewpoint: at this early stage, current cloud adopters are adventurous innovators who love to lead the trend instead of being led or forced by others.

Keywords: Cloud Computing, TOE framework, Innovation adoption, Pricing mechanism, deployment model

Introduction

With the development of computer science and the Internet infrastructure, cloud computing emerges from abstract scribbles in a laboratory into a concrete business paradigm (Armbrust et al., 2010). According to the National Institute of Standards and Technology (NIST), Cloud Computing is defined 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 (Mell and Grance, 2009). " Cloud computing enables customers to rent IT infrastructure, platform, and software services in the cloud when needed (Buyya et al., 2009; Dikaiakos et al., 2009; Nurmi et al., 2009). Thus, cloud clients can deploy their business applications, store data, and run analyses via the Internet on a pay-per-use basis (Sultan 2010, 2011).

With the special and unique characteristics listed above, cloud computing revolutionizes the traditional IT adoption issue. Historically, expensive IT innovations are usually first adopted by large firms since only large firms can afford the expense. Now, it is believed that cloud computing will benefit small and medium-sized businesses (SMBs), as well as startups, by "eliminating the up-front commitment," and allowing companies to "pay for use of computing resources on a short-term basis (i.e., pay-as-you-go)" (Armbrust et al. 2010; Hofmann and Woods, 2010; Sultan, 2011). However, with all the benefits presented above, there are still warnings about the dark side of cloud computing hiding behind the seemingly wonderful business propaganda. A variety of issues, such as "security," "confidentiality," "performance instability," "latency," and "network bottleneck," are listed as the trade-offs for choosing a cloud computing solution (Dillon et al., 2010; Hofmann and Woods 2010; Motahari-Nezhad et al. 2009; Sultan, 2011). Given the pros and cons listed above, cloud computing is

something of a double-edged sword; therefore, it is never easy for corporate executives to decide whether they should move their original IT systems onto the cloud. Thus, a thorough investigation of the adoption issue has been called for by many scholars and practitioners (Armbrust et al., 2010; Dillon et al., 2010).

Since cloud computing is a new business model and a trend that reveals the next-generation application architecture, most existing cloud studies (Dillon et al., 2010; Iyer and Henderson, 2010; Lin and Chen, 2012; Marston et al., 2011; Motahari-Nezhad et al., 2009; Prodan et al., 2012; Sultan, 2011; Wu et al., 2011) are exploratory, descriptive, or case-based research. These studies focus on the general concepualization and definition of cloud computing, qualitative discussion of the cloud's benefits and concerns, or hypothetical benefit calculations based on cloud vendors' pricing lists. While the extant literature provides a fundamental understanding of cloud computing, it lacks empirical studies with broad datasets that rigorously examine the factors that might affect the adoption of cloud computing (Behrend et al., 2010; Lin and Chen, 2012; Low et al., 2011). Furthermore, most current cloud adoption literature treats cloud computing as merely another IT adoption issue. However, there are many unique cloud characteristics that are very different from traditional IT innovations, such as its target customers (small and medium firms), its pricing mechanism (pay-as-you-go), and its deployment models (public/private), that were seldom analyzed in previous cloud adoption studies (Böhm et al., 2011; Kakumanu and Portanova 2006; Qu et al., 2011), Therefore, this study will bridge the gap by investigating the determinants of cloud adoption level through the lens of the Technology-Organization-Environment (TOE) framework.

Theoretical Foundation: Technology-Organization-Environment Framework

When discussing IT adoption from diffusion of innovation theory (DOI), the most complete and well-designed framework is discussed by Tornatzky and Fleischer (1990). Those researchers co-created the Technology-Organization Environment (TOE) framework, which offers insights on IT adoption by using technological, organizational, and environmental contexts. The technological context describes the characteristics of the technologies themselves that will influence decisions about IT adoption. Factors in the technology context include the availability and characteristics of the technology, such as technology readiness, technology integration, perceived benefits, and concerns about the technology. The organizational context addresses the traits and characteristics of the organization that will also influence IT adoption decisions. These organizational factors include, but are not limited to, human resources, financial slack, organization size, etc. Finally, the environmental context deals with concepts, such as pressure from competitors, trading partners or government, regulations and policies etc., which are common factors that may influence a firm's decision on adopting new technologies.

Research Model and Hypotheses

The proposed research model shown in Figure 1 is developed through the TOE framework, and each factor will, subsequently, be addressed.

