Establishing a Cloud Computing Success Model for Hospitals in Taiwan

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Abstract
The purpose of this study is to understand the critical quality-related factors that affect cloud computing success of hospitals in Taiwan. In this study, private cloud computing is the major research target. The chief information officers participated in a questionnaire survey. The results indicate that the integration of trust into the information systems success model will have acceptable explanatory power to understand cloud computing success in the hospital. Moreover, information quality and system quality directly affect cloud computing satisfaction, whereas service quality indirectly affects the satisfaction through trust. In other words, trust serves as the mediator between service quality and satisfaction. This cloud computing success model will help hospitals evaluate or achieve success after adopting private cloud computing health care services.

Keywords
cloud computing, health care services, information systems success model, trust, cloud computing success model

Introduction
Since 1995, Taiwan has provided its citizens with nationwide health insurance. However, a few years after the implementation, the funding for national health insurance incurred a shortage; therefore, many policies have since been proposed to mitigate the funding gap, such as diagnosis-related groups. In 2013, the second generation of the National Health Insurance Program was implemented with additional supplementary insurance fee to address the funding problem. For hospitals, under the various medical payment standards of national health insurance, reducing operating costs became an important objective and a source of competitive advantage. To achieve this goal, information technology (IT) has been utilized as a critical weapon. Using the characteristics of information systems (IS), hospitals can provide good health care services at lower costs. These health care IS include picture archiving and communication systems (PACS), hospital information systems (HIS), and radiology information systems (RIS), among others.

Recently, with the emergence of the cloud computing era, generating electronic medical records (EMRs) has become more feasible than traditional IT platforms. According to its applications, the deployment models of cloud computing can be divided into private cloud, public cloud, and hybrid cloud. Many hospital-based applications can benefit from this novel platform. Over the past few years, more and more hospitals in Taiwan have adopted cloud computing as their IT services platform. However, previous studies were focused on critical factors that affect adopting decisions. In contrast, very few studies have been conducted to understand the success of cloud computing for hospitals. The work of Garrison et al emphasized the critical role of 3 IT capabilities (managerial, technical, and relational) toward the success of cloud computing. However, they only focused on IT capabilities, other IS success related factors were not considered. Besides, their study has not applied to the health care industry which has particular characteristics than other industry.

This study, to address the insufficiency of related research, attempts to establish and verify a cloud computing success model for Taiwan hospitals. By integrating IS success model and trust, the hospital cloud computing success model has been established and validated using the questionnaire survey administered to hospital chief information officers (CIOs). This study has 3 major contributions. First, it addresses the inadequacy of current research available in the literature. Second, it can be referenced by hospitals that, in the future, will adopt cloud computing. Finally, it can be utilized by hospital management for evaluating the success of their cloud-based e-health care systems.

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Theoretical Framework and Hypothesis

The major theoretical base of this study is the IS success model proposed by DeLone and McLean in 1992. Ten years later, DeLone and McLean integrated various challenges and IS environment evolutions, and proposed an updated IS success model and applied it in the context of e-commerce and electronic business environment. This model has been verified by previous IS researches. It has also been used to understand electronic health record (EHR) success in the hospital. Therefore, it is suitable for understanding the feasibility of cloud-based hospital IS. It indicates that information quality, systems quality, and service quality are 3 critical factors that will positively affect user intention and satisfaction. In addition, user intention will affect user behavior and will consequently affect user satisfaction. With better user satisfaction, it will enhance use intention, thereby resulting in a loop. Finally, success of IS will result in net benefits and increase the continued intention to use the IS. This cycle is illustrated in Figure 1.

In addition to the IS success model perspective, previous studies indicate that cloud computing adoption is usually a kind of IS outsourcing. For hospitals, transitioning from traditional IS platform to a cloud computing environment is a large-scale transformation. Most hospitals will look to collaborate with professional third-party cloud service providers. Hospitals in Taiwan are no exception. Therefore, integrating IS success and IS outsourcing perspectives will be helpful to understand cloud computing success in hospitals.

