TOWARD A MATURITY MODEL FOR CLOUD SERVICE CAPABILITY ASSESSMENT

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ABSTRACT

This research develops a maturity model of public cloud services, with which firms would determine their current usage level of public cloud services and the types of capabilities required to manage and benefit from the adoption of public cloud services. The data analysis shows that the three important capabilities that influence the support of using public cloud services are IT assets, integration, and reconfiguration and transfer. In addition, higher usage level for public cloud services leads to higher benefits, and human-based resources do not have significant impact on supporting greater usage level of public cloud services. The findings help companies to transfer effectively from their existing IT system to a cloud-based system.

INTRODUCTION

Cloud computing ranked number 17 in the list of key technologies in 2009, and moved up to number 5 in 2010 [12]. A survey by VMware also showed that 88 percent of the respondents regarded cloud computing as high priority in their organizations over the next 18 months, and two thirds of the respondents were planning or had already adopted cloud computing technologies [16].

However, the fact that cloud computing brings positive benefits to companies does not mean that these companies will actually obtain the benefits simply by adopting cloud computing. Some companies enjoy the benefits of adopting public cloud services, while others obtain limited benefits. Because the IT maturity varies from one company to another, different companies are at different usage levels of public cloud services. The usage level depends on particular IT capabilities that the companies own when they adopt cloud computing. Research has shown some of the concerns that companies face when they adopt cloud computing include cloud outages, security problems, and compliance [11]. Although prior research have noted issues that companies should consider before adopting cloud computing, insufficient attention has been paid to the types of capabilities companies should build regarding cloud computing adoption. Moreover, different companies have different situations for their IT systems and therefore also have different levels of maturity when adopting cloud-computing services.

The purpose of this research is to develop a maturity model of public cloud services. Using this model, companies can understand their current usage level and the benefits pertaining to each level. In addition, it also shows the capabilities that the companies should acquire to move up to the next level. The two research questions this study intends to answer are: “What important capabilities must companies build

to adopt public cloud services well and increase their usage level?" and "Does a higher usage level for public cloud services lead to higher firm performance?"

LITERATURE REVIEW

This study focuses on public cloud services, whose cloud infrastructures and services are hosted by third-party vendors and are available to the general public. Public cloud services are available through a pay-per-use model.

Levels of Cloud Computing Usage

The extent of firms' usage of cloud computing can be complicated but is critical. Massetti and Zmud [13] have evaluated EDI usage using four facets, namely volume, diversity, breadth, and depth. We used a similar method to describe the usage level of public cloud services, and there are three dimensions that we use to assess the extent of usage. These dimensions are volume, diversity, and breadth. The *volume* of public cloud services refers to the number of distinct public cloud services that a firm has adopted. The more public cloud services that a firm has adopted, the more likely it is that the firm is at a higher usage level. The *diversity* of public cloud services represents the extent to which a firm has adopted different types of cloud services (IaaS, PaaS, and SaaS). It indicates the complexity of the firm's cloud environment. The *breadth* of public cloud services indicates how many departments within the firm have adopted public cloud services. This index measures how widespread the public cloud services are in a firm.

Resource-Based Theory

According to resource-based theory, a firm's competitive advantages are a result of the specific resources and capabilities possessed by the firm [2][9]. These resources and capabilities should be valuable, rare, and difficult to imitate and substitute [2]. Although Barney [2] regards capabilities as one of the specific resources of the firm, Grant [9] separates capabilities from resources by indicating that resources are the source of capabilities and capabilities represent the performance of tasks or activities. Resource-based theory provides the firm with a good reason to develop a suitable strategy to reduce the resource gaps and increase profit [9].

Grant [9] and Barney [2] indicated six categories of resources: financial, physical, human, technological, reputational, and organizational resources. Other researchers have extended the traditional view of resource-based theory because they believed that a firm should have additional dynamic resources and capabilities that would enable itself to confront the complicated and rapidly changing environment. Using the dynamic resource-based view, capabilities can be divided into three parts: capabilities regarding organizational and managerial processes, capabilities regarding the firm's asset positions, and capabilities regarding paths [15]. Bharadwaj et al. [3] further proposed a resource-based view of IT: tangible IT infrastructure, human IT resources, and intangible IT-enabled resources.

