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Research paper

Cloud Computing Adoption in Government Agency

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Abstract

As accessibility to government online services is critical, MAMPU has outlined strategic directions for the implementation of Public Sector ICT. This included cloud computing adoption which aims to optimize service delivery but is progressing slowly due to resource-sharing and standardization issues. This calls for the need to assess contributing factors of technology acceptance within a public sector. Employing Malaysia NRD as a case study, we aim to identify factors of cloud adoption and determine how NRD could strategize Cloud Computing adoption. Using the DOI and TOE theories, we assessed cloud computing adoption in terms of ¬Technology Characteristics, Organisational Readiness, and External Environment through a case study. It was found that that all constructs are significant to cloud adoption with security and service quality being the highest concern. Moreover, several elements such as compatibility, readiness and more need to be in place to enhance the impact of cloud computing adoption.

Keywords: *Cloud Computing; Diffusion of Innovation Theory; Technological, Organizational and Environmental Framework; Technology Acceptance, Human Perception.*

1. Introduction

Cloud computing is a ubiquitous, on-demand network access to a shared computing resources comprising applications, services, and storage among others. Its key feature is its intangibility allowing rapid provision with minimal managerial effort. The applications have been gaining momentum a few years back, but the concept has been discussed since the early 1950s with J. Licklider conceiving the idea of "Intergalactic Computer Network". According to US National Institute of Standards and Technology (NIST) [1], cloud computing comprises five essential characteristics which are on-demand self-service, broad network access, resource pooling, rapid elasticity and measure service. It can be deployed as a private, community, public or hybrid cloud with services ranging from Software as a Service (SaaS), Platform as a Service (PaaS) or Infrastructure as a Service (IaaS).

The growing trend of cloud computing has attracted many organizations to participate in this new market actively. The benefits of cost reduction in system development and operation as well as proper utilization of human resources is a motivating factor for these organizations including the public sector. This is corroborated from the Cloud Readiness Index Study (CRI) done by the Asia Cloud Computing Association (ACCA) involving fourteen Asian countries [2]. They found that the readiness for cloud computing has significantly improved for the Asian countries with an even better position compared to their western counterparts. Malaysia ranked eight among the fourteen Asian countries and scored particularly well in terms of privacy, IP protection, business sophistication, broadband quality and cybersecurity. In light of this, Malaysian Administrative Modernisation and Management Planning Unit or MAMPU, which is responsible in transforming government agencies service delivery to the citizens, has taken steps to streamline strategic direction of ICT implementation through the Public-Sector ICT Strategic Plan (PSICTSA) 2016¬-2020. One of the main agenda is the provision of Government Cloud Computing where public sectors could utilize the cloud infrastructure and platforms using applications such as 1GovUC (a communication channel for email, instant messaging, video conferencing and identity management), Digital Document Management System (government digital document system accessible ubiquitously) and myMesyuarat (paperless meeting management system).

NRD or National Registration Department is one of the Malaysian government agencies spearheading the PSICTSA 2016-2020. They have worked out the ICT Strategic Plan (ISP) 2012-2016 roadmap aligning three cores which are ICT security, information sharing and consolidation of the ICT infrastructure. However, an initial study conducted found that the cloud computing adoption in NRD is surprisingly slow. A preliminary survey conducted with the NRD staff found that the cloud computing adoption raises concerns in terms of delivery satisfaction, security and the overall impact of cloud computing on government ICT. This echoes the findings from the many research on cloud computing where the adoption is challenged by security issues [3] - [5], trust and accountability [6] - [9].

Any implementation of technological system can be costly, and it becomes more undesirable should the implementation garner low success rate. Without a true understanding on the factors for successful technological implementation, a technology will only become another list of "keeping in with the times" but offer no practical value. This obviously calls for factors to be grouped into a model that investigates user perception on cloud computing use in public sector.

In realization of this situation, we have set to understand why government agencies such as NRD has been slow in adopting cloud computing even though the adoption has been stipulated as a directive by MAMPU. We adopted the approach of case study to explore this issue where we selected NRD as the research scope

and their IT staff as the stakeholder. The following sections shall discuss on the conceptual model applied by the study using elements from DOI and TOE framework. This is followed with the description of the study setup and elaboration on the results analysis. We believe the findings of the study would highlight the associated costs of migration and adoption of cloud computing.

