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Cloud computing and prospective business and economic impacts in developing country: A case study of Thailand

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TITLE:

**Cloud Computing and Prospective Business and Economic Impacts in Developing
Country: A Case Study of Thailand**

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 along with its economic benefits. The author proposes that there is an endogenous relationship between the cloud computing and each of the business and economic variables, namely output, employment, and labour productivity. In order to forecast the impacts of the cloud computing adoption, the Vector Autoregressive (VAR) model is constructed. Thailand is selected as ground for investigation. Apart from the bi-directional causality, the results also show prospective positive impacts of the cloud computing adoption on the growth of output, employment, and labour productivity. Despite the macroeconomic benefits, some policy implications include the encouragement of the cloud computing adoption in universities and banks in order to realise the benefit of scalability and efficient usage of computing resources.

JEL CODES: E37, L86, O53.

KEYWORDS: Cloud computing, Macroeconomic indicators, Forecast, Thailand

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I. Introduction

For the time being, one cannot deny the fact that the online world has become more accessible through widespread of Internet connection. Higher bandwidth speed and size are a necessity. Many contents have been developed with different platform compatibility. Businesses that are inevitably and extensively utilising the ICT need to maintain their competitive advantages. Therefore, they require cost-efficient resource utilisation in the computing systems.

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. 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.

This paper provides basic knowledge of the cloud computing and some examples of the existing cloud services providers. Descriptive economic analyses are presented to show benefits of the cloud. The objective of this study is to gather all the information regarding the cloud computing and forecast the possible economic benefits of the cloud utilisation in a developing country and firms in which Thailand is selected as a case study. The vector autoregressive (VAR) model is used to estimate the relationship and forecast the future benefits in terms of output, labour productivity, and employment.

The structure of the paper is as follows. Part II 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 III shows the general, but necessary knowledge of cloud computing including the definitions and processes. Part IV incorporates the economic analyses of the adoption of cloud computing services. Part V describes the information regarding the cloud computing in Thailand. Part VI consists of hypotheses to be tested. Part VII explains the data and methodology of the VAR modelling. Part VIII shows the results and explanations. Part IX elaborates potential of cloud computing utilisation in Thailand along with several policy implications. Finally, the conclusion is provided in Part X.

II. 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. 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.

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

¹ For more information, see Jin et al. 2010, p. 13.

² For more information about grid computing, see Foster et al. 2009

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.

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.

III. Cloud Computing Overview

In general, the term cloud computing is often referred to as the utilisation of computing power from a set of pooled computing resources via the Internet interface. 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). 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 the ICT industry. 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.

a. 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 the public cloud provider.

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.

b. 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 websites³

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. 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.

IV. Cloud Economics

There are several benefits of the adoption of cloud computing model. Some of them have been briefly discussed earlier. This section categorises the economic impacts and benefits of the cloud computing then elaborates them in detail. The impacts of the cloud can be seen directly in microeconomic level, while they are leading to the macroeconomic level, eventually. Most of the benefits are believed to contribute to small and medium enterprises, while large companies may witness some benefits from the cloud. With the impacts in the industry level, the country's production sector is subject to substantial changes as the cloud computing model has been commonly adopted.

a. Impacts on ICT Spending

According to the fact that cloud computing is associated with online service utilisation

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://deephoughtsofatwentysomething.files.wordpress.com/2011/02/internet.jpg>

rather than offline task achievement, the client can access through the online portal and manage VMs corresponding to business needs. The company adopting the cloud may witness some impacts on its ICT investment.

First, the company is likely to witness a fall in its ICT investment as a large reduction comes from the reduced spending in hardware and software. For the hardware, the cloud computing model allows the company to utilise VMs, which are considered similar to on-premise machine. Instead of purchasing a lot of computers, only a few, or even one machine is sufficient for parallel tasks as long as the Internet connection is available. For the software point of view, the company can save a lot of money from software licence fees because the cloud service or XaaS normally comes with pre-installed software that does not require extra charges apart from the usage fee.

Second, even though one may understand that the adoption of the cloud computing model leads to a possibility of lower ICT spending as of savings on hardware and software, sometimes the company often witnesses an increase in the ICT spending in the short run. This happens when the business is performing so well that there need to be a sharp increase in the number of computing VMs in order to cope with the rising demand during the peak period, which may last a day to a month. As more of the VMs are used, combining with the traffic and time spent on the computing activities, the usage charge increases. Hence, during temporary peak, the company is inevitably subject to an increase in the ICT spending.

In summary, the adoption of the cloud computing model can generate a decrease or increase of the company ICT spending because of the possibility of adjustment and flexibility of computing power utilisation. For a dynamic perspective, such the impact can vary in each period of time. Generally, an enterprise realises the benefit of a decline in hardware and software spending as a result of the cloud computing adoption. However, the firm usually cannot predict the demand for its business accurately and ends up facing increased ICT spending from the cloud usage in some temporary periods in which seasonal peaks occur.

b. Cost Reduction

One of the greatest benefits from the adoption of the cloud computing model 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. 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.

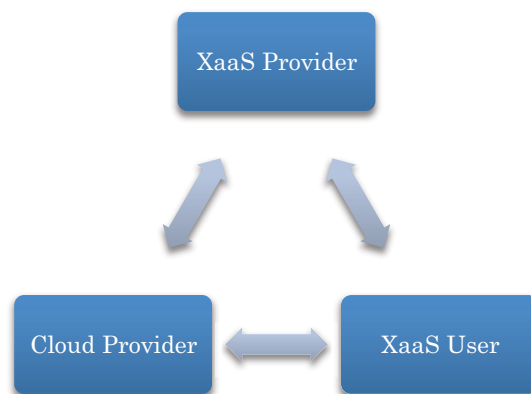
Third, the cost reduction comes from the elimination of high costs of hardware investment and software licence fee as well as burden of upgrade and maintenance of the system. Under the cloud computing model, the cloud service provider is the one who is responsible for such the burden to ensure customers 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, while a similar incident is concerned with the necessary purchase of on-premise computers and the required software such as operating systems, office software, and security packages along with the update.

