# Factor Analysis on Enterprises Adopting Cloud Computing

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*Abstract*—**To enhance the successful rate of enterprises adopting cloud computing, understanding factors influencing enterprises adopting cloud computing is important. Therefore, this study collects the factors affecting the use of the cloud computing service from literature review to establish a three-layer hierarchy factor table based on Technology - Organization - Environment (TOE) Framework as the theoretical basis., The analytic network process (ANP) method is used to determine the weights of each factor through experts' survey to understand the importance of each factor. The research results can be also provided for cloud service providers to understand clients' demands and propose operating and marketing strategies.**

*Keywords-cloud computing; adoption factors; ANP; TOE*

## I. INTRODUCTION

Cloud computing service has been widely discussed in the market. In recent years, IBM, Microsoft, Amazon and Google have invested in the development of cloud computing architecture and software in order to meet the demands of enterprises and individuals for cloud services. This indicates that leading global software technology corporations believe cloud computing service will play an important role in system development in the future. Cloud computing service can allow users to divide a computer operating system (including operating system, application programs, etc.) into many subprograms and sub-functions, and perform operations and data access through a connected remote server. In brief, users can use any access device to perform cloud computing programs or files.

Miller and Veiga [1] stated that new cloud computing service face the same challenges due to information and network technologies, such as performance, security, flexibility, operation, data transfer, and transition period from the old system. Chong and Parvan [2] and Sila and Dobni [3] considered that enterprises worry whether investment can be reduced if the major factors affecting the use of an IT technology system can be known. Thus, understanding factors influencing enterprises adopting cloud computing is important.

Therefore, this paper uses the Technology-Organization-Environment Framework (TOE) theoretical framework [4] as the basis, and discusses the issues through the analytic network process (ANP), as follows: (1) first, previous literature used the TOE as a theoretical framework to discuss the factors of using innovative technologies in organizations. For example, Racherla and Hu [5] used TOE to discuss the factors of using customer relationship management (CRM) system factors in hospitals. Van Huy et al. [6] used the TOE framework as a test model and conducted a questionnaire survey to investigate the factors of using e-commerce in 926 middle and small sized enterprises (SMEs) in Vietnam. San Martín et al. [7] investigated the mobile commerce performance of enterprises by combining customer value with TOE. Ramdani et al. [8] investigated the factors of CRM, e-procurement, and other information, in SMEs. These research results shown that TOE is a suitable framework for researches in adoption of IT system. Thus, the TOE framework should be able to review various factors in various forms; (2) most studies related to factor selection used either case studies or multiple regression analysis methods. Although $\beta$ in the multiple regression analysis method can reflect the importance of factors, an estimate of $\beta$ may have deviation or negative values [9]. Thus, few studies used $\beta$ of the multiple regression analysis method to determine the weights (or importance) of factors. To determine the weights of factors affecting enterprise to use cloud computing service is one multicriterial decision making (MCDM) issue. In this study, ANP (Saaty, 1996), which is an MCDM tool, is used to solve the MCDM issues. That is, ANP is used to obtain weights of factors through experts' survey. The study results can also allow enterprises to allocate resources according to the weight of each factor with lower cost and higher efficiency to enhance successful rate of adopting cloud computing service. In addition, the research results can be provided for cloud computing providers to know clients' needs and propose relevant operations and marketing strategies.

## II. METHODOLOGY

This study considers that the research problem is the multiple criteria decision making (MCDM) issue. The common MCDM method is Analytic Hierarchy Process (AHP). However, AHP have some shortcomings. Therefore, Saaty [10] developed the analytic network process (ANP) to improve the deficiencies of AHP.

The biggest difference between the ANP and AHP methods is the ability to deal with problems that have

interdependence and feedback, and determine the criteria of decision making objectives, elements, and alternatives through a supermatrix algorithm. While the research design is similar to AHP, the actual importance of factors may be calculated by repeatedly asking the respondents. This study consults the research steps of Agarwal [11], and Gencer and Gürpinar [12] in implementation of ANP, as follows:

Step 1: Establish objectives of the problems

Step 2: Establish pairwise comparison matrix

Step 3: Structure and calculation of the Supermatrix

Step 4: Calculate the weighted index

Step 5: Obtain the overall weights of index.

## III. ESTABLISHING HIERARCHY AND DATA COLLECTION

All factors of past literature are introduced, as follows, according to the hierarchical order of factors. The first layer, the objective layer, is comprised of the technology dimension, organization dimension, and environment dimension. In the second criterion layer, technology dimension can be subdivided into [system security], [system quality], and [system function]; the organization dimension can be subdivided into [organizational support], [organizational characteristics], and [organizational readiness]; and the environment dimension can be subdivided into [industrial environment], [general environment], and [cloud service providers]. The third sub-criterion layer makes the three factors into an internal network relationship, and the criterion layer has 27 factors (Table I), which importance of factor had been verified by previous studies and this paper do not need to verify their important again.