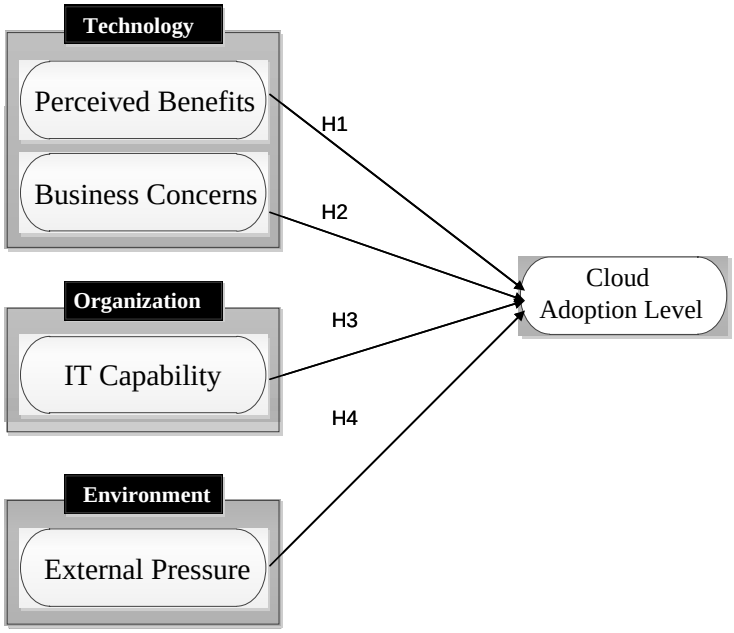

Figure 1 Cloud Computing adoption model

Cloud Computing Adoption Level

Cloud computing is a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to customers using Internet technologies. Cloud computing itself is a complex summation of different service models, and a firm can choose various combinations of distinct service models in order to adopt cloud computing. In general, there are three cloud service models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). NIST defines Software as a Service (SaaS) as: *consumers can access software or applications from various client devices through the Internet, and do not manage or control underlying cloud infrastructure (such as servers, operating systems etc.* The NIST definition of Platform as a Service (PaaS) is: *consumers can deploy onto the cloud infrastructure their own-created or acquired applications using programming languages and tools supported by cloud vendors.* The NIST definition of Infrastructure as a Service (IaaS) is: *consumers are provided with processing, storage, networks, and other fundamental computing resources from cloud vendors* (Fenn 2010; Mell and Grance 2009; Vaquero et al. 2008). In this research, the overall "Cloud Adoption Level" construct is measured by the summation of the

three service models (SaaS, PaaS, and IaaS). For each of the three service models participants have the choice of three response options: “Hasn’t adopted,” “Planning to adopt within 12 months,” and “Already adopted.” That is, the “Cloud Adoption Level” is the summation of the degree of SaaS, PaaS, and IaaS adoption.

Technology Context

As shown in the proposed model, there are two factors in the technology context, perceived benefits and business concerns. Support for the importance of the perceived benefits of innovative technology is abundant in the IT adoption literature (Grandon and Pearson, 2004; Venkatesh and Bala, 2012; Zhu et al., 2006a, 2006b). Perceived benefits refer to the operational and strategic benefits a firm can expected to receive from cloud computing, and some of those advantages are mobility, efficiently reducing computing costs, easy installation and maintenance, and easy performance of data analysis over the Internet (Armburst et al., 2010; Buyya et al., 2009; Dikaiakos et al., 2009; Nurmi et al., 2009). Since cloud computing delivers its service completely through the Internet, employees do not have to stay on-site to perform data analyses and other operations; with an Internet connection, mobility is greatly enhanced. Also because of cloud computing, firms no longer need to invest formidable amounts of resources on building information systems because the installation, maintenance, and upgrade routines are now managed by the cloud computing venders, which can further reduce IT-related costs. Based on the previous explanation, cloud computing can generate an incomparable advantage (Hayes, 2008; Iyer and Henderson, 2010; Vaquero et al., 2008). Therefore, the argument above leads to the following hypothesis:

H1: A firm that perceives a higher level of cloud benefits is more likely to adopt a higher level of cloud services.