2. Research Method

This section will discuss the methods employed in our case study of cloud computing adoption in Malaysia public sector

2.1. Context of Study

NRD was chosen as the context of the study as this is the main government agency dealing with citizen identity and serves as the main anchor amongst various government agencies when verifying citizens' details. We focused on the NRD headquarters located in Putrajaya as it is the main unit of decision making for the agency's branches nationwide.

2.2. Conceptual Framework

As the nature of this study is aligned towards technology adoption, we feel it is important to consider contributing factors of technology adoption from organizational and user behaviour perspectives. A study by [10] have listed several models and frameworks that examine factors affecting technology adoption which are Technology-Organizational-Environment Framework (TOE), Theory of Diffusion of Innovation (DOI), Institutional Theory, Lacovou Model, Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB). The study also showed that a high number of research has very much utilized TOE [11] and DOI [12] compared to the other models due to its broader constructs and feasibility of assessment.

DOI was developed by [12] to explain and forecast technology adoption rate based on internal and external organizational characteristics (i.e. centralization, complexity, formalization, interconnectedness, organizational slack size and system openness) as well as user perception towards the technology (i.e. attitude towards change). However, technological and environmental constructs are also critical in technology adoption as they centralize on technology availability and accessibility as well as considering the regulations, constraints and opportunities that are already in place. Therefore, TOE was seen to overcome the shortcomings of DOI as it not only caters the technological aspects, but also non-technological aspects such as environmental and organizational factors [13].

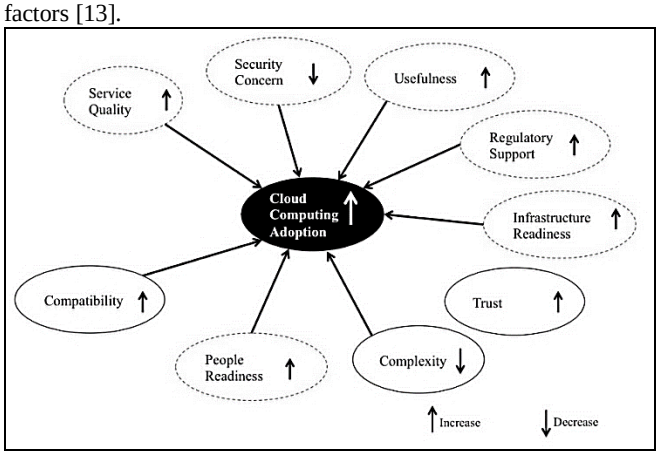

Fig. 1: List of Attributes Influencing Cloud Computing Adoption Rate in Public Sector. (Note: The solid oval striped shows empirical factors; the arrows in the oval indicate how these attributes should be changed to influence rate of adoption)

Due to the breadth of constructs offered by TOE and DOI, we have decided to adopt both models into our study where we foremost contextualize it by relating the constructs to the influences of cloud adoption rate in the public sector. This is done through critical Literature Review of articles pertaining to cloud computing adoption, trends and opportunities.

We further our analysis through document analysis where we studied MAMPU's PSICTSA 2016-2020 documents, the ISP of NRD as well as NRD's ICT procedures and policies. The themes for the document analysis were devised based on the study by [14]. [14] found that contributing factors of cloud service adoption include compatibility, complexity, auditability and security issues among others. This triangulation has resulted into a more focused model of attributes influencing cloud adoption rate in Malaysia public sector, which is illustrated in Figure 1. The attributes are then reorganized into TOE and DOI measures of adoption as can be seen in Figure 2. This serves as our research conceptual model.