The questionnaires are designed according to the suggestions of Saaty and Vargas [13]. The factors in each layer are measured using a ratio scale through the pairwise comparison method. The questionnaires were distributed to the senior management of 887 manufacturing enterprises from Taiwan's 1000 large companies via Industrial Development Bureau (IDB) of Ministry of Economic Affairs (MOEA), according to Taiwan's Commonwealth Magazine, and finally, the IDB of MOEA collected 86 questionnaires. After review, there were 55 questionnaires with incorrect answers or failed to pass consistency testing (CR $\leqq$ 0.1) deleted from the 86 questionnaires. Finally, there were 31 valid questionnaires.

According to the suggestions of Saaty and Vargas [13], the group decision making opinions of the collected valid questionnaires are integrated using the arithmetic average in order to obtain a pairwise comparison matrix of each dimension and criterion. As ANP is not based on a statistical method, its greatest advantage is that no samples with statistical significance are required [14], thus, attention shall be paid to whether the samples can correctly represent the overall image, whether there are sufficient observed samples [15]. Besides, with regard to the sample size of expert questionnaires, Delbecq et al.[16] claim that 15 to 30 is a reasonable sample if the group of experts is highly homogeneous, while Robbins [17] state that five to seven samples is reasonable. The preliminary image can be plotted

using the opinions of the 31 experts, and the answers to these questionnaires were completed by the senior management of the manufacturing companies. The investigated group meets expert feedback requirements, and although the sample size is small, the samples are applied to this study. Finally, the overall weights of factors are calculated by using ANP procedures as shown in Table II based on 31 valid questionnaires.

TABLE I. THE THREE LAYER HIERARCHY FACTORS AFFECTING ENTERPRISES ADOPTION OF CLOUD COMPUTING SERVICE

| Criteria | Sub-Criteria | Attributes |
|---|---|---|
| Technology (T) | system security ($C_1$) | data access security ($e_{11}$) |
| | | information transmission security($e_{12}$) |
| | | fallback cloud management security ($e_{13}$) |
| | system quality ($C_2$) | Information system and communication stability ($e_{21}$) |
| | | Information system integration ($e_{22}$) |
| | | Information reliability($e_{23}$) |
| | system function ($C_3$) | Usful of system operations ($e_{31}$) |
| | | System expandability ($e_{32}$) |
| | | Ease to use of system operation($e_{33}$) |
| Organization (O) | organizational support ($C_4$) | senior management ($e_{41}$) |
| | | employee acceptance ($e_{42}$) |
| | | Interdepartmental coordination ($e_{43}$) |
| | organizational characteristics ($C_5$) | Organizatioan scale ($e_{51}$) |
| | | Innoc=vative and design ability of organizational procee ($e_{52}$) |
| | | Organizational system ($e_{53}$) |
| | Organizational readiness ($C_6$) | Organizational infrastructure ($e_{61}$) |
| | | Degree of education training ($e_{62}$) |
| | | Usable resource ($e_{63}$) |
| Environment (E) | industrial environment ($C_7$) | Degree of industrial adoption ($e_{71}$) |
| | | Development of cloud service industry ($e_{72}$) |
| | | Pressure of market competition ($e_{73}$) |
| | overall environment ($C_8$) | Promotion of Governmentpolicy ($e_{81}$) |
| | | Government reguration ($e_{82}$) |
| | | National infrastructure ($e_{83}$) |
| | cloud service providers ($C_9$) | Reasonable charge of cloud service ($e_{91}$) |
| | | Ability of cloud service providers ($e_{92}$) |
| | | Relationship with cloud service providers($e_{93}$) |

