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ABSTRACT

The cloud computing model is a modern concept of computation that provides a number of benefits for its adopters. This online computing model has been widely used in the western world and accepted to have some business and economic impacts. This paper provides some basic knowledge about cloud computing and discusses the greatest benefit which is cost reduction in fixed ICT capital and services. With such the benefit, this study attempts to find the determining factors for cloud computing adoption in various industries and proposes some policy recommendations accordingly in order to facilitate the diffusion of the innovative computing model as well as the extensive realisation of its benefit. Thailand is selected as ground for investigation. The discrete choice model of logistic regression is selected as an econometric tool to extract the relationships of different attributes and the probability of cloud computing adoption in 206 industries. The results point out significant determining factors categorised into Internet and technology; cost; and some difficulties in ICT usage. Hence, some policy implications in order to increase the possibility of adoption include an effort to improve internet capability of employees; provide some investment incentives such as tax reduction and low-cost loans for initial set-ups of cloud computing systems; and develop reliable internet network with advanced capability and low cost of use.

JEL Classifications: C25; D22; O31; O53

Keywords: Cloud computing; Economic benefits of the cloud; Cloud computing adoption; Binary regression; Thai industries

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1. Introduction

Cloud computing is meant to serve the businesses by increasing the computing performance, storage capacity, universal accessibility and cost reduction. This can benefit most of the small and medium enterprises (SMEs) in the initial stage of business development in terms of fixed and maintenance cost reduction in the ICT investment of both hardware and software as well as computer services. Even though this kind of computing systems has been in the online world and applied to various services in western countries, namely the US for many years, the concept of cloud computing is still new to many developing countries including Thailand in which there are emerging businesses essentially longing for low costs of establishment and efficient processes. Moreover, there are macroeconomic benefits from the cloud. Indeed, the cost reduction feature of the cloud computing model results in higher possibility of business creation, especially SMEs, which then leads to higher employment and output for the country.

This paper provides basic knowledge of the cloud computing and some examples of the existing cloud services providers. An important benefit of the cloud, cost reduction, is pointed out. The objective of this study is to find out factors that affect the cloud computing adoption in various industries in Thailand. The discrete choice model of logistic regression is employed in order to extract the determining factors of the probability of cloud computing adoption. Policy implications are also derived from the results of the model.

The structure of the paper is as follows. Part 2 consists of relevant works of literature regarding the issues of cloud computing and its impacts on the economy in both macro and microeconomic perspective. Part 3 shows the general, but necessary knowledge of cloud computing including the definitions and processes. Part 4 elaborates the economic benefit of cost reduction from the adoption of the cloud computing. Part 5 describes the information regarding the cloud computing in Thailand. Part 6 is the data and methodology. Part 7 shows the results and discussions. Part 8 points out some policy implications for both private and public units. Finally, the conclusion is provided in Part 9.

2. Related Literature

Preliminary, there is a work of literature regarding the fundamentals of cloud computing service definition. The most comprehensive taxonomy may be derived from an article of Rimal et al. (2010) that provides not only an overview of the cloud computing architecture, but also detailed explanations of each of the components consisting of modes of cloud computing services, virtualisation management, core services, security, data governance, and management services. Their work contributes a great deal of better understanding of the classification of the cloud computing and its applications to further research of similar issue including this study.

Another relevant work of literature points out the foundation technology that is used to make available the cloud computing systems. The technique is called virtualisation technology (Jin et al., 2010). The article also elaborates the virtual machines or VMs, which are the outcome and backbone of the cloud computing utilising the power of a computing model called MapReduce.[1] The research describes the VM as a software implementation of a machine that can run programmes like an ordinary computer. According to the finding, there are different kinds of VM. Some examples are process VM, which is pre-installed with a single programme and can execute only the installed software such as Java Runtime Environment (JRE), and system VM of which its functions are close to a computer in the sense that the user can control the whole platform, the operating system (OS), and execution of different software applications.

In term of definition, Foster et al. (2009) have compared the cloud computing and grid computing and propose similarities and differences between the two concepts.[2] They are similar in terms of their vision, architecture, and technology. However, there are differences originated in various aspects such as security, model of business, programming, computing and data as well as applications and abstractions. Nevertheless, the comparison of both kinds of computing is beyond the scope of this study.

Therefore, this paper concentrates mainly on the issue of cloud computing and its knowledge. For that regard, an interesting overview of the cloud computing is explained in an article by Armbrust et al. (2010). In the article, they provide a basic definition of the cloud computing and the process of the service delivery along with 10 obstacles and opportunities of the utilisation of the cloud computing with practical examples including a case of data transfer bottleneck. Moreover, the economic benefits of cloud computing are concretely outlined in the paper by Talukder et al. (2010). This piece of literature assembles economic benefits and costs of cloud computing along with its internal economy such as charging, billing, and taxation of the cloud products and services. They show that economic benefits are to some extent exclusively derived from the concept of pay-as-you-go pricing. In fact, they also point out the reduction in initial set-up costs of the online content providers and a sharp increase in the number of accessible services to the end-users. Despite the attractive incentives to adopt the cloud computing model, businesses face an important concern consisting of privacy and security issues (Kshetri, 2011). Such issues include the anonymous location of data storage and unlawful access of sensitive information. A great deal of concern has been put in developing countries as they are usually considered a source of cyber crime.

A quantitative analysis of the impact of the cloud computing is conducted based macroeconomic modelling and data of European countries. Indeed, Etro (2009) employs

[1] For more information, see Jin et al. 2010, p. 13.
[2] For more information about grid computing, see Foster et al. 2009

the dynamic stochastic general equilibrium (DSGE) approach to verify the impact of the cloud computing in term of the reduction in fixed costs of SMEs and concludes that a gradual introduction of the cloud computing model results in the creation of businesses and employment through lowering the initial cost of ICT capital.