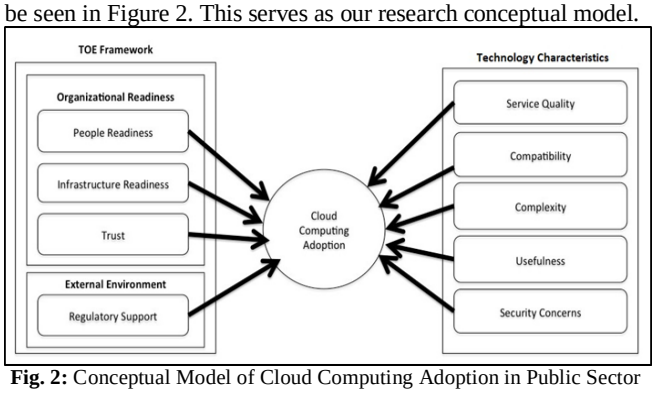

Fig. 2: Conceptual Model of Cloud Computing Adoption in Public Sector

Table 1: Element Description for Conceptual Model Constructs

Constructs	Associated Elements and Description
Technology Characteristics	**Service Quality** •Cloud computing should enable IT service delivery •Organization is ready in case of service downtime
	Compatibility •Cloud computing fits with the organization's workstyle and business operation •Cloud computing can integrate with existing system architecture
	Complexity •Cloud computing is too complex or too difficult to be implemented in the organization
	Usefulness •Cloud computing can manage business efficiently •Cloud computing can increase organization's productivity •Cloud computing helps perform tasks immediately •Cloud computing offers new opportunities
	Security Concerns •Data security and data privacy in cloud computing is important •Data privacy issues would not prevent the use of cloud computing
Organizational Readiness	**People Readiness** •The stakeholders feel cloud computing can support business operations •The IT staff have the necessary skills to use cloud computing •The management supports cloud computing implementation
	Infrastructure Readiness •Organization's infrastructure is ready to adopt cloud computing •Organization's IT Strategic Plan included investment for cloud computing
	Trust •The organization believe that cloud computing is a well-reliable technology •Stakeholders have trust in cloud computing
External Environment	**Regulatory Support** •There is legal protection in the use of cloud computing •Existing policies are sufficient in protecting the use of cloud computing

2.3. User Perception on Cloud Computing Adoption

2.3.1. Respondents

A user survey to gather user perception on cloud computing adoption was conducted where the target respondents are government employees working in the IT Division. For eligibility, the respondents must have at least basic knowledge in Information Technology (IT) and working in the ICT Management and Communication Department of the NRD Agency. They were chosen as they would directly deal with any technology migration and adoption particularly on cloud computing adoption initiatives.
At the time of the study, there were a total of 250 government employees in the NRD IT department. A further review of the respondents' eligibility found that only 100 staffs were eligible to respond to the survey due to their job scope dealing specifically with cloud computing adoption. However, out of the 100 staffs only 93 staff were able to complete the form. Based on [15], for a given 100 user population size, at least 80-sample size is required. This concludes that the 93-response sample we collected was more than acceptable.

2.3.2. Questionnaire

A structured questionnaire was designed based on the constructs depicted in the conceptual model (see Figure 2). Most of the items in the questionnaire were adapted from published article. The questionnaire was divided into three (3) parts as follows:

- Part A consists of six user demographic questions such as gender, age, duration of employment, education background, scope of works and general awareness on cloud computing
- Part B focuses on gathering user agreement on factors affecting cloud computing adoption.
- Part C were Likert Scale questions with five scales format to elicit user concerns on the rate of cloud implementation stages in the current situation of NRD. It looks on the constructs as depicted in the conceptual model

To validate the suitability of the questionnaire, a pilot study was conducted, and it was found that the user survey was well understood by the respondents. The questionnaire was then distributed as google form where the link was provided to the staff via email invitation. The form was made available for two weeks where they could respond within the timeframe only once.

2.3.3. Survey Analysis

The demographic data in the user survey was analysed using frequency and descriptive statistics. Whilst for Part B and C, a descriptive analysis was done on the former while the latter was analysed using Kolmogorov-Smirnov test, Shapiro-Wilk test as well as Spearman's Rank Order Correlation Test. All statistical analyses were done using SPSS 23. The aim of the analysis was to help project patterns and trends on arising issues of cloud computing adoption in NRD. The findings were then used to validate our conceptual model.

3. Results and Analysis

This section provides a comprehensive discussion on the user survey results as well as the validity of the conceptual model proposed in this study.

3.1. Respondent Demographic

There were 35 male and 58 female respondents of the questionnaire where 77.4% of them were within the age range of 31 to 40 years old. The respondents have varying work experience however most of the respondents have 5 to 10 years of working experience (73.1%). All respondents have specific job scopes in the IT department. These initial findings indicate that our respondents are IT savvy and are applying their IT knowledge into their daily work tasks.

