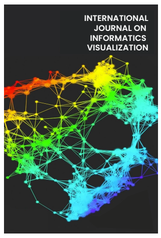
JOIV : Int. J. Inform. Visualization, 8(2) - May 2024 554-563

INTERNATIONAL JOURNAL
ON INFORMATICS VISUALIZATION

journal homepage : www.joiv.org/index.php/joiv



Adoption of Industry 4.0 with Cloud Computing as a Mediator: Evaluation using TOE Framework for SMEs

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Abstract— **Industry 4.0 represents a significant shift in production processes, necessitating the integration of humans, products, information, and robots into digitalized workflows. While this transformation offers numerous benefits, its adoption, particularly among small and medium enterprises (SMEs), is hindered by various challenges such as financial constraints, maintenance costs, and a lack of digital culture and awareness. This study examines the adoption of Industry 4.0, specifically through cloud computing technologies, within the manufacturing and service sectors of SMEs in Malaysia. Cloud computing is economical, straightforward, and easily implemented for SMEs. We propose a conceptual model based on an extended Technology-Organisation-Environment (TOE) model, integrating refined constructs and considering digital organizational culture as a moderator, with cloud computing acting as a mediator to enhance firm performance. The study investigates the relationship between these constructs and addresses overlooked factors influencing adoption. Utilizing a structured questionnaire with 54 items derived from previous research, we employ partial least squares structural equation modeling (PLS-SEM) to analyze data collected from a pilot study. Our findings confirm the reliability and validity of the proposed conceptual model, meeting established criteria for composite reliability, average variance extracted (AVE), Cronbach's alpha, and discriminant validity (HTMT Criterion). Furthermore, this study presents empirical findings on technological, organizational, and environmental influences on adopting cloud computing. The insights gained from this research offer valuable guidance to enhance the performance of SMEs in the Industry 4.0 landscape.**

Keywords: **Cloud computing; small, medium enterprise (SME); digital organizational culture; technology-organization-environment (TOE) Framework; SME performance.**

Manuscript received 25 Sep. 2023; revised 7 Oct. 2023; accepted 23 Feb. 2024. Date of publication 31 May. 2024.

I. INTRODUCTION

Industry 4.0 integrates humans, products, information, and robots into digitalizing production processes. The technological development of Industry 4.0 is accelerating faster than any previous revolution in human history, impacting ordinary people's and businesses' daily operations in ways that were never imagined. Technological advancement has forced traditional businesses and organizations to evolve and adopt more innovative technology. This situation has become more demanding for SMEs. SMEs who fail to embrace Industry 4.0 may risk losing the advantages of this technology application. With the rise of the Internet of Things (IoT), artificial intelligence (AI), 3D printing, robotics, quantum computing, fast developments of mobile devices, and many other technologies, a wave of limitless opportunity has unleashed those who can adopt and utilize such technology for enhanced organization performance. SMEs must escape from the computerization trap and change their organizations through digital transformation by using cloud computing to optimize their process operations. It is crucial to achieve the next efficiency level and expand company development through innovative business models, goods, and services using the latest technological tools [1], such as cloud computing.

Several gaps and challenges exist in adopting cloud computing in SMEs, leading to SMEs failing to implement Industry 4.0-based technology. Such failures may affect the company's long-term viability and financial consequences [2], [3]. This is due to the rapidly changing market trends that demand fast responses to the technological improvements associated with Industry 4.0. Elevating the technical efficiency of SMEs will boost their business outreach and performance [4]. Organizational flexibility and agility have also been determined as the main challenges facing SMEs in adopting Industry 4.0. Another barrier is the significant financial investments and expenditures required to digitalize processes by installing new software, tools, and equipment [5]. In addition to installation costs, maintenance costs must be maintained to ensure that tools and equipment are continuously in good condition and that utilization remains optimum. Maintenance cost was therefore identified as another challenge that influences SMEs in adopting Industry 4.0. Providing competency training to staff to ensure readiness is an additional factor [6]. The lack of digital culture and awareness regarding the advantages of Industry 4.0 technologies at an organizational and individual level was identified as a significant issue influencing SMEs' adoption of Industry 4.0 [5], [7]. A significant concern of SMEs is the security issues related to information technology. According to Abubakar et al. [8], cybersecurity issues remain a significant concern for both large and small organizations. Cybercrime has led to the loss of billions of dollars. It causes computer system malfunctions, destroys critical information, and compromises network integrity and confidentiality. These effects can be catastrophic if cybercrime targets SMEs [8].

