

Secure cloud adoption model: novel hybrid reference model

Aiman Athambawa, Md Gapar Md Johar, Ali Khathibi

Post Graduate Centre, Management and Science University, Shah Alam, Malaysia

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ABSTRACT

This article discusses research conducted to conceptualise a secure cloud adoption model. The study surveyed SMEs in the Sri Lankan information technology industry using a questionnaire to determine cloud computing adoption factors. The study used Rogers' diffusion of innovation (DOI), Tornatzky and Fleischer's technology-organization-environment (TOE) framework, Venkatesh and Bala's technology acceptance model 3 (TAM3), and Venkatesh, Thong, and Xu's Unified theory of acceptance and use of technology 2 (UTAUT2) as the theoretical foundation for evaluating the reference model. Two hundred and fifty-six key officials from information technology (IT) organisations in Sri Lanka participated in the survey. The study used quantitative data coding and analysis methods with the SPSS and AMOS softwares. The findings from previous research and existing technology adoption frameworks and models were summarised to support the secure cloud adoption model (SCAM).

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Corresponding Author:

Aiman Athambawa

Post Graduate Centre, Management and Science University, University Drive

Off Persiaran Olahraga, Section 13, 40100 Shah Alam, Selangor Darul Ehsan, Malaysia

Email: matheeh@yahoo.com

1. INTRODUCTION

Over the past few decades, researchers have attempted to establish the factors influencing technology adoption. There are several different theories and models to research the process of adopting new technologies introduced. The major theories used in this field are the diffusion of innovations (DOI) [1], the technology-organisation-environment (TOE) framework [2], the theory of reasoned action (TRA) [3], the technology acceptance model (TAM) [4], the technology acceptance model 2 (TAM2) [5], the technology acceptance model 3 (TAM3) [6], unified theory of acceptance and use of technology (UTAUT) [7] and unified theory of acceptance and use of technology 2 (UTAUT2) [8].

Among these theories, DOI, TOE, TAM3 and UTAUT2 are the most widely used theories which attempt to explain and forecast cloud computing adoption. Most of these theories describe and predict the decision to an adoption based on technology factors themselves. In addition to the adoption models, information security is used to validate the security adoption in cloud computing.

Ismail [9], Naresh and Bharathi [10] and Zaballos and Rodriguez [11], there are several opportunities created by the adoption of cloud computing, whereas [12]-[15] emphasise the risks associated with the adoption of cloud computing. [10], [11], [16], [17] indicated enterprises' challenges when cloud adoption was made. Further, [18] describe the information security responsibilities when cloud computing was adopted. Also, the researchers [19]-[25] identified that information security influences cloud computing adoption. Behavioural Intention is the strong mediating factor identified by many research [5]-[8], [23]-[27] that mediate the adoption of cloud computing with all independent variables.

Table 1 summarises the adoption frameworks or models that relate the significant factors that influence cloud computing adoption with the recent references. Opportunities is an independent factor that

comprises five dimensions: Relative advantage, price value, performance expectancy, effort expectancy and hedonic motivation. Risks is an independent factor that comprises four dimensions: output quality, performance of external control, compatibility and complexity. Challenges is an independent factor that comprises three dimensions: top management support, technology readiness and government regulations. Information security is another independent factor, and behavioural intention is the mediating factor which mediates the the relationship between independent factors and the dependent factor: Adoption of cloud computing.

The main objective of this study is to design a secure cloud adoption model (SCAM). The findings from previous researches and existing technology adoption frameworks and models were summarised in the Table 1. These findings are supported for modelling the SCAM.