3.2. Cloud Computing Awareness in General

From the 93 respondents, 86% of them claimed to know the concept of cloud computing while 6.5% of them expressed no knowledge. Further analysis found that this small number is attributed to the new staff in NRD with less than 5 years working experience. This imply that they may have not been formally trained in cloud computing.

3.3. User Perception on Factors Affecting Cloud Computing Adoption

Table 2 summarises user perception on the factors affecting cloud computing adoption rate in NRD. Table 2 shows that all factors outline in the conceptual model play significant role in cloud adoption rate with service quality and security being the top most important factors. As the system deals with citizens data, matters pertaining to data loss and data leakage is very critical [16] - [18]. They feel a solid data protection must be in place as it will be managed in a digital platform accessible by other relevant government agencies in Malaysia whereby NRD no longer has sole ownership to this data.

Table 2: User Perception on Factors Affecting Cloud Computing Adoption (values are in percentage)

Statements	Yes	No
Do you agree that service quality is important in adopting Cloud Computing in your organisation? *(e.g.: Service performance in term of availability, reliability and stability)*	100	0
Do you agree that usefulness of cloud technology is important in adopting Cloud Computing in your organisation? *(e.g.: Cloud computing characteristic and benefits)*	97.8	2.2
Do you agree that security concerns are important in adopting Cloud Computing in your organisation? *(e.g.: Uncontrolled shared environment of user data, applications and services)*	100	0
Do you agree that complexity of cloud technology is important in adopting Cloud Computing in your organisation? *(e.g.: Software engineering challenges for design, develop and deploy solutions with cloud computing)*	90.3	9.7
Do you agree that IT infrastructure readiness is important factor in adopting Cloud Computing in your organisation? *(e.g.: Existing network and system architecture able to support the implementation of cloud)*	96.8	3.2
Do you agree that trust is important in adopting Cloud Computing in your organisation? *(e.g.: Perception of term cloud that evokes negative reactions)*	95.7	4.3
Do you agree that regulatory concern in public sector is important in adopting Cloud Computing in your organisation? *(e.g.: JPN's and MAMPU's policy)*	98.9	1.1
Do you agree that people readiness is important in adopting Cloud Computing in your organisation? *(e.g.: Awareness, lack of knowledge or expertise)*	93.5	6.5
Do you agree that compatibility is important in adopting Cloud Computing in your organisation? *(e.g.: Integration with existing system)*	98.9	1.1

Having regulations in place is very important to the NRD staff as it helps with standardization of infrastructures as well as mechanism of usage. This also helps them feel that the management is supporting them with the adoption.
However, cloud computing adoption must also consider compatibility with existing system. Further discussion with NRD staff indicate that migrations to new system is often costly as it involves staff training as well as running existing systems and cloud in parallel as to ensure the business model is not interrupted. If the migration requires the purchase of new software or peripherals, it would send further kick back to the agency's budget which would affect expenditure plan on other NRD departments. Hence why

96.8% feels IT Infrastructure readiness is also essential in cloud computing adoption.
The elements of trust, people readiness and complexity seem to fall on a lower side of the 90% frequency. In most government policies, a migration that comes as a directive would eventually take place regardless if the trust towards the system is lacking or the staff is not overly ready to accept the technology. This is where training becomes useful as it helps them to understand the mechanism of the system as well as prepare them for the technology.
Complexity showed the lowest factor in cloud computing adoption rate as this is beyond the scope of their expertise. The NRD staff is not required to develop their own cloud computing infrastructure as this is provided for by MAMPU. They simply need to be trained in managing it as relevant to NRD job scope henceforth complexity is less of an issue for them.

3.4. Cloud Computing Implementation Perception as Per Conceptual Model

User response on Part D of the survey was first evaluated according to the conceptual model constructs. The construct validity of the instrument was assessed where it can explain the phenomenon that is required and the extent to which it can be described in the actual measurement. Therefore, reliability test was used to assess the validity of these constructs.

3.4.1. Reliability Testing

Cronbach's Alpha was utilized to assess the reliability of the constructs. The minimum test value must be greater than 0.70 for the construct to be acceptable. Table 3 summarises the results of the Cronbach's Alpha Analysis. It shows that all constructs have a value of 0.8 and above indicating a good internal consistency.