The relevant factors that can influence the successful adoption of Industry 4.0 must be thoroughly discussed, as well as the best adoption practices to increase the performance of SMEs. Thus, this study fills the current gaps by examining the best method for measuring the adoption of Industry 4.0 with a specific focus on cloud computing technologies. Based on previous literature, this study also explores the elements that influence an organization's technology adoption. Since the adoption of Industry 4.0 should include both technical, human behavior, and organizational culture, this study further focuses on the human and organizational factors and the technical areas. This study investigates the mediating effects that technological, managerial and environmental factors could deliver with a specific focus on cloud computing technology. The adoption of cloud computing and the motivational factors, such as a firm's performance, may influence the redefinition of their relationship.

This study further examines the moderating effect between digital organizational culture, technological, managerial, and environmental factors, and the adoption of cloud computing. We propose an extended framework based on the TOE framework, as cited in the literature. The TOE framework is commonly used to evaluate the adoption of technological innovation research. Our scope is limited to SMEs in Malaysia.

This paper is structured as follows: Section 2 discusses the related works from the literature review concerning technologies under Industry 4.0, with a focus on cloud computing adoption from the technological perspective. We also consider the organizational and environmental frameworks, organizational performance, and digital organizational culture as factors that influence adoption. Section 3 discusses the development of the evaluation concept using our proposed and extended TOE framework and the hypotheses. Section 4 presents the results and analysis. Section 5 concludes this paper by summarizing future recommendations.

II. Materials and Method

Industry 4.0 is a concept built by researchers and industrial stakeholders that focuses on nine guiding pillars: cloud computing, cybersecurity, autonomous robots, simulations, system integration, the Internet of Things (IoT), big data, additive manufacturing, and augmented reality [9]. As one of the main pillars of Industry 4.0, cloud computing will enable individuals and organizations of all sizes to rapidly develop and adapt new technologies, allowing them to take full advantage of the opportunities that Industry 4.0 can offer to become more competitive and sustainable.

A. Cloud Computing

Cloud computing has been defined by the National Institute of Standards and Technology (NIST) as a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources [10]. The computing resources include servers, networks, storage, applications, and scalable computing services. Cloud computing allows flexibility and enables the rapid provisioning of computing services. Cloud computing-based services can also be deployed with minimum effort to manage the infrastructure. It requires less interaction with service providers, making it convenient for easy adoption. NIST categorized cloud computing according to three primary service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Technology Software as a Service (SaaS) [10].

Cloud computing has the potential to fundamentally alter how businesses function and how computer services are created, distributed, managed, maintained, and compensated [12]. In recent years, there has been a significant shift towards using the latest technology to achieve competitive advantages. While the reasons for adopting cloud computing differ, organizations often fall into one of the following categories: cost-saving, availability, scalability, flexibility, and time-to-market. Cloud computing can provide significant advantages to companies, particularly SMEs, who often cannot afford significant investments in information technology infrastructure. In return, cloud computing will enable them to focus more on their core business. Establishing cloud computing platforms allows organizations to access the most up-to-date data, processes, and applications without building a sophisticated physical infrastructure. Cloud computing solutions are easily adaptable and changeable as company requirements and technological options improve. Cloud computing enables organizations to be more flexible from any location, according to their specific requirements [13]. Any business or organization can employ cloud computing to harness the power of technologically sophisticated applications and solutions, allowing them to take their operations to the next level. Cloud computing requires simpler management than when a company needs to host everything on-premises, as shown in Fig. 1, offering less burden for SMEs to utilize cloud computing.

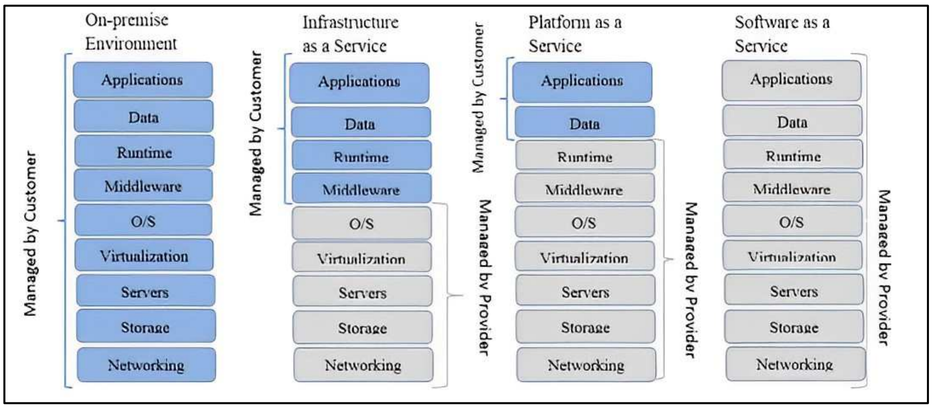

Fig. 1 The traditional IT model and cloud computing service models [11]

B. Overview of SME Performance in Malaysia

SMEs are crucial in propelling the engine of the economy forward. In the manufacturing and service sectors, SMEs play a vital role in the country's overall development. According to the Economic Census 2016: Profile of SMEs, the services sector has accounted for more than 89.2% of all SMEs in Malaysia, amounting to 809,126 SMEs, followed by the manufacturing sector contributing 5.3% (47,698). Approximately 4.3% of SMEs (39,158) were involved in the construction sector, with the remaining 1.2% in the agriculture, mining and quarrying sectors [1].