The importance of business concerns related to innovative technology has been shown in

previous studies (Chau and Tam, 1997; Khajeh-Hosseini et al., 2012). Business concerns refer to perceived problems or risks that a firm can encounter adopting innovations. Some of the concerns related to cloud computing include data lock-in, confidentiality, insufficient service quality guarantee, bandwidth bottlenecks, and reliability (Armburst et al., 2010; Buyya et al., 2009; Dikaiakos et al., 2009; Nurmi et al., 2009). Adopting cloud computing means handing over part of a firm's daily operation, equipment, and even critical data to a cloud computing service provider. Once a decision is made to cooperate with a certain cloud provider, the firm needs to upload data and perform operation on the provider's machines; thus, the firm not only relies heavily on the single cloud computing service provider but also runs the risk of breaches of confidentiality. Moreover, since the cloud computing relies heavily on the Internet to transfer data and provide services, there are possible bandwidth bottlenecks and infrastructure-level issues that may occur due to different degrees of the infrastructure completeness. With all these uncertainties present, the service quality guarantees between service providers and firms are difficult to predict, measure, and maintain (Armbrust et al., 2010; Hayes, 2008; Leavitt, 2009). Therefore, the argument above leads to the following hypothesis:

H2: A firm that perceives higher levels of concern is less likely to adopt cloud services.

Organizational Context

As shown in the proposed model, the organizational context includes IT capability which consists of IT resources and IT employees (Bharadwaj, 2000). IT resources refer to the firm's annual budget for the IT department to install, maintain, and upgrade the company's information systems. The number of IT employees is an indicator to determine whether a firm has sufficient IT employees to support daily operations; perform installation, maintenance and upgrades; and handle emergencies. Most previous studies, as well as the TOE framework, indicate that a firm with a higher level of IT capability is more likely to adopt new

technology (Kamal, 2006; Kuan and Chau 2001). Firms that have successfully implemented information technologies in the past have better technical knowledge, fostered skills for implementing new IT solutions, and developed a deeper understanding of the economic and organizational impact of new IT (Cohen and Levinthal, 1990; Zhu et al., 2006a). Acquired primarily through learning-by-doing, such skills and capabilities are critical for successful adoption of newer technologies (Cohen and Levinthal, 1990). Nevertheless, when discussing cloud computing, it is believed that firms with lower IT capability may be more likely to adopt cloud computing, which is diametrically opposed to the findings of past studies (Hofmann and Woods, 2010; Sultan, 2011). Since cloud computing is still in its infancy, there is no evidence to support which kinds of firms are more or less likely to adopt the technology. Therefore, this study hypothesizes the following and will test it by examining data we collected.

H3: A firm with lower levels of IT capability is more likely to adopt higher levels of cloud services.

Environment Context

As shown in the model, the external pressure factor is included in the environmental context. There are three perspectives from which to discuss the external pressure: pressure from trading partners, competitive pressure, regulations and government policies (Chwelos et al., 2001; Kuan and Chau, 2001; Zhu et al., 2006a, 2006b). Trading partner pressure suggests that perceived pressure from upstream and downstream business partners influences a firm to adopt new technology in order to maintain cooperative relationships. Competitive pressure refers to perceived pressure from business competitors that forces a firm to adopt new technology for the sake of maintaining competitiveness. Regulations and government policies mean that governmental support requires a firm to adopt new technology. There are abundant studies to support the idea that the greater the external pressure, the greater the motivation for

a firm to adopt information technology (Chwelos et al. 2001; Grandon and Pearson 2004; Kuan and Chau 2001;Zhu et al. 2006a, 2006b). In recent cloud computing adoption research, Low et al. (2011) mentioned that pressure from trading partners has significant influence on the adoption of cloud computing. Also, Kirkpatrick (2011) reported that competitive pressure can force firms to adopt cloud computing. Therefore, the arguments above leads to the following hypothesis:

H4: A firm facing more external pressure is more likely to adopt a higher level of cloud services.

Methodology

Data

To test our research model, a questionnaire was designed to collect data on each of the variables in the model. Each of the items on the questionnaire was reviewed for content validity by an expert panel comprised of faculty whose work focuses on cloud computing, as well as some practitioners and consultants from industry. The initial questionnaires were pilot tested on ten firms randomly selected from the sample frame and, based on the responses received, some items were revised for clarity. After the questionnaire was finalized, we conducted a survey. The selected businesses for the survey were evenly distributed in four sectors of Taiwan's main industries: Information and communications technology (ICT) manufacturing, ICT service, general service, and general manufacturing industry. Anecdotal evidence suggests that firms in the four industries tend to adopt cloud computing differently, with ICT industries leading in the use of cloud, while traditional industries appear to be laggards. Thus, the four industries provide appropriate testing fields for our research model. Eligible respondents for our survey are CIOs or senior IT mangers in each company.