From the IS outsourcing viewpoint, previous studies indicate that the degree of trust between organizations and service providers is most critical for successful cooperation. In addition, the work of Petter et al. also indicated that trust plays one of the critical factors that will affect IS success. Therefore, trust has been integrated into the proposed cloud computing success model and is validated in the context of the private cloud computing in hospitals. In Figure 2, we can find that the proposed model has 3 quality factors from the IS success model and integrates the fourth factor, trust. The dependent variable is the satisfaction of cloud computing that is derived from the IS success model. Therefore, 7 hypotheses have been inferred:

Hypothesis 1 (H1): Information quality of cloud computing will positively affect hospitals’ trust toward the IS service providers.
Hypothesis 2 (H2): System quality of cloud computing will positively affect hospitals’ trust toward the IS service providers.
Hypothesis 3 (H3): Service quality of cloud computing service provider will positively affect hospitals’ trust.
Hypothesis 4 (H4): Information quality of cloud computing will positively affect hospitals’ satisfaction.
Hypothesis 5 (H5): System quality of cloud computing will positively affect hospitals’ satisfaction.
Hypothesis 6 (H6): Service quality of cloud computing service provider will positively affect hospitals’ satisfaction.
Hypothesis 7 (H7): Hospitals’ trust toward computing service provider will positively affect their satisfaction.

Research Design

Materials and Methods

A mail-based questionnaire survey was used in this study. Measurements used in this survey were adapted from previous studies and were modified to suit the research context. Working definitions and employed measurements of each variable are summarized in Table 1. Because the original measurements are not designed for the cloud computing development in the hospital, following steps were followed to develop the questionnaire and confirm its reliability and validity. First, English and Chinese specialists translated each statement into Chinese and verified the equivalency of the Chinese and English meanings. Next, to ensure content validity, 3 experts (2 from the field of information management and 1 from the hospital managerial level) were asked to review the questionnaire, and accordingly the content was modified. Because the population is scarce in this study (the population in this study is only 502 hospitals in Taiwan), only qualitative methods were used in the pilot test to
confirm the validity and reliability. Finally, 48 items were used to measure the variables in the research model.

The respondents were the CIOs of the hospitals. Data collection was conducted from March 2015 to May 2015 for 502 hospitals in Taiwan. Subsequently, the study received 214 valid questionnaires. The response rate was 42.6%. Among them, 163 hospitals (76.2%) had already adopted cloud computing whereas 51 respondents (23.8%) indicated that they had not used cloud computing. Moreover, among the 163 hospitals that adopted cloud computing, 64 (39.3%) adopted private cloud computing, 49 (30.1%) utilized public cloud, and 50 (30.7%) used hybrid cloud computing. Owing to the different characteristics and requirements of various cloud computing deployment types, this study focuses on private cloud computing success for 2 major reasons. First, separate different cloud computing deployment models will avoid any unnecessary ambiguities. This is because different deployment models of cloud computing have different purposes and applications. Moreover, owing to security concerns, many hospitals have chosen to adopt private cloud as their first priority. This study also has similar findings; therefore, focus on the technology utilized by the majority is more critical.

We utilized 64 samples to validate the proposed research model. Partial least squares (PLS) was used as it is suitable for samples larger than 10 times the number of independent variables. This study has 4 independent variables; therefore, the minimum required sample size is 40. This implies that the selected sample size is sufficient for advanced analysis. SmartPLS21 and SPSS have been used for the following data analysis.

### Results

#### Respondents’ Demographic Characteristics

The 64 respondents are predominantly male, with 53 males (87%) and 8 females (13%); 3 missing data were excluded. Their ages ranged mainly between 31 and 50 years (75%). Fifty-six (88%) participants had a college degree or higher. Most of them had rich experience in the health care informatics field (47% had more than 10 years of experience in the health care industry). The respondents were mainly CIOs and leaders of informatics-related departments.

Among the 64 participating hospitals, there were 4 (6%) medical centers, 16 (25%) metropolitan hospitals, and 44 (69%) regional hospitals. This distribution is similar to the population, thereby making the data set representative. Among the 64 hospitals, 17 (28%) had adopted cloud computing in the past 2 years and 13 (21%) had 2 to 3 years of experience with cloud computing. The 3 major applications on the cloud platform are PharmaCloud System, EMR, and PACS. Finally, most of the respondents (87.5%) noted that they collaborated with a third-party information service partner for constructing their private cloud computing platform.