Table 1. Factors of adoption of cloud computing

Framework/ Model	Opportunities					Risks				Referen ces
	Relative Advanta ge	Price Value	Performa nce Expectan cy	Effort Expectan cy	Hedonic Motivati on	Output Quality	Perception of external control	Compa tibility	Comple xity	
TOE, DOI	✓							✓		[28]
TOE, DOI, UTAUT2	✓	✓						✓	✓	[19]
TOE, DOI	✓							✓	✓	[20]
TOE, DOI	✓							✓	✓	[29]
TOE, DOI, UTAUT2		✓						✓	✓	[21]
UTAUT2		✓								[22]
UTAUT2		✓	✓	✓	✓					[25]
UTAUT2		✓	✓	✓	✓					[26]
UTAUT2		✓	✓	✓	✓					[27]
UTAUT2		✓	✓	✓	✓					[24]
UTAUT2			✓	✓	✓					[23]
TAM3						✓	✓			[30]
TAM3						✓	✓			[31]
TAM3						✓	✓			[32]
DOI, TOE									✓	[33]
Total	4	7	5	5	4	3	3	5	5	
Framework/M odel	Challenges			Other factors				Referen ces		
	Top manage ment support	Technology Readiness	Government Regulations	Information Security	Security	Behavioural Intention				
TOE, DOI	✓	✓	✓							[28]
TOE, DOI, UTAUT2	✓	✓	✓			✓				[19]
TOE, DOI	✓	✓	✓			✓				[20]
TOE, DOI	✓		✓			✓				[29]
TOE, DOI, UTAUT2	✓		✓			✓				[21]
UTAUT2						✓				[22]
UTAUT2						✓		✓		[25]
UTAUT2								✓		[26]
UTAUT2								✓		[27]
UTAUT2						✓		✓		[24]
UTAUT2						✓		✓		[23]
TAM3										[30]
TAM3										[31]
TAM3										[32]
DOI, TOE									✓	[33]
Total	5	3		5		7		6		

✓ - Significant factor that influences the adoption of cloud computing

2. THE COMPREHENSIVE THEORETICAL BASIS

The study extensively reviewed technological adoption models such as DOI, TOE framework, TAM3, and UTAUT2 to draw a theoretical foundation for evaluating the novel reference model. The theory of Diffusion of innovation (DOI) [1] was initially developed in 1962 by Roger and is still in use for adoption, leading to technological innovation. The theory defines the factors that influence the diffusion of emerging technologies or perceptions in a society [1]. Roger identified that innovation is consists of five key factors: "relative advantage, compatibility, complexity, trialability and observability" [1]. Among these five factors, the most impactful on adopting different innovations are relative advantage, complexity, and compatibility [34].

Tornatzky and Fleischer [2] developed the technology organisation environment (TOE) framework. They identified three factors that affect adopting and implementing technological innovation in an organisation: technological, organisational and environmental. Within the technology factor, they identified relative advantage, uncertainty, compatibility, complexity, and trialability are dimensions. The Organisation factor comprises the behaviour of top management, organisational structure and communication as dimensions. Competitors, government regulations, industry characteristics and market scope are identified as the dimensions of the Environment factor. Many recent studies [35]-[39] used the TOE framework. Among the factors, relative advantage, compatibility, complexity, the behaviour of top management and government regulations are adopted for SCAM model.

Technology acceptance model 3 (TAM3) is given by Venkatesh and Bala [6] based on the impact of information technology (IT) adoption and effective usage strategies. The model combines TAM2 by Venkatesh and Davis [5] and the model of determinants of perceived ease of use by Venkatesh [40]. TAM 3 model comprised of the following factors; "Perceived usefulness, perceived ease of use, subjective norm, image, job relevance, output quality, result demonstrability, computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment, objective usability, experience, voluntariness and behavioural intention" [6]. Among the factors, output quality, perception of external control and behavioural intention are adopted for the SCAM model.

Theory of acceptance and use of technology 2 (UTAUT2) model is proposed by Venkatesh *et al.* [8]; it is the second iteration of UTAUT proposed by Venkatesh *et al.* [7] by adding additional factors that influence the technology use acceptance. UTAUT2 comprises the following factors; "Performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, habit, awareness, behavioural intention and use behaviour" [8]. From these factors, performance expectancy, effort expectancy and behavioural intention are adopted to form the SCAM model.

3. RESEARCH METHOD

The study mainly focuses on designing a secure cloud adoption model (Figure 1), especially for SMEs in the IT sector. The novel reference model incorporated by evaluating with four major technology adoption theories that are Rogers' DOI [1], TOE framework [2], Venkatesh and Bala's TAM3 [6], and Venkatesh, Thong, and Xu's UTAUT2 [8]. As per the literature review and the tests conducted among the Sri Lankan information technology industry SMEs in this study, it is identified that there are four independent variables for making a secure model for cloud adoption that are Opportunities, risks, challenges and information security. Twelve (12) dimensional variables were identified for these three independent variables as tabled in Table 2. In addition to that, a mediating variable, Behavioural Intention and a dependent variable, adoption of cloud computing, were identified.