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

c. Risk Sharing

Another economic benefit of the cloud computing model is its special feature of risk sharing. Indeed, nowadays the technology world evolves so fast that it is impossible for someone to catch up and specialise in all aspects of particular technology. The cloud computing model is the solution in which each of the parties involved are experts in their aspect of technology provisioning. Altogether, the whole chain of cloud services can be completed resulting in a variety of services to end-users. For example, the end-users do not have to worry about software update and maintenance because they can transfer this problem to the SaaS provider. In the same manner, the SaaS provider is not subject to the risk of providing sufficient computing power and server maintenance because it can transfer this problem to the cloud provider. The last party, the cloud provider, then can be certain about its huge investment in the server infrastructure that it will be utilised as long as the number of SaaS provider is sharply increasing. The risk of utilisation will be shared greatly by the SaaS provider and its services consumed by the end-users.

Figure 2 Risk Sharing in the Cloud



Source: The Author

Figure 2 shows a complete cycle of risk sharing in the cloud computing model. One can see that each of the parties involved shares a different kind of risk regarding its activities. Recall that the XaaS user can also be the XaaS provider by an aid of modern interactive technology such as mashups. This feature is called collaborative competency in which business activities are shared among different entities in order to achieve similar purposes (Parker, 2010). Under this model, all parties grow together through their shared activities and risk transfer even though one party may fall. In fact, when a particular party falls, it does not mean that the whole cycle will collapse. Due to the low cost and high availability of XaaS resulting from the cloud computing model, the level of competition in service provision is high. A new cycle can be formed and the cloud computing activities can be pursued. For example, a user of SaaS can always find another service provider that provides a similar, or even better software for his purposes if the contracting one should go out of business.

This feature of the cloud computing is considered beneficial to both small and large enterprises. The risk of data loss due to hardware or software instability is unlikely to occur in the cloud storage systems because of the distribution of data over a number of pooled servers. Companies using the IaaS for their data storage can leverage the risk of data loss resulting from the hardware or software failure to the cloud service provider. Indeed, this greatly benefits the small firm, which is poorly prepared for such the failure and disaster recovery. Besides, the large enterprise with a lot of data requiring reliable storage can allocate its excessive investment in internal data centres to usage-based cloud storage.

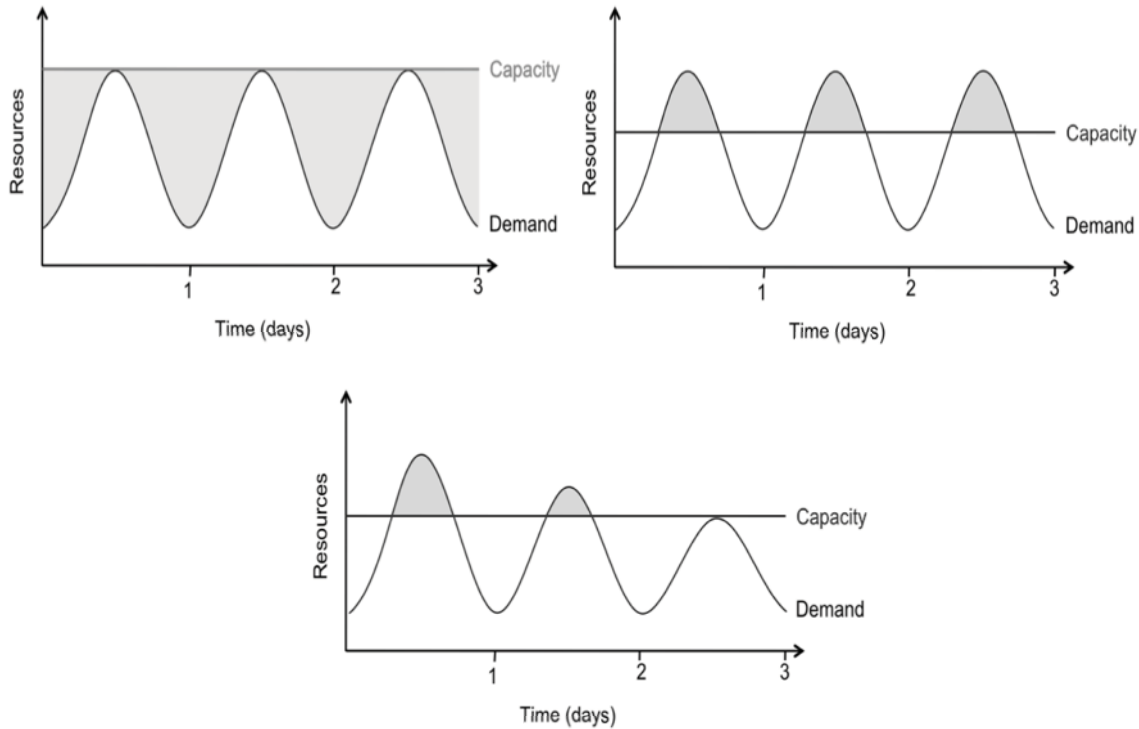
d. Demand Management

The cloud computing model is a very good approach to handle different kinds of demand for computing activities. Its special feature of scalability is the key. Along with the usage-based pricing, XaaS providers and end-users can obtain the benefit of load balancing and appropriate provisioning. The traditional method of business computation cannot follow the expanding online world and serve growing potential customers, while the cloud computing model can cope with such problems. There are two cases of demand that can lead to provisioning and utilisation problems with internal on-premise data centres. First, time-variant demand can lead to a serious problem of underutilisation of resources. This happens when the demand that the business faces varies with time. Usually, there are only a few peaks within particular period of time. For example, high demand may occur once a month or season. The traditional method is investment of data centres just to handle the seasonal demand. This approach works just fine, but the problems are the underutilisation of the computing facilities and waste of resources at non-peak time. Second, it is the case when the demand is unknown in advance. Unlike the previous case, the growing and falling demand is unknown and hard to predict. It depends greatly on the nature of the business and market competition. For example, during start-up periods, a business may be able to handle the demand for its products and services with the company's data centres, but as it has become popular, or nonprevalent, the demand sharply increases, or decreases. The existing on-premise data facilities cannot efficiently handle the volatile demand. Indeed, during the time where increased demand is witnessed, the company has to forgo some revenues from the unserved customers. Similarly, the company needs to sacrifice the cost of idle data facilities during the time of decreased demand. The use of traditional data centres generates a problem of underprovisioning where a company has to forgo the revenue from the increased demand. The situation can be worse if the rejected customers permanently turn away from the company due to bad experiences in poor service provisioning.