Our target sample was 200 Taiwanese firms. In total, 623 potential respondents were

contacted with a response rate is 32.1%. Figure 1 shows the sample's statistics. We found that our surveyed companies were composed of 65% SMBs (< 200 employees) and 35% large corporations, which is in consistent with statistics indicating most Taiwanese companies are SMBs. Second, although Taiwan is famous for its high-tech industries, the numbers of IT employees and their IT budgets are pervasively low. Of the companies surveyed, 72% have fewer than 5 IT employees, and 72.5% of the surveyed companies have an annual IT budget of less than 5 million NT dollars (0.17 million USD). Based on this observation, it can be deduced that IT departments in Taiwanese companies serve a supporting function instead of having a core development focus. Given this, it can be interpreted that firms in Taiwan having low numbers of IT technicians and low IT budgets may view the adoption of cloud computing services as a reasonable substitute for their original IT systems.

Table 1: Sample Characteristics

Items	Frequency	%
Numbers of Employee		
Under 200	130	65%
200~500	45	22.5%
Above 500	25	12.5%
Industry		
ICT Service	53	27%
ICT Manufacturing	53	27%
General Service	51	25%
General Manufacturing	43	21%
Employees in IT department		
0-2	80	40%
3-5	64	32%
6-10	30	15%
11-50	19	9.5%
Over 50	7	3.5%

IT Budget in 2009		
Under NT. 1 million	63	31.5%
NT. 1-5 million	82	41%
NT. 5-10 million	22	11%
NT. 10-20 million	16	8%
Over NT. 20 million	17	8.5%

Descriptive statistics

As listed in Figure 2, among those advantages that cloud computing can bring to a firm, "Easy to install/upgrade/maintain," "Off-site backup," and "Reduce IT expenses (e.g.: IT devices, IT employees, IT maintenance)" are the top three benefits that most IT managers indicated.

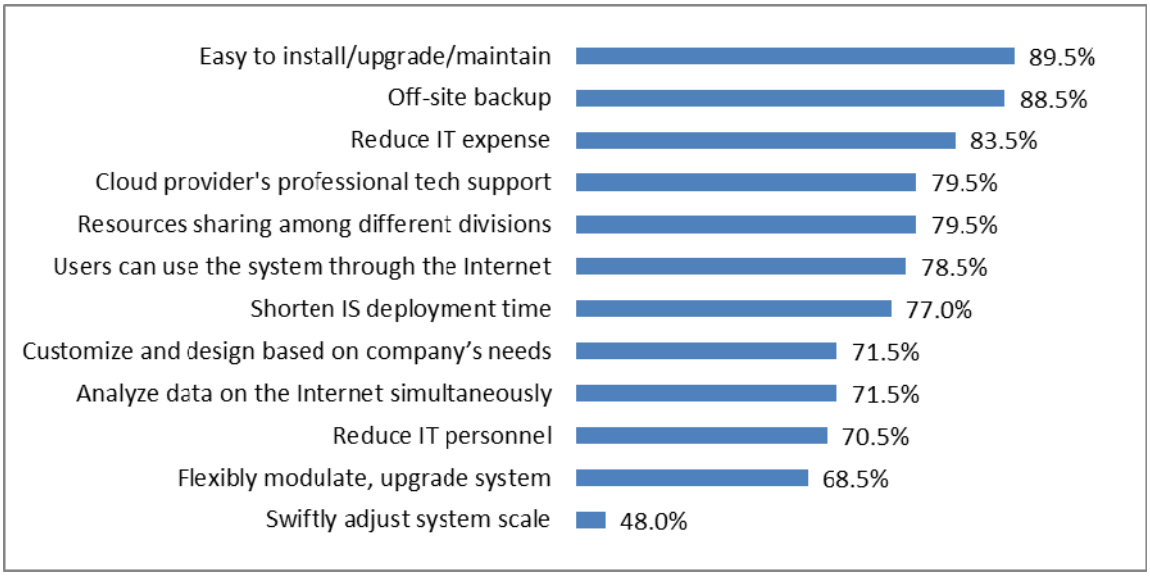

Figure 2 Perceived Benefits

As for the disadvantages of the cloud service listed in Figure 3, the top three concerns are "Cloud provider cannot deliver quick response," "Unexpected service outages," and "Confidentiality". It can be implied from the data that, due to the whole new concept of cloud service, it is still too risky for decision makers to hop on the bandwagon. Generally, IT managers in Taiwan maintain a reserved attitude toward cloud computing.