### Measurement Validity and Reliability

The following criteria are utilized to evaluate the validity and reliability of the measurements used in this study: composite reliability (CR) > .7, average variance extracted (AVE) > 0.5, Cronbach’s alpha value > .7, and the square roots of AVE are greater than the correlation coefficients to ensure discriminant validity. From Table 2, we can see that all of the indexes

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**Table 1. Variable Definitions and Measurements.**

| Variable                  | Operational definition                                                                 | Item No. | Source       |
|---------------------------|----------------------------------------------------------------------------------------|----------|--------------|
| Information quality16     | The quality of the information that a cloud-based hospital IS providing to users       | 9        | Teo et al16  |
| System quality16          | The level of system design quality and user friendliness of cloud-based hospital IS   | 6        | Teo et al16  |
| Service quality17         | The service quality provided by the cloud service provider                            | 22       | Pitt et al17 |
| Trust14                   | The degree of hospital’s trust toward the cloud service provider                      | 4        | Han et al14  |
| Satisfaction16,18         | The degree of hospital’s satisfaction toward the cloud-based IS system                | 7        | Teo et al16; Ifinedo18 |

**Note.** IS = information systems.

**Table 2.Validity and Reliability.**

| Variables       | CR   | AVE  | Factor loading | $R^2$ | Cronbach’s $\alpha$ |
|-----------------|------|------|----------------|-------|----------------------|
| Information quality | .95  | .71  | 0.72-0.90      | NA    | .94                  |
| System quality  | .96  | .82  | 0.75-0.95      | NA    | .96                  |
| Service quality | .99  | .82  | 0.85-0.91      | NA    | .99                  |
| Trust           | .99  | .97  | 0.98-0.99      | .27   | .99                  |
| Satisfaction    | .97  | .84  | 0.91-0.93      | .65   | .97                  |

**Note.** CR = composite reliability; AVE = average variance extracted; NA = not applicable.
are acceptable. Only 1 of the 9 items measuring information quality was omitted because of low factor loading (<0.5).22 Therefore, 8 items were employed to measure service quality. Other measurements remained unchanged from the original instruments. As regards discriminant validity, the square roots of AVE were computed and compared with the correlations between constructs.23 According to the above criteria, the results indicated that the discriminant validity of each construct is acceptable. On the basis of the above testing, we can ensure that the data set can be used for advanced analysis.

**Hypothesis Testing**

The PLS results indicate that the critical determinants of hospitals’ private cloud satisfaction are information quality (H4), system quality (H5), and trust (H7). The $R^2$ is 65.4%. Moreover, trust serves as the mediator between service quality and satisfaction. It implies that service quality will directly affect trust (H3), whereas satisfaction will be affected indirectly. Overall, 4 proposed hypotheses are significant, H3, H4, H5, and H7. The results are summarized in Table 3 and Figure 3.

**Discussion**

From the perspective of the IS success model, this study indicates that only information quality and system quality directly affect satisfaction. Service quality will directly affect hospitals’ trust toward their partners ($R^2 = 27%$) and the level of trust will significantly affect their satisfaction. The overall explanatory power of the sequential dependent variable, cloud computing satisfaction, is 65%. In other words, in the context of private cloud computing in hospitals, integrating trust and IS success model can improve the understanding of the success of cloud computing. In contract to traditional viewpoint, this study found that only information quality and system quality have a direct effect on satisfaction. The effect of service quality on satisfaction, however, is indirect. This is

| Hypotheses                        | Path coefficient ($\beta$) | $t$ value | Support |
|-----------------------------------|---------------------------|-----------|---------|
| H1: Information quality \(\rightarrow\) Trust | .04                       | 0.23      | No      |
| H2: System quality \(\rightarrow\) Trust    | .25                       | 1.26      | No      |
| H3: Service quality \(\rightarrow\) Trust    | .37                       | 2.54*     | Yes     |
| H4: Information quality \(\rightarrow\) Satisfaction | .34                       | 2.29*     | Yes     |
| H5: System quality \(\rightarrow\) Satisfaction | .35                       | 2.04*     | Yes     |
| H6: Service quality \(\rightarrow\) Satisfaction | (.14)                     | 1.76      | No      |
| H7: Trust \(\rightarrow\) Satisfaction | .37                       | 2.65**    | Yes     |

*p < .05. **p < .01.* Parenthetical value indicates negative value.

the major theoretical contribution of this study. This finding also confirms the opinion proposed by Paul.24 He indicates that in the context of commercial cloud computing environment, service-level agreement and quality of service requirements of users determine the level of trust toward cloud computing.24 Present study advanced finds that trust will not only affect users’ satisfaction but also serve as the mediating role between service quality and satisfaction. Finally, compared with information quality and system quality, service quality is relatively intangible; therefore, it will not affect users’ satisfaction directly but indirectly. This phenomenon will be meaningful for future studies about cloud computing.