Klems et al. (2009) additionally emphasise on the need for valuation of the cloud computing and propose a framework for estimation and comparison of different kinds of the cloud utilisation. Their research is meant to assist decision makers in adopting the cloud computing as their IT solution. The evaluating cases consist of the application of cloud computing services by New York Times TimesMachine, which is an active online news provider, and Major League Baseball that uses the cloud to cope with seasonal peaks in demand for online broadcasting of legendary matches.

There are several attributes that endorse the evolution and provision of the cloud computing. These factors are explained by Gartner (2009). The enabling factors of the cloud consist of service-based computing, scalable and elastic computing resources, shared resources, pay per use pricing, and service delivery through the Internet.

For the literature regarding the cloud computing in Thailand, Oradeedolachet (2010) insists that this modern computing model will be the new ICT trend that benefits various enterprises whose core businesses may not necessarily concentrate in the ICT field. He promotes a specific mode of services called process as a service that will benefit the users, or customers, by creating a link between related business units and granting the power of service integration based on the cloud service. One of his examples is a cloud service interface that can securely connects all processes in obtaining the credit from a financial institution ranging from inputting customers' information to using the authorised amount for a purchase at another company. This can save a lot of time and money compared to the traditional paper-based process.

3. Cloud Computing Overview

The definition of the cloud computing is basically a kind of computation that is conducted in anonymously-shared resources with the output being delivered to the users through Internet interfaces. Indeed, innovations and implementations of modern Internet technology are the driving force that facilitates the cloud evolution. Under the cloud computing regime, the information is stored, or usually uploaded, in servers and provided as services. The provision of computing power as a service has extensively taken place after the development of Web 2.0 in which the software platform can be utilised through the Internet (O'Reilly, 2007). For decades, the cloud computing model has been utilised in a variety of applications one may not even notice. Examples include web-based emails, online search engines, and social networking sites (SNS). The users do not need to install any specific software. All they need is a web browser to access the online service interface. In addition, they do not need to know how and where the computing is being conducted as

they are not responsible for any difficulties in the process. The delivered output is the only concern.

There are several modes of service which will be discussed later in this section. According to Jin et al. (2010) and Armbrust et al. (2010), it is to be noted that there are three main types of the cloud. First, it is the public cloud that offers computing services to anyone on a usage-based pricing principle, or the pay-as-you-go concept. This type of cloud can be regarded as utility computing as it is more or less similar to the consumption of public utility such as electricity and water. Public cloud providers store their clients' information in a set of shared servers. Later analyses of this paper are based on the public cloud principle as it is the main concern with significant impacts to the whole economy not restricted only to different industries. Second, it is the private cloud. This type of cloud offers the computing services to a specific enterprise or a group of firms that share analogous interests or require high security as the computing servers are not shared with others. The last type of cloud computing is the combination of the first two types. Hence, it is called hybrid cloud. The provision under the hybrid cloud includes some part for general purposes under utility computing and some dedicated servers under private agreement.

3.1. Categories of Service Delivery

As mentioned earlier, the cloud computing can be delivered under different modes of service via web interface. For the ease of simplicity and understanding, three obvious categories of cloud service delivery are elaborated (Rimal et al., 2010). Note that all the services are consumed real time over the Internet and most examples are public cloud providers.

First, Software as a Service (SaaS) is the most common form of the cloud service delivery. SaaS is based on the concept of multitenancy where a single instance of software can serve different clients simultaneously. The end-users often experience the SaaS provision through applications of online contents such as Google Applications, Facebook, and Sales Cloud by SalesForce.com.

Second, Platform as a Service (PaaS) evolves as support for the developer in the sense that it eliminates the burden of generating and maintaining infrastructure in on-premise systems, and shortens the development time with a great number of real-time available tools and services with scaling capability. Indeed, this mode of service provides an online platform of complete cycle for web application developers to develop, test, deploy and deliver their applications through hosting services. Examples of PaaS include GoogleAppEngine, Microsoft Azure, and Heroku.com.

Third, Infrastructure as a Service (IaaS) on the other hand provides computer infrastructure as a service in which customers can access online via web interface. IaaS users benefit from a great deal of flexibility in data storage and its payment based on the pay-as-you-go concept. With the advantage of latest technology, the customers can achieve

fast services and time to market of their products. Another advantage is that the storage capacity under IaaS is also scalable according to usage demand. Some examples are SmartDataCenter by Joyent, Amazon Elastic Compute Cloud (EC2), and GoGrid.

3.2. Cloud Computing in Practice

Some general concepts of cloud computing have been elaborated earlier, it is worth to witness how the cloud can be utilised in reality. For the reference point of view, the cloud computing combines both XaaS, where X stands for software, platform, infrastructure, or any other kinds of service emerging in the future, and utility computing. Therefore, it may or may not include the private cloud. The utilisation of cloud computing can not be conveyed separately. In fact, three parties are involved.

First, it is the preliminary unit that can facilitate the development of cloud computing. The cloud provider accumulates necessary hardware and computing infrastructure in order to provide computing power according to usage-based pricing. One of the prominent examples is Amazon whose computing facilities are commercialised through Amazon Web Services (AWS).

Second, it is the cloud user or XaaS provider that actively develops and provides novel applications with the remunerable endorsement of infrastructure and tools provisioning by the cloud provider. Obvious instances include those web content providers such as Facebook (SaaS), eyeOS (PaaS), or Amazon EC2 and Simple Storage Service (S3) (IaaS).

Third, it is the XaaS user who consumes any kind of service delivered mostly through web interfaces. The XaaS user can be anyone ranging from individual web surfers, private enterprises to government entities. Remarkably, the cloud user can also be the XaaS user as well. This happens when the cloud user develops any kind of XaaS using compatible application programming interfaces (APIs) and delivers it via a mashup that integrates the service from other XaaS providers. An example may be an online navigation service provider who integrates its maps and locations to be displayed in Google Maps.