SMEs must adopt cloud computing to provide on-demand self-service (auto scalability), broad network access, information storage, complete availability of resource pooling/ sharing, rapid elasticity, and measured service that allows clients to access almost unlimited computing power without significant investments to the infrastructure [14], [15], [16]. Cloud computing technologies also provide easy network connectivity with minimum reaction time and large bandwidth. It ensures the real-time availability of information-sharing across multiple systems and networks [17], [18].

Our paper argues that SMEs can improve their performance by utilizing cloud computing technology. We propose that cloud computing can enhance productivity by improving efficiency. Our proposal is supported by research on the organizational level, which includes the financial and non-financial returns of IT investments [19], [20], [21]. Based on previous research, several methods for assessing and evaluating the performance of SMEs have been highlighted. Most studies have evaluated SMEs' long-term viability and competitiveness and the level of innovation of their products, processes, and management systems [22], [23]. Duygulu et al. [24] evaluated the performance of SMEs based on three mission components: (1) survival, growth, and profit, (2) philosophy and value, and (3) public image. Previous research further noted that organizational culture is essential in evaluating the success of projects that involve organizational changes [25].

In Malaysia's case, the definition of SMEs is based on the company's sales with a turnover not exceeding RM50 million or the employment of less than 200 full-time workers in the manufacturing sector. For different services and other sectors, SMEs are defined as having sales turnover not exceeding RM20 million or employing less than 75 full-time workers [26]. According to the published SME Annual Report 2019/2020 [26], Malaysian SMEs contributed 38.9% of the Gross Domestic Product (GDP) in 2019, employed 48.4% of the country's workforce and made up 98.5% of total business establishments in the country [26].

C. Digital Organizational Culture

Adopting a digital organizational culture is essential as it helps to determine the important criteria or aspects that must be evaluated to boost SME performance. Previous studies have suggested numerous definitions for organizational culture throughout the years. According to Kilman et al. [27], as cited by Owens & Steinhoff [28], organizational culture was defined as "shared philosophies, ideologies, values, assumptions, beliefs, expectations, attitudes and norms that knit a community together." Barney [29] also described organizational culture as a "complex set of values, beliefs, assumptions, and symbols that define how a firm conducts its business." Schein [30] stated that organizational culture is a "pattern of basic assumptions that a given group has invented, discovered, or developed in learning to cope with its problem of external adaptation and internal integration, and that have worked well enough to be considered valid, and, therefore, to be taught to new members as the correct way to perceive, think, and feel about these problems" [30]. In the digital domain, digital organizational culture can be defined as a set of shared assumptions and understanding of how organizations operate in the digital world [31]. Based on the study by Padilha & Gomes [32], organizational cultures that support innovative activities are more likely to be involved in creativity and improve innovation performance.

Digital Organizational Culture stands out as an essential factor in digital innovation evaluation. It is a group of critical attributes, understanding, beliefs, and conventions acknowledged by organization members [33]. Organizing culture is the method of thinking and working with a group of people at the exact location. This includes policies, rules, and procedures, customs, traditions, values, and beliefs. It also involves the assumptions and nature of the language used for communication [34]. In this research, we applied the Digital Organizational Culture as a related theory that can help determine the elements or factors that influence the adoption of cloud computing in SMEs.

However, some organizations have failed to enjoy the benefits and advantages of adopting digital transformation due to cultural conflict [35]. Hoffman & Klepper [36] further highlighted that managers often overlook or underestimate the role of organizational culture when evaluating the success or failure of new technology adoptions [36]. Additional research is required to determine how digital organizational culture may benefit organizations in this sector with their digital transformation. An influential framework, the TOE framework, has been established to evaluate the elements related to technological innovation research and help integrate various perspectives based on domain research. This research discusses the moderating effect of digital organizational culture on the relationship between the identified components used as the evaluation criteria for SMEs.

D. Technology, Organization, and Environment (TOE) Framework

Several researchers have shown the relevance of the TOE framework, developed by [37], in demonstrating the effects of environmental, technological, and organizational dimensions on the decision to implement technological advancements [38]. TOE is superior to other technology adoption and usage models since it integrates technological, managerial, and environmental dimensions [12]. Despite its origins in 1990, TOE is still widely used to model and measure the influence of TOE components on the adoption of new developing technologies and applications, such as cloud computing [39], [40], [41] and TOE and information system innovations for SMEs [42], [43]. However, the TOE constructs must be revisited based on the current Industry 4.0 scenario to ensure their relevance and efficiency in evaluating SME adoption of Industry 4.0.