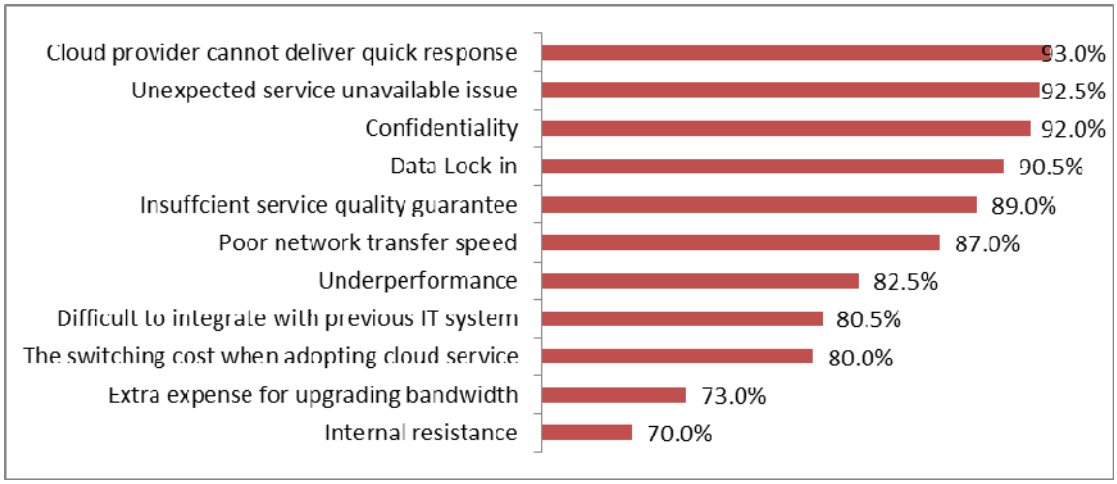

Figure 3 Business Concern

Based on Figure 4, it can be observed that, when addressing environmental issues, Taiwanese companies are mainly concerning about the readiness of basic Internet infrastructure and the integrity of government regulations. One possible explanation might be that, since cloud computing is mainly distributed through the Internet, the image of highly dependable Internet access is on business practitioners' minds (Lin and Chen, 2012). Other than Internet infrastructure and government legal enforcement, there is less concern about issues like whether other companies, competitors, or business partners already adopted cloud computing services. The respondents' answers indicate a sense of being technology pioneers, who are not easily influenced by others (i.e. peers, competitors, or business partners) when facing new technology adoption issues.

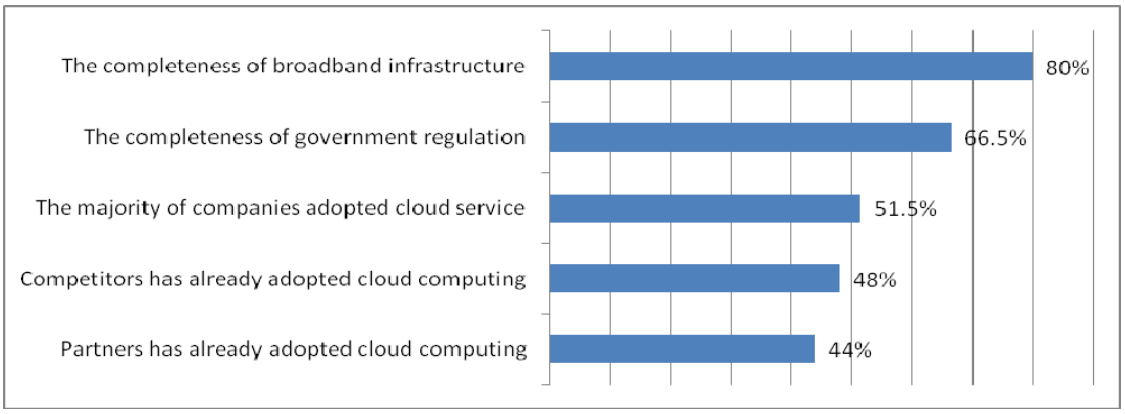

Figure 4 Environment issues

We further investigated firms' intentions to migrate their current information systems to cloud. According to Table 2**,** the most popular information system already in cloud is the email system, and it also has the highest possibility of being transformed into a cloud-based system within one year. On the other hand, and probably due to privacy and confidentiality issues, the IT systems least likely to be migrated to cloud are Human Resources, Supply Chain Management (SCM), and Project Management systems.