Figure 1 Cloud Computing Utilisation Process

Source: Images from websites[3]

[3] For the sources of the images, see http://farm3.static.flickr.com/2369/2084311380_0906fd827d_o.jpg, http://www.pgntech.com/Stock%20Images/bigstockphoto_Web_Computer_436712.jpg, and http://deepthoughtsofatwentysomething.files.wordpress.com/2011/02/internet.jpg

The relationship is apparent as shown in Figure 1 that in the cloud computing model, the online service providers (cloud users) can utilise the computing facilities of the cloud provider with full control of the system in addition to the simplicity in software installation with no maintenance burden under utility computing or pay-per-use basis. New applications can be developed, stored, and deployed easily. Through the web applications, the end-users can realise the benefits of information sharing, comprehensive APIs, and data storage for SaaS, PaaS, and IaaS, respectively.

An example case is that MTV, which is one of the world's famous entertainment broadcasting networks with several channels of its own, uses video encoding services from Enconding.com in order to cope with tremendous incoming videos sent from around the world in different formats. The videos are then transferred to Encoding.com cloud service and being processed resulting in 6 MTV-compatible files in every 10 seconds. All the completed files are automatically delivered to MTV streaming service for its audience (Encoding.com, 2011). Encoding.com then rely on Amazon Web Services such as Elastic Compute Cloud (EC2) and Simple Storage Service (S3) (AWS, 2011). The financial flow starts at MTV (SaaS User) when it pays for the video encoding service, according to minute of use, from Encoding.com (SaaS Provider/Cloud User), which then pays for the computation and storage services from Amazon (Cloud Provider). One can see that the cloud user and end-users do not need to purchase the necessary infrastructure and worry about the maintenance-related expenses, while they need to spend only some money on the services provided online.

4. Cloud Economics

Apart from the fact that there are several benefits from the adoption of the cloud computing model pointed out by Armbrust et al. (2010) and Talukder et al. (2010), it can be derived that the most important one for an industry is the cost reduction. Obviously, this benefits small firms at initial stages or large firms associating with new IT-related projects. There are several aspects to cover.

First, according to the fact that the cloud services are usage based or pay-as-you-go pricing, both small and large enterprises can initially adjust the usage and cost of their IT-related businesses in an efficient way. This idea is similar to the pricing of public utility such as water, electricity, and gas in which the user only pays for the usage and there is no need for investment in the infrastructure or specific equipment, which may account for a lot of money. Most of the time, the cloud services may be utilised at a lower rate in the beginning and at either higher or lower rate according to the demand. This happens when the business has become standardised or the cloud services have been widely accepted for more business activities and become highly reliable. Therefore, the firm going into the cloud can experience the cost reduction at the beginning and the flexibility of cost management at a later time in its IT-related activities.

Second, the preceding usage-based pricing feature of the cloud computing model gives rise to the conversion of capital expenditure (CapEx) to operational expenditure (OpEx). Indeed, small enterprises with limited investment ability can save a lot of money in the fixed investment of ICT capital such as computing machine by utilising the cloud services and managing the flexible OpEx. Only a few computers with high-speed Internet connection are sufficient to experience the cloud benefit. For example, the firm can use the cloud computing service to accomplish a task taking 10 hours and 5 VMs today and no usage afterwards.[4] The payment to the cloud service provider is calculated from only the 10-hour usage and collected only once until the next usage is generated. The company pays only the usage cost without having to purchase the required potential computers equivalent to 5 VMs and let them go idle after the task is done. Therefore, the company can efficiently manage its OpEx rather than has to stick with the high level of inefficient fixed investment of CapEx.

Third, the cost reduction comes from the elimination of high costs of hardware investment and software licence fee as well as computer service-related burden such as upgrade and maintenance. Under the cloud computing model, the cloud service provider is the one who is responsible for such the burden to ensure customers reliability and stability of the developing computing facilities. The company can witness this direct benefit immediately after the adoption of the cloud computing. In fact, it can direct the investment to the all-in-one computing usage without concerns over issues such as hardware and software associated costs and systems maintenance. A higher number of VMs on the cloud is charged according to the usage without other financial and service-related burdens such as purchases of on-premise computers and the required software such as operating systems, office software, and security packages along with the update. All the economic benefits of the cloud computing are summarised in Figure 2.

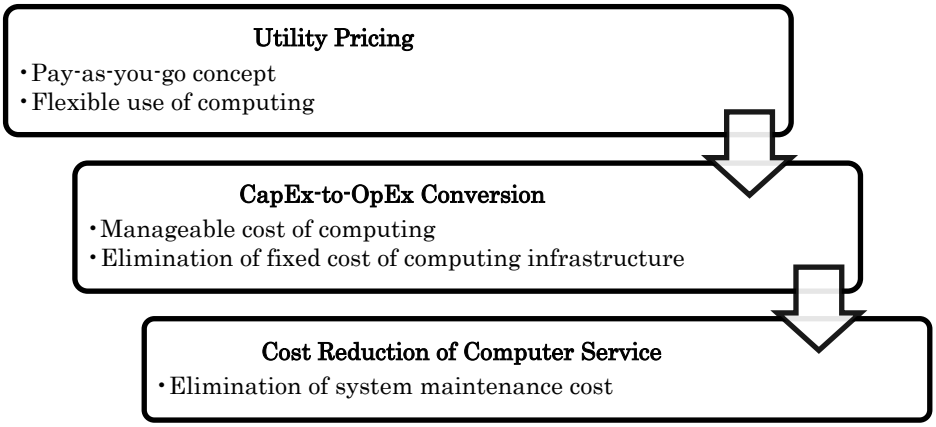

Figure 2 Cloud Adopter Cost Advantage

A good example case where the cost reduction is experienced is the decision to go