A conceptual framework for this research was developed based on the identified variables used to study the adoption of cloud computing in the IT industry SMEs. Research findings indicated that the DOI, TOE, TAM3 and UTAUT2 were used to prepare a mapping to develop the conceptual framework. Table 2 provides the mapping of the SCAM. The mapping detailed each dimension derived from the adoption models and where they have been used in recent studies.

Further, nine (9) hypothetical relationships are formed based on the literature and summarised in Table 3. Two hundred and fifty-six (256) information technology (IT) organisations in Sri Lanka participated in the survey to test the hypothesis. Data was gathered from the key officials from the organisations. The study used quantitative methods for collecting data using a pre-structured questionnaire. The collected data is coded and analysed with SPSS software version 27, and the reliability of the collected data is checked using Cron batches alpha. Also, the cloud usage factors such as cloud service models and deployment models were analysed. To obtain the model fit of the conceptual model, AMOS software version 28 is used, and results are generated.

Table 2. Mapping the factors/dimensions in SCAM

Initial Factors of Secure Cloud Adoption Model (SCAM)	Supported by Previous Technology Adoption Models	Supported by recent literature.
Opportunities (OPP)		[9]-[11]
- Relative Advantage	TOE [2] , DOI [1]	[19], [20], [28], [29]
- Price Value	UTAUT2 [8]	[19], [21], [22], [23]-[27]
- Performance Expectancy	UTAUT2 [8]	[23]-[27]
- Effort Expectancy	UTAUT2 [8]	[23]-[27]
- Hedonic Motivation	UTAUT2 [8]	[23]-[26]
Risks (RSK)		[12]-[15]
- Output Quality	TAM3 [6]	[30]-[32]
- Perception of external control	TAM3 [6]	[30]-[32]
- Compatibility	TOE [2], DOI [1]	[19]-[21], [28], [29]
- Complexity	TOE [2], DOI [1]	[19]-[21], [29], [33]
Challenges (CHL)		[10], [11], [16], [17]
- Top management support	TOE [2]	[19]-[21], [28], [29]
- Technology Readiness	TOE [2]	[19], [20], [28]
- Government Regulations	TOE [2]	[19]-[21], [28], [29]
Information Security (IS)		[19]-[25]
Behavioural Intention (BI)	UTAUT2 [8], TAM3 [6]	[5]-[8], [23]-[27]

Table 3. Research hypothesis

Hypothesis	Relationship
H1	There is a significant relationship between Opportunities and Behavioural Intention
H2	There is a significant relationship between Risk and Behavioural Intention
H3	There is a significant relationship between Challenges and Behavioural Intention
H4	There is a significant relationship between Information Security and Behavioural Intention
H5	There is a significant relationship between Behavioural Intention and Adoption of Cloud Computing
H6	There is a significant relationship between Opportunities and Adoption of Cloud Computing
H7	There is a significant relationship between Risk and Adoption of Cloud Computing
H8	There is a significant relationship between Challenges and Adoption of Cloud Computing
H9	There is a significant relationship between Information Security and Adoption of Cloud Computing
H10	Behavioural Intention mediates opportunities towards the Adoption of Cloud Computing
H11	Behavioural Intention mediates risk towards the Adoption of Cloud Computing
H12	Behavioural Intention mediates challenges towards the Adoption of Cloud Computing
H13	Behavioural Intention mediates information Security towards the Adoption of Cloud Computing

3.1. Secure cloud adoption model (SCAM)

The secure cloud adoption model depicted in Figure 1 was developed in response to the literature review, current technological adoption models, and survey results as discussed. Hypothesis H1, H2, H3 and H4 are used to check the relationship between independent variables opportunities, risks, challenges and information security to mediating variable behavioural intention. Hypothesis H5 is used to check the relationship between mediating variable behavioural intention and dependent variable adoption of cloud computing. Hypothesis H6, H7, H8 and H9 are used to check the relationship between independent variables opportunities, risks, challenges and information security to dependent variable adoption of cloud computing. Further, Hypothesis H10, H11, H12 and H13 are used to check mediating relationships.