The TOE theory was targeted explicitly for technology acceptance and is the most popular in information security research [44]. TOE is a well-established framework that presents a broad collection of characteristics to explain and estimate the potential of innovation/technology adoption [37]. Three variables that influence innovation acceptance or implementation have been proposed in the framework. The variables are organizational conditions, technological development, business and organizational reconfiguration, and industry environment. This framework includes the influence of human and non-human elements, including internal and external factors such as environment, organization size, and organization strategy. Three contexts that leverage technology innovation adoption and implementation process of the TOE framework are listed in Fig. 2 [45].

The organizational dimension examines an organization's qualities and resources that influence the acceptance and implementation of innovations [46]. Some of the standard organizational features that affect the choice to embrace cloud computing include the size of the company, top management support, organizational culture, organizational structure, the accessibility of the workforce, and spare resources [46], [47], [48]. The environment dimension consists of the environments in which an organization operates. It may also refer to the company's surrounding environment, such as industry characteristics, rivals, rules, and government laws and regulations [46], [47], [48], [49]. The TOE framework is not restricted to a specific firm size or industry type, making this framework suitable for directly incorporating SMEs [37].

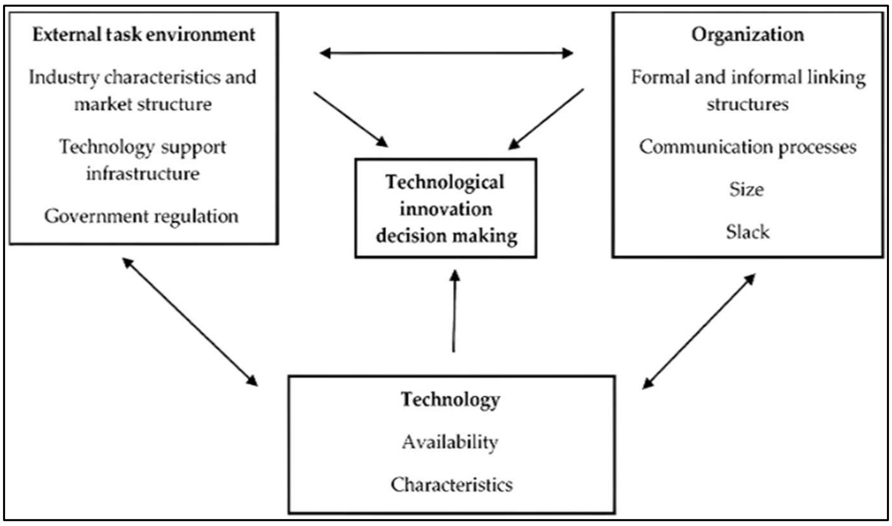

Fig. 2 The TOE framework [37]

As previously mentioned, a suitable framework is needed to measure the adoption of cloud computing. Despite the importance of these technological factors, we found that human factors, such as digital organizational culture, must also be included since they can also influence the adoption of cloud computing in SMEs. Thus, this study proposes a conceptual framework based on the original TOE framework with refined constructs, digital organizational culture as a moderator, and cloud computing's mediating role on a firm's performance.

E. Development of Extended TOE Framework using Identified Constructs

We established a preliminary conceptual framework in [50] that includes the following constructs: "Adoption Cost" for the organization dimension, "Cybersecurity" for the technology dimension, and "Government Support" for the external environment dimension. These constructs were determined to be relevant in validating SMEs' adoption of Industry 4.0 based on the original theory of the TOE Framework. According to our proposed preliminary framework [50], [51], we worked with identified experts to further enhance the framework. Interview sessions were conducted with four experts from the industry to validate and improve the framework and constructs most suitable for achieving the objectives of this research. Two experts involved in this process are from SMEs, and another two are from the Malaysian government agency responsible for industrial development. This study focuses on the two most significant components of each technological dimension: organizational and environmental. From the discussion with the experts, the conceptual framework was refined and underwent the validation process for this research, then developed and shown in Fig. 3. Based on experts' suggestions, for the technology dimension, the selected constructs are “Relative Advantages” and “Cybersecurity.” For the organization dimension, two constructs were adopted: “Top Management Support” and “Adoption Cost,” while for the environment dimension, two constructs were also adopted: “Government Support” and” Business Partner.” Since organizations sometimes overlook the importance of digital culture when adopting new technology, experts are suggesting including digital organizational culture in the framework.