[4] For discussions about virtual machines (VMs), refer to Jin et al. (2010)

into the cloud by New York Times senior software engineer Derek Gottfrid. His project, TimesMachine, previously succeeded in converting TIFF images to PDF and made them available for the articles from 1851 to present. However, as the volume grew vastly, the internal facilities were not sufficient. Besides, it is more convenient and efficient to have pre-generated PDF files rather than convert them from the image files. Hence, he decided to use Amazon's Elastic Compute Cloud (EC2) and Simple Storage Service (S3) to handle the task. With the parallel computing ability, the company could handle 4 Terabyte of data in a short time. The whole process of uploading the files to S3, reading and converting them in EC2, and storing them back to S3 could be accomplished in 36 hours (Gottfrid, 2007). The company can save a lot of money from using the cloud service. It can eliminate the high fixed capital investment and engage in low and adjustable operational expenses, which are likely to occur randomly. There is no additional investment in the hardware and software because only the usage is charged. The company can also bypass the maintenance problems and continue with its core business activity.

5. Cloud Computing in Thailand

Although the cloud computing has gained its popularity and extensive utilisation in the western world, it is still under the preliminary stage of development and deployment in Thailand. Even so, there is a good sign that the new model of computing is being considered for adoption and utilisation in both of the public and private sector in the country as of the realised benefits in other countries.

5.1. Cloud Computing in the Public Sector

The Thai government has realised the burden of the people in the public health care service in the sense of information collection and storage. Indeed, it is hard to transfer patients' data from one health care entity to another because of incompatible systems. Each of the entity collects data independently of one another using its own methods and software stack. Most of the data collection and storage activities are done within the health care unit. It is rarely possible that relevant data of a patient can be transferred from one hospital to another even for better diagnostic services because of the technical problem of compatibility.

Ministry of Science and Technology hosted an event in which the Prime Minister was a chairperson in January, 2011 in order to handle such the problem by developing and facilitating the standardisation of the transfer and exchange of health-related information. The Memorandum of Understanding (MOU) was signed by all parties involved in the issue, namely Ministry of Science and Technology, Ministry of ICT, Ministry of Public Health, Ministry of Industry, and Ministry of Education. One of the projects is to develop a cloud computing infrastructure and its compatible software instances in order to create efficient data transfer among various entities. The project is still in progress handled by research groups from Ministry of Public Health and National Electronics and Computer

Technology Center (NECTEC), which is a subsidiary of the Ministry of Science and Technology. They named the project "Smart Health." At the moment, the study is being conducted on preliminary issues such as process and tools to convert and verify the data as well as security requirement of sensitive information (NECTEC, 2011).

5.2. Cloud Computing in the Private Sector

For the time being, only a few companies in Thailand are using the cloud computing because the model is still new to the country and in the preliminary phase where a lot of tests are required to ensure reliability of the system. This is due to little knowledge about the cloud and lack of comprehensive software, or applications. Moreover, there are only a few domestic cloud providers. Hence, it is the stage of provision of information and testimonials of the cloud at the moment. Many companies have a positive view toward the cloud computing model and are willing to adopt it for their business. With this issue, a major domestic cloud provider, True IDC, was established in 2004. For many years, it had realised that its potential customers were still short of software development knowledge for the cloud. Therefore, it collaborated with Software Park, which is a public organisation responsible for the development of software experts, in order to host seminars providing cloud computing knowledge and compatible software development. The collaboration project ran from March to December, 2010 at Software Park facilities in which the cloud computing experts and systems were provided by True IDC. In the seminar, software developers from both large and small companies got to know about relevant information of the cloud computing model and how it could be used for business purposes in practice. After that, in order to ensure compatibility, application development processes were performed on True IDC platform. The company provided free usage of its VMs for software development and data storage to every participant of the project (Bangkokbiznews, 2010).

As a result, the number of companies that can utilise their IT infrastructure by going into the cloud increases. In addition, True IDC also provides more services to meet customers' demand for IT solution. The cloud provider claims that it continues to grow with reliable cloud services because of its dependable IT infrastructure and international partner, which is DACOM from South Korea. Most of the clients of True IDC at the moment consist of domestic low-cost airlines and online gaming companies. The services being offered are co-location, dedicated servers, web hosting, and some value added services such as storage back-up and security firewall.[5]

6. Data and Methodology

From the previous information about the cloud computing, it is true that this model can create a lot of economic benefits. Private enterprises receive a great deal of benefit from the cloud computing adoption as portrayed in papers by Armbrust et al.

[5] For more information about True IDC, see http://www.trueidc.co.th/

(2010) and Talukder et al. (2010). The most attractive incentive is a great deal of reduction in firm's ICT spending. Theoretically speaking, the cloud computing is also believed to generate significant impacts on the economy as it leads to improvement of the country's macroeconomic factors (Etro, 2009). Therefore, the cloud computing is said to have an influence on not only business, but also macroeconomic development of the country.

An assumption for further analyses is that different firms will find ways to minimise costs. According to the fact that the cloud computing is still in the preliminary stage of development in Thailand, there is no direct quantitative measurement for it. However, the cloud computing adoption can be hypothetically measured in terms of potential adoption with respect to variation in the cost of ICT services.

6.1. Data

The dependent variable or the proxy for the cloud adoption is measured as a ratio of computer service spending to total ICT spending. Any industry that has the value more than the average value of all industries is presumably considered a cloud adopter. Indeed, this ratio measures the perception of the cost of computer services, which include system upgrade, maintenance, and protection against data security threat, for a particular industry. When the value is higher than the average, that industry perceives its computer service spending to be high; therefore, is willing to accept any new approach to lower such cost. As explained earlier, the cloud computing model can provide the benefit of cost reduction of the computer services; hence, the industry with a high value of the ratio can be considered a potential cloud adopter. Since this is an indirect measurement of the cloud computing adoption, the dependent variable is called hypothetical cloud adoption (HCA) whose derivation is depicted in Figure 3.