Table 3: User Perception on Factors Affecting Cloud Computing Adoption (values are in percentage)

Constructs	Cronbach's Alpha	N of Items
Technology Characteristics	.844	15
Organisation Readiness	.822	8
External Environmental	.842	2

3.4.2. Descriptive Analysis

Descriptive analysis was performed to analyse the level of Cloud Computing Adoption Readiness based on Technology Characteristics (Service Quality, Compatibility, Complexity, Usefulness and Security Concerns), Organisational Readiness (People Readiness, Infrastructure Readiness and Trust) and External Environmental (Regulatory Support). All these variables were measured using 5-point Likert scale from 1 ("Strongly Disagree") to 5 ("Strongly Agree") and its level evaluated based on the value of mean for each variable.

Table 4: The Level of Score based on the Scale of Mean

Scale of Mean	Level of Adoption Rate	Tendency to Adopt Cloud Computing
1.00 – 1.99	Poor	Poor
2.00 – 2.99	Low	Low
3.00 – 3.99	Medium	Medium
4.00 – 5.00	High	High

The values of mean were then divided into four groups that indicate the level of score for each variable as shown in Table 4. Table 5 indicates the value mean and standard deviation for each construct. All variables of Cloud Computing adoption indicate that the level of Cloud Computing Adoption tendency on Technology Characteristics, Organizational Readiness and External Environment are "Medium" with the mean value (after rounding up), for Technology Characteristics = 3.54, Organisational Readiness = 3.77 and External Environmental = 3.39. This may be due to less exposure and awareness to cloud computing either generally or specifically [18].

Table 5: The Value Mean Construct of Cloud Computing Adoption Factors

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Stat	Stat	Stat	Stat	Stat	Stat	Std. Error
TC	93	2.87	5.00	3.6803	.44695	.984	.250
OR	93	2.72	5.00	3.7712	.52538	.267	.250
EE	93	1.00	5.00	3.3871	.93579	-.182	.250
Valid N	93						

Note: Stat = Statistics, TC = Technology Characteristics, OR = Organization Readiness, EE = External Environmental

3.4.3. Assessing Normality

The normality of distribution scores was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk test [19] – [20]. Table 6 shows that the results of the analysis where the scores for the three constructs are normally distributed, in terms of skewness and kurtosis.
However, the normality test should also refer to the Kolmogorov-Smirnov and Shapiro-Wilk value (p or sig value) and a visual inspection of the histograms. Table 7 shows the test of normality with Kolmogorov-Smirnov and Shapiro-Wilk value. A non-significant result requires that the sig value must be more than 0.05 ($p > 0.05$) to indicate normality. In this situation the sig value is at a range of 0.00 to 0.037 (rounded) for all variables (Technology Characteristic, Organizational Readiness and External Environmental). As the sig value is less than 0.05 ($p < 0.05$), this suggests that the distribution of scores are reasonably 'non-normal' for all variables. Moreover, the normality can also be supported by an inspection of the normal probability plots (labelled Normal Q-Q Plots) for all constructs. In these plots, the observed value for each score was plotted against the expected value of the normal distribution. However, all variables in this study did not achieve a reasonably straight line, further illustrating a non-normal distribution. The graphs are shown in Figure 3, 4 and 5.

Table 6: The Descriptive Results for Each Conceptual Model Constructs

		Statistic	Std. Error
TC	Mean	3.6803	.04635
	Skewness	**.984**	**.250**
	Kurtosis	**1.263**	**.495**
OR	Mean	3.7712	.05448
	Skewness	**.267**	**.250**
	Kurtosis	**-.206**	**.495**
EE	Mean	3.3871	.09704
	Skewness	**-.182**	**.250**
	Kurtosis	**-.537**	**.495**

Note: TC = Technology Characteristics, OR = Organization Readiness, EE = External Environmental

Table 7: Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TC	.119	93	.002	.936	93	.000
OR	.095	93	.037	.969	93	.027
EE	.174	93	.000	.935	93	.000

Note: TC = Technology Characteristics, OR = Organization Readiness, EE = External Environmenta