Table 2 Firms' intention to migrate current information systems onto Cloud

	Already used cloud	Will migrate to cloud in one year	No intention to migrate to cloud
Email System	18%	26%	56%
ERP	10%	13%	78%
Human Resource system	8%	9%	84%
Information Security system	8%	22%	71%
Video conferencing system	7%	25%	68%
CRM	4%	24%	73%
e-Business	3%	21%	76%
Project Management system	3%	18%	80%
SCM	1%	17%	82%

The questionnaire was designed in 5-point Likert scale and Table 3 shows descriptive statistics in more detail. We noted that the mean values of items in "Business Concerns" generally are higher, indicating firms are very cautious about the possible problems from using cloud computing, such as "confidentiality," "vendor lock-in," and "service outages".

Table 3: Descriptive statistics

Constructs	Items	Code	Mean	Std. Dev.
Perceived Benefits (PB)	Customization	PB1	3.82	1.022
	Easily analyze data on Internet	PB2	3.79	0.982
	Reduce deployment time	PB3	3.87	1.007
	Reduce IT costs	PB4	4.13	0.968
	Reduce IT employees costs	PB5	3.74	0.971
	Ubiquitous access	PB6	4.03	0.959
Business Concerns (BC)	Confidentiality	BC1	4.68	0.808
	Incompatibility	BC2	4.4	0.946
	Insufficient service quality guarantee	BC3	4.24	0.969
	Internet Bottleneck	BC4	4.2	0.985
	Service Outages	BC5	4.67	0.809
	Underperformance	BC6	4.3	1.086
	Vendor lock-in	BC7	4.68	0.808
IT Capability (IC)	Number of IT employees	IC1	3.05	1.191
	Annual budget for IT department	IC2	2.21	1.214
External Pressure (EP)	Competitors Pressure	EP1	3.03	1.261
	Government policy support	EP2	3.91	1.105
	Partners pressure	EP3	3.12	1.285
	Regulations	EP4	3.68	1.272

In Table 4, our results show that cloud adoption is still in its initial stage since the adoption rate is very low (SaaS adoption rate = 30%; PaaS adoption rate = 5%; IaaS adoption rate = 13%). Most Taiwanese companies are still conservative when considering cloud adoption, even though cloud has been discussed intensively over the past few years. Furthermore, when combining “planning to adopt” and “already adopted,” we found that the SaaS solution has a

relatively higher acceptance rate over the PaaS and IaaS solutions, which indicates that, at this early stage of cloud computing, firms are more willing to give SaaS application a chance to test cloud computing.

Table 4. Distribution of SaaS, PaaS, and IaaS adoption

	SaaS Adoption		PaaS Adoption		IaaS Adoption	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
No intention	57	28.5	176	88	161	80.5
Will adopt within 12 months	83	41.5	14	7	13	6.5
Already adopted	60	30	10	5	26	13

Data Analysis and Results Discussion

Cloud Adoption Level:

The results of the structural model are shown in Figure 2. Among the four factors listed in the proposed model, Perceived Benefits, Business Concerns, and IT Capability significantly influence cloud computing adoption, while External Pressure is not a significant factor.