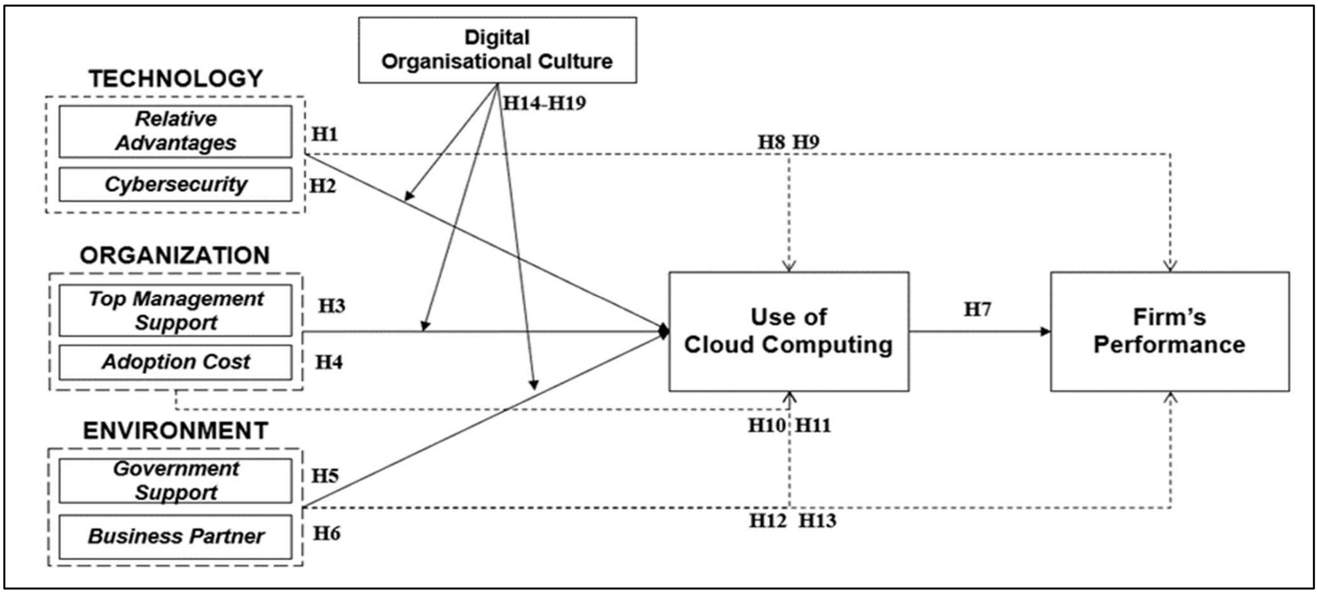

Fig. 3 Conceptual model of the study

F. Hypotheses Development

Based on the literature review in Section 2 and the validated conceptual framework created according to the recommendations of experts, this study suggests the following hypotheses:

- H1: Perceived relative advantages positively influence the use of cloud computing
- H2: Cybersecurity positively influences the use of cloud computing.
- H3: Top management support positively influences the use of cloud computing.
- H4: Adoption cost positively influences the use of cloud computing.
- H5: Government support positively influences the use of cloud computing.
- H6: Business partners positively influence the use of cloud computing.
- H7: A firm’s performance is positively influenced by using cloud computing.
- The relationship between perceived relative advantages and firm performance is mediated by using cloud computing.
- H9: The relationship between cybersecurity and firm performance is mediated by using cloud computing.
- H10: Cloud computing mediates the relationship between top management support and firm performance.
- H11: The relationship between adoption cost and firm performance is mediated by using cloud computing.
- H12: The relationship between government support and firm performance is mediated by using cloud computing.
- H13: The relationship between business partners and firm performance is mediated by using cloud computing.
- H14: Digital organizational culture moderates the relationship between perceived relative advantages and the use of cloud computing.
- H15: The relationship between cybersecurity and the use of cloud computing is moderated by digital organizational culture.
- H16: Digital organizational culture moderates the relationship between top management support and the use of cloud computing.
- H17: The relationship between adoption cost and the use of cloud computing is moderated by digital organizational culture.
- H18: The relationship between government support and the use of cloud computing is moderated by digital organizational culture.
- H19: Digital organizational culture moderates the relationship between business partners and the use of cloud computing.

Based on the established hypotheses, the instruments for data gathering were successfully developed.

G. Development of Instruments

In this study, we employed the survey technique for data collection and focused on SME organizations. A pilot test data was conducted to investigate and validate the reliability of the suggested constructs of the model. The structured survey questionnaire consists of 54 items adapted from previous research. The questionnaire is measured using a 5-point Likert scale: (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree and (5) Strongly Agree. The questionnaire was validated through a pre-test conducted with four academic computer science experts and one expert for proofreading. After validation, the questionnaire was further improved according to the experts' advice. It was then distributed to 30 respondents in the target population, primarily SMEs in the manufacturing and services industries in Kuala Lumpur. These steps were executed according to a study by Hoque et al. [52], [53] who stated that researchers who modify and tailor previously established instruments and items according to their current research goals must perform a pilot study to identify their accuracy with the current study population's socioeconomic, racial and cultural differences. This is crucial since circumstances can vary from the work accomplished in previous studies. This step will further confirm whether some items in the questionnaire should be removed due to their not being appropriate for the scope of the study. Table I presents the details of the respondents' demographic criteria.