TABLE II. WEIGHTS OF FACTORS OBTAINED BY ANP

| Criteria | Sub-Criteria | Attributes | Weights | Order |
|---|---|---|---|---|
| Technology (T) 0.555067 | (C₁) 0.272755 | (e₁₁) | 0.1614 | 1 |
| | | (e₁₂) | 0.1404 | 2 |
| | | (e₁₃) | 0.0910 | 4 |
| | (C₂) 0.175894 | (e₂₁) | 0.0332 | 8 |
| | | (e₂₂) | 0.0271 | 11 |
| | | (e₂₃) | 0.0242 | 14 |
| | (C₃) 0.106419 | (e₃₁) | 0.0321 | 9 |
| | | (e₃₂) | 0.0250 | 13 |
| | | (e₃₃) | 0.0206 | 15 |
| Organization (O) 0.298776 | (C₄) 0.143975 | (e₄₁) | 0.1116 | 3 |
| | | (e₄₂) | 0.0597 | 5 |
| | | (e₄₃) | 0.0380 | 7 |
| | (C₅) 0.096956 | (e₅₁) | 0.0176 | 17 |
| | | (e₅₂) | 0.0195 | 16 |
| | | (e₅₃) | 0.0139 | 20 |
| | (C₆) 0.057844 | (e₆₁) | 0.0156 | 18 |
| | | (e₆₂) | 0.0140 | 19 |
| | | (e₆₃) | 0.0090 | 23 |
| Environment (E) 0.146157 | (C₇) 0.061813 | (e₇₁) | 0.0408 | 6 |
| | | (e₇₂) | 0.0289 | 10 |
| | | (e₇₃) | 0.0260 | 12 |
| | (C₈) 0.053735 | (e₈₁) | 0.0102 | 21 |
| | | (e₈₂) | 0.0089 | 25 |
| | | (e₈₃) | 0.0087 | 26 |
| | (C₉) 0.030609 | (e₉₁) | 0.0098 | 22 |
| | | (e₉₂) | 0.0089 | 24 |
| | | (e₉₃) | 0.0039 | 27 |

## IV. RESULT ANALYSIS

The research results showed that the importance of technology (0.555067) is far greater than that of organization (0.298776), but the importance of organization is greater than that of environment (0.146157) when enterprises introduce cloud computing on the criterion layer. Regarding the sub-criterion layer, the experts consider that the system security ($C_1$) under the technology is more important than other factors, the second most important is the system quality ($C_2$), and the third most important is the organizational support ($C_4$) under the organization, Finally, the fourth to ninth most important factors are system function ($C_3$), organizational characteristics ($C_5$), industrial environment ($C_7$), organization readiness($C_8$), overall environment ($C_8$), and cloud computing providers ($C_9$).

This study aggregates the weighted values of the attributes layer, obtains value 1, then divides the value by the total number of 27, and obtains the average value of 0.037037. There are seven factors greater than the average value, the top seven factors account for 64.3% of the weights of all factors, and the percentage is greater, thus, these factors are the core factors, which are discussed, as follows:

(1) The first most important factor is data access security ($e_{11}$) (0.161403), which is under system security, and reflects that enterprises pay greater attention to privacy and confidentiality of cloud computing. This factor is the top priority.

(2) The second most important factor is information transmission security ($e_{12}$) (0.140407), as some enterprises must transmit data to cloud computing through the internet when selecting public cloud computing due to cost, and the internet has many security problems. For example, hackers may capture confidential data during transmission. Thus, the protection mechanism by a cloud computing provider is very important.

(3) The third most important factor is support and participation by senior management ($e_{41}$)(0.111615), as the introduction of new technology is an important strategy that requires coordination between enterprise strategies and resources, as well as the support and participation of senior management. If senior management is not willing to provide support, then introduction of new technology will be hindered. Thus, support of senior management is an important influential factor.

(4) The fourth most important factor is the fallback cloud management security ($e_{13}$) (0.091016). It can be seen that, enterprise senior management consider that enterprises may suffer great loss if cloud computing cannot provide service after disaster occurs. Thus, the cloud computing system must be shock proof, fire proof, have an uninterruptible power supply, and other fallback mechanisms, in order to maintain high SLA.

(5) The fifth most important factor is employee acceptance ($e_{42}$) (0.059656); if employees can accept new technology, the probability of using cloud computing would be increased. When enterprises decide to use cloud computing, discussion and communication would be conducted within the enterprises in order to reach consensus, and relevant personnel should be trained.

(6) The application degree of enterprises ranks sixth place, as enterprise senior management considers that their industry may affect business information processing requirements, which further affects enterprises' willingness to use cloud computing. If more and more enterprises within the industry apply cloud computing, other enterprises would be more willing to implement cloud computing. The research results are the same as the findings of Lin and Chen (2012).

(7) Interdepartmental coordination (e43) (0.038029) ranks seventh place, as enterprise senior management must consider, if enterprises use cloud computing, the enterprises must establish an interdepartmental team to coordinate completion of the plan. After completion of the plan, the interdepartmental personnel must use it together in order to give full play to cloud computing, thus, maximizing efficiency.

## V. CONCLUSIONS

This study uses the TOE framework to establish a hierarchy table of the factors affecting the use of cloud computing in enterprises, and conducts analyzes. After analysis of the factor weights, it can be found that the technology has the greatest impact on enterprises, followed by organization and environment. This study summarizes and prioritizes seven key factors: data access security, information transmission security, support and participation of senior

management, fallback management security, employee acceptance, application degree of industry, application degree of industry, and interdepartmental coordination; and raises suggestions, practical implications, and research implications, which can serve as reference for enterpriser in cloud computing adoption. In the future, enterprises should allocate resources according to these seven factors in order to increase the success rate of using cloud computing.

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