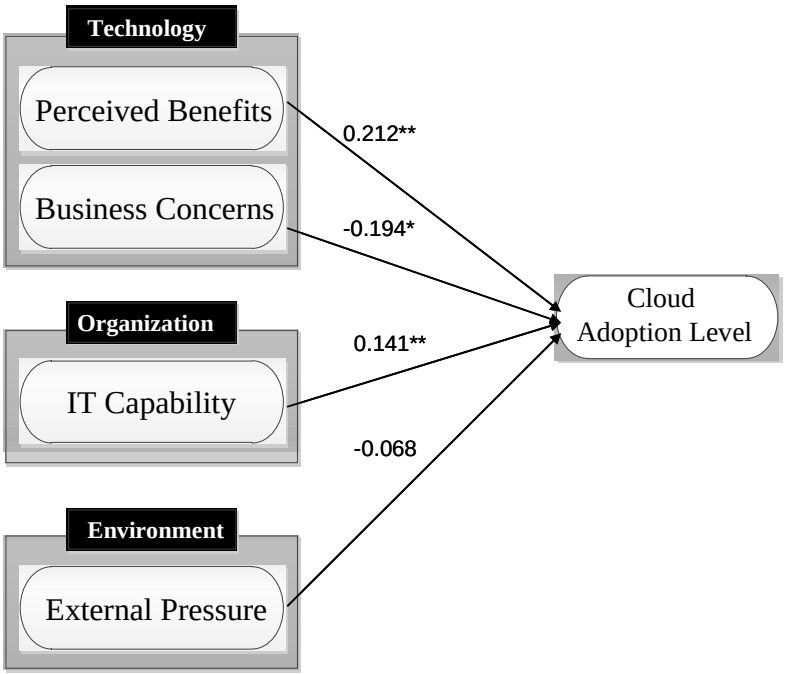

Figure 2 Results of Structural model (*$p < 0.1$; **$p < 0.05$; ***$p<0.01$)

"Perceived Benefits" has a significant ($p < 0.05$) and positive coefficient, and it is the most

influential factor (0.212) when firms consider cloud adoption. It indicates that, at this stage, IT managers are instilled with the knowledge that cloud computing technology can be beneficial to their organization (e.g., reduces IT expense, easy to install/upgrade/maintain, etc.) and the more benefits they perceive the greater the level of cloud computing adoption. Thus, Hypothesis H1 is supported.

As for Business Concerns, our results show that it has a significant ($p < 0.1$) but negative connection with the cloud computing adoption. Although slightly weaker than the influence of Perceived Benefits, it still indicates that, at this early stage of cloud computing, business concerns, such as confidentiality, service outages, and vendor lock-in, will hinder firms from adopting innovative cloud services; in other words, the more Business Concerns a firm perceives, the lower the likelihood for the firm to adopt cloud computing technology. Therefore, Hypothesis H2 is supported.

The third factor, IT Capability, is also significant ($p < 0.05$), but "positively" influences the adoption of cloud computing technology. This result is contradictory to our original Hypothesis 3: a firm with lower levels of IT capability is more likely to adopt cloud. H3 resulted from experts' predictions and cloud vendors' propaganda based on the cloud computing's economic premise. However, our results indicate that firms with higher IT capability (more IT employees and greater IT budget) prefer cloud computing, probably because these firms are more familiar with the latest information technology, and keep up with dynamic IT trends. Also, greater familiarity with information technology infers a higher level of knowledge to use in the operation of newer information technology; thus, greater IT capability might allow for better management of, unpredicted turbulence brought by cloud, without undue economic impact. Lin and Chen's (2012) recent qualitative study interviewing 19 IT professionals in regard to their firms' intentions to adopt cloud yielded similar findings.

A firm's IT capabilities, such as existing knowledge and skills among personnel and the company's experiences, are the keys when considering cloud computing adoption (Lin and Chen, 2012). Our empirical results confirm their qualitative finding.

The fourth factor, External Pressure, is not significant ($p > 0.1$) and what is noteworthy is that, at this initial stage of cloud computing, external pressures from other companies, business partners, or even competitors and government regulations are not important factors when considering cloud adoption. A possible explanation of the result is that current cloud adopters somehow share the 2.5% "innovator" characteristic in the innovation diffusion lifecycle (Rogers, 1995). These pioneers love to embrace just-launched technologies and are not easily affected by other people. They lead the trend instead of being led. Therefore, external pressure is not a significant factor, which is quite different from previous innovation diffusion studies focusing on more mature technologies.

Conclusion

Cloud computing is a new technology paradigm that requires a careful and thorough examination when considering firm-level adoption. This empirical research, with 200 respondents, systematically examines cloud computing adoption through the lens of the TOE framework. The results indicate that when talking about cloud adoption level, three factors significantly influence the final decision; "Perceived Benefits" and "IT capability" are positively related, while "Business Concerns" is negatively related to cloud computing adoption. Among the three significant determinants, "perceived benefits" has the strongest effect, and this result provides empirical evidence to support previous qualitative cloud adoption studies: early cloud adopters appear to place more emphasis on the perceived benefits of technology (Lin and Chen, 2012).

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