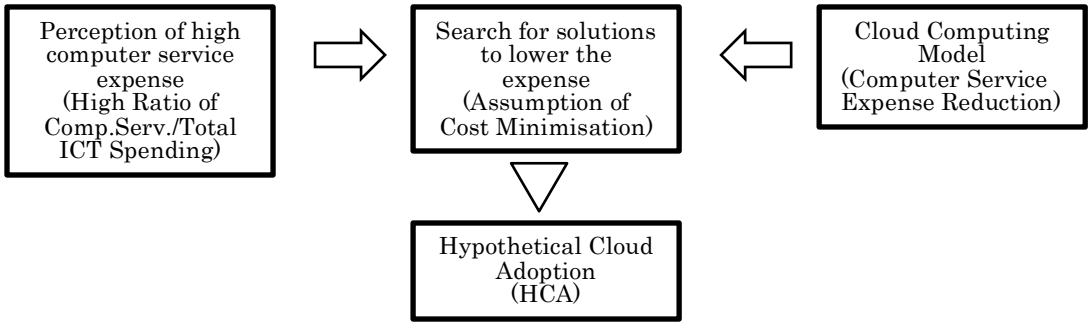

Figure 3 Formulation of the Dependent Variable (HCA)

The calculation can be divided into two stages. First, a share of computer service spending in total ICT spending for each industry is computed. Then the average of the computed ratios is calculated. Again, industries that experience a higher value than the average are the potential cloud adopters because they want to reduce the computer service spending, which is made possible by using the cloud computing model.

There are totally 820,137 establishments categorised by nature of business into

206 industries. All survey results are obtained from the National Statistical Office (NSO). The year of study is 2007. The sample group consists of different entities from all parts of Thailand.

The interested industry-specific factors can be categorised into five different attributes. They are general factors, Internet and technology, web site usage, cost factors, and difficulties in ICT usage. All four attributes are measured in terms of number of establishments, while the cost factors are measured as amount of actual spending in domestic currency (Thai Baht). The last attribute is to be remarked that one establishment is allowed to choose more than one difficulty option in the survey. Within each attribute, there are sub-attributes, which then make 32 explanatory variables in total.

All the variables and their abbreviations are shown in Table 1 below. Each variable represents a specific attribute of one industry. One industry is a combination of many establishments of similar nature.

Table 1 Summary of Variables

Variable	Description	Mean	Std. Dev.
Dependent Variable			
HCA	=1 if the industry is a potential cloud adopter; =0 otherwise		
General Factors			
GF1	Number of Establishments	3 981	12 717
GF2	Number of Employees	20 447	41 227
Internet and Technology Factors			
IT1	Number of Establishments with Internet Usage	516	1 217
IT2	Number of Employees using Internet	3 017	8 628
IT3	Number of Establishments using Dial-up Connection	295	733
IT4	Number of Establishments using ISDN	27	94
IT5	Number of Establishments using xDSL (ADSL, SDSL)	205	496
IT6	Number of Establishments using Cable Modem	15	45
IT7	Number of Establishments using Leased Line	26	104
IT8	Number of Establishments using Wireless Connection	8	34
Web site Usage Factors			
WS1	Number of Establishments using Web site	176	431
WS2	Number of Establishments using their own web site	148	359
WS3	Number of Establishments using other web portals	29	87
Cost Factors			
CF1	Total ICT Spending	82 041 414	158 365 997
CF2	Computer Hardware Spending	18 165 504	51 732 997

CF3	Computer Software Spending	9 169 951	23 931 159
CF4	Communication Service Spending	45 470 158	96 313 924
Perception of Difficulties in ICT Usage			
DT1	Number of Establishments perceiving technology changes too fast	542	335
DT2	Number of Establishments perceiving labour lack of ICT skills	426	333
DT3	Number of Establishments perceiving difficulty in finding qualified staffs	365	290
DT4	Number of Establishments perceiving high cost of Internet connection	355	308
DT5	Number of Establishments perceiving technology too complicated	348	296
DT6	Number of Establishments perceiving security concerns	523	459
DT7	Number of Establishments perceiving slow/unreliable data communication	408	405
DT8	Number of Establishments perceiving lost of working time due to irrelevant surfing	283	314
DT9	Number of Establishments perceiving goods/services not suitable for online sales	132	168
DT10	Number of Establishments perceiving customers not ready for e-commerce	137	152
DT11	Number of Establishments perceiving web site maintenance cost too high	165	197
DT12	Number of Establishments perceiving e-commerce development cost too high	162	186
DT13	Number of Establishments perceiving difficulty in e-payment	142	200
DT14	Number of Establishments perceiving uncertainty in contracts/delivery/warranty	128	191
DT15	Number of Establishments perceiving logistic problems	100	142

Apart from the definition and explanation of variables, it is also interesting to provide some descriptive analyses on the cloud computing adoption in different groups of industries. For simplicity, all industries are categorised into four groups according to their general nature, which are manufacturing, construction, business trade, and service. Note that the business trade group does not include financial and banking industries as they are included in the service group.