The conceptual framework represents the relationship between this study's independent, dependent, and mediating variables. The secure cloud adoption model comprises four (4) independent variables, including twelve (12) dimensions, one (1) mediatory variable that influences the dependent variable of adoption of cloud computing in the IT organisation in Sri Lanka for Secure Cloud Adoption as shown in Figure 1. The independent variables were opportunities, risks, challenges and information security. The dimensions such as relative advantage, price value, performance expectancy, effort expectancy and hedonic motivation are classified under the independent variable of opportunities. The dimensions such as output quality, perception of external control, compatibility and complexity are classified under the independent variable risks. The dimensions such as top management support, technology readiness and government regulations are classified under the independent variable challenges. Further, the variable Information Security is an additional independent variable identified. The variable behavioural intention is identified as a mediating variable towards the dependent variable, adoption of cloud computing.

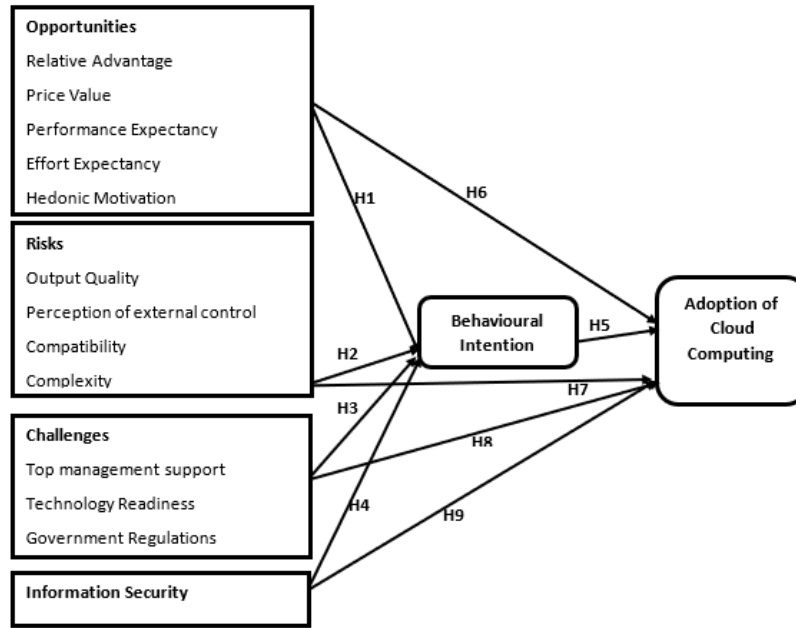


Figure 1. Secure cloud adoption model (SCAM)

4. RESULTS AND DISCUSSION

SCAM model tested hypothetically. The test was conducted among SMEs in the Sri Lankan information technology industry. Initially exploratory factor analysis was performed with SPSS. Then validity and reliability of the results checked. Finally confirmatory factor analysis with AMOS performed and the results generated as mentioned in the Table 4.

Table 4. Results of hypothesis testing

Hypothesis with direction	P-value (p<0.05)	Estimate value	Findings
H1: OPP → BI	0.000	0.217	Accepted
H2: RSK → BI	0.000	0.422	Accepted
H3: CHL → BI	0.000	0.585	Accepted
H4: IS → BI	0.005	0.152	Accepted
H5: BI → ACC	0.000	0.501	Accepted
H6: OPP → ACC	0.000	0.371	Accepted
H7: RSK → ACC	0.942	0.004	Rejected
H8: CHL → ACC	0.000	0.337	Accepted
H9: IS → ACC	0.919	0.004	Rejected
H10: OPP → BI → ACC	0.010	0.109	Accepted and Partial Mediation
H11: RSK → BI → ACC	0.944	0.211	Rejected
H12: CHL → BI → ACC	0.020	0.293	Accepted and Partial Mediation
H13: IS → BI → ACC	0.990	0.076	Rejected

- Hypothesis 1 is accepted: The strength of the relationship between opportunities and behavioural Intention is +0.217, and the p-value is statistically significant. Hence, it could be concluded that the opportunities are significantly and positively correlated with the intent to adopt cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 2 is accepted: The strength of the relationship between risks and behavioural Intention is +0.422, and the p-value is statistically significant. Hence, it could be concluded that the risks are significantly and positively correlated with adopting cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 3 is accepted: The strength of the relationship between challenges and behavioural Intention is +0.585, and the p-value is statistically significant. Hence, it could be concluded that the challenges are significantly and positively correlated with adopting cloud computing among IT industry SMEs in Sri Lanka.