TABLE I
DEMOGRAPHIC INFORMATION (N = 30)

Demographic Criteria	Frequency	%
Gender		
Male	26	86.7
Female	4	13.3
Age		
< 20	1	3.3
20-30	6	20.0
31-40	14	46.7
41-50	5	16.7
51-70	4	13.3
Level of Education		
High School Diploma	3	10.0
Vocational/Technical degree	5	16.7
Diploma	6	20.0
Bachelor's Degree	13	43.3
Master's Degree	2	6.7
Doctorate Degree	1	3.3
Nature of Business		
Manufacturing	8	26.7
Services	18	60.0
Others	4	13.3
Organization/Company Size:		
< 5 employees	0	-
6 - 20 employees	6	20.0
21- 50 employees	13	43.3
51 - 75 employees	9	30.0
76 - 100 employees	2	6.7
> 100 employees	0	-
Years of Establishment:		
Less than three years	2	6.7
3 - 5 years	11	36.7
6 - 10 years	9	30.0
10 - 15 years	6	20.0
Over 15 years	2	6.7
Experience in Cloud Computing: (Duration)		
< 1 years	0	-
1 - 5 years	15	50.0
6 - 10 years	9	30.0
10 - 15 years	3	10.0
Over 15 years	3	10.0

III. Results and Discussion

A. Measurement Model Analysis

This study applied a partial least square structural equation modeling (PLS-SEM) analysis. The analysis was conducted using SmartPLS 3.0 software. The SmartPLS 3.0 software is an analysis tool that examines the measurements and structural models utilized without conducting a normality assumption. The reason, as discussed in [54], is that the survey research is not normally distributed.

The exogenous variables in the data are perceived relative advantages (PR-9 items), cybersecurity (CY-4 items), top management support (TMS-5 items), adoption cost (AC-6 items), government support (GS-5 items), business partner (BP-6 items) and digital organizational culture (DOC-4 items). Cloud computing (UCC- 4 items) and firm performance (FP- 11 items) are endogenous variables.

This paper presents the pilot data collection of 30 respondents, focusing on the measurement model analysis to determine the quality criteria of the model. The study results expected to be achieved are i) internal consistency (composite reliability), ii) indicator reliability/factor loading (indicator loading), iii) convergent validity (average variance extracted (AVE)), and iv) discriminant validity (HTMT criterion). The structural model analysis will require a more extensive sampling size to test and validate the hypotheses, which is also accomplished at a later stage of our research.

1) Internal Consistency (Composite Reliability): Previous research has mentioned that Cronbach's alpha can be applied to determine the data's internal consistency. A high Cronbach's alpha value indicates that the components within the construct have a comparable range [55]. It provides an estimate of reliability based on the inter-correlation of observed indicators. Studies also noted that the acceptance value for Cronbach's alpha should be above 0.7 [56]. Apart from Cronbach's alpha, the alternative reliability measure, known as composite reliability, is also analyzed. Although Cronbach's alpha measure's internal reliability, composite reliability considers the loadings of indicators. Acceptance values above 0.7 are considered satisfactory for composite reliability. Table II displays Cronbach's alpha, composite reliability, and AVE values for each construct used in our study. Based on the results, we confirmed that for all proposed constructs, Cronbach's alpha and composite reliability values are more significant than 0.7, signifying their reliability.

2) Indicator Reliability/Factor Loading (Indicator Loading): The results of the indicator reliability or factor loadings of the constructs in this study are shown in Fig. 4. According to Hair et al. [57], all loadings that exceed the recommended value of 0.708 are reliable and can be utilized for the following steps in data gathering. Thus, all proposed constructs will be maintained in the next steps of this study. Items with low loadings, CY04 (0.374) and PR01 (0.590) were subsequently removed from the model. After deleting the lowest loadings, the PLS algorithm was repeated. From the results of Fig. 4, items BP03 (0.642), BP06 (0.681), GS03 (0.601), PR03 (0.587), and PR05 (0.682), which have low loadings below 0.708, are retained. This is based on the suggestion of Byrne [58], who stated that when the loading value is less than 0.708 but more than 0.5, it can still be considered acceptable, provided that the summation of loading results of high loading scores that contribute to AVE scores are more significant than 0.5 [58].