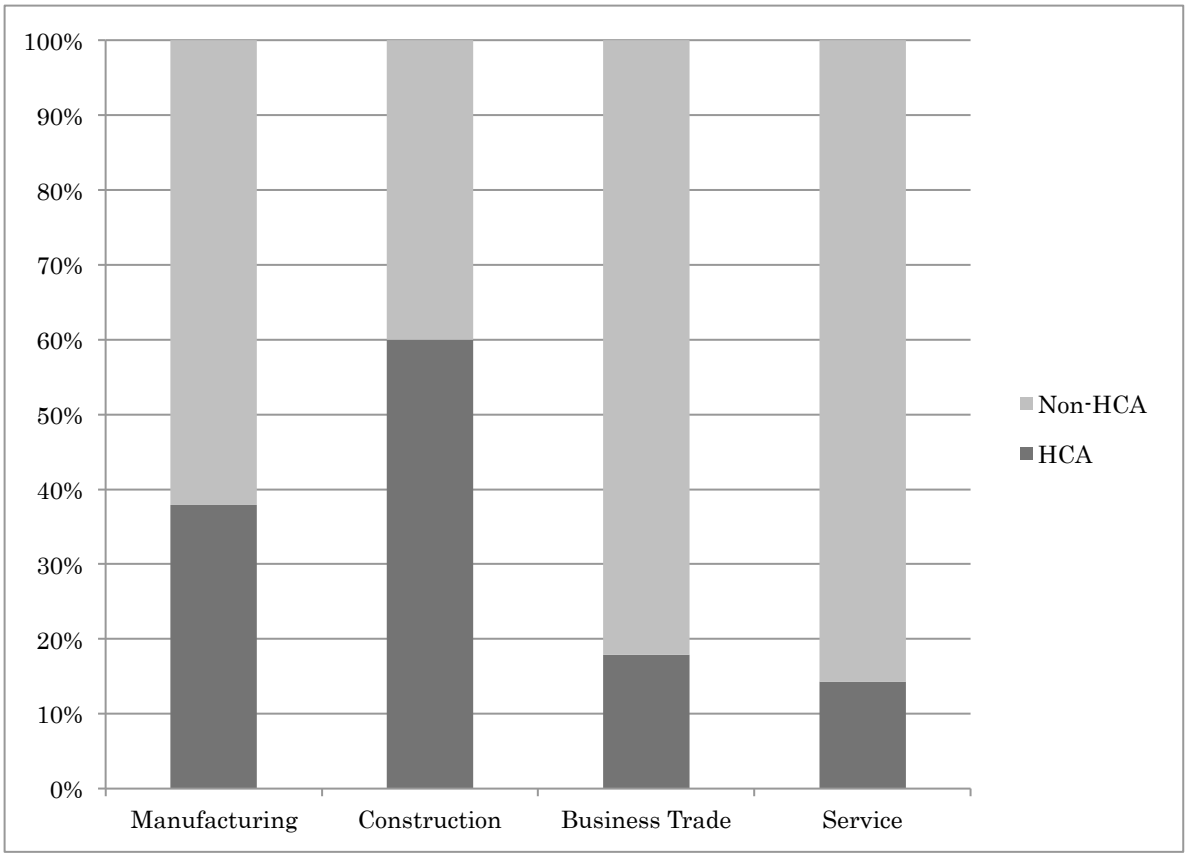

Figure 4 Percentage of Cloud Computing Adoption in Different Groups of Industries

Source: The Author

Figure 4 shows that the cloud computing adoption is considered high in construction and manufacturing group while it is still low in business trade and service group. Indeed, the cloud computing model is adopted by almost 60 and 40 percent of industries in the construction and manufacturing group, respectively. On the other hand, around 10 – 20 percent of industries in the business trade and service group are potentially choosing the cloud.

6.2. Methodology

According to the fact that this study attempts to analyse survey data, a discrete choice model is considered feasible. In order to handle randomness and non-normality of the collected data, the binary logit model is employed for reliable outcomes. The estimating logistic equation is as follow:

$$HCA_i = \alpha_0 + \sum_{n=1}^{2} \beta_n GF_{n,i} + \sum_{n=1}^{8} \gamma_n IT_{n,i} + \sum_{n=1}^{3} \delta_n WS_{n,i} + \sum_{n=1}^{4} \tau_n CF_{n,i} + \sum_{n=1}^{15} \phi_n DT_{n,i} + \varepsilon_i \qquad (1)$$

where HCA is the binary dependent variable. There are five attributes with the sub-attributes according to the number represented by *n*. The model is estimated with respect to different industries, *i*, which has the total value of 206. The estimation approach for equation (1) is based on maximum likelihood (Gujarati & Porter, 2009).

Equation (1) is estimated in order to explain the influence from each attribute on the probability of an industry adopting the cloud computing model.

7. Results and Discussions

An overview of the estimation results starts from the value of R^2. This figure then supports the explanatory power of the model up to about 40 percent. For the simplicity in interpretation, marginal effects, rather than coefficients, are presented along with other necessary statistics in Table 2. Therefore, further discussions of the relationship between the explanatory and dependent variable should be construed as a change in probability of cloud computing adoption resulting from a change in each of the attributes with the magnitude equal to the corresponding value of marginal effect.

Table 2 Results of Logistic Estimation

Variable	Marginal Effect	Std. Err.	Z-Stat.
General Factors			
GF1	-0.0001	0.0001	-1.3800
GF2	4.69E-06	2.93E-06	1.6000
Internet and Technology Factors			
IT1	-0.0004	0.0013	-0.3100
IT2*	3.87E-05	2.10E-05	1.8400
IT3	0.0017	0.0014	1.1900
IT4*	-0.0079	0.0046	-1.7100
IT5	-0.0004	0.0016	-0.2600
IT6	-0.0047	0.0037	-1.2700
IT7*	0.0050	0.0028	1.7700
IT8	-0.0054	0.0052	-1.0300
Web site Usage Factors			
WS1	0.0130	0.0316	0.4100
WS2	-0.0131	0.0318	-0.4100
WS3	-0.0150	0.0321	-0.4700
Cost Factors			
CF1***	1.03E-07	2.19E-08	4.7000
CF2***	-1.21E-07	2.51E-08	-4.8300
CF3***	-1.13E-07	2.56E-08	-4.4100
CF4***	-1.17E-07	2.50E-08	-4.6800
Perception of Difficulties in ICT Usage			
DT1	-0.0034	0.0043	-0.7800
DT2	-0.0032	0.0058	-0.5400
DT3	0.0076	0.0047	1.6200