- Hypothesis 4 is accepted: The strength of the relationship between Information Security and behavioural Intention is +0.152, and the p-value is statistically significant. Hence, it could be concluded that Information Security is significantly and positively correlated with the intent to adopt cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 5 is accepted: The strength of the relationship between behavioural Intention and adoption of cloud computing is +0.501, and the p-value is statistically significant. Hence, it could be concluded that Behavioural Intention is significantly and positively correlated with the adoption of cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 6 is accepted: The strength of the relationship between opportunities and adoption of cloud computing is +0.371, and the p-value is statistically significant. Hence, it could be concluded that behavioural Intention is significantly and positively correlated with the adoption of cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 7 is rejected: The strength of the relationship between risks and adoption of cloud computing is +0.004, and the p-value is statistically not significant. Hence, it could be concluded that risk is not correlated with the adoption of cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 8 is accepted: The strength of the relationship between challenges and adoption of cloud computing is +0.337, and the p-value is statistically significant. Hence, it could be concluded that challenges is significantly and positively correlated with the adoption of cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 9 is rejected: The strength of the relationship between opportunities and adoption of cloud computing is +0.004, and the p-value is not statistically significant. Hence, it could be concluded that Information security is not correlated with the adoption of cloud computing among IT industry SMEs in Sri Lanka.
- Hypothesis 10 is accepted: The strength of the relationship between opportunities and adoption of cloud computing is mediated by behavioural Intention. The strength is lower (+0.109) and the p-value is statistically significant. Hence, it could be concluded that the effect of opportunities on the adoption of cloud computing is partially mediated by behavioural Intention among IT industry SMEs in Sri Lanka.
- Hypothesis 11 is rejected: The relationship between risks and adoption of cloud computing is mediated by behavioural Intention is not statistically significant. Hence, it could be concluded that the effect of risks on the adoption of cloud computing is not mediated by behavioural Intention among IT industry SMEs in Sri Lanka.
- Hypothesis 12 is accepted: The strength of the relationship between challenges and adoption of cloud computing is mediated by behavioural Intention. The strength is +0.293 and the p-value is statistically significant. Hence, it could be concluded that the effect of challenges on the adoption of cloud computing is partially mediated by behavioural Intention among IT industry SMEs in Sri Lanka.
- Hypothesis 13 is rejected: The relationship between Information Security and adoption of cloud computing is mediated by behavioural Intention is not statistically significant. Hence, it could be concluded that the effect of Information Security on the adoption of cloud computing is not mediated by behavioural Intention among IT industry SMEs in Sri Lanka.

5. CONCLUSION

The secure cloud adoption model can be used for decision-makers to adopt the cloud computing infrastructure to their organisation with the concern of the opportunities (benefits) that they will gain, risks of adoption whether its complete migration, partial migration or slow migration to cloud from the traditional computing, challenges they will face by adding new infrastructure to their business and the security protection of their information by adding their data in the cloud. According to the survey results, the world is moving towards cloud computing, and several organisations partially adopted and planning to adopt it in the future. The SCAM model indeed benefits anyone who wishes to migrate into the cloud.

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BIOGRAPHIES OF AUTHORS







Aiman Athambawa     received his BSc (Hons) Degree in Information Technology from Sheffield Hallam University, UK in 2007. His MSc Degree in Computer Forensic and System Security from University of Greenwich, UK in 2011 and is currently reading for his Doctor of Philosophy at Management and Science University, Malaysia. His research interest includes cloud computing, cyber security, computer network and the Internet of things. He can be contacted at email: matheeh@yahoo.com.



Prof. Dr. Md Gapar Md Johar     is Senior Vice President Research, Innovation, Technology and System of Management and Science University, Malaysia. He is a professor in Software Engineering. PhD in Computer Science, MSc in Data Engineering, and BSc (Hons) in Computer Science and is a Certified E-Commerce Consultant are among his qualifications. Working and teaching in several organisations for more than 40 years has given him a broad range of expertise. His research interests include data mining, learning content management system, blended assessment system, knowledge management system, RFID, e-commerce, character recognition, image processing, and healthcare management system. He can be contacted at email: mdgapar@msu.edu.my.



Prof. Ali Khatibi     has spent 39 years in academia and industry, holding various prominent academic and administrative roles at The Management and Science University and contributing to research, teaching, and administration. a Marketing Professor and SVP He has been awarded as Senior Research Fellow, has received the Gold and Silver Medals for "Invention and Innovation research," has over 300 publications, has served as Editor-in-Chief, and has written many books. He can be contacted at email: alik@msu.edu.my.