Figure 3 shows different demand situations occurred with traditional on-premise data centres. Case (A) is when underutilisation of computing resources occurs as a result of provisioning of excess capacity during the non-peak periods. Case (B) shows the situation when the demand is unknown and underprovisioning occurs during the periods of randomly increased demand. Consequently, some rejected customers are permanent loss to the business because they

will never return as shown in case (C). The last case of underprovisioning is severe because it can lead to the problem of underutilisation as the demand keeps falling.

Figure 3 Demand Situation



Source: Armbrust et al. (2010)

The cloud computing model is appropriate for demand management because the client can scale up or down according to the experienced demand without having to invest for data storage facilities. In fact, the only expense is the usage fees paid to the cloud provider in exchange for computing power, which vary along with the actual usage. During the peaks, companies can scale up the cloud usage by increasing the number of computing instances, VMs, and pay only the usage fees for the period. Under normal periods, the companies can shut down some of the excess, or idle VMs and adjust the computing facilities efficiently with the ordinary demand. Therefore, the problem of underutilisation for non-peak time disappears. In the same manner, for the case of unknown demand, the companies that are uncertain of future demand may opt in for automatic scaling, which ensures that they will always have sufficient computing capacity for the increased or decreased demand for their services. The problem of underprovisioning will not occur. No customers will be rejected and permanently lost.

Small and large enterprises can benefit from the cloud computing model in the sense that they both can manage their experienced demand accordingly. The small firms do not have to concern about their computing capacity for their seasonal or unknown future demand, while the large enterprises can utilise the scalability and parallel processing feature of the cloud in their one-time tasks, which require a lot of computing power for a specific task at a time. The previous

example of New York Times shows that the company's decision to use the cloud computing service helps facilitate the task by using multiple computing resources with parallel computation simultaneously.

An example company that can handle the seasonal demand with the cloud service is Major League Baseball (MLB) Advanced Media. The director of operation, Ryan Nelson, was faced with a new challenge to develop a chat service on the MLB website for the 2007 season. Due to the limited capacity of the existing data centre in Manhattan, he decided to use the cloud services by Joyent in which 30 VMs could be utilised. There were 10 VMs needed for the development cluster and 20 VMs for the chat service cluster. After 2 months of testing the process, the service was launched. It was right on time before the season started in September. Later on, the company could immediately add extra 15 VMs and corresponding RAM in order to handle the increasing seasonal demand when the games started. When the games ended, unnecessary VMs were shut down (Desmond, 2007). One can see that the ability to scale up is important to cope with seasonal demand. The cloud computing model also gives the benefit of scaling down when needed.

e. Efficient Resource Allocation

The last economic benefit of the cloud computing in this section is associated with the special feature of the cloud that is multitenancy. It is the case in which a single software instance provided on a server can be utilised by multiple clients. Many users of the cloud service can simultaneously access and manage their services any time and anywhere. In the multitenancy computing, there is no idle resource because the computing software is automatically allocated to different users, which are mostly business enterprises, in order to serve their purposes. This then generates a system of efficient computing resource allocation in the cloud world.

For example, office applications such as word processing, spreadsheet, and presentation can be designed and hosted in cloud servers in order to be ubiquitously provided through a web interface. The famous SaaS provider in this field is Google with its Google Docs service where users can access, create, and manage document files as well as download the finished files. With only one set of applications, different users can access simultaneously, or at a different time and realise similar benefits from the service. Due to the online provisioning feature, a client can access Google Docs applications at the same time as another client. When the task is done and one client disconnects from the service, there will be some other clients using the applications from somewhere in the world.

This feature is contrasted with the traditional way of software utilisation in which each client needs to install individual software stacks and uses them unconnectedly. Inefficiency can occur when there is no computing activity and the applications are idle, especially beyond working time of the company. Nevertheless, with the cloud computing, pre-installed applications on the servers can be accessed all the time depending on the Internet connectivity. Therefore, the multitenancy feature of the cloud computing model leads to efficiency in computing resource allocation.

V. 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.

a. 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).

b. 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.⁴

VI. Hypothetical Foundation

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. (2010) and Talukder et al. (2010). Theoretically speaking, the cloud computing is 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 both business and macroeconomic development of the country.

An assumption for further analyses is that the cloud computing adoption and other business or economic development indicators have a significant relationship, which can be either positive or negative. This is valid in the case of Thailand as well as in the studied group of countries in previous literature. The interested business and economic development indicators are labour productivity, output, and employment level, respectively. Even though all the variables have a relationship with the cloud computing, the direction of the relationship is not clear whether there is one-way dependency. Hence, there are hypotheses to be tested.

a. Hypothesis 1: Endogeneity of Cloud Computing and Output

The first hypothesis is that the cloud computing activity and level of output have a two-way relationship. First, the cloud computing adoption can lead to a higher level of output as of its benefits in terms of cost reduction as well as time saving. For example, a software company adopting the cloud computing can produce more of software and applications then deploy them in form of cloud services such as SaaS. With that, it can reach a lot of online customers regardless of

⁴ For more information about True IDC, see <http://www.trueidc.co.th/>

location. For a company whose core business is not related to IT such as those in manufacturing and trade industry, the cloud computing adoption can help reduce the IT cost, increase efficiency in the use of IT for support of main business, and reduce a lot of time for IT-related burden such as software and hardware set-up and maintenance. The company then can allocate more resources to the production of output for the main business resulting in a higher level of output after the adoption of cloud computing. Second, the relationship can be reversed in practice. It is the case when any company that has realised an increased level of output allocates more IT investment to the cloud computing as it believes in the efficiency and benefits of the model. Indeed, a large company producing a lot of output is considered successful in business to some extent. This kind of company has a lot of investment capability and higher level of failure tolerance. The company tends to invest more in the cloud computing as it can greatly benefit from the computing model for future production of output. An example is an online social network giant named Facebook, which decided to use the cloud service in order to efficiently handle future output to customers after a lot of its service-based applications had been produced and made available around the globe.