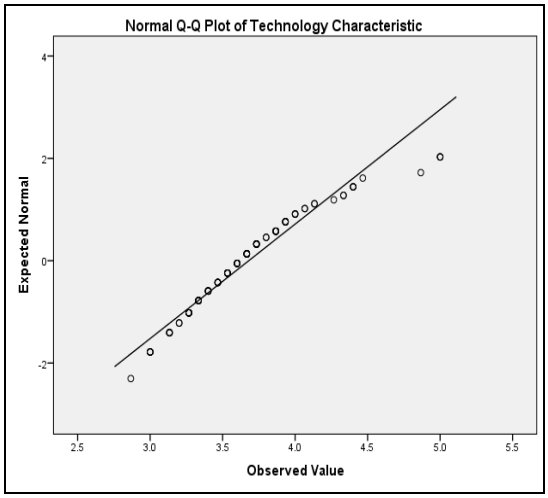

Fig. 3: Normal Q-Q Plot of Technology Characteristics

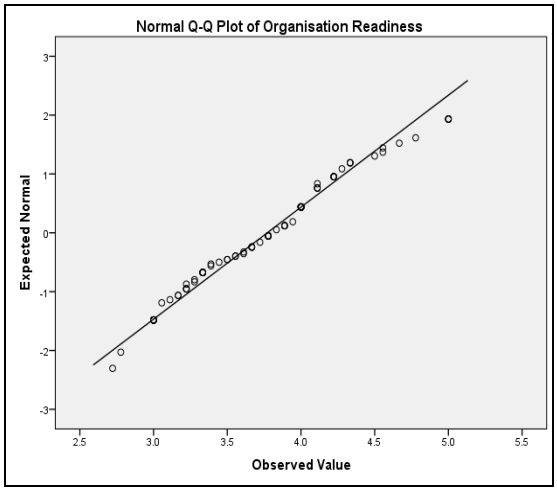

Fig. 4: Normal Q-Q Plot of Organisation Readiness

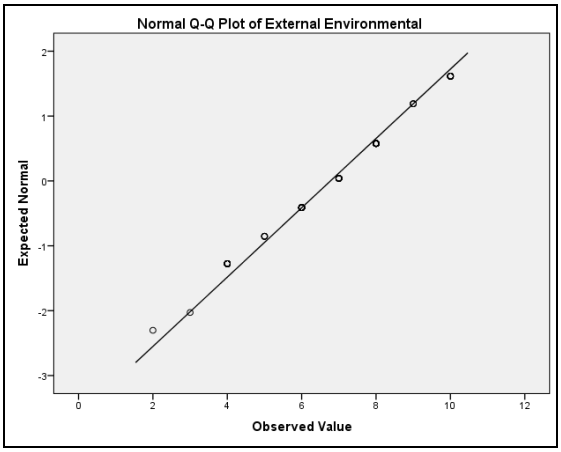

Fig. 5: Normal Q-Q Plot of External Environmental

3.4.4. Measuring Relationship of Adoption Factors and Cloud Computing Adoption

Correlation is used to explain the strong point and direction of the Cloud Computing Adoption correlation to the constructs. Since the distribution of score for all constructs (Technology Characteristics, Organisational Readiness, and External Environments) are reasonably 'non-normal', the bivariate Spearmen's Rank Order correlation coefficients were obtained. The value of Spearman's rho correlation coefficients (r) indicates the strength of the relationship between two variables. A correlation of 0 indicates no relation at all, a value of 1.0 indicates a perfect positive correlation, and in contrast a value of -1.0 indicates a perfect negative correlation. As references to interpret the values between 0 and 1, [19] suggests the following guidelines as shown in Table 8.

Table 8: Strength Guideline for Variable Relationship

r value	Correlation	Relationship
r=.10 to .29 or r=-.10 to -.29	Small	Weak
r=.30 to .49 or r=-.30 to -.49	Medium	Medium
r=.50 to 1.0 or r=-.50 to -1.0	Large	Strong

Table 9 shows the Sig. (2-tailed) (p) and Spearman's rho correlation coefficients (r) value for all constructs consist of Technology Characteristics, Organisational Readiness, and External Environmental.