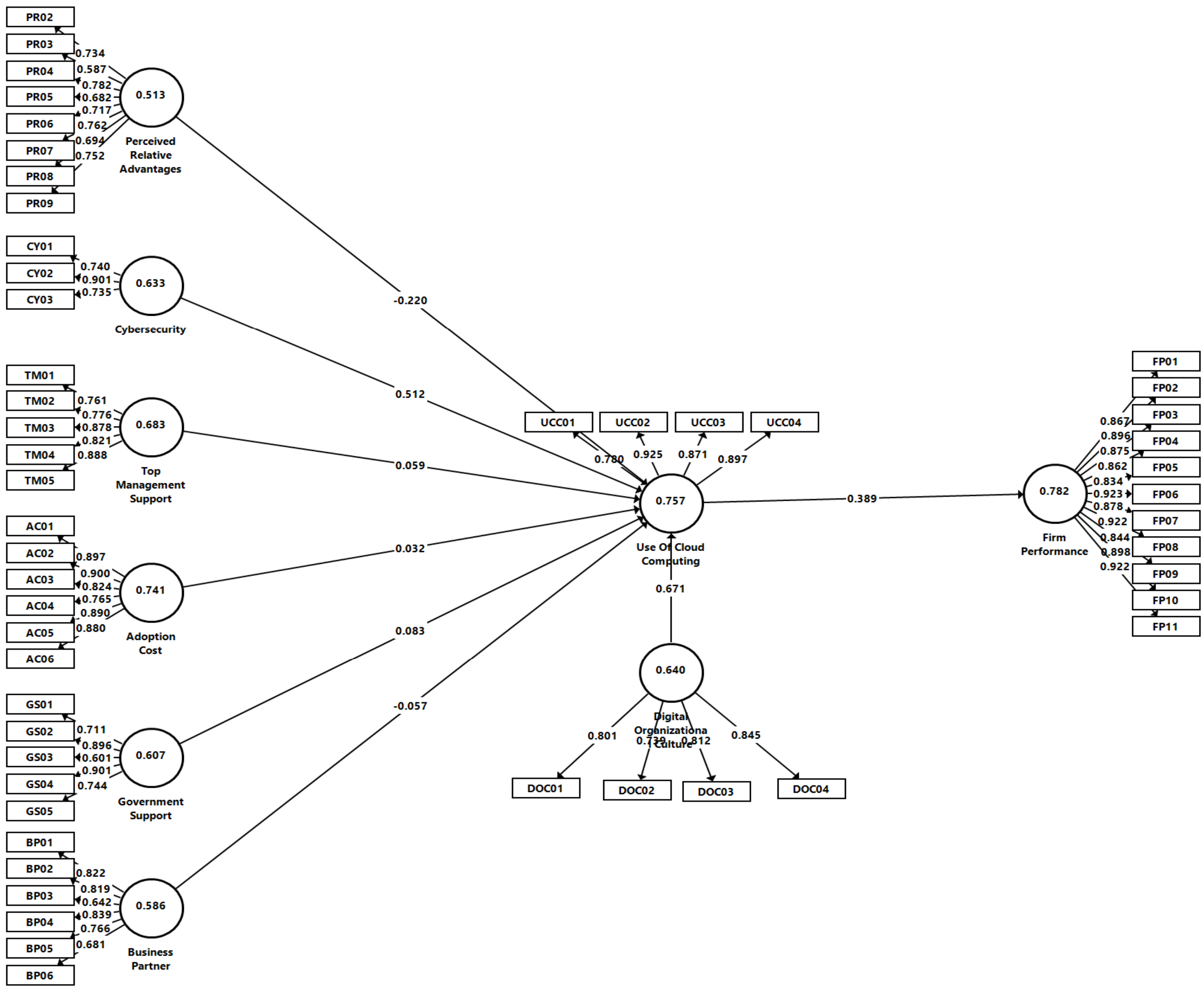

Fig. 4 Indicator reliability/Factor loadings and AVE (*PR01 and CY04 were deleted due to low loadings*)

3) Convergent Validity (Average Variance Extracted (AVE)): In [59], Urbach et al. mentioned that convergent validity is related to how individual indicators will reflect on a construct converging to indicators when measuring other constructs. Hair et al. [60] defined AVE as a grand mean value of the squared loadings of all indicators associated with the constructs. It is the degree to which a latent construct explains the variance of its indicators[60], [61]. Table II presents the values of AVE for each construct. All constructs have an AVE value of more than 0.5 (after deleting low-loading items). This is based on the threshold value suggested by Fornell et al. [62]. The AVE value of more than 0.5 indicates that each construct accounts for at least 50 percent of the assigned indicator's variance.