b. Hypothesis 2: Endogeneity of Cloud Computing and Employment

The cloud computing adoption can reduce a huge amount of fixed cost for IT infrastructure. With the lower initial set-up capital expenditure, a number of SMEs can emerge in the market faster and more easily. Even though the size of the new businesses may be small, they are great in number. The new firms require production resources such as labour, software, and hardware. Therefore, it is obvious that the adoption of the cloud can lead to an increase in the level of employment. Nevertheless, a reverse causality can be inferred. When a firm's business is growing, it is inevitable to accept more labour as well as machine for a particular worker to utilise for the production of output. Therefore, as the number of worker increases, the firm then decides to adopt the cloud computing model in order to reduce the machinery and equipment costs originating from the worker such as purchases of individual computers, software, and hardware licences.

c. Hypothesis 3: Endogeneity of Cloud Computing and Labour Productivity

This is derived from a part of the first hypothesis that the adoption of cloud computing leads to a reduction in costs and efficient resource allocation resulting in more output. Given a number of labour, the productivity of labour increases because of the increase in output level. Indeed, with more available production resources allocated to a worker, he can be more productive. Thus, the cloud computing adoption leads to the improvement in the labour productivity through more efficient resource allocation. However, the relationship can be viewed in an opposite direction. In the short run when the number of workers cannot be flexibly changed, a firm that primarily experiences a low level of labour productivity decides to use cloud computing services in order to increase its output as well as the productivity of labour.

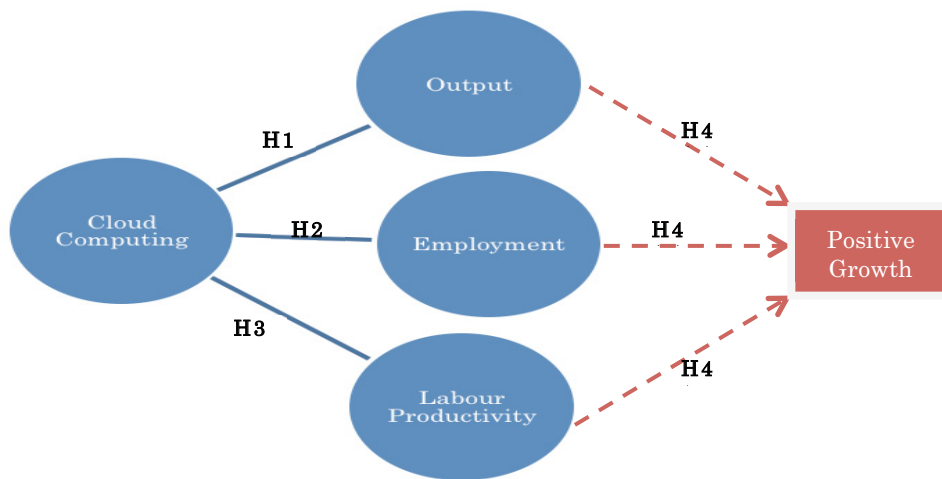
d. Hypothesis 4: Reliable Models Including the Adoption of Cloud Computing Can Be Made And Forecast Prospective Positive Impacts on Output,

Employment, and Labour Productivity.

Despite the endogenous relationship between the cloud computing and each of the variables, it is possible to predict positive impacts as a result of the inclusion of cloud computing adoption with an aid of appropriate estimation approach and reliable models. The positive impacts that will occur in the future include positive growth of output, employment, and labour productivity.

Figure 4 captures all the hypotheses and explains them in a comprehensive framework. First, the endogenous relation of the cloud computing and each of the variables is shown with the corresponding hypothesis. Second, the last hypothesis of the prospective positive impacts on each of the variables is shown with dashed arrows.

Figure 4 Summary of Hypotheses



Source: The Author

VII. Data and Methodology

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 can be measured in terms of expected outcome in the future when the model is being adopted at mass.

a. Data

This study analyses and forecasts the impacts of cloud computing on Thai economy. Therefore, there are totally four variables to elaborate. First, the proxy of the cloud computing is measured as the expected outcome that will occur after the cloud computing adoption. Because of the fact that cloud computing is a new computing model that has a major influence on the company's cost structure, namely cost reduction and conversion of capital to operational expenditure, a good proxy for the cloud computing is the change in the firm's ICT spending. It can

be either negative or positive over time. The negative case means that the ICT spending is lower compared to the previous period as the cloud computing adoption reduces a lot of fixed investment in hardware and infrastructure for data centres. The positive case occurs randomly because most of the firms initially going into the cloud are subject to increasing ICT spending for issues such as setting up the cloud systems, cloud-compatible software and application development, and new systems of security. This proxy is, however, in contrast with the one used in the paper by Etro (2009) in which only the reduction of fixed cost is considered. The proxy for the cloud computing is measured as the periodical difference of private investment in post and telecommunication services. The private investment in post and telecommunication services is measured as the difference between the total post and telecommunication value added of GDP originated from transport, storage, and communications and private consumption of post and telecommunication services derived from total private consumption expenditure. Second, the labour productivity is taken into account as an indicator of business and economic development. The calculation for this variable is straightforward. It is the ratio of GDP per number of employed labour in the country. Third, the level of output is considered as another economic development indicator. The measurement is simple as the value of GDP is used. Fourth, the level of employment is also considered as the last macro-economic indicator for this study. The number of employed labour is derived from the total domestic labour force.

Table 1 Summary of Variables

Abbreviation	Explanation
DIFF_CI	Proxy of cloud computing adoption
LP	Labour productivity
GDP88	Output level
LABOUR	Employment level

Source: The Author

Abbreviations for each of the variables are shown in Table 1. All data are in quarterly basis ranging from 2000 to 2010. All figures are adjusted at 1988 prices in order to avoid inflationary impact. National Economic and Social Development Board (NESDB) provides data for GDP, value added of GDP originated from transport, storage, and communications, and private consumption expenditure. The number of employed labour is obtained from the labour force survey conducted by National Statistical Office (NSO).