Table 9: Correlation Results on Conceptual Model Constructs

			TC	OR	EE	CCA
Spearman's Rho	**TC**	Correlation Coefficient	1.000	.451**	.428**	.669**
		Sig. (2-tailed)	.	.000	.000	.000
		N	93	93	93	93
	OR	Correlation Coefficient	.451**	1.000	.451**	.404**
		Sig. (2-tailed)	.000	.	.000	.000
		N	93	93	93	93
	EE	Correlation Coefficient	.428**	.451**	1.000	.228*
		Sig. (2-tailed)	.000	.000	.	.028
		N	93	93	93	93

Note: TC = Technology Characteristics, OR = Organization Readiness, EE = External Environmental

**. Correlation is significant at the 0.01 level (2-tailed).*

**. Correlation is significant at the 0.05 level (2-tailed).*

The summary of bivariate Spearman's rho correlation coefficients results was then organized as illustrated in Table 10. The results show that each construct of Technology Characteristics, Organizational Readiness and External Environment are correlated to one another. The strength of the relationship is medium and positively correlated except for Technology Characteristics and Cloud Computing Adoption, which had strong and positive relationship. This finding is similar to [3], [9], [22] - [25]. On another note, External Environmental had slightly weak and positive correlation with Cloud Computing Adoption with only one-way relationship and the level of signification correlation is at 0.05.

Table 10: Summary of Correlation between All Constructs

Relationship	Sig. (2-tailed) Significant 'p' (rounded)	Spearman's rho correlation coefficients 'r' (rounded)	Strength of Relationship
TC → OR	.000	0.45	Medium, positive
TC → EE	.000	0.43	Medium, positive
TC → CCA	.000	0.67	Strong, positive
OR → EE	.000	0.45	Medium, positive

OR → CCA	.000	0.41	Medium, positive
EE → CCA	.028	0.23	Weak, positive

Note: TC = Technology Characteristics, OR = Organization Readiness, EE = External Environmental

The relationships of each constructs were then mapped to the conceptual model as can be seen in Figure 6. The aim is to assess if the relationship of each constructs to the cloud computing adoption component were significantly correlated. The results show that most of the variables were strongly correlated with their intended constructs and the value were above 0.70 except for Technology Characteristic (Service Quality, Complexity and Security Concerns) which had correlation value less than 0.70 ($r < 0.70$). This finding implies that our conceptual model is valid.

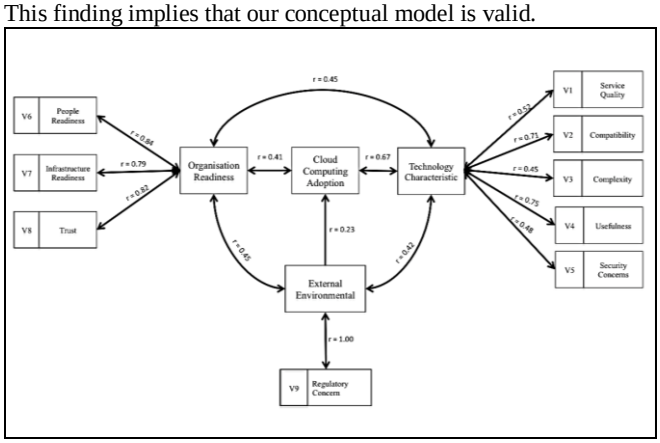

Fig. 6: Correlation between Conceptual Model Constructs

4. Conclusion

This paper has presented an overview of Cloud Computing adoption in Malaysia public sector, mainly studying the factors that influence adoption rate based on user perception. The results showed that many factors play a role particularly security and service quality. Meanwhile the level of cloud adoption is showing medium tendency of adoption except for the Technology Characteristics, where it shows strong and positive relationship with the cloud computing adoption. This suggests that the success of cloud computing adoption is highly dependent on service quality, compatibility, complexity, usefulness and security. Nevertheless, organizational readiness and external environmental (i.e. regulations) are also essential to ensure a holistic adoption and acceptance of the technology.

A further analysis should be conducted to understand the pattern of attributes through regression analysis. Moreover, underlying specific strategies for NRD to employ as initiatives to expedite cloud computing adoption should also be identified. Obviously, this information would be further helpful for other government agencies when streamlining strategies on cloud computing adoption in the future.

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