DT4**	-0.0137	0.0060	-2.2700
DT5**	0.0111	0.0051	2.1900
DT6	0.0045	0.0049	0.9200
DT7	-0.0104	0.0071	-1.4800
DT8	0.0037	0.0053	0.6900
DT9	-0.0061	0.0136	-0.4500
DT10	-0.0070	0.0107	-0.6500
DT11	0.0005	0.0134	0.0400
DT12	0.0009	0.0147	0.0600
DT13	-0.0058	0.0138	-0.4200
DT14	-0.0017	0.0147	-0.1100
DT15	0.0328	0.0210	1.5600
Number of observation		206	
LR chi2(32)		110.5	
Prob > chi2		0.0000	
Log likelihood		-70.7574	
Pseudo R^2		0.4385	

Note: *, **, and *** represent significant level of 10, 5, and 1 percent, respectively.

7.1. General Factors

It is obvious that both GF1 and GF2 are not statistically significant. This means that neither the number of establishments nor employees has any impact on the adoption of the cloud computing in sample industries. Therefore, it can be construed that the size of industry does not matter in the decision to adopt the cloud computing model. Even though it has been stated that the benefit of cost reduction is realised especially in SMEs (Etro, 2009), industries in Thailand, regardless of size, may have similar interests in going into the cloud.

7.2. Internet and Technology Factors

An interesting result to point out here is the significance of IT2. Indeed, this shows that the important driving force for an industry to adopt the cloud computing is the number of employees using the Internet, rather than establishments using the Internet (IT1). With 90 percent confidence level, an industry with a higher number of employees using the Internet has a higher probability of cloud computing adoption. This emphasises the fact that the cloud computing model is based on Internet interfaces and human resource with Internet literacy is considered necessary to facilitate the usage of the cloud computing applications in a particular industry.

For the technology aspect, one can see that statistically speaking, there are two significant variables, which are IT4 and IT7. The former one has a negative sign meaning that it has a negative impact on the cloud computing adoption, while the latter one can be

interpreted in an opposite way as of its positive sign. Again, with 90 percent confidence level, an industry with a higher number of establishments using ISDN (IT4) experiences a lower probability of cloud computing adoption, but that with a higher number of establishments using leased line (IT7) has a higher probability to adopt the cloud computing model. In other words, one more firm using ISDN lowers the probability of cloud computing adoption by about 0.8 percent, while the same increase with leased line technology results in 0.5 percent increase in the adoption probability for the industry. The discussion here is that even though cloud computing activities do not require in-house sophisticated computing resources, they require a reliable high-speed Internet connection in order to avoid data bottleneck problem (Armbrust, et al., 2010). For that issue, the ISDN does not satisfy the efficient usage of the cloud computing in terms of speed and reliability as compared to the leased line connection. Hence, it results as a hindrance to the adoption of the cloud computing.

7.3. Web site Usage Factors

None of the web site variables are statistically significant. Thus, whether or not an industry has a number of web site users is not relevant to the decision to use cloud services. Even though the users (XaaS User) can manage the computing process via web interfaces, it is not necessary that business users needs to use web sites frequently, or have their own web site. The web interface of the cloud services is simplified with extensive user-friendly environment. It is an outcome-oriented, rather than process-oriented system. The users do not have to concern how the computing activity is done, nor do they have to consider maintenance burden. This feature of the cloud services is different from the existing web sites. Therefore, one can witness irrelevance of number of firms using web sites, either own or hosting, in the adoption of the cloud computing for a particular industry.

7.4. Cost Factors

All variables here have the highest level of statistical significance, which is 99 percent confidence level. The total ICT spending (CF1) is positively related to the probability of cloud computing adoption, while hardware (CF2) and software spending (CF3) as well as communication service spending (CF4) result in negative impact.

In general, it is widely accepted that the cloud computing model is cost-saving in the sense that it can help an industry to bypass a huge amount of capital expenditure in computing infrastructure to a small amount of variable costs according to each computing task (Talukder, et al., 2010). Thus, an increase in the total ICT expense makes the cloud computing adoption more attractive to the industry provided that one of its important goals is cost reduction. This results in a higher probability of adoption of the cloud services following the increased ICT expense. Nevertheless, for specific aspects of the cost

structure, the negative relationship between the probability of cloud computing adoption and computer hardware and software expenses may be explained by the fact that in the short-run fixed investment in computing resources and software licences cannot be foregone due to usage contracts and agreements. The last explanation for another specific sub-attribute is quite straightforward that the probability of cloud computing adoption is lower as a result of an increase in communication service expenses because it incurs a higher cost to the usage of cloud computing. Indeed, when the cost of necessary Internet connection is considered high, the adoption of the cloud services is detrimental. This is a common situation; hence, hiders the diffusion of cloud computing model in a developing country whose network infrastructure for Internet connectivity is underdeveloped and unreliable in general.

7.5. Perception of Difficulties in ICT Usage

For the difficulties in ICT usage, statistically speaking, there are two significant variables. With 95 percent confidence level, an increase in the number of establishments expressing high cost of Internet connection (DT4) leads to a fall of around 1.4 percent in the probability of cloud computing adoption. However, an increase in the number of establishments perceiving technology too complicated (DT5) results in a rise of 1.1 percent in the probability of the adoption.