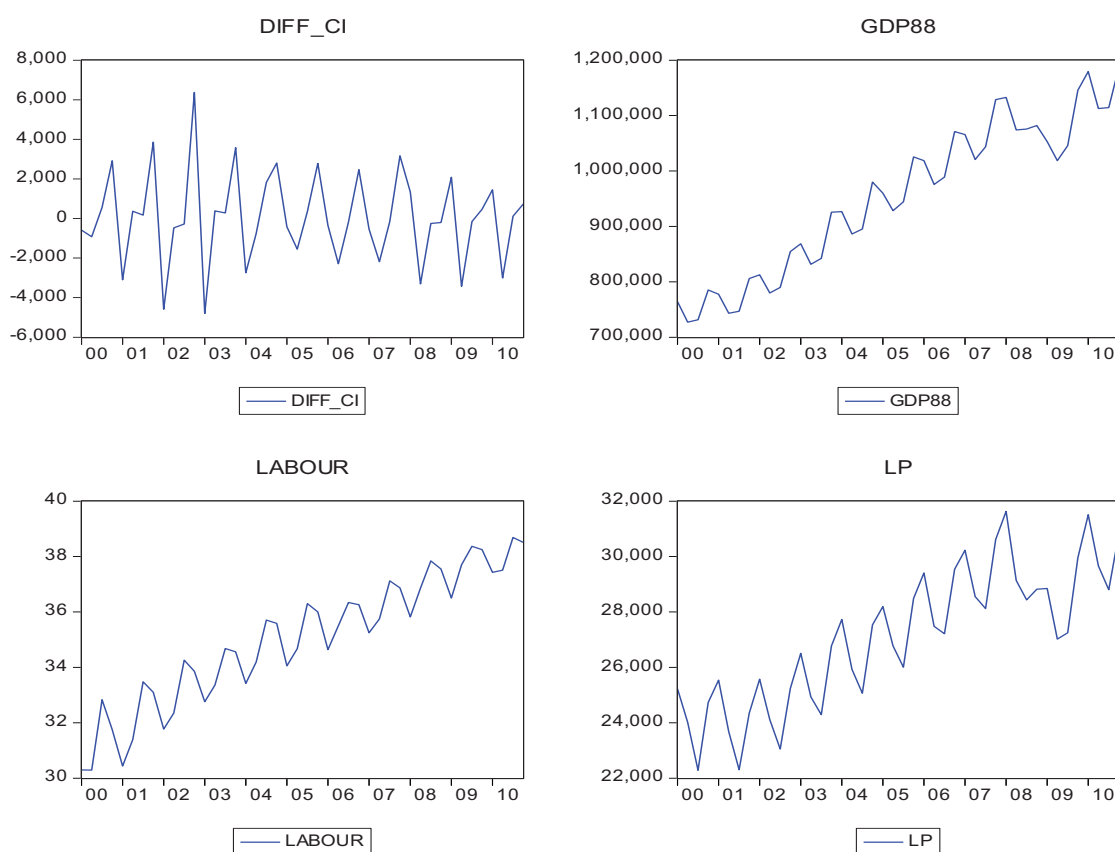
Some descriptive statistics are shown here in order to provide some clue about the robustness of the data for each variable. Table 2 shows that all variables are normally distributed. In addition, Figure 5 shows that most of all variables have an increasing trend, while DIFF_CI exhibits an unclear trend with some fluctuations over time.

Table 2 Descriptive Statistics of Variables

Descriptive Statistics	DIFF_CI	GDP88	LABOUR	LP
Mean	40.94	951,607.50	35.00	27,077.89
Median	(155.92)	967,832.50	35.38	27,232.03
Maximum	6,373.27	1,189,068.00	38.69	31,627.21
Minimum	(4,797.11)	727,229.00	30.29	22,285.31
Std. Dev.	2,311.90	137,460.40	2.34	2,466.98
Jarque-Bera	0.30	2.84	1.95	1.38
Probability	0.86	0.24	0.38	0.50

Source: The Author

Figure 5 Multiple Graphs of All Variables



Source: The Author

b. Methodology

First, the hypotheses regarding the endogeneity between the cloud computing and each of the variables (H1-H3) are tested by Granger causality test. The results of bi-directional causality are expected in order to accept first three hypotheses. The model of causality consists of three pairs of equations as follow.

The causal relationship of DIFF_CI and GDP88 (H1) is estimated by:

$$DIFF_CI_t = \alpha_1 + \sum_{n=1}^N \beta_n GDP88_{t-n} + \sum_{n=1}^N \gamma_n DIFF_CI_{t-n} + \varepsilon_{1t} \quad (1.1)$$

and

$$GDP88_t = \alpha_2 + \sum_{m=1}^M \tau_m DIFF_CI_{t-m} + \sum_{m=1}^M \omega_m GDP88_{t-m} + \varepsilon_{2t} \quad (1.2)$$

The causal relationship of DIFF_CI and LABOUR (H2) is estimated by:

$$DIFF_CI_t = \alpha_1 + \sum_{n=1}^N \beta_n LABOUR_{t-n} + \sum_{n=1}^N \gamma_n DIFF_CI_{t-n} + \varepsilon_{1t} \quad (2.1)$$

and

$$LABOUR_t = \alpha_2 + \sum_{m=1}^M \tau_m DIFF_CI_{t-m} + \sum_{m=1}^M \omega_m LABOUR_{t-m} + \varepsilon_{2t} \quad (2.2)$$

The causal relationship of DIFF_CI and LP is (H3) estimated by:

$$DIFF_CI_t = \alpha_1 + \sum_{n=1}^N \beta_n LP_{t-n} + \sum_{n=1}^N \gamma_n DIFF_CI_{t-n} + \varepsilon_{1t} \quad (3.1)$$

and

$$LP_t = \alpha_2 + \sum_{m=1}^M \tau_m DIFF_CI_{t-m} + \sum_{m=1}^M \omega_m LP_{t-m} + \varepsilon_{2t} \quad (3.2)$$

where each pair of equations, namely (1.1) and (1.2), (2.1) and (2.2), and (3.1) and (3.2), indicates the model that will be estimated separately from one another. Totally, there are three models. The letter n and m represent the number of lag for each equation in a pair. Their value can be equal. The error terms are denoted by ε_{1t} and ε_{2t} for each particular equation in a pair.