Adoption Issues for Public cloud Services

There are five types of adoption issues for cloud computing, which include availability, security, support, vendor lock-in and interoperability, and compliance [10]. The *availability* issue concerns the outage of cloud services. Precautions such as service level agreements (SLAs) from providers are needed to avoid such problems. Placing valuable data and services with an outside provider poses a fundamental *security* risk. However, Won has argued that the off-premises cloud is no less secure than on-premises computing. Cloud service providers must hire and train sufficient *support* staff to provide better support than users receive with on-premises computing. Moreover, firms should avoid vendor lock-in to be able to migrate

and integrate data, application, and services among different providers' clouds (*interoperability*). Because firms need to maintain business legal documents and assure integrity to comply with law regulations, cloud service providers must ensure that users' data satisfy their *compliance* requirements. Emerson [6] and Shimba [14] both offered similar viewpoint on this issue. The former indicated that data security, availability, and performance are top concerns for cloud service adoption, and the latter indicated that security is the most important concern, followed by integration, availability, and compliance. Géczy et al. [8] also pointed out the three aspects of cloud-related concerns. *Alignment* with the existing operating model in the organization, including integration, customization, availability, performance, and transfer assures operational efficiency. Customization is the ability to provide customized cloud-based services at several levels to accommodate diverse needs and does not represent the capability of the cloud adopter. *Management and control* of data and services consists of security, management, relocation, control loss, and data loss. Many cloud services providers regard these abilities as added value, and claim that they can provide better security tools than those currently used by firms. The *legal* concerns consist of liability, disclosure, and legislation. These concerns are restrictions that come into play during cloud service adoption.

Public Cloud Service Performance

Prior research suggests that the performance improvement due to cloud computing include increasing profit/decreasing cost, flexibility, and mobility. For *increasing profit/decreasing cost*, cloud computing offers direct benefits to the firm and reduces redundant investment in hardware, software, and the cost of maintenance and management [1][4]. Cloud computing also provides a utility-style payment, allowing firms to pay only for the resources or services that they actually use [8]. With the *flexibility* of cloud computing services, firms can easily scale the capacity upward or downward, depending on the users' needs [7]. Moreover, flexibility allows firms to efficiently handle peak demands [5]. Lastly, as a result of the *mobility* of cloud computing services, employees can use the information, resources and services easily regardless of location. Cloud computing also provides a collaborative environment for firms because multiple users can connect to the services at the same time but on different types of OS [1].

RESEARCH MODEL AND HYPOTHESES

Figure 1 shows the research framework of this study. This study focuses on firms' capabilities regarding public cloud services. According to the RBV theory and findings of prior studies, we developed a research framework that includes four resources to form public cloud capabilities, which affects three usage levels and three performance areas.

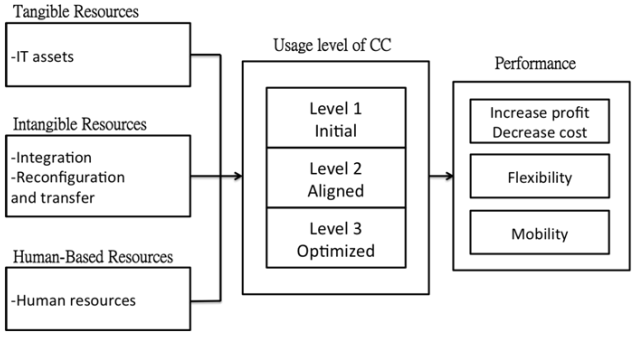

Figure 1. Research Model

As discussed earlier, the usage of public cloud services is divided into three levels and measured using three dimensions: volume, diversity and breadth. At the initial level, firms adopt only one type of public cloud service in only one department. At the aligned level, firms adopt two or three different public cloud services in two or three departments but under the same type of cloud service (IaaS, PaaS or SaaS).

At the highest level, the optimized level, firms tend to heavily adopt many cloud services, especially across different types of cloud services, in most departments. Table 1 below shows the usage levels for public cloud services.

We propose four resources that form the public cloud capabilities: (1) IT assets, (2) Integration, (3) Reconfiguration and transfer, (4) Human resources. The first resource can be regarded as a tangible resource, the following two intangible resources, and the last one human-based resource.