The discussion here is redundantly straightforward. First, similar to the cost attributes, when a number of establishments perceive that the cost of Internet connection is high, the probability of adopting the cloud computing model for the whole industry is lower. Again, a reliable Internet connection is essential for the cloud computing, and such the connection is often exclusively priced. Second, it is an interesting discussion about the complexity of the technology that drives an industry towards the cloud. This can be explained by a special feature of the cloud computing model that makes computation simple because it is service-based and task-oriented of which all the necessities in computing processes are being taken care by the cloud or XaaS provider (Gartner, 2009). Hence, when an industry considers existing technology too complicated, it has a high tendency to adopt the cloud computing model for simplicity in computation apart from the cost benefit.

There are other interesting results worth a discussion even though they are not statistically relevant. First, the number of establishments expressing a concern on the difficulty of finding qualified personnel (DT3) is a driver for the industry to adopt the cloud computing model. This can be considered supportive to the simplicity and readily-operational feature of the cloud computing as mentioned before. Even though qualified staffs are hard to recruit, the industry is better off adopting the cloud since it can be utilised by people from various backgrounds. Second, security concerns (DT6) are not important in the adoption of the cloud computing model for the sample industries. This

contrasts with a proposition of Kshetri (2011). The reason may include the fact that the cloud computing concept is still new in this country and most industries put higher weights on cost and technology factors as seen in previous findings. Third, the perception of low and unreliable data connection (DT7) is considered an obstacle to the cloud computing adoption. Once again, this emphasises the concern on data connectivity as it is vital in the cloud world; hence, it confirms the previous results.

8. Policy Implications

There are certain policy implications derived from the results of the study that the cloud computing adoption is associated with three main factors for a particular industry. These are cost reduction, simplicity of use, Internet-literate labour and reliable Internet connection. The policy implications in this section are encouraged for both industry and government as they are important players in the promotion of cloud computing adoption in a country.

First, each industry, industry leaders, unions, or authority may attempt to improve the rate of cloud computing adoption by providing trainings and knowledge of how to utilise Internet interfaces to their workforce. Such the trainings may include seminars and discussions of the Internet as well as the cloud services, which are built and able to simply operate over online interfaces. This will increase the Internet literacy rate for employees and prepare them for the approaching cloud computing adoption. Apart from that, the industry and involved parties in the private sector may consider to equip their enterprise with reliable high-speed Internet connection in order to be able to go into the cloud world at a faster pace.

Since the concern is raised at developing countries on which the role of government is almighty as market mechanism cannot solely be relied, the policy recommendations require more effort, even though they are involved in a lot of public investment, the effect is believed to be long-lasting resulting in sustainability in the country's telecommunications development. To begin, the government and public authority such as National Regulatory Agency (NRA) may provide some cost incentives to enhance the cloud computing adoption. Such the incentives include tax reduction on ICT capital, especially the usage costs such as enterprise leased-line connection, low-cost loans for initial set-up of cloud computing-related systems, and some concrete remedies on the existing fixed investment of ICT for a particular industry. The last incentive is mentioned because the current fixed ICT capital, especially in hardware and software, is considered hindrance to the adoption of the cloud computing. Such the remedies may include procedures to transfer fixed ICT-related assets into freed-up capital ready for investment in the cloud computing systems, instead.

Moreover, the government may attempt to develop infrastructure for advanced Internet connection such as fibre and new generation networks (NGNs) in order to provide

fundamentals for the cloud services and prevent the problem of bottleneck. The main reason the government should be the main player in the infrastructure building, or at least be in charge of the process, is to ensure reasonably low costs. Indeed, industries will consider adopting the cloud computing if the cost of reliable Internet connection is low.

9. Conclusion

There are a number of benefits occurred from cloud computing as seen in the western world. One of the greatest benefits emphasised here is the cost reduction in fixed ICT investment and services. This study tries to find the determining factors for the cloud computing adoption by using a discrete choice model. The developing country selected as ground for investigation is Thailand in which the cloud computing model is still in its initial stage, but has received attention from both public and private sector.

The cloud computing has received a lot of attentions from government and private enterprises in Thailand. Preliminary, the government is trying to promote cloud computing utilisation in the health care sector in which health-related information will be stored and transferred more efficiently on compatible cloud system. The project Smart Health has already started under collaboration of five ministries. In the private sector, True IDC is a very active in the promotion of cloud computing adoption in the country. The company has been organising a lot of seminars in order to educate IT personnel in all kinds of business about the cloud computing and its benefits. At the moment, there are some users of the cloud services in which most of them are low-cost airlines and online gaming companies.

The proxy for the cloud computing adoption is the ratio of computer service spending for a particular industry. If it is more than the average of all industries, then that industry is a potential cloud computing adoption provided that the cloud computing model can reduce the costs of computer service such as update, maintenance, and protection, and each industry seeks to minimise costs of operation.

The results show that determining factors for the adoption of the cloud computing include Internet and technology, costs, and some difficulties in ICT usage for an industry. For the first factor, Internet-literate employees as well as leased-line connection are drivers, while ISDN technology results in a negative impact in the cloud computing adoption. Second, higher costs of total ICT spending is a driving force towards the cloud, while that of hardware, software and communication service spending are hindrance of the adoption. Finally, the perception of high cost of Internet connection is considered an obstacle, while the complication of technology is the driver for an industry to go into the cloud.

Policy implications start from the private side that include human resource development with emphasis on Internet literacy to prepare an industry for the cloud world. Then the government or public authority may initiate low-cost infrastructure

development for high-speed reliable Internet connection as well as provide relevant incentives such as tax reduction and low-cost loans for the set-up of cloud computing.

Further research may be conducted after the cloud computing has already been widely used in different enterprises in the country in order to witness the actual impact of the cloud computing adoption by using a more appropriate proxy. Comparative studies can be done regarding the case of Thailand and some other countries.

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