Second, the last hypothesis (H4) is to be tested. Primarily, an appropriate estimator model is constructed based on the preceding results of the causality test. Indeed, if there is a clear relationship of dependency, an OLS estimator will be used for future prediction of the impacts of the cloud adoption on output, employment and labour productivity growth. Nevertheless, if all the preceding hypotheses (H1-H3) cannot be rejected, a vector autoregressive (VAR) model will be used to forecast the positive impacts since this kind of estimator takes into account that all variables are endogenous. The estimating equation of the VAR model is as follow.

$$\begin{bmatrix} LG_GDP88_t \\ LG_LABOUR_t \\ LG_LP_t \\ DIFF_CI_t \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \begin{bmatrix} \beta_{1,1}^p & \beta_{1,2}^p & \beta_{1,3}^p & \beta_{1,4}^p \\ \beta_{2,1}^p & \beta_{2,2}^p & \beta_{2,3}^p & \beta_{2,4}^p \\ \beta_{3,1}^p & \beta_{3,2}^p & \beta_{3,3}^p & \beta_{3,4}^p \\ \beta_{4,1}^p & \beta_{4,2}^p & \beta_{4,3}^p & \beta_{4,4}^p \end{bmatrix} \begin{bmatrix} LG_GDP88_{t-p} \\ LG_LABOUR_{t-p} \\ LG_LP_{t-p} \\ DIFF_CI_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{bmatrix} \quad (4)$$

All variables are expressed in matrix form in which they are treated as endogenous

variables appearing on both sides of equation (4). The growth of GDP88, LABOUR, and LP is expressed in logarithmic transformation denoted by LG . The small letter p represents the number of lag to be included in the analysis starting from 1. Note that the last matrix consists of specific error terms for each equation, which vary across time.

VIII. Empirical Results

First, the bi-directional causality is found between the cloud computing adoption (DIFF_CI) and each of the variables, namely output (GDP88), employment (LABOUR), and labour productivity (LP). Not surprisingly, two-way causality is also found between output and employment, output and labour productivity, and employment and labour productivity.

Table 3 Results of Granger Causality Test of All Variables during 2000Q1 – 2010Q4

Null Hypothesis:	Prob.	Result	Hypothesis
GDP88 does not Granger Cause DIFF_CI	3.26E-02	GDP88 <--> DIFF_CI	H1
DIFF_CI does not Granger Cause GDP88	7.00E-05		Accepted
LABOUR does not Granger Cause DIFF_CI	1.00E-05	LABOUR <--> DIFF_CI	H2
DIFF_CI does not Granger Cause LABOUR	7.00E-07		Accepted
LP does not Granger Cause DIFF_CI*	0.0149	LP <--> DIFF_CI	H3
DIFF_CI does not Granger Cause LP*	0.008		Accepted
LABOUR does not Granger Cause GDP88	2.00E-12	LABOUR <--> GDP88	Additional
GDP88 does not Granger Cause LABOUR	3.00E-13		
LP does not Granger Cause GDP88	5.00E-12	LP <--> GDP88	Additional
GDP88 does not Granger Cause LP	5.00E-16		
LP does not Granger Cause LABOUR	2.00E-14	LP <--> LABOUR	Additional
LABOUR does not Granger Cause LP	3.00E-17		

Notes: The maximum lag up to 8 periods is added, while the best results arise from 2 periods.
* indicates the different lag of 1 period.

From Table 3, it is clear that all variables have a causal relationship flowing two directions between each pair. The results are significant at both 5 and 1 percent. The hypotheses of endogeneity (H1-H3) are accepted as well as some additional bi-directional causal relationships are witnessed. Therefore, it is to be admitted that the endogeneity exists among all variables. This fact then leads to the use of VAR model for estimation and forecast of future positive impacts of the cloud computing adoption on growth of output, employment and labour productivity. In order words, the last hypothesis (H4) will be tested by using the endogenous estimator model.

As mentioned earlier, the VAR model will be employed in order to handle the endogenous variables. After a few trials, a reliable model for each variable can be formed. The focus here is on the economic and business variables, namely output, employment, and labour productivity. In fact, the positive impacts of the cloud computing adoption on each of the mentioned variables will be forecasted. Such the impacts are the growth of each variable. Hence, logarithmic transformation is used.

Table 4 Estimation Output of VAR Model for All Variables

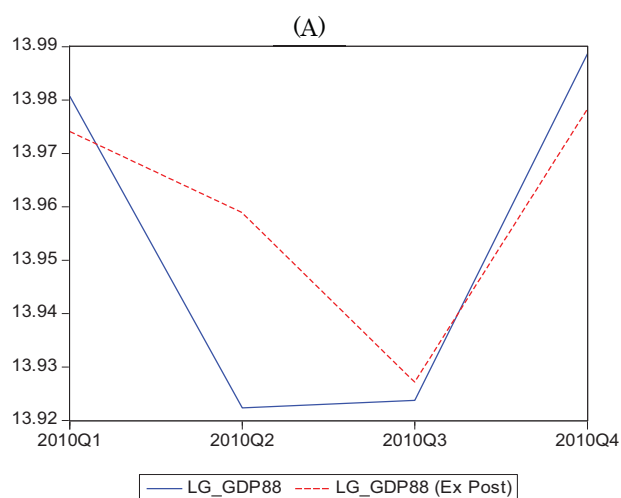
Variable	DIFF_CI	LG_GDP88	LG_LABOUR	LG_LP
DIFF_CI(-1)	-0.6008 [-3.5384]	-2.50E-06 [-1.0604]	-1.31E-06 [-0.9243]	-1.19E-06 [-0.4882]
DIFF_CI(-2)	-0.0850 [-0.5539]	-2.88E-06 [-1.3525]	-2.79E-06 [-2.1791]	-9.79E-08 [-0.0442]
LG_GDP88(-1)	619,370.50 [0.1618]	19.9058 [0.3743]	5.4883 [0.1720]	14.7353 [0.2670]
LG_GDP88(-2)	-243,613.10 [-0.0641]	41.7772 [0.7917]	28.2386 [0.8921]	13.7398 [0.2509]
LG_LABOUR(-1)	-545,564.60 [-0.1424]	-17.7544 [-0.3337]	-5.2985 [-0.1660]	-12.7736 [-0.2314]
LG_LABOUR(-2)	167,029.40 [0.0439]	-42.5627 [-0.8066]	-27.6898 [-0.8748]	-15.0743 [-0.2753]
LG_LP(-1)	-598,592.30 [-0.1563]	-19.0141 [-0.3574]	-5.8555 [-0.1835]	-13.4764 [-0.2442]
LG_LP(-2)	222,893.00 [0.0587]	-41.9726 [-0.7954]	-27.7224 [-0.8758]	-14.4514 [-0.2639]
Constant	8,858.76 [0.1918]	1.8030 [2.8114]	-0.5815 [-1.5116]	2.3841 [3.5829]
R-squared	0.6598	0.9817	0.9653	0.9534
Adj. R-squared	0.5773	0.9773	0.9569	0.9421
F-statistic	7.9999	221.4865	114.8211	84.3661

Notes: 1. The maximum lag up to 8 periods is added, while the best results arise from 2 periods.
2. LG indicates logarithmic transformation.