Table 1. Usage Levels of Public Cloud Services

Dimensions \ Levels	Level 1 Initial services	Level 2 Aligned	Level 3 Optimized
Volume	1	2~3	>3
Diversity	1	1~2	>1
Breadth	1	2~3	>3

The research hypotheses to be examined are:
H1: Firms with more IT assets are able to support greater usage levels of public cloud.
H2: Firms with greater cloud integration are able to support greater usage levels of public cloud.
H3: Firms with greater capabilities in reconfiguration and transfer are able to support greater usage levels of public cloud.
H4: Firms with more human-based resources are able to support greater usage levels of public cloud.
H5: Firms with greater public cloud usage are more likely to achieve better firm performance.

RESEARCH METHODOLOGY

Before we proceed with data collection, we interviewed two major public cloud service providers in Taiwan, Hicloud of Chunghwa Telecom and ASUS Cloud. Hicloud generally agreed with the viewpoint on cloud capabilities presented in our research, especially in terms of integration ability. Dr. Wu, Managing Director of Chunghwa Telecom, also believed that adopting cloud services is more than simply applying a new IT tool. ASUS Cloud indicated that our research model has considered most of the adoption issues and that it may work in practice. Dr. Wu, CEO of ASUS Cloud Corporation, noted that public cloud services could reduce pressure on the firm to provide particular IT technologies such as virtualization and security because service providers would provide these services to users, and users would only need to know how to use them.

Data collection proceeded through online survey. We directed our sample at companies that have adopted public cloud services and at respondents who are staff who doesn't necessarily work in the IT department. We mailed the link for the online questionnaire to the respondents. We also posted the link on popular technology web forums to collect as larger number of responses as possible. Data collection lasted for one and a half month, and we finally received 158 responses, among which 117 were complete and valid.

RESEARCH FINDINGS

Data analysis showed that all the proposed hypnoses, except H4, were supported. We summarize the major findings as follows. First, *the three important capabilities that influence the support of using public cloud services are IT assets, integration, and reconfiguration and transfer*. IT assets, including physical IT assets and financial assets, are essential resources to provide basic support for firms to adopt public cloud services. Integration is the ability to coordinate internal and external resources and activities. Reconfiguration and transfer can be regarded as the ability to dynamically optimize resources,

which help firms to adopt public cloud services in a more efficient way. Second, *the most influential factor between Initial level and Aligned level is reconfiguration and transfer. The most influential factor between Aligned level and Optimized level is integration. These two factors have the nearly the same score and much higher than that of IT assets.* Between Initial level and Aligned level, the Wald values of IT assets, integration and reconfiguration, and transfer, were 3.962, 7.439, and 8.034. Between Aligned level and Optimized level, the Wald values for these three factors were 8.057, 18.748, and 15.930. These three factors were all significant at the $p < 0.05$ level. The last two factors had nearly the same high Wald values, indicating these two capabilities as having high influence on adopting public cloud services. Third, *firms with greater public cloud usage are more likely to achieve better firm performance.* We found that the score of performance at Optimized level was significantly higher than those at both Initial and Aligned levels. However, the score of performance at Aligned level was not significantly higher than the score of performance at Initial level ($p < 0.399$). It might be due to the small sample size we obtained to discriminate the two groups, especially when these two group's average scores were close. On the other hand, if firms can raise their usage level up to Optimized level, they can realize the obvious improvements in IT performance. Fourth, *human-based resources do not show significant impact on supporting greater usage level of public cloud services.* One reason may be due to the small sample size as discussed earlier. One other possible reason relates to the fact that most firms in Taiwan do not provide complete training on the new concept of cloud computing to their staff, except those in the IT department. Because the survey does not focus only on the respondents in the IT department, the score of human-based resources was thus low.

LIMITATIONS AND FUTURE RESEARCH

The first limitation regards the online survey. Second, the survey was conducted in Taiwan. A larger scale survey could help the generalizability of this study. Third, the selection of respondents might also influence the results of the analysis. Lastly, the measurement of performance was to ask the respondents to compare the situation before and after adopting public cloud services. Because the standard of comparison may differ from one firm to another, it may lead to inconsistent results across firms.

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