For applicability in hospitals, cloud-based applications need to provide reliable, timely, compactable, and clear information for users. Besides, it also needs to meet users’ information requirements to ensure the quality of information. Regarding systems quality, cloud-based applications must ensure ease of use from a user perspective, and in particular, for doctors. A friendly user interface will help users complete their tasks without the task being cumbersome to execute. As regards the cloud service provider, this study finds that only promoting service quality is insufficient to ensure user satisfaction. Improved service quality is required to promote trust level simultaneously. Only this approach can improve user satisfaction. This study suggests that cloud service providers must express their transparency and not make decisions catering to their own interests. Finding solutions that consider the interest of both parties is critical.

Overall, this study has both practical and theoretical implications. In practice, this study aggregated the status of private cloud computing development in Taiwan hospitals and determined the critical success factors. The results can be referenced by the hospitals in Taiwan and other countries, especially in the Asia-Pacific region. In terms of theoretical contribution, this study extends the traditional IS success model to the issues facing the establishment of cloud computing environments in hospitals. In addition, we established and validated a cloud computing success model for hospitals in Taiwan. These results contribute to the research streams in the IS success model, thereby enriching the research context of the IS success model.

**Limitations and Future Directions**

There are some limitations and future research directions proposed in this study. First, this study only focused on private cloud computing in hospitals. Based on the definition proposed by National Institute of Standards and Technology (NIST), cloud computing has different service models and deployment models. However, this study only focused on private cloud computing in hospitals. In addition, hospitals in Taiwan have their own characteristics. Therefore, future studies can conduct more research across different cloud computing types and industries. Moreover, this study is a cross-sectional study, and cloud computing is still in its
development progress, particularly in hospitals. Therefore, longitudinal research will be needed for this research area.

Second, to make more significant contributions to the literature in this research area, future studies can apply the proposed model to different cloud computing platforms and compare their differences and similarities. Besides, the data set only includes hospitals in Taiwan; therefore, we suggest that data from different countries will enable researchers to make more meaningful contributions. Third, only 4 independent variables are included in the proposed model, even though the $R^2$ value obtained is acceptable. We believe that more critical variables can be included to understand the success of cloud computing in hospitals. Regarding the respondents, CIOs normally are responsible for IS development and could be also end users. Surveying CIOs is one perspective for system success and, however, should be different from surveying normal users in the results. Therefore, findings from regular users other than CIOs may be different. Future study can conduct comparative research to get a better understanding of this topic. Finally, previous studies had argued the potential problems of small sample size in PLS; however, the population in this study is only 502 hospitals in Taiwan, and among the valid respondents only 64 adopted private cloud computing. This causes another limitation. Future study can focus on end users to release this restriction.

Conclusions

This study integrates the characteristics of cloud computing by combining the IS success model and trust to investigate the critical success factors that affect the success of private cloud computing in hospitals. Based on this cloud computing success model, we conducted a questionnaire survey to validate the proposed model and hypotheses. Overall, the explanatory power ($R^2$) of this model is 65.4%. In addition, the results of the hypothesis testing indicate that, similar to previous studies, information quality and system quality of private cloud computing in hospitals no double can have positive and direct effects on cloud computing users' satisfaction. However, service quality indirectly affects users' satisfaction. Trust is the mediator between service quality and satisfaction. In other words, maintaining a healthy partnership between third-party information service providers and hospitals is critical when developing private cloud computing. Besides, this study also finds that adopting private cloud computing is a major trend among hospitals in Taiwan. The 3 major applications on the cloud platform are PharmaCloud System, EMR, and PACS. Finally, this study found that 87.5% of the respondents have collaborated with third-party partners for establishing a cloud computing environment in their hospitals. On the whole, this proposed cloud computing success model will help hospitals evaluate success after adopting private cloud computing health care services and achieve its value creation purpose.

Declaration of Conflicting Interests

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