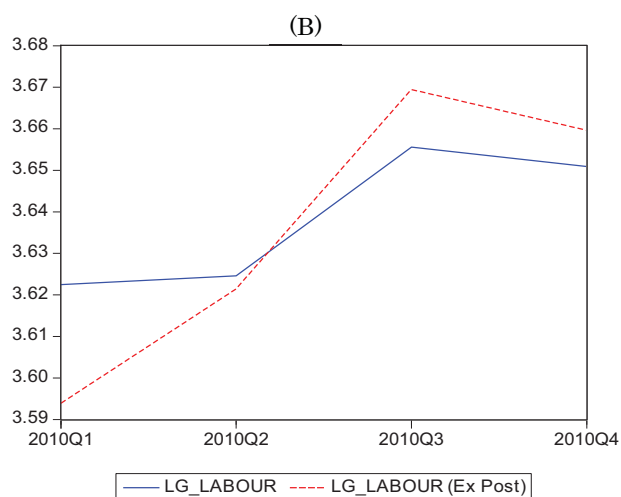
From Table 4, it is clear that the estimator model for the interested variables, which are

output, employment, and labour productivity, has a high level of robustness as shown by high level of R-squared and F-statistic. All coefficients are significantly acceptable. This also means that the models can be sufficiently used for prediction. The robustness in prediction power of the models is shown by Ex Post forecast for a sample of the last four quarters, which the actual data is present, in 2010. The forecasted values are compared with the actual ones in order to ensure fitness of the models.

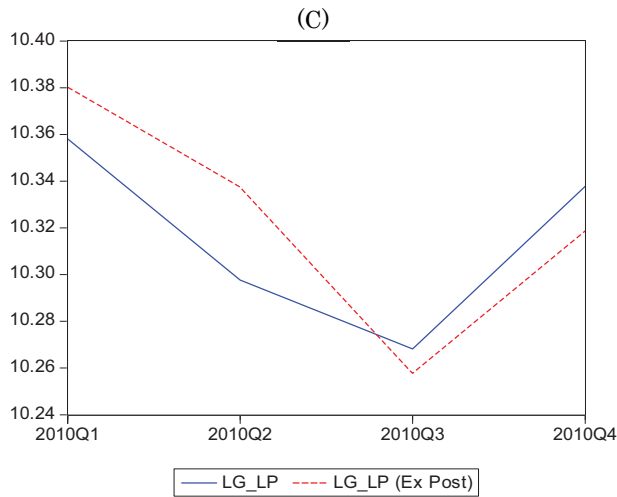
Figure 6 Ex Post Forecast and Actual Data Comparison



Obs.	LG_GDP88	LG_GDP88 (Ex Post)
2010Q1	13.9807	13.9741
2010Q2	13.9224	13.9589
2010Q3	13.9238	13.9272
2010Q4	13.9887	13.9783



Obs.	LG_LABOUR	LG_LABOUR (Ex Post)
2010Q1	3.6225	3.5939
2010Q2	3.6246	3.6215
2010Q3	3.6556	3.6695
2010Q4	3.6509	3.6596

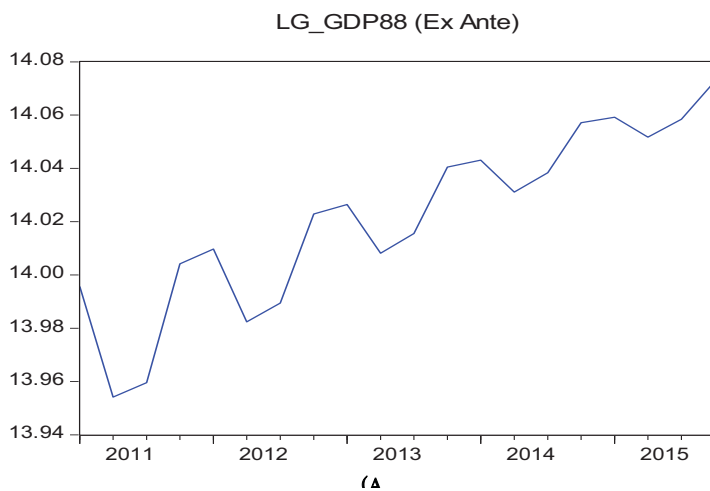


Obs.	LG_LP	LG_LP (Ex Post)
2010Q1	10.3581	10.3802
2010Q2	10.2976	10.3374
2010Q3	10.2682	10.2578
2010Q4	10.3378	10.3187

Figure 6 illustrates the fact that the aforementioned models produce almost accurate values of each of the interested variables for the Ex Post period. Although, there is a huge gap in (A), the forecasted values become closer to the actual ones. For both of the remaining variables, namely the growth of employment and labour productivity, the models can predict the values close to the actual ones as shown in (B) and (C).

Apparently, the models are suitable for forecast of this data series as each of them can be used to predict the values that are close to the actual ones. Therefore, the models are used for further forecast in order to witness the positive growth of each variable and test the last hypothesis.