TABLE II
RELIABILITY AND NORMALITY TEST

Construct	Cronbach's Alpha	Composite Reliability	AVE
Adoption Cost	0.930	0.945	0.741
Business Partner	0.871	0.894	0.586
Cybersecurity	0.714	0.837	0.633
Digital Organizational Culture	0.814	0.877	0.640
Firm Performance	0.972	0.975	0.782
Government Support	0.849	0.883	0.607
Perceived Relative Advantages	0.869	0.893	0.513
Top Management Support	0.884	0.915	0.683
Use of Cloud Computing	0.892	0.925	0.757

4) Discriminant Validity (HTMT Criterion)

The next step of this study is to assess the discriminant validity of the model. This is accomplished by following Fornell & Larcker's criterion and the Heterotrait-Monotrait (HTMT) correlation ratio. According to previous research, the discriminant validity can be evaluated using the cross-loading of the indicator. We assessed the Heterotrait-Monotrait (HTMT) correlation ratio developed by Henseler et al. [63], who suggested that HTMT values close to 1 indicate a lack of discriminant validity. Thus, using the HTMT as a criterion involves comparing it to a predefined threshold. If the value of HTMT is higher than this threshold, we can conclude that there is a lack of discriminant validity for the proposed constructs. Table III presents the results of this study. All values fulfill the criterion of HTMT since they are less than 0.90 [64] and the HTMT is less than 0.85 [65]. The values reveal that the discriminant validity has been verified. Henseler et al. [63] also noted how the results of HTMT inference contribute to the confidence interval. Our outcomes did not attain a value of 1 on any of the proposed constructs, thus confirming our study's discriminant validity.

TABLE III
HETEROTRAIT-MONOTRAIT RATIO (HTMT)

	AC	BP	CY	DOC	FP	GS	PR	TM	UCC
Adoption Cost									
Business Partner	0.358								
Cybersecurity	0.400	0.571							
Digital Organizational Culture	0.290	0.463	0.251						
Firm Performance	0.319	0.534	0.614	0.376					
Government Support	0.516	0.508	0.336	0.311	0.580				
Perceived Relative Advantages	0.352	0.720	0.683	0.583	0.736	0.62			
Top Management Support	0.313	0.442	0.199	0.525	0.662	0.558	0.434		
Use of Cloud Computing	0.385	0.355	0.61	0.776	0.386	0.257	0.483	0.402	

IV. CONCLUSION

In this study, we proposed the conceptual framework for SMEs' adoption of cloud computing technology. The industry within our research scope includes manufacturing and services SMEs in Malaysia. This paper discussed the background study, which contained the technological and non-technological aspects. This paper further examined the relationship between the TOE framework and the research gaps that organizations often overlook in digital organizational culture as moderators and the mediating role of cloud computing on a firm's performance.

Based on the literature, we proposed a conceptual framework that was validated and improved according to the panel of expert advice. The constructs were justified as relevant for the context of this study. The hypotheses were developed to investigate the effects and relationship of each construct proposed in our conceptual framework. A pre-test was conducted to confirm that the experts checked and enhanced the survey questionnaire. Evaluation of the pilot data is critical. Current research must conduct a pilot study since the population's socio-economic, racial, and cultural differences vary from previous research. From the initial 54 indicators, two indicators were removed from the questionnaire due to low loadings. Items BP03, BP06, GS03, PR03, and PR05 were retained according to Byrne's suggestion [58]. From the results, the validity and reliability of the model had all met the satisfactory requirement of composite reliability, average variance extracted (AVE), Cronbach's alpha, and discriminant validity based on the Heterotrait-Monotrait ratio (HTMT). The reliability and validity of the conceptual model were confirmed based on the results obtained from the pilot data.

The model's analysis in this pilot study was limited due to the minimal sample size. This limitation aligns with studies that have also used sample sizes to explore the acceptance and intention to use other Industry 4.0-based technologies such as blockchain and cryptocurrency [66], [67], [68], [69]. Future endeavors will involve collecting field data from a larger sample of respondents using a structured questionnaire.

The study's outcome contributes in two ways. The first contribution is theoretical, specifically observing cloud computing as a mediating role in the performance of SMEs and the moderating effects of digital organizational culture. After the field data collection, the research will evaluate the relationship and impact of cloud computing and digital organizational culture as mediators and moderators within the TOE framework. The findings will contribute to new theoretical knowledge and provide empirical evidence on the constructs of the TOE framework, the mediating impact of cloud computing, the moderating effects of digital organizational culture, and how they can improve a firm's performance.

The second outcome of the study is the practical contribution. Since the adoption rate of cloud computing in SMEs is still low, with the study's outcome, SMEs will be able to identify the constructs that significantly affect the adoption process. The outcome will further support empirical evidence on whether a firm's performance will improve with adopting cloud computing. Our future work will include more extensive data collection that targets more significant respondents according to pre-determined sampling based on the respondents' demographic criteria.

ACKNOWLEDGMENT

This paper is fully supported by The Malaysia Ministry of Higher Education (MOHE) and the National Defense University of Malaysia (UPNM) under FRGS Grant FRGS/1/2021/ICT07/UPNM/02/1. The authors fully acknowledged the MOHE and UPNM for the approved fund, making this critical research viable and effective.

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