Figure 7 Ex Ante Forecast



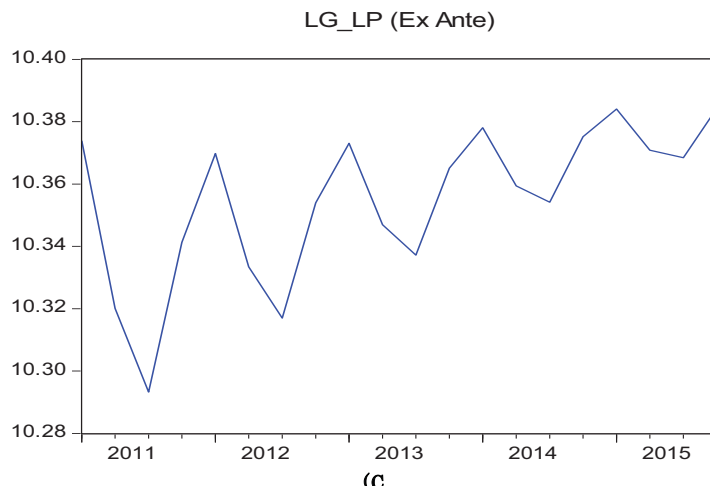
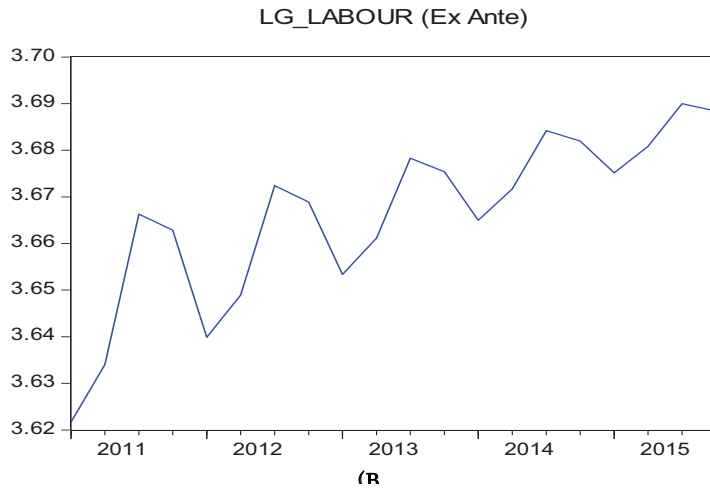


Figure 7 shows the forecasted values of growth of output, employment, and labour productivity as results from the models in which the cloud computing adoption is also considered as an explanatory variable. One can see that in the forecast period of 2011 to 2015, the growth of each of the interested variables follows an upward trend. This can be viewed as the positive impacts that will occur after the cloud computing adoption in the country as represented by the lagged value of DIFF_CI. Indeed, the reliable models in which the cloud computing adoption is considered predict positive growth of output, employment, and labour productivity for five years from 2010. Therefore, the last hypothesis is also accepted.

IX. Implications and Potential Cloud Computing Utilisation in Thailand

First, it is clear that the cloud computing has an interrelationship with output, employment, and labour productivity. This implies that it is unclear to distinguish between the cause and effect. At a point in time, the cloud computing can be the cause of change of the output, employment, and labour productivity. On the other hand, the cloud computing adoption may occur as a result of a change in the mentioned variables. Hence, in order to predict positive impacts from

the cloud computing adoption correctly, the constructed models must be able to take into account such the phenomenon.

Second, even though there is two-way causality, the adoption of the cloud computing can be implied to sufficiently predict the positive growth of output, employment, and labour productivity. Indeed, firms engaging cloud computing activities can benefit from various aspects, especially cost reduction. They then can produce more output with a higher level of efficiency. New businesses can emerge more easily as of lower IT set-up costs compared to the traditional on-premise data centres. This leads to the increasing growth of employment. Moreover, the efficiency in resource utilisation and allocation from the cloud computing adoption generates an upward growth of the labour productivity.

Apart from the aforementioned macroeconomic benefits, some policy implications and potential cloud computing adoption in Thailand may include the usage in public and private organisations. First, universities and educational institutes can benefit at great deal if the cloud computing model is used only during the periods when a lot of computing resources are required. The seasonal usage of the cloud can include the registration, examination grading, and graduation verification. These activities require high and reliable computing power at the time of occurrence, while only a few computers can handle the routine computing activities. The scalability of the cloud is the key to help the universities save a lot of investment of state-of-the-art computing infrastructure, which is not fully utilised at other time. Second, banks and financial institutions can also benefit from the cloud usage. Because of the security concern, such the enterprises should establish a community or private cloud in which each member can be fully identified and trusted. The established cloud systems can be very beneficial in automation activities such as credit line authorisation, loan amount grant, or early detection of NPL. Applications for the screening and grading of the banks' customers can be developed and deployed on the cloud and accessed by all cloud members. This can save a lot of individual investment and increase the computing performance as well as allocate the resources more efficiently among the members.

X. Conclusion

There are a number of benefits occurred from cloud computing as seen in the western world. This study tries to forecast positive impacts of the cloud computing adoption on economic and business factors that are output, employment, and labour productivity. 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 is related to different kinds of service delivered over the Internet. Three kinds of service delivery are discussed, which are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). The process of the cloud involves three main parties that are cloud providers, cloud users or XaaS providers, and XaaS users or end-users. The cloud provider provides cloud servers based on pay-as-you-go pricing to the XaaS provider,

which then develops and deploys cloud services through applications hosted in the cloud provider's facility. The XaaS user or end-user can consume the services according to the demand, regardless of location and time.

There are some economic aspects of the cloud computing model, which are worth mentioning in this paper. They include the impacts of the cloud to the firm's ICT spending, cost reduction, risk transfer, demand management, and efficient resource allocation.

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.

Even though there are several benefits from the cloud computing adoption, the author proposes that the problem of endogeneity exists. Indeed, one cannot see a clear one-way causality between the cloud computing adoption and output, employment, and labour productivity. Therefore, in order to make a promising forecast of the impacts of the cloud computing adoption on each of the interested variables, the VAR model is used.

The result is that the inclusion of cloud computing adoption into the models of output, employment, and labour productivity, helps with the forecast of each variable. The Ex Post forecast shows that the models can predict the values close to the actual ones. The Ex Ante forecast shows that positive growth of output, employment, and labour productivity is predicted from the models. This result is similar to that of Etro (2009) despite differences in methodology and sample group of countries.

Apart from the increasing growth of the economic and business factors, the cloud computing adoption can be considered beneficial to public and private organisations in Thailand. Universities can benefit from the scalability of computing resources, while banks can realise the benefit of multitenancy and shared computing resources.

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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